DISTRIBUTED PRACTICE AND PRACTICAL NEGOTIATION IN A TECH ED CLASSROOM::
THE WAY THINGS ARE DONE IN TECHNOLOGY EDUCATION

By

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ABSTRACT

This inquiry is about the sense-making of students in a technology education class as they build a prototype electric car in a secondary school manufacturing shop. I make sense of their sense-making by examining their talk and interaction in the interplay of the social, material, institutional, and organizational resources constituting what I call "distributed practice." This involves a move away from defining understanding and learning as self-contained structures in the minds of people, but instead sees learning as spread out in the broad social context of activity and participation. Distributed practice theorized in this way is about the interplay among "complex social relations, technologically constituted." Technologies and their use in practice provide us with a realm through which we can discuss issues related to the understanding of learners. In many respects, this dissertation is an exploration of how "the way things are done" becomes understanding and alternately, how understanding becomes "the way things are done." The analysis moves towards a social and cultural practice view of learning I call "practical negotiation."

RÉSUMÉ

Cette étude traite du développement de la compréhension chez des élèves d'une classe de technologie qui travaillent à la réalisation d'un prototype de voiture électrique dans l'atelier d'une école secondaire. Pour étudier ce développement, j'examine leurs conversations et leurs interactions dans le cadre des échanges sur les plans social, matériel, institutionnel et organisationnel qui constituent ce que j'appelle la « pratique répartie ». Ce faisant, j'y définit la compréhension et l'apprentissage non plus comme un ensemble de structures autonomes faisant appel à l'intelligence mais plutôt comme un ensemble qui s'étend au contexte plus large des activités et de la participation. Examinée de ce point de vue, la pratique répartie touche les échanges entre « relations sociales complexes, constituées sur une base technique ». Les technologies et leur utilisation dans la pratique nous offrent un domaine dans lequel il est possible de discuter de questions liées à la compréhension de la personne en situation d'apprentissage. Sous bien des aspects, la présente dissertation est une exploration de la manière dont la « façon de faire » devient compréhension et, inversement, comment la compréhension devient la « façon de faire ». L'analyse en vient à considérer l'apprentissage comme une pratique sociale et culturelle que j'appelle une « négociation pratique ».

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From the outset Jan and I thought that this project would only work if we remained healthy as a couple and family. Doctoral studies have dominated our plans over the past five years, so much so, that when Jan informed our daughter Kaija that I would be submitting the dissertation soon, she responded with disbelief! This project has stretched over half of her, and our son Keji's lifetimes. Now that it is all but done, there are many projects to be taken up with them more directly. The time of course, has been borrowed from them, and it would not have come to completion as it has without their love, and unconditional support.

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INTRODUCTION: LEARNING WITH BOTH HANDS

> ...being an active practitioner with an authentic form of participation might be one of the most deeply essential requirements for teaching
> (Wenger, 1998, p. 277)

Currents and Undercurrents

I begin with two stories about my experience and the assumptions I carry into this inquiry. The first story traces a personal learning trajectory from my own student days, and the second is about my professional and research interests. Both serve as an introduction to the institutional and research context of the dissertation.

Learning with both hands

The most meaningful memories I have of secondary school apart from participating in sports, are projects I did in my woodworking classes and a particular project in my first year science class. I was completely uninterested in anything academic, especially science (which I was failing). My science teacher asked me to do a special experiment: build an incubator and open an egg each day throughout the incubation period. I went to the experimental farm at the Department of Agriculture and found out what was required. I made the incubator with my parents and carried out the experiment with my classmates. I loved it. To this day, I understand the incubation for a chicken is twenty-one days long and their eggs need to be rotated regularly and kept in a moist atmosphere within a certain temperature range. A number of things were created in that experience for me: how to make an incubator, the idea of an incubation period, the concept of a suitable environment for growth, and my feelings of accomplishment that remain to this day.

I subsequently left school early and sought out a trade. My experience in the world of work contrasted sharply with most of my secondary schooling. Working as a carpenter, I was constantly making and building things. Productive activity was the way I made sense of the world. Making things was the medium through which I defined myself as a person; a fixer and maintainer of houses and canoes. Later, as a woodworking teacher in secondary school, I understood that "making activity" and the "made" world helped organize what happened there. It didn't matter what was made, whether furniture, canoes, sculpture, knick-knacks: They all provided opportunities for learning related things like math, environmental concerns, histories etc. "Learning with both hands" continues as an organizing thread underpinning my understanding about learning.

Appearances that mislead

The second story and way of thinking about what happens to students in classrooms came to me as I put the finishing touches to my master's thesis (Kozolanka, 1993). In one instance, I used my observations and what I already knew about the attitudes of two students for forming some thoughts about the nature of what they were doing. One student appeared to be working hard; the other did not. When I interviewed both later that day, I asked them what they were thinking about. I was surprised by what each had to say. The hard working student criticized the value of the work he had been doing. He communicated some of his dissatisfaction with the overall nature of the house they were building. The student who *appeared* to not care articulated a sophisticated understanding of the significance of the project for him. He linked their house building project to the broader community as an enduring pattern through the years, conveyed in terms of his own growth and "meaning making". I used what both students said for supporting my thesis that each enacted their own unique "pattern of engagement" (Kozolanka, 1993 p. 171) I attributed to their individual differences. Learning was framed in the context of an individualistic, empiricist research tradition informed principally by behavioural and cognitive psychology.

Both of these stories serve as useful starting points for introducing the thesis I develop in this dissertation. My incubator story identifies my assumption that practical activity holds the social, cultural and technical means for mediating experience and learning, an area of interest I began exploring in the wake of my master's research[1]. My comment about misleading appearances reveals that

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1. For a detailed explanation of the dialectical relationships between practical activity and learning in the context of teacher education, see Kozolanka (1994).

researching practical activity in classrooms requires more than attention to observing what people do or listening to what they say about what they do. It also requires careful attention to the theories that guide or frame our understanding. My earlier research, for example, uses the presence and absence of "flow experiences" (Csikszentimihalyi, 1975) for gaining a view of student social engagement[2]. However, the formation of the classroom context in that research is left unanalyzed, which context I present unproblematically and separate from any broader enabling habitat. By contrast, the main idea I follow in this dissertation is that local classroom action and "sense-making" provide a window for seeing that there is something more than what appearances might provide. What, then, might this something more be, and what form does "it" take?

A sketch of the argument: Something more

This dissertation is about examining the way things are done as students construct an electrically-powered car in a secondary school shop. I examine their actions in the theoretical context of other research, exploring practical activity like those imitated in this proto-engineering classroom. I begin by problematizing the institutional context as a "learning by doing" approach, a popularly-held pedagogic notion that links doing with learning. There are

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2. In that analysis I used what Bruner (1990) describes as an "inside out" view of learning. For an argument that action cannot be accounted for by an exclusive attention to intrapsychic expressions see Bruner.

undoubtedly good reasons for using doing as a way of thinking about learning, but given my earlier research, I wanted something more than accepting appearances that doing forms an unproblematic link to learning. The "way things are done around here" is an inquiry challenging the rhetoric of learning by doing embodied in one case of technology education in Ontario.

Recent advances in learning theory informing this analysis here suggest that when we examine people going about their everyday activities, we find that "things" matter as much as "thinking". We find on examination that things are endowed with rich social and cultural meanings; meanings that work their way into our understanding as we interact with them. A main analytic thread followed in this research is exploring the presence and workings of these meanings and subsequent understandings in the way things are done. An assumption of this view is that the specific circumstances of the way things are done carry with them a history constitutive of learning[3]. The implication is that there is an indirect relation between instruction and learning. I argue that this indirect relation is constituted within a social and culturally organized "access" to everyday practice. The access afforded to students through such an organization accordingly becomes a focus of attention as the inquiry progresses.

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3. For an explication of practical activity and artifacts as historically developing, see Cole (1990).

The making of an electric car is a fruitful object for analysis because it imitates the communities and cultural traditions of both workplaces and schools. My classroom and the students in it are constituted by understanding in many forms; objects like tools, processes like a division of labour, knowledges in the form of procedures and propositions, and the intentions of various people. I refer to these versions of understanding broadly as "technologies of doing". Taken together with other learning resources like "co-participation" and the "requirements of working practice", they form a social and culturally organized access I call "distributed practice". The latter is a way of theorizing the notion that activity provides more than its own context: that it is a historical, political, social, as well as a cultural act.

I characterize student actions and their sense making within distributed practice as a negotiated interplay where students both exhibit as well as generate their classroom circumstances. Distributed practice is both enacted and negotiated by these students as they exhibit existing understandings as well as generating emergent ones. Their classroom consists of an inherited and constructed world at the same time. Accordingly, distributed practice not only provides learning resources for negotiation and appropriation, it can also provide the means for doing so. The dissertation moves towards a social and cultural view of learning in this technology education classroom practice by paying attention to the notion that there is something more than appearances, or that doing has a direct and unproblematic relation to learning.

Tech Ed and Learning by Doing

Tech Ed

Tech Ed has been receiving unprecedented interest internationally [4]. At the same time, the study of Tech Ed and its relationship within the mainstream of Canadian schooling is emerging as a field of social and educational inquiry. Layton (1994) suggests that the reasons for this scholarly interest are complex and compelling:

> In many education systems around the world, irrespective of whether the country is low income and developing or high income and industrialized, the case for technology as a component of general education is under examination and is impelling specific curriculum innovations...Support for technology education now comes from powerful sources including governments and industry. International conferences, a regular feature in the calendars of present-day technology educators and researchers, have enabled a productive exchange of information about country developments and have assisted the identification of issues critical for the future of the innovation (p. 11).

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[4]. There are numerous conceptions and definitions of technology and technology education which in the main, are dependent on approaches taken as much as the jurisdictions in which they take place. These differences can be confusing. "Tech Ed" generally refers technical education which is ordinarily associated with developing technical skills in a trade rather than an education about living in a technological world. "Technology education" is the most common term used in the United Kingdom and North America for the describing a portion of the school subject under study here. Ontario is the only domain that uses the term "technological education". For an overview, see Hansen & Froelich (1994) as well as Layton (1994).

Questions concerning what Tech Ed could and should be are at the centre of political, ideological and educational debates outside of Canada. Competing visions of what the "subject" should be are also being played out (Beynon & Mackay, 1992; Black & Atkin, 1996; Layton, 1994, 1995; McCrory, 1987; Raizen, Sellwood, Todd & Vickers, 1995; Young, 1992). There are numerous paradoxes and contradictions in these conceptions as responses to various pressures of economic crisis, social upheaval and other aspects of change are felt. Competing visions of what technology education seems to be about have invoked "technogical literacy/capability" (Beynon and MacKay, 1992) as an organizing concept--a term which covers a range of views from different interests including those of economic instrumentalists, business people, professional technologists, sustainable developers and liberal educators (DeVries, 1994).

Broad-based Technological Education

In the early 90's, Tech Ed in Ontario underwent a redesigning phase which culminated in new guidelines for elementary and secondary schools. Now Tech Ed is a core requirement up to and including the first year of secondary school. Broad based Technological Education (BBT) is the name given to re-structured secondary school programs in Ontario. These programs are characterized by a move to integrated "clusters" where previously separate courses are now arranged together in related areas. By way of explanation, I include an excerpt from the guideline describing the new "Manufacturing Technology" course,

> ...manufacturing technology courses should not stop with the study of the traditional industrial assembly line, but should examine other production methods and different aspects of the production process. In studying a manufacturing process like the production of milk, for example, students could explore such topics as the use of computerized feeding systems to increase milk yields, the processing of milk into various end products, and the packaging and marketing of these products (Ontario, 1995, p. 17).

Implementation of BBT has occurred through an updating and consolidation of curriculum, renewed equipment, newly developed approaches to program delivery, and strengthened partnerships with business, industry, and the community (Hill, 1993). The notions of literacy and capability are invoked in Ontario policy documents (Ontario, 1994, 1995) as "practical competence" and are commensurate with the international conceptions cited by Layton (1994) and Devries (1994). As a BBT classroom, Electric car is a proto-engineering classroom similar to what would be found in an engineering school.

The organizational features of the BBT guideline include orientations to pedagogy and conceptions of learning common to social constructivism (Black & Atkin, 1996, p. 62; Phillips, 1995), informed in the main by cognitive and behavioural psychology. Additionally, problem solving language and design processes figure prominently in the provincial guideline (Ontario, 1995, p. 9), reflecting their Deweyan pragmatic roots (Miller & Sellers, 1990)[5]. Tech Ed classrooms are places where "learning by doing", and "practical competence" are promoted and highly regarded as "key features" of BBT (p. 5). Apart from Franklin's (1999) social critique of technology, which is not specifically directed at Tech Ed, and Simon (1992) and Simon, Dippo and Schenke's (1991) critiques of work study education, these foundations have rarely been challenged in the Canadian context [6]. This inquiry is informed by Franklin's (1999) work and a growing body of research in the area of situated learning that addresses workplace learning and practical activity.

Situated perspectives are relevant sources for examining the way things are done in Tech Ed classrooms for three reasons. First, one can not delve into the social relations and organization of a local culture like a classroom without encountering technologies in one form or another. As mediums in which understanding takes form, "technologies of doing" loom large as objects of study in this inquiry. Second, these Tech Ed classrooms mimic imitative pedagogic

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5. There is a body of research dealing with design and problem solving which in the main, draw on centred views of knowledge production. According to Welch (1996) there are few empirically based studies concerning Tech Ed. Welch studied students solving technological problems, comparing them to theorized versions of design. This study uses different theoretical, conceptual, and analytic resources and is unconcerned generally with issues of cognition, or cause and effect relations. For a treatise on design addressed in the context of a social theory of learning, see Wenger (1998).

6. For an overview of conceptual, structural, and functional issues related to Tech Ed in Ontario, see David N. Wilson's (1997) research commissioned by the Ontario Ministry of Education and Training. See also "Key Directions in Secondary Curriculum development" also developed for the Ministry by an expert panel (Ontario, May 1997).

orientations comparable with apprenticeship models of learning. The theoretical resources contributing to this inquiry are drawn from recent research concerning technologies and learning through apprenticeships and other practical activity. Franklin's (1999) social perspective and those emerging from activity and situated learning perspectives represent fundamental critiques of conventional educational psychology and to a lesser extent, Deweyan pragmatism which underpin Tech Ed philosophy, curriculum, pedagogy, and classroom practice. This inquiry principally addresses this last area through an engaged social inquiry carried out in a Tech Ed classroom, where a "learning by doing" ethic exists as an organizing feature of classroom life.

<u>Learning by doing</u>

"Learning by doing" (Ontario, 1995, p. 5) endures as a common folk pedagogy (Bruner, 1996, p. 44), an intuitive and tacitly held theory of how people learn. Learning by doing implies a particular way of thinking about learning processes and a corresponding conception of learners: It reflects current educational psychology thinking and it reflects a call for authenticity and relevance in classrooms. This type of learning is felt to be in tune with progressive practice in society and the workplace and legitimizes the processes and organization of Tech Ed classrooms. Curricula based around new technologies, for example, are perceived as affording opportunities for all sorts of interesting, engaging and motivating activities. Underlying learning by doing is a developed sense, or "nose", for what are good learning situations in general. Curriculum planners and accordingly, teachers, "know them when they see them," and when kids are busily occupied and interested that "can't be bad." As folk pedagogy, learning by doing in Ontario documents is also expressed as "activity based" and "project driven" curricular intentions (Ontario, 1994, 1995; Wilson, 1997). Undoubtedly, there are good reasons for using learning by doing as a basis for teaching--but recent advances in learning theory, particularly those associated with situated perspectives, suggest there may be a way to rethink mind, classroom cultures and education.

An overview of theoretical issues

This inquiry follows a line of thinking about learning situated in social practice, and uses these ideas to explore the case of technological education. In doing so, it draws on several strands of theory that I will preview briefly here and then describe more fully in later chapters. My use of these theoretical resources is intended to be a way of finding ways to think about situated action in the context of broader social infrastructures without reducing one to the other. They provide an analytic path which follows the talk, action and sense making of students and their teacher as I locate the workings of the social and cultural order in the way things are done in this classroom.

Situated approaches to learning

Conventional accounts of learning rely to varying degrees on the notion of transfer and a centred view of the individual. These views, based primarily in cognitive and behavioural psychology, have been subject to a growing critique. Recent developments within the emerging field of cultural psychology (Cole, 1989; Wertsch, 1985) and situated approaches less concerned with cognition as a main focus, hold some promise for developing a more robust construct of learning[7] and a corresponding reconstruction of how we might understand education. This research draws its inspiration from these developments, though as it will become evident, I have been drawn toward socio-cultural theory inspired more by sociological than cultural-psychological perspectives.

The emerging disciplines of cultural psychology and related forms of scholarship such as situated learning and activity theory derive from the Russian sociohistorical school (Vygotsky, 1978, Wertsch, 1985), and provide a perspective through which we can explore practical activity in education. Cultural psychology draws from two general areas of scholarship which represent a broad range of perspectives on the constitution of mind, and culture. In the main, cultural psychologists seek to expand on the relationship between

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7. For an explanation of these issues from a psychology standpoint which traces the ongoing transition through behavioural to cognitive to culturalist approaches, see two works by Jerome Bruner (1990, 1996). See also Cobb and Bowers (1999), who delineate differences between cognitive and situated learning theory by examining their metaphorical underpinnings.

mind and mental functioning (as found in cognitive and developmental psychology) on the one hand, and cultural, historical, and institutional settings (as found in interpretive, and critical anthropology) on the other. This dual perspective seeks to explain how people think through the things they make and how these things in turn, provide a medium for defining who they are (Cole, 1989; Shweder, 1990). Situated learning theory extends this approach by exploring knowledge as co-produced between learners and situations. Activity theorists (Engeström, 1987, 1993; Keller & Keller, 1993) see knowledge produced similarly with more of an emphasis on links to broader social infrastructures. Situated perspectives are represented among others, in the writings of Jean Lave (1988), and Lucy Suchman (1987), two early contributors to the field.

Anthropologist Jean Lave (1988) studied people using math in supermarkets and found that their everyday use differed from the way it was taught to those people in school. Lucy Suchman (1987) researched clerical workers doing office work and discovered they produced ways of doing things that are themselves social processes rather than reflections of plans or procedures for doing things. Lave and Suchman provide us with a view of the way things get done that runs counter to the manner in which they are theorized in curriculum and skills profiles respectively. Brown, Collins and Duguid (1989) subsequently articulated some of the main ideas of situated learning based on the notion that knowledge is contextually situated and comes into being through the activity, culture, and context in which it is used. My interest in making and other practical activity as a medium of development derives from this theoretical tradition.

Along with Lave (1988), social theorist Etienne Wenger (1990, 1998) expresses a situated view by ethnographically studying a number of different apprenticeships with the goal of contributing to a general theory of learning. Together, Lave and Wenger (1991) broadened traditional connotations of apprenticeships from master/student relations to those of changing participation and identity transformations within what they called "communities of practice". Lave and Wenger's contributions to this inquiry are central, in that they assist me in situating knowledge as a social relation, describing knowledgeability as flexible processes of engagement in activity. In the introduction to Lave and Wenger's (1991) collaborative work, Hanks implies that,

> learning is a way of being in the social world, not a way of coming to know about it. Learners, like observers more generally, are engaged both in the contexts of their learning and in the broader social world within which these contexts are produced. Without this engagement, there is no learning, and where the proper engagement is sustained, learning will occur (p. 24).

Lave and Wenger do not ask what cognitive processes and conceptual structures[8] are involved in learning, or how thinking is influenced by circumstances separate from the self. Instead, they are interested in what kinds of social engagements provide appropriate contexts for learning to take place. The analysis that follows traces such actional contexts. In doing so, the theoretical resources introduced here are more suitably situated and explicated in the evolving circumstances of my fieldwork.

Technology as social and cultural practice

At the outset of this chapter, I used a schooling story about learning with both hands for introducing the centrality of productive activity in my personal and professional life as a maker of things. My incubator story introduced us to the presence of technologies in practical activity. Whether using technologies like materials, operating tools in certain ways, applying knowledges like incubation periods, or realizing intentions like suitable growth environments, all are imbued with social and cultural meanings. One way or another, these social and cultural meanings migrate and otherwise work their way into communities and practices separate from their places of origin. Thus, practice is constantly re-configured technologically, socially and culturally.

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8. Gardner's (1983) theory of multiple intelligences addresses learning from the perspective of learners who possess raw cognitive potential transformed through social and cultural environments. This study takes a different tack by focusing on processes that constitute knowing and learning as matters of social, historical, political, and cultural practice rather than taken as factors influencing individual cognition. For an examination of the differences between centred psychological views and situated ones see Bruner's (1990) seminal contribution to the field.

This research moves away from behavourial and cognitive psychological theories to adopting activity and situated approaches as my analytic perspective in this research. This is a response to puzzling out the "something more" suggested by the unanswered questions in my master's research. Such analytic approaches are appropriate, because resources for learning are located in the technological, social, and cultural organization of the world. Accordingly, "the way things are done" explores learning from the perspective of learners and the everyday, rather than structured by the conceptual practices of behavioural and cognitive learning theory.

The situatedness of experience is also informed by resources from other disciplines. In philosophy, what Heidegger says about the relation between people and technology finds its way into this analysis through contemporary interpretations of his work. Phenomenologists Ormiston (1990) and Mitcham (1994) draw our attention to the ubiquity of technology as a social and cultural relation. Mitcham (1994) conceptualizes technology broadly as understanding. He suggests that there are unlimited examples of these understandings in the form of objects, processes, knowledge and/or the intentions of people as they are experienced in the everyday. Following on Mitcham, Franklin's (1999) social critique of technology informs the analysis that follows in important ways. As the title of this dissertation suggests, this inquiry is about technology defined as a practice and expressed by Franklin as "the way things are done around here" (p. viii). The later implies ways of thinking about technology the way it is experienced and understood in the everyday. These ideas are central to my analytic focus in this inquiry.

Linking technology and understanding to practice is consistent with Wenger (1990), who defines technology as "understanding made instrumental through mediating artifacts" (p. 98). Wenger offers the caveat that the interpretation of a particular technology is dependent on its use, a common theme[9] among philosophers of technology who make connections between technology, understanding and practical action. More recently, Wenger (1998) refines his use of technology by an attention to what he calls "reified" versions of understanding (p. 57), where meanings are attributed to things separate from the actions of people. Wenger's research provides useful ways of thinking about the "something more" associated with technologies and their use. In many respects, this inquiry is an exploration of how the way things are done become understanding and alternately, how understanding becomes the way things are done. This is a dialectical thread that also runs through much of this inquiry.

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9 Placing technology within human affairs follows two general lines of thinking; socially determinist and technologically determinist positions. The former holds that decisions about context and use are more prominant than the latter, which holds that technologies follow their own line of development. For an appraisal of technology from widely divergent points of view see Hickman's (1990) compilation. Additionally, Ihde (1990) provides an account of human-technology relations in the context of their cultural embeddedness.

The emphasis on practice in recent research about both technology and learning (Chaiklin & Lave, 1993; Franklin, 1999; Lave, 1988, 1997; Wenger, 1998) treats the relations between persons and the worlds they know and act in as cultural, social, historical, and political products. This is to say that doing, making, and otherwise acting in the world are not separate from learning and knowing. Rather, they are indistinguishable. In her earlier work, Lave refers to knowing in practice as knowledgeability, a concept developed further by Wenger (1990) separately and together (Lave & Wenger, 1991) as they develop their analytic perspective on learning. As a flexible process of engagement in the practical world, knowledgeability is a way of theorizing knowing constituted through practical activity.

Thinking about knowledgeability *constituted* within social, cultural, historical, and political processes suggests an interplay between understanding in various forms. These forms of understanding get played out in classrooms as students produce and are produced through and by social and cultural structures. The basic idea is that people change themselves and their circumstances through the production of artifacts, tools and other technologies[10]. Social and cultural environments do not exist separately from the way that people in them make

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10. I use the terms 'artifact' and 'tool' interchangeably, although there are differences between them. Both are subject to multiple interpretations. For clarity, all tools are artifacts but not all artifacts are tools. For my purposes here, a tool is more connected to particular uses and processes than an artifact which may be a discussion of artifacts as components of technology.

sense of them. Further, in the process of making sense, people modify their environments (Shweder, 1991). I call this process "practical negotiation"[11]. Cultural psychologists refer to these environments as "intentional worlds" (Shweder 1991, p. 74) made up of products, processes, and intentions which in the absence of people would not exist. People also pass on these changes to subsequent generations. Cultural psychology and situated approaches identify these characteristics as central to a fuller understanding of education (Bruner, 1996), particularly educational programs that are activity based and project driven as is the case in Ontario Tech Ed classrooms.

Franklin's (1999) social critique of technology raises political questions concerning the "social mortgages" connected to the introduction of, and our use of technologies in many forms. She develops an analysis suggesting we live in a culture of compliance where we are conditioned to accept orthodoxy and social rituals as naturally occurring (p. 17). Because we increasingly live in a technologically constituted world we do not fully understand, seeing through appearances to 'something more' becomes an important project for schools and schooling. Thus, the phrase, "seeing through things" is a folky way of drawing attention to our (in)ability in gaining a broader understanding of doing what we do. The explicit changes fostered through our use of technologies seem

11. My use of the term negotiation derives from Wenger (1990), Shweder (1991), and Stairs (1994) who all use the term for describing developmental relations between people and situations.

obvious, but what are the less obvious consequences of their use? Although we may be able to use many technologies, we often do not understand something of their significance in ways that reveal our relationship with them as enabling or limiting. Seeing through things is a way of suggesting that the way things are done in Tech Ed classrooms warrants some scrutiny. Understanding the social and political significance of prescriptive technologies is promulgated by Franklin as the key to "understanding our own real world of technology" (p. 13).

Thinking about technology as social practice turns our attention to the notion that technologies are not naturally occurring in the sense that they require an enabling social and cultural infrastructure. Technologies as social and cultural practice come into being and are enacted by knowing subjects. Tracing these moments in practice in a Tech Ed classroom is another element of my intended analysis in this classroom research.

Summary and dissertation overview

This chapter begins with a couple of stories about student activity in classrooms by introducing the concept of "making" and the made world as a feature of knowing. The second story in particular emphasizes assumptions regarding the actions of students and how appearances can mislead. I link these stories to the current institutional context of technological education organized loosely around the notion of learning by doing and my intention to explore appearances and assumptions underlying this approach. Then I introduce a number of theoretical resources focusing on the contextual nature of knowledge production, emerging concepts of social and cultural practice, and situated knowing. In what follows, I use these resources for developing a thesis that moves towards a social and cultural practice view of learning in Tech Ed. I focus principally on the sense students make of their actions taken in the context of some institutional, and organizational considerations. The principal focus here is from that of learners and learning rather than a direct attention to teachers and teaching. Accordingly, with the exception of Chapter six, which focuses on sense making by their teacher, the voices heard here are primarily those of students along with my own.

Chapter two reviews the basic principles of methodology which underly this inquiry, and introduces related field procedures I use in the research. Then it sets the scene for all the data that follows by telling the story of the Race Day, which was the culminating event for much of the activity reported here.

In Chapters three and four, I present a detailed analysis of my conversations with two key students with appearances by other players from the Electric Car classroom. Chapter five reports on my conversations with the teacher of this class, exploring the implicit and explicit principles of pedagogy guiding his actions. Finally, in Chapter six I revisit and sum up the analysis. I conclude by moving towards a social cultural practice view of learning, and then I offer my reflections on the significance and implications of the study.

Formatting and organization

Much of this dissertation is punctuated with numerous blocks of descriptive and narrative writing. They include interview excerpts, descriptions from my field books, and conversations recorded between other people. This is my voice and is presented in this font and style throughout. All interview excerpts between myself and students are identified as such and are indented with student voices *italicized*. Other excerpts of student talk in the general text are also *italicized*. Descriptions and accounts constructed from my field books are double indented in this font and are identified by source eg. (Field book 2, p. 23). The document alternates between one and-a-half, and double spacing as appropriate. I use gender specific pronouns in appropriate places. At other times when I refer to students generally, pronoun use is arbitrary. Some citations and excerpts contain pronouns exclusive of one gender or another. These have not been altered.

CHAPTER II
ENGAGED SOCIAL INQUIRY IN A BROAD-BASED CLASSROOM

...tracing the curve of a social discourse; fixing it into an inspectable form (Geertz 1973, p. 19).

Methodological Ways and Means

The approach taken in this inquiry focuses on the social, cultural nature of knowledge construction as it contributes to both individual and public knowledges. I draw on what Lave (1993) calls a "transitive analysis of social projects" (p. 20), where connections between local actions and broader social structures are traced. This approach involves raising questions about ways of doing things that originate beyond local contexts but nevertheless find their way into the discourse of how things get done. I choose to open these complementary doors for understanding the way things are done through narrative (Bruner, 1990, 1996; Polkinghorne, 1988; Rosaldo, 1993), a technology of describing unfolding events, particularities of the whole, and their relevance for these students.

Denzin (1994) suggests that "nothing speaks for itself" (p. 500) and accordingly, moving from field to text involves important issues related to storytelling traditions. Bruner (1996) argues that the universal is present in the particulars of our narratives and that they are essential to life in a culture. He refers to it as "the narrative construal of reality".

> When human action finally achieves its representation in words, it is not in a universal and timeless formula that is expressed but in a story - a story about actions, procedures taken, procedures followed, and the rest (p. 158).

Use of narrative in this way has many resonances with the other theoretical tools I use in making sense of the way things are done in this classroom. As a mode of organizing experience, Bruner (1990) argues that narrative acquires its form through tradition, our history of tying together stories in sequences that reveal something of their significance (p. 44). It is narrative artifice that reflects our history of sense making at the same time as providing a means for mediating it in practice. The form or artifice of narrative provides us with what Bruner suggests is its crucial feature, an "apparatus for dealing simultaneously with canonicity and exceptionality" (p. 47) which provide people, and a culture, with a set of interpretive procedures as well as a set of norms for anchoring themselves. Narrative content and artifice provide methodological grounding for the situated transitive analysis developed here by acting in concert with activity theory and phenomenological perspectives. It does so through an attention to a social and historical mediation of activity that makes a link between the canonical (the usual, expectable) and the exceptional (departing from the usual). In what follows, I trace this lead in exploring the links of classroom activity to cultural knowledge and student learning.

The extensive excerpts from conversations with students in this inquiry provide an incomplete but intense glimpse of sense making as students ponder, speculate, and shape their actions in conversation with me. My own sense making mostly revolves around raising questions about how the way things are done sometimes originates beyond the context of the classroom but nevertheless works its way into the discourse of what is said and done. The stories I recount and present here reflect the kind of "double vision" that Rosaldo (1993) describes as an "oscillation" between the social analyst and his subjects (p. 127). I do so by attending to the students and what they have to say. As Rosaldo puts it,

> No analysis of human action is complete unless it attends to people's own notions of what they are doing. Even when they appear most subjective, thought and feeling are always culturally shaped and influenced by one's biography, social situation, and historical context (p. 103).

The student narratives I feature challenge some of what Rosaldo calls the "analyst's sovereign viewpoint" (p. 141), presenting a creative tension between the social reality observed by me on the one hand and experienced by the students on the other. The notion of an "engaged social inquiry" I suggest in the title of this chapter follows from this creative tension and conveys something of my connection to the specific, and in-depth embodied knowledges, expressed by these students. Attending to in-depth embodied knowledge in the context of the way things are done requires an interpretive descent that reveals something more than what appearances often do not. The idea, as Jardine (1995) puts it, is "to understand what is right in front of us in an ecologically sane, integrated way is to somehow see this particular thing in place located in a patterned nest of interdependencies without which it would not be what it is" (p. 262).

My presentation of the events in this classroom makes use of familiar rhetorical and narrative conventions identified by Van Manaan (1988) as "realist, impressionist, and confessional." All are interwoven as the narratives build and the story is told. The most familiar is the "realist" genre which includes the standard, fieldwork description without attending to my part in the making and construction of the narrative or of the unfolding events. I also use what Van Manaan calls "confessional" tales, which include something of my own sense making in coming to understand the events unfolding in the field or at my desk as I puzzled through the data and writing of the analysis. There are also "impressionist" tales, my interpretations of events so the reader may gain some of their own sense and judgement of what is happening. I have arranged each within what I am calling "conversations" with students and then later with their teacher. I use similar unfolding events taken through different gazes and considered in light of distinct, but compatible theoretical resources.

Bruner (1990, 1996), Engeström (1993), and Lave & Wenger (1991), as well as Rosaldo (1993), direct my analytic attention to disruptions in practice as sites of change for the making and remaking of the everyday way things are done. Although not obvious to me throughout much of the active fieldwork phase of this research, the notion of disruptions or perceived contradictions in practice eventually provided the analytic grist for gaining some sense of what I later construe as their practical negotiation of distributed practice. This proved to be a practical negotiation characterized by its dialectical tacking between exhibiting existing forms and generating new versions of the social and cultural order of the classroom.

Fieldwork Ways and Means

An electric car race

The flyer is simple enough. It reads in part:

> Attention...Secondary School Technology Students, you are invited to enter THE GREAT Electric car RACE hosted by the Technological Education Department at the Faculty of Education, Queen's University (Perkins 1998).

An exciting idea for sure. I come across the flyer quite by chance on a bulletin board in a rural secondary school close to my home. On the reverse are the details of eligibility, aims, technical criteria, and judging information. I am looking for a Tech Ed classroom as a site for doing some field work. While chatting with Lassitter, the department head, he mentions that his design and technology class will enter the race. I am immediately interested as Lassitter fills me in on details. He extends an invitation to the classroom, indicating I can participate if I want to. There are two months to go before the competition and the design team is just completing the first stage of the program arranged around designing the various systems making up the car.

I subsequently visit the Queen's University Technological Studies department to find out more about the Electric car competition. I had done my teacher training and later my MEd at Queen's, and am familiar with the people and programs there. Through an informal chat with the department's administrative assistant, himself a qualified Tech Ed teacher, I found out some the details behind the competition. The aim is to support the implementation of BBT in schools. In particular--as the flyer states--it is to "promote integrated learning using the design process while producing outcomes related to scientific principles, mathematical concepts, technological systems, and societal needs" (Perkins, 1996). I am interested in this because my recent inquiry investigating the nature of Tech Ed across Canada is in progress, and one of the findings coming out of that research indicates that BBT is the way in which the over sixty-five discrete subject areas in Ontario are now organized into "clusters" or BBT areas for Grades 10 -12. The findings of that inquiry show that clustering disciplines into broad groupings is becoming a way through which students supposedly gain the multi-skilled competencies that market forces demand in the shifting needs of workplaces. Six of nine provinces now use broad groupings of technology disciplines for organizing their secondary school tech ed curriculum (cf. Kozolanka & Medway, 1998).

Gaining access

The sponsoring of an electric car competition--intended to foster the implementation of the new BBT initiatives--by the Queen's University Faculty of Education piques my interest. I am particularly interested in examining the everyday relations arising in a BBT program. A competition sponsored by a Tech Ed program preparing teachers for the field seemed like an ideal field opportunity in which to do this.

I revisit the secondary school and subsequently receive school and board approval to attend classes throughout the winter semester. I am familiar with the school, having completed one of my practicums there as a teacher candidate years before. Occasionally, I also teach there as a substitute teacher. The school is located in a small town (population 5000) in rural Eastern Ontario. It has an urban-rural mix of students from predominantly Anglo-Saxon, middle-class families dependent on a rich mix of industrial, commercial, service, and light farming vocations. This school is not presented as wholly typical or representative of others in the area, although there are many similarities. My presence in the school begins in February 1997, early in the winter semester, as I first attend a number of the Tech Ed classes as a friendly observer and colleague of two teachers who work in the Tech Ed department. After I come across the Electric car flyer, Lassitter the Tech Head offers me his classroom as a research site. I begin by attending his Design & Technology (D & T) class three times a week for March and then after school as the design team begin work on the actual construction of the car. The (D & T) class begins in February and until the end of March, they spend most of their time building models of frames as well as studying automotive front end configurations. During one of my earlier visits, Lassitter asks the students to put together frames using wire and plasticine. The students came up with a variety of solutions; boxes, triangular shapes, and even a tubular configuration. They test them by placing weights on them until they collapse or show signs of stress. They discover, for example, that a triangular shape is generally the strongest. Similar activities and experiments continue for testing various configurations for a front end.

Interviewing

With six weeks left before the car competition, Lassitter is worried there is not enough time to complete the car, so he asks the class for after-school volunteers. Six students come in regularly after school over the ensuing six weeks. Over that time, I follow Seidman's (1991) three interview series (p.10), first interviewing five students from the electric car class. The first interview is an attempt to place the student's past experience in the context of their presence in the particular class and program. I want to know what their parents do for a living, what they do after school, and the reasons they are in the program . The second interview is directed more at their day to day participation, where they tell me what they are thinking about as they go about their after school activities. In the third interview, I ask them about specific incidents and their understanding of them. The first interviews are informal and conducted after we discuss the research and they (and their parents) give permission to participate in the research. The first interview is process recorded in my field book and conducted soon after the evening activities begin. The second interview comes two weeks before the competition and the third after. Both of these are tape recorded and transcribed. They are all conducted at the Tim Horton's close tc the school. I buy drinks and donuts, and they talk. I also interview Lassitter twice, once before and once after the competition. Although I generally follow Seidman's three interview series protocol, my questioning takes on a conversational quality that often moves with the moment in unstructured ways. I rarely go into these interviews with written questions but depend instead on an intuitive sense of what was possible with that particular student at that time and place.

Participant observation

I attend a number of the D&T classes at the beginning and then at the end of the semester after the competition. The bulk of my time spent in the school, however, is after school in the manufacturing shop, where the six design team students work on the car. While I also spend time in the D&T classroom during the day, my involvement there is more detached than my participation in the manufacturing shop after school. In the D&T class, I usually sit at the back taking notes, with few opportunities for interacting with students informally. My interest in the didactic teaching of the classroom wanes after a week or so, then I stop attending the day classes altogether. When the after school activities start in earnest, I have constant opportunities for chatting and direct involvement with the students. I usually arrive about the time classes end at 3:10pm and stay until the students leave or I drive them home. I take part in their discussions and contribute by offering comments and suggestions. I also take time for sitting back and watching them work. Often, I am alone in the shop as they go off on one errand or another, some connected to the project and others that had no apparent connection at all. Most nights there are three or four students present and as the weeks wear on, four students become regular attendees.

My participant observer status undergoes a dramatic shift as I move from the more formal nature of the Design and Technology classroom to the manufacturing shop. It sways to and fro in the after school activity as well. Hammersly and Atkinson (1993) cite an apt description of my participant observer status in their reproduction of Junker's (1960, p. 36) schematic depiction of theoretical roles for fieldwork. At one end is the "complete participant" and at the other the "complete observer". Although I range freely between the two as the situation and my interest dictates, I do not engage in any observation where I am completely concealed, nor do I do any work to the exclusion of others there. I recall many evenings where I say very little. Rather than trying to be "everywhere at once" (p. 206) I gradually migrate to the micro-activities in the shop and the sense making a few of the students make of what they are doing. I explore their actions from a number of vantage points rather than locking myself into any particular one.

A research trajectory

Personal experience

I develop close ties with the after school students. I drive them home when they are sick, meet their parents when they drop by, lend them money (they pay me back). I loan my van, and help one of them move their stuff at the end of the semester. It is impossible not to get wound up in their lives. It is easy to feel like an outsider at the outset when I begin visiting their classroom during the day. There I feel more like a sojourner and researcher than I do after school in the manufacturing shop with the design team members. There is an air of informality amidst the action of putting together the car. Rosaldo (1993) tells us that "one rarely studies culture from a neutral position" (p. 221) that choosing what we want to know is primarily a political and ethical act. My primary positioning is that of a researcher, but one who does not leave his teaching, trade and shop teacher experience at the door. While some of this experience gives me a unique vantage point as a researcher, some of my other experience and understanding limits the gaze I bring to the fieldwork.

I begin the research thinking about the social world of this classroom and others like it as one of cause and effect relations, where actions are thought to be shaped by other actions and circumstances. This reflects my initial understanding of learning in contemporary educational psychology terms, an understanding that undergoes some revision as I progress through the fieldwork and analysis. Understanding the interplay of various social, cultural, and technological relations as "constituting" rather than "shaping" the other is another thread that runs through my analysis. The difference in meanings between these terms are subtle yet profound. My use of the latter term "shaping" conceptualizes social and cultural communities as "made up" by their components rather than the "effect" a thing or person has on another. The assumption of this view is that communities exist in the form of activities rather than activities taking place in a context of community. The methodological implications are that there is no privileged standpoint or detached position for participating and observing. Explicating and working through these differences in practice begins with the actions and sense making of the students realized through informal contacts, observations and formal interviews.

The extended interview excerpts I present here show something of the way in which I orient myself to interviewing within the general guidelines that Seidman (1991) provides. As "joint products" (Mishler 1991) between players, the conversations that follow use discursive moments as ways of revealing understandings of what happens in specific places, at particular times, under certain conditions. These conditions and the understanding produced through them do not occur as planned, or sequentially, as I arrange them in this text. Much of what the students say in our interviews occur in a hit and miss manner. The conversations range widely, covering their thoughts on a number of activities and instances of classroom life. There are also a number of moments I take note of in their day to day, hour by hour activities. I use excerpts from conversations, interviews and field book descriptions and reflections for piecing together a cadence of activities, noises, feelings, and measures of thought ranging from the poignantly awkward to the eloquent.

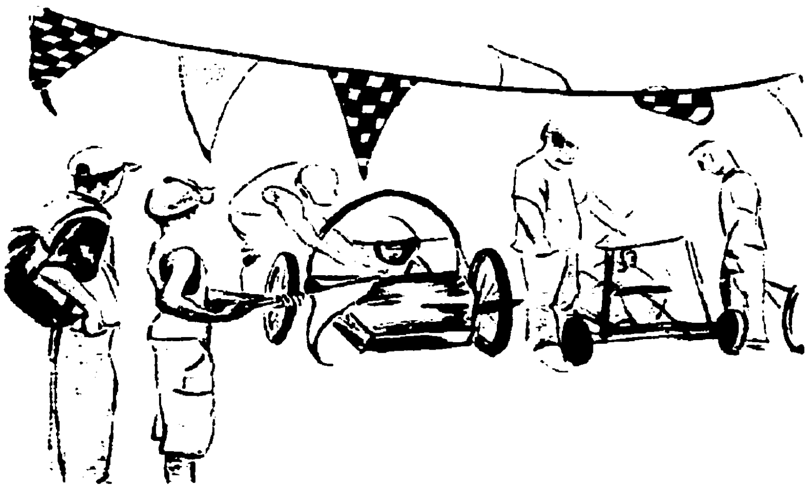
What follows traces the arc of a number of discourses . They converge in a somewhat linear, but progressive, analytic structuring. I take one circumstance and conversation at a time and add to it as I move deeper into an interpretive descent of classroom relations. Kirby and McKenna (I989) refer to rethinking "conceptual baggage" in analysis as "layering" (p. 52). There are multiple views arising through this layered analytic progression. I take similar talk and action, trace and then retrace them in different moments using related analytic resources: I end up seeing through some of the assumptions I carry into the research. I use talk and activity from different moments, places, conversations, and observations for building a discourse about the way things are done. The upshot is something like building electric cars: a bricolage of discrete events, feelings, and sense making.

I make no claims that the students or classrooms reported here are representative or typical of some larger population, and thus I make no claims as to generalizability in the statistical sense. However, I do suggest that the dynamics explored here are not isolated cases, in Ontario or similar school systems. Thus readers who have received experience in other Tech Ed classes may find much of relevance and interest to them here, and much that may be worthy of more systematic investigation in future. Before turning to the bulk of my fieldwork and analysis directly, I continue here with my account of "race day", the major culminating event for which the electric car is built by these students.

Race Day

> The "West Campus" of Queen's University is an ideal site for a car competition because of the hills and curves which wind around the stadium situated behind the Education building. I arrive to find at least two dozen cars spread out in the four rows of what is usually a parking lot. The "pit area" is full of activity and each car is surrounded by small knots of people. Many of the cars are up on

stands that allow the wheels and steering to be worked on without interference. Around most of the vehicles is an array of tools, parts, supplies. A few teams have barbeques going! A couple of sites are festooned with pennants and there is even a gazebo set up as a "shady" garage. At least a half-dozen sites have displays including everything from pictures mounted on cardboard with attached "project" sheets to one with a booth complete with generator and a computer-aided video presentation. In a corner of Pit Row there is a concession trailer marked "Constructed by the Technology Students of Such and Such High School." The hotdogs are cheap at a dollar each.



It is mid-morning and the PA system crackles as the Director welcomes everyone with an introductory address, the day's schedule and instructions regarding the program are announced. The students hand in their design reports and the vehicle safety checks begin. The competition is on! A number of cars gather for a trial run of the race circuit before the start which is still over two hours away. Some cars are pushed into position by pit crews eager to test their cars on the demanding course. At least half of the cars will do a practice lap or two before reporting for the mandatory safety check. After some instructions, the cars doing practice laps are started down the course in groups of five. The cars come around the curve that joins the pit area with the race circuit and onto the middle of the long downhill. A rather substantial crowd has gathered--at least a hundred people. There's a lull after the last car disappears on the steep uphill portion behind the stadium. About five minutes later, the first car reappears at the top of the hill ready to begin the downhill slide to the right angle turn at the bottom where I am standing. The cars are spread out now as--in turn--they come around the corner.

> Boz, one of Lassitter's students, appears at my side and we strike up a conversation about strategy. He's been talking to someone--probably Lassitter--about how to drive the course. In order to conserve the battery, they have decided to use it sparingly, and only when needed. It makes sense to me because the object is to see who can go the furthest. Their strategy will be to use enough of the battery juice to just make it to the top of the long uphill grade which makes its way around the stadium to the top of the long downhill stretch in front of us. Boz tells me that the idea will be to coast as much as possible over as much of the course as they can.
>
> After Boz leaves, I turn my attention again to the cars zooming by on their test runs. A car with "Royal" emblazened on the front appears at the top of the hill. It sits high off the track and has the appearance

of a crab with wheels extending down from its very fragile body. "Royal" picks up speed as it comes down the hill weaving from side to side in a long sweeping motion. I realize about halfway down the hill that it is out of control. I yell to a group of students watching from the road entrance to the pits and they scramble in all directions as the car careens in a long arc towards them. One of the group is cradling a coffee in one hand walking away from the approaching car, oblivious to the approaching danger. As the group clears out of the way the car hits him squarely from behind. His coffee goes straight up in the air and the student falls forward as the car runs him over like a dog. He rolls over twice under the car and pops up to his feet. I run over and grab him by the arm asking if he's all right, and he is. It is amazing. He ends up with a few scrapes and a small cut on the back of his head and that is it. I turn to the driver--a young looking kid--and he looks more shaken up than the guy he hit. Others arrive, shepherding them both off the course. Others wheel the car into the pits. I'm left standing there looking down at the blotch of coffee left on the pavement. An interesting start to the race, I think to myself, as I lean over to pick up the still intact styrofoam cup.

The test runs are over and there's a lineup for the safety check up along the back wall of the tech wing. Each car is looked over for brakes, steering, and controls as they complete first a static check and then a moving one as the cars each navigate a rough figure eight. On the other side of the median in Pit Row, a number of the teams are working feverishly on one thing or another. Here a wheel is off and three students are bent over a sprocket assembly. Beside them "Royal's" front end is being looked at. I go over and chat with them and they explain how the front end just needs "some adjustments." I'm somewhat sceptical but don't say anything. Up and down Pit Row similar scenes are being played out. It is now less than an hour until the start and it is clear from the activity and noise that the energy levels are high. Finally, it is race time and the cars are ordered to the starting line. A wholesale migration of cars heads back to the starting line decorated with racing pennants. A half dozen cars are left strewn across Pit Row still not ready to go. A few of them do not look like they will make it to the start.

An adult sidles up beside me as final instructions are given to the drivers and people are cleared from the track. He says something to the effect that if they make it through the first lap without killing anyone they should be okay. I laugh in response and ask him if he saw the accident. He smiles at me but before he can reply the starting gun fires and they're off! In bunches of five--Indy style--they roll down and around the curve that joins with the downhill. Two cars fail to get going and they are quickly wheeled out of the way by puzzled pit crews. One of them rejoins the next bunch of cars at the starting line. They start, quickly accelerating to the first curve. The lead driver takes it by leaning heavily to one side, just managing to miss the concrete curb but in a perfect line for the downhill section leading to the hairpin. I can hear the guy beside me sucking in his breath in anticipation as the lead driver approaches the hairpin, but he slows down in time making it without incident. We both smile and shake our heads. I say "Well, I guess we wouldn't do it any differently eh?" The other guy laughs.

The afternoon moves slowly as car after car goes by at different rates of speed, making different noises. One fancy looking car is pushed back over the grass median to the pit area. It is very slick-looking, with a molded fibreglas body shaped like a fat cigar and a plexiglas bubble on top. It looks like the body has come loose and is dragging at the back against the wheels. The driver is looking quite disgusted, and the others are arguing. I follow them across the track into the pit area listening to what they are saying. The driver wants to just remove the body completely and get back in the race. The other two say it'll take too long and it makes more sense to secure it properly. After consulting with their teacher who has also been listening, they decide to remove the fibreglass cowling. Other cars are also in the pit area. There are about 7 or 8 of them in various states of repair. Two of them seem completely abandoned.

I turn my attention back to the race looking for Lassitter's car. I can tell it's still on the course because Lassitter is standing at the top of the hill waiting. He's chosen a good spot to chat with Dan, their driver, as the car is at the top of a long grade and moving slowly. Each time the car appears Lassitter runs beside it asking questions, yelling instructions, and shouting encouragement. It is a bit of a scene each time Dan appears over the rise, as none of the other teachers do more than shout their encouragement as their cars go by. The car appears again and both Lassitter and Ross, another student, run beside it, telling Dan he needs to come in so they can check how the drive train is holding up.

There are still ten or so cars on the track and they are becoming more familiar to me as they appear in sequence lap after lap. The course is a few kilometres long and most of the cars seem to have completed about ten laps. There is no sign of the fancy-looking car back on the track as yet. I spot one of the crew and he tells me that they are finished for the day. It turns out that the cowling had damaged the drive train and it is unrepairable. He's quite disappointed as their car--clearly the most classy--has travelled less than a lap. Most of the other cars have dropped out, at least six of them with a dead battery. Others have stripped gears, there's one broken axle, an inoperable front end, and another with a bent front wheel. Some come off the course pushed by their crews but most of them break down out of sight and are retrieved mostly with snowmobile trailers and pick-up trucks that are dispatched from the pit area. The field thins out.

Two hours have gone by since the start and there are only three cars still on the course. Lassitter's bunch are clearly in the lead, at least five laps ahead of the closest car. The car is moving much slower now but still looking like it could go all afternoon. Boz informs me that it is "in the bag" and I tell him that "It ain't over until its over." He laughs and says "It's over." It turns out he is right. The organizers have realized that it is just possible that this could go on for a long while and they still have to complete the design presentations by the various teams. This will take some time so they decide to cut the race short. Meanwhile, their closest rival finally drops out and they are left on the course with a car that is far behind and almost out of power. As Dan nears the top of the hill on their 17th lap, the battery gives out and they are finished too. It is over and they have won.

I have a picture in my mind. It is a view looking down into the pit area up against the tech wing of the Education building where their car has just been wheeled in. Word has gone around--seventeen laps--at least five more than the second place car. There are at least fifteen people gathered in a crowd surrounding the car, Dan, and the others. Dan stands there with his crash helmet hanging from one hand and a soft drink can in the other. As I move in closer to listen in, it is obvious he's 'holding court' so to speak. The others are patronizing him, asking questions about strategy and other more technical details like how they managed to keep the motor cool. The gathering is interrupted by someone who announces that the oral presentations of the design portfolios are to take place. I move back up to side of the hill as I make notes, the dozen and-a-half crews begin their brief presentations as everyone stands or sits in a large semi-circle watching and listening.

It is later and the judging[12] is almost completed. Some of the teams are already gone but not Boz, Dan, Ross, and Lassitter. They are basking in their success, still flushed with the attention they have been receiving since the end of the race. This is different from the guarded comments and stares they received when they arrived for the

10 The judging of the competition was carried out by volunteers; tech teachers and members of the faculty. Each team had to submit a written and oral presentation describing both technical details as well as an account of how it was put together. In addition to the report and presentation worth 20% of the total, the judging included the following areas:endurance (distance travelled on a single battery charge) 30%; efficency of control (turning and braking) 15%, technical design 15%; quality of work; and aesthetics 20%.

competition earlier in the morning. In a later conversation, Boz reflects on this moment and how they were initially treated by some of the others,

> *...we knew we were going to lose the looks part, but we thought well, we're here now, we might as well race and show them up because they thought ours wouldn't go very far because of the way it looked. Like everyone was around looking at everyone else's car. A couple of people came over and sneered and snickered at ours, but we showed them up in the end. We lapped them and kept that lap* (Boz Interview 1, p.11).

It is time for the announcement of the results and they are read out and posted on a flip chart. They've come in fifth despite winning the endurance race. It seems like I'm more disappointed than any of the students. Lassitter is philosophical about it, and laughs when Boz jumps Dan and pretends to beat him up for not doing a good job of the design report and presentation. They seem genuinely pleased with their fifth place finish even though the first place team did not go nearly as far as they did. In a later chat with Boz, he revealed a bit of how he was feeling about one of the other cars that didn't go as far, but finished ahead of theirs in the overall standings,

> *...the one group we were the most worried about was the Sutton group because they had a bus for their car and all those kind of things. They had a whole bunch of sponsors and a lot that we didn't have, like theirs broke down the first lap, and it just faded out of the whole thing. They ended up getting third overall, but that was okay, 'cause we beat them in the race* (Boz, Interview 1, p. 7).

Dan, Ross and Lassitter felt similarly. They would have liked to win the whole thing but my sense was that they didn't feel like they deserved to. Many of the other cars were more sophisticated and they looked it. They came with full electrical and lighting systems, innovative braking systems connected to the drive train, removable molded cowlings, radio communications between car and pit, student manufactured parts rather than bicycle parts and so on. The students were aware of the innovations that other teams had developed in their cars.

Aftermath

It is a week later and I'm back at the school. I walk into the Design and Technology classroom and find the class grouped together in small numbers of two, three and four. As usual, it is noisy. Most of them barely give me a glance. I put it off to familiarity rather than indifference, but change my mind as one kid looks up at me with a bored expression on his face.

The classroom is sectioned off from a larger shop area that was an electricity shop before the recent move away from 'isolated' subjects to 'integrated' ones[13]. The walls are still covered with circuit boards and other electrical equipment and the tables are taken up with woodworking projects in various stages of completion. Off to one side the frame of a kayak sits on a pair of sawhorses. On this side of the glass partition Lassitter's design class is evaluating the electric car after its triumphant return from the competition over the weekend. It's sitting there in the centre on the floor surrounded by high drafting

[13] For a discussion of curriculum integration in the Canadian context see Case (1991).

tables. The students are standing, sitting around and it is pretty noisy with some of them yelling, others bending over the car, tape measures in hand taking dimensions and transferring them to their drawings. I ask someone what's happening and he says in a kind of drawl, that they're "assessing the car or something like that." Someone else--obviously a friend--says, "you asshole we're evaluating the car for efficiency." The first guy says, "Same thing, and don't call me an asshole, you asshole." They both laugh and I try to look stern but I can't manage it, instead I sort of smile in what I think is a disapproving manner...

Activity has spilled over into the shop next door and two of them are drilling holes with a drill press, the only machine in the room. Lassitter and I exchange glances and he hurries through the door. One kid is bouncing a ball off the concrete block wall and Lassitter says as he strides by, "let me have that will ya? Not the time or place eh?" He goes over to the press and puts his hand on the shoulder of one of the students. They both look up as he says "the safety glasses are over there on the wall eh?"

Elsewhere the class activities continue. They have just been given an assignment due at the end of next week. They are to assess the vehicle project according to a set of guidelines that Lassitter has given them. They have to evaluate the car, its weaknesses, strengths, etc. The idea is to measure and draw the car to scale and then answer the questions posed by Lassitter in their groups. Dan, Boz, and Ross are enjoying their roles as "insiders" or "people in the know". They have all kinds of information about the construction of the car and the others in the classroom are asking them questions.

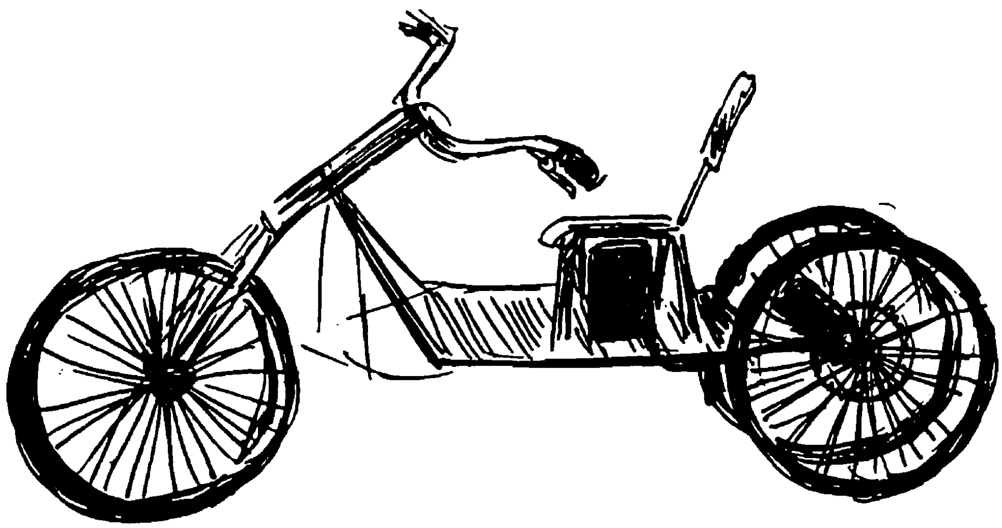
I catch some of these comments as Boz explains some ideas to a group of four.

...we lost some battery power, we could make it look better for next year, 'cause we're probably going to use the same car 'cause we'll most likely get the race part of it down pat, 'cause we had four laps ahead of the closest competitor. So, now all we've got to do is concentrate on looks...perhaps build a body around it and make it a nice fancy design. Maybe a dome shape or something . Anything that's going to make it look good, make it look better...

(Fieldbook 4, p. 35)

Everyone is busy at one thing or another. Lassitter works his way around the eight groups in the class answering questions about the assignment; how much it's worth, can one person write it up, format etc. The other groups continue with their working drawings, transferring dimensions and sketching out the geometry of the car. Most of them have one person doing the sketching at the drafting table. Others move back and forth with their tape measures calling out figures. One student has stationed himself on the floor beside the car in conversation with someone else. Every so often his "sketcher" makes a request and he calls out the dimension before returning to his conversation.

The class winds up with a call by Lassitter for "Clean up." A box is passed around which quickly fills with rulers, tape measures, paper, a roll of masking tape, etcetera. Lassitter is at the front still giving out instructions about the assignment, answering a never-ending stream of questions. Most of the students are bunched up near the door, or at least positioned near it in the leaving ritual that has everyone exiting as soon as possible after the buzzer goes off. Two of them manage to slip out early down the hall but no-one says anything. The rest leave quickly at the buzzer. The room, and the car, are deserted.



CHAPTER III
SOCIAL ENGAGEMENT IN MAKING AN ELECTRIC CAR - PART ONE

Learning the grammar of a different kind of participation
(Bateson 1994, p. 153)

Conversing with Ross

Introducing Ross

Ross is a bit older than the others on the design team. He is sixteen and likes to draw using computer aided graphics and sees his tech courses as tickets to moving on to post-secondary studies. He is undecided whether he will go into graphic arts, designing things on the computer, or becoming a mechanical engineer designing cars. Ross is a successful student who does not experience problems handling the academic part of the program he is taking along with his tech courses. Ross took the Transition Years[13] Program last year in his first year in secondary school, which involved a number of tech credits as well as the compulsory subjects such as English, math, history, geography, and science. Ross does design work for the school newspaper and is quite computer capable. He is comfortable with a number of arts-based and design programs, *one of the best* as he put it. For this design and technology class, Ross reads about all kinds of automotive systems as background for the design of the car.

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The "Transition Years" in Ontario schools are designated as Grades 7 - 9 which overlap elementary (Kindergarten to Grade 8) and secondary school (Grades 9 - 12).

In the following conversation excerpts we take a look at the sense Ross makes about designing and building the car: the front end; the drive train; and who does what. Figuring out these things (front end, the drive train and who got to do what) go to the heart of the activity of car making. After the shape of the frame, these three facets of activity influence--in different ways--the aesthetic and functional sense of the car and how it comes together. The class decide early in the semester that a three wheel setup in a triangular body will work best. The front end defines the 'look' of the car in the same way that the lines of a canoe convey its artistic sense and utility. The placement and mechanical configuration of the drive-train for the electric car would similarly convey a sense of its aesthetic and purpose. In what follows I take some talk, activity, and sense-making of both Ross and myself and use them in exploring his social engagements.

The front end decision

The decision-making process making the front end differs from that of making the drive train. The students decide on a single-wheeled design for steering and support because of the looming competition. They make the decision quickly after Lassitter, Ross, Dan and Boz, play around with some bicycle wheel possibilities. I want Ross to tell me about the eventual and somewhat abrupt decision to go with the idea of taking a whole front end from a bicycle and attaching it to the triangular frame.

We checked out to see how easy they'd be to collapse, so we picked the best one, and we never ended up making the best one. We just, we just ended up making the easiest one, besides Mr. Lassitter really decided it.

Mr. Lassitter what? He...

I think he, he was really the one that designed the car.

Is that right, yeah?

Well, we started off, we all designed it, but he gave us the main idea.

So he was sort of there suggesting things?

Yep. The steering system was his idea. Most of it was all his idea.

What about the steering, what idea was that?

To just take the front off a bicycle

The bicycle. And use it instead of like inventing the steering system.

Yeah. Instead, like having tie rods and everything else, like the others did.

(Ross Interview 2, p. 4)

His answer surprises me, even though it makes perfect sense what with the restrictions of time, the need for something light, with little drag, capable of supporting the weight of a driver and the car. Some of the front end models made earlier in the semester are in the Design and Technology classroom. Some are made out of wood scraps in scissor-like fashion. Unconnected to anything, they can be held and manipulated by holding an end in each hand and articulating them to and fro. They appear complicated, but looking closer one sees that they are quite simply made up of wood scraps with nails holding them together. I remark to myself at the time that if I was asked to build one I might have some difficulty putting one together.

After all the work the class does with their sketching and modelling, Ross tells me that Mr. Lassitter is the one responsible for selecting the design, one that comes ready-made rather than designed in-situ. Discarding the use of one of the other traditional tie-rod assemblies makes sense because of the time constraint. A front end with a single wheel does not need the sophisticated linkages that a dual wheel system requires. I recall thinking of the good sense in using a ready-made front. The drive-train configuration however, works out differently.

The drive train

Making a mechanical connection from the motor to the rear wheels turns out to be less of a cut-and-dried affair than the selection of the front end. The basic idea of the drive train is to connect a lead-acid car battery to an electric motor, which in turn, links to the rear wheel of the car. Somewhere in between the components a switch is needed for turning the power on and off. The alignment of the components is important to their functioning efficiently, as the students discover with their first attempt. They decide to go with an electric starter motor from a car, because they are designed to be powered by a battery and switches for controlling them are readily available. The team avoids a chain drive between the motor and the rear axle, which would mean a lot of extra friction-and power loss--which ultimately reduces the longevity of the battery. They decide, though, to go with the chain idea because it seems like the simplest solution given the availability of cheap bicycle parts. The construction of the drive train begins as the front end solution is worked out and the bicycle forks are welded to the frame a week before the competition.

They begin by mounting the electric starting motor to an upright frame member which is lined up with the gears attached to the right rear bicycle wheel. It merely copies what one would find on a regular chain drive for a bicycle, a front and rear gear connected by a chain. The motor attaches to the front gear instead of pedals so that when the motor turns on, the rear wheel turns.

> *It's time to try it out. Boz is sitting on the seating arrangement which still has to be fastened permanently to the frame over the drive train and battery. Dan is fiddling with a wire hooking up the positive side of the solenoid switch to the switch on the handlebars. The other end coming out of the handlebar switch has already been hooked up to*

the battery. We're ready. Some one says "clear that stuff out in front so we don't knock over the table," Boz says, "Don't worry about it, the back wheels are off the ground, we're not going anywhere." After glancing at Lassitter, Boz hits the button switch with his thumb. Nothing happens. Lassitter looks puzzled and Dan lets out a groan. "Okay", says Lassitter, "it's gotta be continuity, check out the wires to and from the motor." "Ground" says Lassitter, "Ground?" replies Dan. "Yeah the ground is no good, look at this." Lassitter reveals that the spray paint job has covered the bolt and the wire used for the ground wire to the bottom plate on the frame. Boz and Dan work feverishly for a few minutes, Boz wants to use the grinder to clean it up, but Dan convinces him that a bit of emery cloth will do. They finish up and Dan jumps on the seat to the disappointment of Boz..."okay...okay"...Dan pushes the button and with a loud clacking noise the chain connecting the two sprockets just goes from standing still to moving very fast. The rear wheel whirrs as it spins on its stands. Dan and Boz are giddy with excitement. Boz actually squeals as Dan releases his thumb and pushes it on again. They decide to try it out on the ground and the stands are removed and the car is dropped to the floor and quickly wheeled into the sunlight through the big shop door. "Helmet, get a helmet" says Lassitter but Dan completely ignores him and instead pushes the button again. The front end of the car leaps up about a foot and-a-half into the air and a surprised Dan lets go of the switch before it flips right over. "Holy shit" says Boz.

(Field book 3, p. 31).

The bicycle wheel does not stand up to the tremendous force that this configuration puts on it. During the test-run which follows, they run the car around the track a few times and the wheel rim becomes so distorted--from the jerking force of being turned on--that the chain eventually pops off the sprocket each time the power comes on. In the following conversation excerpt we are talking about changing the drive configuration to one that would stand the force exerted by the motor. In addition, the motor does not stand up to the load that the chain drive put on it. The replacement motor donated by Canadian Tire is much bigger and has a built-in bearing at one end of the gear which means a different set-up. Here, I ask Ross for his version of how the drive train comes together

> *Ah, (pause), well we had to, we couldn't find a good way to actually get the motor connected to the wheel, so, we first tried the chain and that kind of blew the motor and everything, 'cause that was the only one that had the shaft and bearing, and something like that had the bearing inside of the shaft or something.*

Yeah, that

> *The other ones we could cut off.*

Ah, right. So one had the shaft, had an exterior bearing like on the end, right? A bearing, right? So you couldn't use the chain on that. You couldn't get a sprocket on it

Yeah. Yeah.

So, in a way the limitations of the parts sort of improved your design in a way, didn't it?

Yeah.

'Cause in the end that was really good wasn't it?

Yeah. Right.

It worked out well. Yeah. So what happened then?

Then we got the fly wheel and mounted it to the wheel

Yeah

By taking the part, the sprocket, and ah, putting it on the wheel.

Okay. So you mounted that up, and how did it work?

It worked, ah, it worked good other than too much power and everything else.

Like too much power eh? (Chuckle)

Yeah, way too much power. It bent the wheel a few times. I brought the wheel home and took all the spokes out...

Did you? Yeah?

> *...took every spoke out and then I stepped on the rim. I tried to bend the rim and then I put each spoke back in. I ended up putting them into a motorcycle rim instead.*

So how did it improve that?

> *By not putting too much power from the motor, and the motorcycle wheel. Stronger wheel, yeah and less power with the new motor* (chuckle).
>
> (Ross Interview 2, p. 7)

Ross begins by explaining how the original starter-motor is set up differently. It can accommodate a sprocket at the end of its shaft connected by a chain to the rear wheel gear. But the replacement motor drive gear cannot accommodate a chain on it because of the housing covering the end. They are unable to cut off the housing because it needs support at both ends. Without support, the load will distort the shaft, rendering it useless. So they decide on a direct-drive instead of a chain connecting the sprocket on the motor to the rear wheel. The direct drive means the gear on the motor will be mounted right up against a huge flywheel welded onto a gear that in turn, is threaded onto the bicycle wheel hub. A direct drive configuration mimics those on automobiles. On most cars, the starter motor gear meshes with the flywheel directly. The flywheel welded to the bicycle hub is later attached to a much stronger motorcycle rim. They end up with a hybrid car-bicycle-motorcycle drive train.

The week immediately before the electric car competition turns out to be quite hectic. The front-end gets welded onto the frame just a few days before the race. The students set up the initial drive configuration before realizing that the forces on the rear wheels are too much for bicycle parts designed to withstand lighter loads. I remark in my field book at the time that it seems strange the assigned responsibilities for completing various components of the design--such as the lights and body parts--are still incomplete. I follow this up with Ross, asking him about the final week as they wrestled with the problems of the drive train whilst completing many other details of the car.

Who did what

> *Well, it was real busy. And with the motor blowing two days before, so we had to work really hard to get the motor working right.*

Yeah.

> *The brake lights we didn't get it done.*

You wanted to eh?

Yeah. We should have had more people working on ah, we had to have more of the class working on this, but there were only six of us so we could only do so much.

Ah, right.

And we didn't, like lots of times when we stayed after school most of us were just watching ah, other people do work so it wasn't, we never started on lots of things I said before. We could have started on the brake lights the first day but we started on them the last week. So, you know, and also with ah, lots of other things. We could have put a body on it. And maybe a two wheel drive or something. 'Cause there's lots of ways to tie in that we didn't do any work.

Hmm. So how would you have done it all differently? It sounds...

Well ah, what we did was we all worked on one thing at a time, and if we split each other up and each worked on a different project, then come together and then

Like a person working on a braking system?

Yeah, one person working on braking system, one person or two people working on frames, one person working on the steering system, and all different, we could have got it done.

Hmm. But as it was it was the same people doing, doing like the same, how did it work then?

All six of us were working on the frame at one time

Ah, yeah, okay.

And then all six of us were working on the steering system, all six of us were, so it was hard. And two people can't weld at the same time, so, on the same thing, so, but most of us couldn't do anything. We should have been working on other things.

Hmm. Gotcha. Isn't that interesting. Um, so here you are and you're up there on Saturday, so what was your first impression at the competition when you arrived there?

Well, like, we didn't think our car was the best with the looks and everything. All the others had really nice bodies and everything else. Sort of embarrassed bringing ours eh?

You were sort of embarrassed?

Yeah, bringing ours in looking like it did, but when they took their bodies off they looked pretty much the exact same as ours underneath, just they looked a lot better. They had some, ah, some better parts too. They had around 20 sponsors, we had about one or two sponsors, so...

Right, so their access to parts was important, eh?

Yeah.

Hmm. Interesting. Um, so your first impression was that you were embarrassed. Why's that?

Because theirs looked so much better than ours.

Oh yeah? Does that mean it was going to do better, like go further?

No. They just looked better, so, they all had many more features. We didn't have any features on ours, which they had, a lot more things such as ah, solar panels, braking systems, and bodies, and lighting. We could have had, like headlights on, when it came to the race just turn off all the lights so we wouldn't use any power, but use them for looks, so you get more points. And our steering, wasn't the best, I guess. It wasn't bad, but when, well, pressing on the throttle you can't turn the best 'cause of so much power.

Yes. I remember. So, yours was really simple.

Yeah. Everyone else's was more complicated, but like we had direct drive, they all had chain. Ours, no, ours was real simple. We had nothing but the necessities on ours.

Hmm.

Which turned out good because they had a lot of problems with other things, like bodies, so didn't have any problems 'cause we didn't have many things on ours. So when it came to racing we came in first.

Because there was less to go wrong?

Yeah.

Did you plan it that way?

We just never had time to do anything else.

(Laughter). So it wasn't by design.

No, it was just by accident, it's just the way it happened.

(Ross Interview 2, p. 8).

Ross reveals how he felt about arriving at the competition with a car that could have looked better than it did. He suggests that with a different division of labour, the car might have brake lights, a body, good looks, etc. He feels embarrassed by this on race day, although the other cars looked much like theirs when the bodies were removed. He makes the point though, that in the competition the simplicity of their car meant that there was less to go wrong. He suggests that they won the race because the car is simple and more energy efficient. Finally, when I ask him about planning, he laughs saying no, *it was by accident, it's just the way it happened.*

In these three conversation excerpts, Ross reveals his sense of how the front end and drive train are constructed as well as some thoughts on who did what. He tells us how one design is chosen by the teacher and how trial and error activity characterizes the day to day making activities like putting together a drive train at the last minute. He also makes a somewhat inadvertent insight as to the advantages of simplicity which poor organization and a lack of time produces. He calls this the accidental nature of making the car. We now take a look at these insights and the way things are done in terms of their significance as learning resources.

Everyday relations and Ross

The way things are done

Ross starts off saying that Lassitter is really the one that designs the car by giving the students the main ideas. It appears that Lassitter does make a number of the decisions. He contributes a number of suggestions--like choosing the front-end for the car--as well as coming up with other important ideas. One instance occurs as part of the work replacing the drive-train. Everyone is concerned with the jerking of the car during the initial test run. Each time the power is switched on--the car leaps forward and to the left--partly out of control. It is quite scary as the force transfers to only one wheel which means that the car jerks uncontrollably towards one side. This happens as the power suddenly transfers from the battery to the motor and then to the rear wheel. Lassitter suggests the use of a large capacitor--an electrical device which 'holds' power--between the battery and the motor for controlling the surge of current going to the motor. The capacitor regulates the electrical current going to the back wheel. None of the design team members are capable of coming up with such a solution. This takes experience and know-how with electronics. They would have been foolish to ignore what he had to say and they did not. Lassitter's training as an engineer provides important insights and suggestions as to possibilities when working out solutions. In this first section of analysis we take a look at the historically developing nature of such practices.

Co-participation

The front-end and drive-train conversation excerpts provide contrasting versions of the way things are done constructing the car. In the former we have activity by students producing a number of possibilities while making a front end. It is an off-the-shelf solution chosen by their teacher, a natural enough thing in a classroom or any community where there are more experienced and less experienced practitioners. The development of the drive train provides a different account of how things are done in the development, selection, and fabrication of the front end. This work is shared and developed by the students with the support of Lassitter. How things are done in each of these accounts has the appearance of being somewhat disorganized and perhaps inefficient. Both conversation excerpts offer clues that the activities consist of mostly trial and error work. But both excerpts also show the presence of established, engrained processes. Lassitter's experienced suggestions and the constraints of the Electric car Design Brief are but two of these. However, the front end development and the drive-train reconstruction also occur as improvisations arising from the requirements of simplicity dictated by strict constraints of time, and the need for an energy efficient car.

Emergent & engrained processes

The front end and drive train conversations reveal some features of how things are done in this classroom. Ross draws attention to the choice of the front end as an off-the-shelf item--by Lassitter--and in a somewhat oblique way illuminates the contradiction between teaching a design process and then more or less ignoring it. Both activities are marked by improvisational trial and error work by the students done co-operatively with their teacher. These accounts indicate that there are different ways of solving the practical problems of putting together the car. Recipes in the form of a ready-made front end or a capacitor-controlled throttle still require improvised action. Improvisations like the activity of making the front end are also mediated by accepted--historical--practices, the do's and don'ts of practice. The front-end is welded onto the frame. Connecting it with fastenings would not have been appropriate. The way things are commonly done--as social practices in work communities--have a tendency to shape the relations there (Franklin 1999). I remember for example, my arrival at a remote airport for a wilderness expedition dressed like a city dweller. The people sent to meet me walked by me a number of times in the small terminal. They didn't recognise me because my clothes didn't match the worn outdoorsy look of the experienced hand. Despite my extensive outdoors background, my status suffered and I wasn't treated as an insider during the expedition. The ways of commonly doing things--such as a discourse--come to define the way that they are done as accepted practice and accordingly, social relations such as status and access to benefits and other resources are affected.

Improvising and following engrained processes provide some resources for beginning a discussion about my use of the reality we end up calling practice in this classroom. I have two observations regarding its constitution. First, I use practice for defining a level of analysis, and a local scene more specific than Tech Ed classrooms in the province generally, or even those in a particular board of education. I study the social relations in two classrooms that represent something of their social and historical roots as locales providing the hands-on, learning by doing opportunities one comes to associate with classrooms mimicking work practices. What have we so far? I identify and describe improvisations and engrained versions of the way things are done. Both offer the equivalent of resources or tools for the sense-making that Ross and others construct as they solve practical problems through making activities. Engrained practice and improvised action represent, in small but significant ways, the continuities and discontinuities characteristic of any community of people who define themselves by what they do.

My second observation concerning the constitution of the reality of this classroom so far, has to do with the appearance of the sense-making activities described in the front end and drive train activities. It would be easy to misconstrue the improvisations and use of engrained practices strictly as cognitive action in the minds of Ross and the other students. Rather, the improvisations and engrained practices make their appearance as actions between students based on what has to get done. This is important because it begins locating my burgeoning sense of classroom practice here as emergent and under review within the constraints and possibilities provided by an array of resources and social infrastructures. Social theorist Etienne Wenger (1998) has something to say about relationships between established ways of doing things and emergent ones in communities of practitioners.

Wenger situates his research exploring a theory of learning within education by suggesting that reified versions of understanding in the form of textbooks, curriculum and the like are common. Reified practices or understanding in identifiable forms provide learners with "visible and fixed" (p. 264) ways of seeing how a particular solution may be realized. Wenger tells us that reifications provide such resources, but at the same time warns that learners may assume a simple and direct relation between problems and solving them. Thus, Lassitter's choice of a bicycle front end could send the message to Ross and other students that developing prototypes merely requires brainstorming, or other techniques associated with creative thinking and problem solving. Research in workplace learning (Wenger, 1990) tells a different story. Wenger shows us how communities of practice are characterized by social practices engrained in relations between people and the contexts of which they are a part of. Communities of practice both construct and sustain what he calls "configurations of reification" as well as "configurations of participation" that enter into their practice (p. 161). Configurations like the engrained and improvised activities identified in the front end and drive train accounts provide Ross with the resources for entering and accessing practices in this classroom. We saw how the drive train activity involves holding the motor in position, while other parts were juxtaposed in an improvised version of what it might look like. We also have some idea of how the bicycle front end, a solution already established in practice, is held up to the frame in a similar manner. While the ready-made front end has the appearance of providing an "easy" solution, it nevertheless requires complex action by Ross. So does the drive train. Both are constructed and sustained in practice. We may begin seeing how engrained or historically developed practices such as the front end come to be mediated through other, improvised ones. Alternately, we may see how improvised activity is mediated through historical processes. Both offer a way of thinking about the way the activity unfolded in the circumstances connected to the front end and drive train construction.

My descriptions of the engrained and improvised activities are also theorized in the related literature associated with cultural psychology. In an important essay written at the request of his peers, Michael Cole (1989) explicated the key features of this re-emerging discipline. The first feature is that people are linked to each other and the world by processes of cultural mediation in the form of symbolic and material artifacts and tools. The second feature is that these symbolic and material tools have developed historically at a number of levels that are constantly undergoing more or less simultaneous revision. The third and final feature is that the means for this development happens through practical activity in the everyday world (Cole, 1990; Shweder, 1991; Wertsch, 1990). The drive train and front end activities show us something of the interplay between historical, or engrained ways of doing things and improvised or emergent ones. Framing Ross's social engagement with others in terms of historically developing actions, we now focus more directly on co-participation as a matter of shared practice between people and situations.

Co-participation as shared practice

Ross has something to say about how things were done and who did what. He says that a different way of organizing themselves would produce a different car, one with more *features* as he put it. In the beginning, responsibility for different systems of the car are assigned to individual students. The brake system for example, is assigned to Ross, but he just never seems gets it together. He makes a few attempts at working out a stop light system connected to the front and rear bike calipers, but he hardly got going on it. Another student, Dan, is given responsibility for the design report but he neglects completing it until a few days before the competition and only then with the assistance of myself and Lassitter. Others on the team also experience difficulty completing individually assigned tasks. I have difficulty observing students working independently until discovering that they avoid it, preferring to work with each other instead. Any individual work I witness passes quickly, and does not appear as productive as the collaborative activity. It is possible that the individual responsibilities are not taken seriously by the design team, or it may have something to do with what the students think is needed. They inform me, for example, that their main goal is to win the race. It seems likely that winning the race has little to do--in their minds--with the car's appearance, a functioning light system, or a professional design report. But there may be more to their apparent lack of attention than ignoring what they think is unnecessary.

Lave & Wenger's (1991) work with masters and apprentices show that there is an undue emphasis on the direct effect that a master has on an apprentice. Rather, they submit that the relations between apprentices organize opportunities for learning rather than asymmetrical relations between apprentices and masters directly (p. 92). The lack of results and production of the individually assigned responsibilities when compared with the productivity of the collaborative work suggest that relations between the students may have provided this kind of collegial support. This support may have been lacking when working alone.

Ross also calls our attention--in a somewhat cynical manner--to the time spent on the design elements of the course, especially the two weeks spent drawing and making a number of automobile-style front end models prior to the decision to go with a bicycle front-end. He separates the activity associated with classroom design from the making of the car. The design work for the drive-train is integrated with the work and not preceded by experimental work in the design classroom.

> It's late and almost time to leave after an hour of fiddling around with the bigger starter motor that Boz and Dan picked up earlier at the Canadian Tire just up the street. Lassitter pops in and suggests that the three of them use a 'C' clamp to hold the motor in place in lining it up and figuring out where it has to go on the frame. Lassitter returns before it is put in place and he takes a closer look at the motor exclaiming that it has a housing and a bearing which will make it impossible to get a chain on.
>
> Boz puts the motor on the bench and connects the battery to the motor with a set of booster cables he's picked off the far wall. Ross holds down the motor with one hand as Boz clips the cables to the terminals. Lassitter turns his attention to them as he explains to Dan and I that the only way it's going to work is if a chain drive can be avoided.

"Put the motor in the vise" he tells Ross and he goes back to explaining to us how the best thing would be to find a way to hook it up directly. Dan agrees with him saying "yeah, if we could just find something to fit the gear then we'd avoid having all that friction."

Boz and Ross continue to fool around with the motor and battery, turning it on and off repeatedly. Things look to me like they aren't going anywhere as the conversation continues between Dan, Lassitter and myself about finding a way to connect the motor up to the wheel. "Lets take a look at that motor again" says Lassitter, so Boz and Ross return it to the car frame where Dan holds it up close to the rear wheel.

"Yeah," says Boz "Something like that. Why not bolt it in there and hook it right up?"

"Where YOU been?" asks Dan in a sarcastic tone,

"Well, makes sense eh? Just hook it up like you do in a car"

Lasssiter turns to Boz and says, "Why not take a flywheel and weld it to the rear wheel? That way it'd be a direct drive. Just like a car"

"Yeah, Mr. Kennedy has a pile of them on the floor down there."

(Field book 3, p. 29)

Like other activities, the drive train reconstruction is improvised. We see how these improvisations are carried out within historical influences such as engrained practices, and other ways of doing things. The overall time constraints and the student's unfamiliarity with some things and familiarity with others all contribute to the car production. In the short description from my field notes above, we get a sense of how the activity proceeds, stops, then speeds up again as the energy and attention of the students and Lassitter shift back and forth as they "work" through puzzling out the details of deciding what they might do. This involves holding the motor in place, "eyeballing" the alignment, moving it around, clamping it, etcetera. The physical relationships between the motor, frame, front-end, and back wheels provide the resources for Lassitter and the others in making appropriate decisions. The social relations involving Lassitter, the students, and myself "fiddling" around have the appearance of a shifting and mutually modifying performance-in-action that results in a series of workable solutions. The subsequent work of finding the right flywheel in the auto shop involves a similar set of circumstances with a number of choices of flywheels, each contributing its own set of limitations and possibilities for a workable drive-train.

The front-end solution is a product of time constraint as well. After a period of talking over a number of alternatives, Lassitter just says something to the effect that it makes more sense to go with the ready-made solution that the bicycle front-end provided. The interesting thing about this decision is that Lassitter has students making models of automobile front ends in the design classroom--but when it comes time for making a 'real' one--they ignore them. I have no way of knowing how much the model-making figures in the final front end decision. With some exceptions, like Lassitter's suggestion of a capacitor and a ready-made front end, the making activities of the shop have the characteristic pattern of a social practice rather than an instructional one, a social practice of a different nature. It is not obvious to me that any instruction happens there, at least not in the manner of the design and technology classroom exercises. The absence of 'teaching' and the presence instead, of opportunities for participating in practices associated with making the car is a continuing theme in this inquiry. My intention here is not making a comparison between classroom design studies as reified versions of practice and valorizing the shop making activity. I acknowledge the importance of reified forms of understanding. What is important for the moment are highlighting how things get done through engrained and emergent forms of activity enacted through frameworks of co-participation. The front end provides a useful instance for illuminating an interplay between engrained, historical processes and improvised ones. Table 1 illustrates the historically developing nature of practical activity as an interplay between these mutually constituting aspects of co-participation.

<u>Table 1 Co–participation as an emergent and engrained relation</u>

emergent (improvisations)
↕ co-participation ↕
engrained (bicycle front end)

Where co-participation emphasizes the way things are done as historically developing within actional contexts, my next analytic focus is on the relations between knowing constituted by the requirements of working practice.

Requirements of working practice

Returning for a moment to the talk and action associated with the front end and the drive train, we can pick up on the interplay between knowing originating with individuals and knowing that originates beyond individuals. Both exist in tandem as social and cultural relations or, as a medium for getting done what gets done. Another way of explaining this relation is describing it as kind of temporary imbalance between the ambiguities of what needs to get done, and the existing or engrained material resources at hand. The electric motor is held in an imaginary place on the frame as the students move it around, speculating how it might work. As the physical relations shift, so do the possibilities for a workable drive-train. Seeing the activity this way, the drive train construction emerges as much a material as a social product. As social and material products, the drive train and front end demonstrate something more of my developing sense of how I construe a practice to be. So far, it is a way of talking about the manner in which the social and the material are expressed through contributing resources such as engrained and emergent actions within the context of co-participation, and now here, as the requirements of working practice. These moments are theorized by activity theorists like Keller and Keller (1993), and situated learning researchers (Lave, 1988) who study similar activities.

<u>Individual and community</u>

In an account of knowing and acting in tandem, Keller and Keller (1993) illuminate the interdependence of individual action and knowing socially distributed among people and objects. Here they describe how one of them--a blacksmith--makes a simple tool.

For even after announcing that he has completed the forging of the skimmer handle and after he has gone on to the final whitesmithing stage, the smith is evaluating the object against the more detailed conceptual representation of it that has emerged in the process of production and against his general standards of aesthetics, style, and function. He returns at least twice to reforge segments of the handle, ultimately changing the shape and thickness of the bearing surface to provide a larger area for attachment of the skimmer bowl (p. 139).

Here we see the interplay between individual knowing and knowing socially distributed, for example, in the form of his "general standards of aesthetics, style and function." The lines between individual smithing action and craft standards become blurred. Keller and Keller show how things commonly done by blacksmiths and individual action mediate each other. Lave suggests that the relevance of Keller and Keller's findings are that "they demonstrate the open-ended processes of improvisation within the individual, social, material, experiential resources at hand" (p. 13). The improvisations of Lassitter and his students use similar resources: social, historical practices like working together, as well as responding to material and social conditions of their work. The talk and action of Ross demonstrates a similar interplay, between individual knowing and knowing socially distributed throughout a craft community.

An incident from Lave's early (1988) research with a weight watchers class also illustrates how in a problem solving context, the work at hand provides both the requirements and the resources for a resolution. It is the instance of a man measuring out and meeting the specifications of quantity laid out in strict dietary guidelines. The requirement calls for three quarters of the two-thirds of a cup the program allows for a cottage cheese ingredient. Lave's description goes like this,

> The problem solver in this example began the task muttering that he had taken a calculus course in college (an acknowledgement of the discrepancy between school math prescriptions for practice and his present circumstances). Then after a pause, he suddenly announced that he had "got it!" From then on he appeared certain he was correct, even before carrying out the procedure. He filled a measuring cup two thirds full of cottage cheese, dumped it out on a cutting board, patted it into a circle, marked a cross on it, scooped away one quadrant, and served the rest (p. 165). Lave makes the point that the requirement of "taking three quarters of two thirds of a cup" is not just a problem statement. The problem statement provides the resources for its resolution; not only the procedure for doing so, but the solution as well! The description in the problem statement is another way of thinking about the requirements of practice. As we move through this analysis I will continue adding to this growing conception. Table 2 depicts two mutually modifying aspects of the requirements of practice.

Table 2: Requirements of practice as a social and cultural relation

individual (choice/creativity)
↕ requirements of practice ↕
community (craft standards)

The social practices mentioned by Keller and Keller, the weight watcher's example by Lave, as well as those enacted by Ross through co-participation and the requirements of work, are also enacted through other social and cultural infrastructures I call technologies of doing.

Technologies of doing

I knew at the beginning of this inquiry that the term 'technology' continues as the subject of much debate and discussion by philosophers of technology generally, as well as those with an interest in technology education. I am interested in expanding my use of "making" as something more than the limiting individual and social conception I used in my earlier graduate work (Kozolanka, 1993). Shortly after beginning this inquiry, I became familiar with Franklin (1999) who links technology directly to culture as sets of socially accepted practices and values (p. 6). I also have my own experience as an early school leaver who possessed little interest or ability in mathematics. Despite this, I subsequently functioned well enough as a carpenter dependent on measuring, calculating and using formulas and algorithms as a matter of daily practice. With these thoughts as a backdrop, consider the following excerpt from a conversation I had with Boz.

A cameo contribution by Boz

Boz is also a regular. He lives on a working farm with his family north of town. Unlike Ross, Boz has few interests in the new information technologies or a job after school that might involve community college or university. He tells me that he will *be a welder or someone like that who puts things together* (Fieldbook 3, p. 16). He likes hanging out in the shop area of the school, particularly the manufacturing areas. By way of introduction, although Tech Ed courses are now compulsory in Ontario secondary schools, Boz has already taken the required number, so I ask him why he is in this non-compulsory course.

> *Ah, I'm not very smart* (chuckle).

What do you mean?

> *Well I'm not good at calculating math and whatnot.*

What do you mean?

Well I have to do it, just nothing like Pythagoras theorems, or X equals Y, and all that stuff. But, ah, I'm pretty good at working with my hands and I just like welding. Something I like to do. It's fun.

Hmm. Tell me more about not having to Pythagoras and stuff like that? What do you mean?

I'm not good at it. I can't remember a lot of numbers, I can multiply things quickly, but I always have to write it out to figure it out.

Don't you have to do that as part of um, welding? Everyday welding stuff.

Yeah, well it's nothing as complicated. Like you get these questions that are three feet long, you know. You don't do that in welding. You know, like ah, three sheets of sheet metal will give you how much...uh, you'll need to know how many rods to weld with and all that. Simpler stuff.

Hmm. So you can convert the sheets of metal into what's needed easier than you can with figures.

Yeah, it's easier.

Any idea why you might be able to do that?

Haven't a clue (chuckle).

(Chuckle), Well, because it's something that I'm more familiar with

(Boz Interview 2, p. 2)

Local and extra-local technologies

This instance points to how 'school math' knowing in the form of geometry and algebra holds a privileged place in the thinking of Boz over what he knows about calculating math related to the practical activity of welding. As he explains the differences between pythagoras and 'x' and 'y', and his welding ability, the 'school math' clearly holds a special place in his thinking. I subsequently spent some time watching Boz mentally calculate and select the appropriate welding electrodes or 'rod' in welding the car. The process could get complicated, but the basic idea had the size of rod controlled by the amperage range of the welding machine, the thickness and type of metal being welded, and kind of weld the situation requires. This means that Boz has to associate rod, metal and the type of weld needed in one circumstance with those in others. Each requires calculations which are confirmed by consulting a classification chart. Boz is good at figuring out what each circumstance demands and he rarely consults the chart, correctly managing his rod selection most of the time. When he does not get it right, he burns right through the work or it isn't hot enough. He accordingly adjusts the amperage or changes the size of rod and completes the weld. Boz definitely has a 'feel' for calculating and figuring out the requirements in a given situation.

After recording the interview with Boz, it became one of those things that stuck in my mind. I described my interaction with Boz to a colleague who immediately recounted Sylvia Scribner's (1984) early work studying milk packers using arithmetic on the job and how their use held little resemblance to school arithmetic. Like Scribner, Lave (1988) also studies people outside of school using math. They both find that the math people use in the everyday world holds little resemblance to how "school math" is used. They also find that how math gets done in school has a tendency to become a model for how it should be done outside school, so much so that people see school math as the only legitimate way to do it. In a social critique of technology, Franklin (1999) refers to such tendencies as the ways that technologies come to supplant other ways of doing things. These other ways of doing things often involve older, more familiar technologies; technologies supplanting technologies. How Boz thinks and feels about the value of welding math has something to do with how he thinks and feels about the importance of school math. The result is that Boz does not see his ability to do welding math to be as authentic as the school math he purports not to know. School math is supported by a complex social structure institutionalized by schools and found in this interaction. But so is welding math supported by a no less complicated social structure institutionalized in craft standards and competence. We can see something of this in the account of practice by Keller and Keller (1993) earlier. Highlighting the differences between extra-local technologies of doing, like school math, and local techologies of doing, like welding math, is addressed later in my comments about situating technologies in what I call a "cultural home". Suffice to say for the moment, that school and welding math each have their own supporting ecology and constituent resources.

I use the term 'technologies of doing' as a way of describing the kinds of material and social infrastructures and institutionalized versions of activities and understanding carried out by people. As a constituent of practice and practical worlds, technologies warrant some scrutiny for both their cryptic and obvious characteristics. Often, it is not easy to figure out the extent that technologies are engrained in how we think about what we do. One only has to think of answering machines and the phenomena of "talking" to someone, making arrangements of various kinds without ever really talking to a real person directly. Franklin refers to this as a move from synchronous to asynchronous (p. 151) forms of contact where reciprocity through an exchange of voices in the present tense is lost. The appearance of course, is that one is still communicating. "Phone tag" is the euphemism used for explaining these asynchronous processes, a name that belies a lost reciprocity. Seeing through ways in which technologies in various forms become engrained in how things get done is important, because of the cryptic ways they become accepted and are perceived as 'normal'.

Franklin's explanation of how a technology can supplant other ways of doing things can be traced to Heidegger's (1977) materialist view. Ormiston (1990), a contemporary interpreter of Heidegger, comments on technology,

> However it is to be known, understood, or determined, technology remains amorphous, in spite of, and because of, its appearance as visible artifact: it withdraws into the structures and processes of thought and culture; and in this withdrawal technology reappears always (p. 23).

The incident with Boz shows how a technology of doing, like school math, can withdraw into the social infrastructure of this classroom. Making technology reappear in a conscious manner–seeing through things--is a thread taken up later in this analysis. There I explore technologies of doing as socially organized ways of regulating access to meaning and understanding. For now, it makes sense to situate my conception of technology after Franklin (1999), as a practice, and as ways of doing things (p. 6). This dissertation is an attempt to make some sense of the ways things are done by examining the interplay of social and material resources constituting technologies of doing and accordingly, classroom practice. In the world of Boz, knowing school math becomes the way of defining what it means to be smart, despite his competence and use of welding math. Table 3 illustrates technologies of doing conceptualized as an interplay of these local and extra-local forms.

Table 3: Technologies of doing as local and extra local relations

local (welding math)
↕ technologies of doing ↕
extra-local (school math)

Considered together in Table 4, technologies of doing, the requirements of practice and co-participation form a socal and cultural organization in practice.

Table 4: A social and cultural organization in practice

emergent	local	individual
↕ co-participation ↕	↕ techs of doing ↕	↕ req of practice ↕
engrained	extra-local	community

Thought of as a social and cultural organization in practice, and illustrated as an interplay of contributing resources, the way things are done raises issues of access permitted through them.

Access issues: Legitimacy and peripherality

Lave and Wenger (1991) have something to say about securing access in work communities. Access issues are addressed here first in terms of legitimacy explained through a division of labour and then peripherality explained through observational practice. Lave and Wenger suggest that master-apprentice relations are characterized less by observable teaching moments and more by what they refer to as activity that confers legitimacy and opportunities for peripheral participation (p. 92). In one of many instances taken from different cultures and apprenticeships, they show how Yucatec midwives learn their specialty by participating in the day-to-day activity of living with their extended families. They also document other people learning a specialty separated from the ordinary activities of day-to-day living. They find that securing access to a community of practitioners is an important issue for them. In the electric car classroom, the teacher provides important cues for securing access by providing opportunities that legitimize the participation of students. My conversations with Ross provide a hint of how Lassitter creates these cues through his interactions and by introducing a division of labour. Expanding on the development of co-participation and the requirements of practice, we turn to a discussion about legitimacy in the context of two aspects of the division of labour; the assigned responsibilities and the decision making by Lassitter.

A division of labour

The division of labour that Ross describes is tolerated, even encouraged by Lassitter. Initially, he divides the students into teams responsible for the separate systems; electrical, frame, front-end, drive-train, brakes, design brief. Instead, the students begin by working together. Lassitter seems content with this, encouraging them as they organize and divide up the work, even in the face of the time restriction leading up to the competition. It strikes me that in accepting this alternate division of labour, Lassitter legitimizes the student's relations with each other. Lave and Wenger argue that it is through relations with fellow apprentices that apprentices organize opportunities for learning and, "that engagement in practice, rather than being its object, may well be a condition for the effectiveness of learning" (p. 93). This is an important point to keep in mind throughout this analysis, because it draws attention to the notion of increasing participation and membership in a community as tantamount to learning.

According to Ross, Lassitter makes many of the decisions. Lassitter takes the lead in selecting the most efficient front-end under the circumstances, and also introduces the idea of using a capacitor to slow down the effects of the power surge on the rear wheel. His insights and decisions are the kind of influence one might expect from an experienced hand in any work community. Apprentices in work communities experience the influences of masters in diverse ways. A master's influence can range from the "benign community neglect" that Lave and Wenger describe, to the direct influences that Ross attributes to Lassitter. Lassitter certainly spends a considerable amount of time absent from the after-school activity of car making. When we direct our analytic attention to the possibilities created for increasing participation, it casts the uncompleted individual work in a different light.

It is possible that uncompleted individual work can provide access to practice. I've been puzzling over why the individual assignments are not taken seriously. Both Dan and Ross tell me that the design brief, the lighting system, and the overall appearance are unimportant because winning the race is their main goal. While accepting this explanation, their uncompleted individual work can also be understood as important facets of their overall participation. Lave & Wenger suggest in their analysis of apprentice-master relations that the peripheral work undertaken by newcomers provides them with an "observational" outlook from which they survey a practice that helps them understand things with less confusion. Lave and Wenger refer to this as a "An extended period of legitimate peripherality [which] provides learners with opportunities to make the culture of practice theirs" (p. 95). In my own work experience, this kind of peripheral activity has some resonance with the tasks one might routinely assign to a labourer or new apprentice on a construction site. An inexperienced newcomer would typically be directed to fetch and carry materials, tools and drawings in an effort to familiarize them with the rudiments of practice. Lave, (1997, 1998) and Lave & Wenger (1991) and others (Hutchins, 1995; Scribner, 1984) document similar peripheral activity in other work contexts. While the individual responsibilities assigned to Ross and the others are not taken as seriously as other work, they may familiarize and provide the students with an appropriate "observational" outlook.

Observational practice

Lassitter's control of some decision making has the appearance of denying access to participation. On the other hand, his expectation that the students work independently has the appearance of providing access to participation. But, what kind of participation is fostered in each circumstance and on what terms? In the former, the expectations are that the students do nothing other than be there as witnesses and providers of information, suggestions etc. In the latter, they are expected to produce a synthesis of tools, problems, materials, intentions and solutions into the workable form of a lighting system, the brakes, a front end, a drive train, etcetera. I suggest that this latter work is more like the core production capabilities associated with more experienced players, not the peripheral work of newcomers like observing others. In practice, our perception of just who is participating gets turned on its head. From a situated learning perspective, Lassitter's initiative in making decisions may well provide Ross with an opportunity for engaging in a peripheral participation, where he has access to how an experienced person like Lassitter comes to make choices. The same holds for the inattention to the individual work by the students. This inattention can provide a peripheral participation which increases as they appropriate the division of labour for their own purposes. This is a division of labour supported and legitimized by Lassitter.

Accepting that participants engage in practice in "observational" ways which helps them get some sense of how things get done and who does what under varying conditions, we may see how not completing work could also be a legitimate way of accessing the activity of a community. Put another way, practice can be thought of as distributed in ways that do not appear immediately useful or productive. Uncompleted work can hold the possibility of contributing to overall productiveness even though it might not have the immediate appearance of doing so. One could make similar assumptions concerning the engagement of students in design processes like those experienced by Ross in the Design and Technology classroom. Those design processes could provide an observational outlook when included as part of an overall approach in the making of the electric car.

For those not participating in the after school activities, the experience would be different, of course. It's possible though, that even for Ross and the other after school students, the classroom activity is removed from--and not peripheral to--the subsequent making activity of the electric car in the shop. Figuring out the extent that classroom activity provides for a legitimate and peripheral access to practice becomes an important question, especially since design studies in Tech Ed is generally promoted as a way of providing students with new and expanded capacities. The presence of various technologies of doing like design studies becomes an object of analysis in figuring out their usefulness as contributing resources in Tech Ed classrooms. How, then, might one make a distinction between activity that is peripheral to, rather than removed from, subsequent making activities?

My earlier introduction of Franklin's (1999) concept of synchronicity helps in making a distinction between activities removed from, rather than peripheral to action in this classroom. We see how a telephone answering machine can loosen, even dislocate people from time and space patterns that give the reciprocity of talking to someone their physical, social, and political dimensions. Such dimensions removed from their own historical and social locations as practice may become problematic when represented as practice separated from these dimensions. This is not to say that asynchronous processes are "bad"; rather, Franklin points out, "their increasing[ly] prevalence, if not dominance" (p.

152) presents problems in practice because of their uncritical acceptance and use in practice. I'll have more to say about the phenomena of removing ways of doing things from their sense of history and identity as social practices in a discussion about "cultural homes" a bit later. For now, synchronous practices are "rooted" as Franklin puts it, "in a common knowledge of past events and their time sequences" (p. 153). The dominance of asynchronous processes have the effect of changing the relationship of people to time, space, tempo, and feelings. These ideas are important for following the thread of a discussion involving the technological constitution of culture which is the concern of philosophers of technology who underpin Franklin's conception of technology as practice. Heidegger (1977), Ormiston (1990), and Mitcham (1994) each contribute to this conceptualization, as does anthropologist Renato Rosaldo (1993) with his conception of culture as emergent and "in motion" (p. 91). Rosaldo's work is relevant, because he draws on local talk and action as ways of exposing the workings of knowledge and power in the everyday way things are done.

In his essay about the fluid nature of a "culture in motion", Rosaldo shows how time, space, and tempo constitutes the measure of cultural practices "laden with consequences and meanings" (p. 108). By way of explanation, consider my relationship with the counter clerk at our local country store. When it is busy, he quickly fills my vehicle with gas, we exchange pleasantries, and I leave with my purchases. When it is not busy, we engage in a friendly banter about our mutual interest in professional hockey. Engaging in an extended analysis of last night's hockey game over the shoulders of other customers just won't do. Neither will our relationship bear the cost of too many "grab and run" forays into the store, without engaging in some meaningful way when it is not busy. In short, there is an established and accepted tempo to the way things are done there. Contrast this with purchasing gas at a self-serve centre. There, I submit my card through a hole in a plexiglas screen to an anonymous clerk. Although the plexiglas screen, the anonymous clerk, and the other self-serve technologies all contribute to the dislocation and possibilities of engaging meaningfully, the point is not the presence of technologies as entities with their own essential, inherent qualities. I would like to avoid the perception that this analysis is based in a technological determinist argument. Franklin suggests that the important thing to consider is not so much technologies as "interposing devices" but our engagement and movement from synchronous to asynchronous processes (p. 151) with their unconscious use. Any shift in social relations accompanying the introduction and use of technologies thus becomes a focus in discussions about the constitution of classroom culture. Additionally, a technologically constituted culture raises issues of access to contributing resources such as co-participation and the requirements of working practice. Introducing a technology is not merely a matter of adding something to a particular local culture, as the actions of Ross and others in this classroom suggest, and attested by Rosaldo (1993), and Franklin (1999). The introduction of extra-local technologies of doing fundamentally alter the timing, space, and tempo of synchronous social relations. The Design Report assignment offers another useful instance where synchronous relations such as those described by Franklin and Rosaldo are fundamentally altered through the use of an extra-local technology of doing.

The design report

The design competition also provides an instance of how an extra-local technology of doing--a design report--ends up as a version that appears, but in practice fails, to account for the kinds of social relations Ross and Dan experience and talk about in our conversations. In the week of school after the weekend Electric car competition, the students put together a report of their design experience organized along the lines of what is commonly referred to as a "design brief." There are many versions of design briefs and reports based on them, but they have common elements evident in most of the curricular materials currently in vogue in many Ontario schools (Hill, 1994) and in the most recent (BBT) guideline (Ontario, 1995). These elements are present in the requirements of the report assigned to the Electric car students. Lassitter asks the students to complete a report that comes under these sections: Construction, Testing, Fund raising, Spare parts, Communication, Education element, Sponsorship, Tech support, and Car criticisms.[14] Each section is structured internally by categories: Successes, Weaknesses, Design, and Improvements.

[14]The Electric car report produced by Ross and Dan is appended.

Each category acts as guide for recording and evaluating their activity. There is little indication of the improvised and sometimes ambiguous activity that characterizes their day to day social engagements. One gets the sense from the report that their activities are predominantly technical ones. The Success, Weaknesses, and Improvement categories are framed exclusively in terms of the material rather than the social aspects of building the car. Although Ross and Dan use the pronouns "I" and "we", one is left to speculate where they are in the report. Although my accounts of doing the Front End, and Dan's talk and action provide some idea of the complex social processes constituting Electric car, the Design Report does not reflect this. Rather, the project is presented as a set of technical relations devoid of their "subjects" - Ross and Dan.

The phenomenon of removing people from the developmental cycles of a community and representing their actions with proceduralized descriptions, abstractions, or extra-local versions of how things are (done) may be problematic. There are lessons in the work of Lave (1996), Scribner (1984) , and Franklin (1999), for using school math or other technologies of practice--for example, the design studies report in this Tech Ed classroom. We can see the difference between school and welding math as it is played out in Boz's experience. The school math has its origins separate from the circumstances of welding and is an abstraction of what we might associate with math situated in the material and social aspects of practice. School math does not provide a universal way of explaining things for Boz. In an analysis of Lave and Wenger's (1991) analytic viewpoint on learning, Brown and Duguid (1996) conceptualize this problematic in terms of "systems narrowly construed vs. systems broadly construed" (p. 52). They help us understand the problematic of the proceduralized, abstracted, and the extra-local as separating people from larger perspectives on what are enabling social practices. They point out that the separation of any technology from its enabling social practice is also problematic, for similar reasons. They suggest that "isolation ultimately makes both design and use overwhelmingly hard tasks because nothing is self-explanatory" (p. 52). When situated broadly within an enabling social context, any technology or way of doing something can be seen in a variety of ways from different vantage points. This has something to do with a later discussion in this dissertation regarding our ability to "see through" the technologically constituted character of social practices. My earlier discussion of "observational practice" is another way of describing how Ross and others find space for themselves at the periphery of practice in this classroom. Access to observational practice, or to the social periphery provides students like Ross and Boz with the means for their sense making.

Lave's (1988) work with apprentices provides examples of how newcomers typically engage peripherally in legitimized practices associated with their craft and apprenticeship status. Lave's later work with Wenger (Lave & Wenger

1991) also underscores the need for "an extended period of legitimate peripherality [which] provides the learners with opportunities to make the culture of practice theirs" (p. 95). When one thinks about peripheral participation, the activity in the Design and Technology classroom could be construed as peripheral. But it could also have the effect of removing students like Ross from an increasing, legitimate and peripheral participation by introducing them to core production processes prematurely. Premature access to legitimate core production activity may pre-empt access to peripheral activity in the manner that Franklin (1999) earlier described technologies dislocating people from the tempo, time, place, and feelings associated with synchronous cultural processes. One effect is to push out other ways of understanding how things are done and understood. Another is that it tends to separate knowing from doing and social relations. The result is that knowing becomes separated from places and people that ultimately give it meaning. What gives the appearance of access, may in practice deny it. Table 5 illustrates the addition of peripherality and legitimacy to the contributing resources already introduced as constitutive of a social and cultural organized practice in this classroom.

Table 5: Peripherality and legitimacy as social and cultural relations

peripherality & legitimacy		
emergent	extra-local	individual
↕ co-participation ↕	↕ techs of doing ↕	↕ req of practice ↕
engrained	local	community
peripherality & legitimacy		

A cultural home

How might one begin understanding these differences for the purposes of classrooms as organized sites for learning? We might assume that decision-making like the ones made by Lassitter would deny student access to participation. But, it provides a way for Ross and the others to engage in a meaningful peripheral participation by providing an observational "perch" for viewing practice. Their peripheral participation may have been pre-empted if they had been left to figure out the front end for themselves in a "sink or swim" pedagogic moment. In a way, being left to figure it out for themselves could result in their moving to the periphery anyway, which is a way of understanding their uncompleted work. What could be more irresponsible than uncompleted work? But this too, can be thought of as observational practice. Consider what Brown and Duguid (1996) have to say about moves by participants to the social periphery of practice when confronted with abstracted tasks: "abstractions become problematic when their own historical and social locations as practice are ignored. They need to be kept close to and reflect actual, ongoing practice" (p. 50). Given the complexity of thinking about the individual work assigned to Ross and the others, braking, electrical, and light systems, it is no wonder they ignored Lassitter's division of labour opting instead to work together on the frame and drive-train. The brakes, electrics and lights, although familiar ideas, may have been too fragmented and abstracted from the work of the car to support their participation. Consider again what Brown and Duguid have to say about the design of technology for learning,

> ...it seems important not simply to fragment or decompose tasks to make them didactically tractable on their own and for individuals. Any decomposition of the task must be done with an eye not to the task or the user in isolation, but to the learner's need to situate the decomposed task in the context of the overall social practice (p. 52).

Situating "decomposed tasks" such as the brakes, electrics and lights, in some kind of social practice, may well have been missing here. Any tradesperson in a given moment will take the lead in solving problems, especially those working with newcomers. While Lassitter's decision-making may well have done this, his division of labour has the appearance of denying it, at least initially.

When one thinks broadly of culture as a social reality "in motion" (Rosaldo 1993) and defined in part by the timing, spacing and tempo of its social practices, we can begin seeing how decomposing, fragmenting or proceduralizing the way things get done as problematic for learning in a workplace or a classroom, especially as it relates to how tasks are often decomposed under the guise of "discovery" learning and the like. Given my use of some of the theoretical resources from workplace learning research (Lave & Wenger 1991; Brown & Duguid 1996), people seem to require an enabling practice more than information or discrete abstracted tasks as learning resources. The disappearance of "in motion" or synchronous characteristics one associates with social practices is accompanied here by student moves ignoring the division of labour. This classroom is a local culture, but a confusing one, in that it is primarily a classroom organized along the lines of a proto-engineering design challenge. It attempts to mimic the social practices one might find in a workplace tasked with designing and making a prototype electric car. But separating school from proto-engineering is proving hard to figure out, especially in light of the analysis regarding access to learning resources. Is this about access to workplace learning resources or those of school? How might we better understand these aspects of practice thought of in this way?

In light of these questions it remains to come to some understanding about identifying what is abstracted or removed from a practice because there is a relationship between situatedness and issues of access. Importing practices, technological or otherwise, into classrooms can mean that people are continually having to deal with forms of practice originating elsewhere. A common thread in the literature associated with situated learning is how people become separated from the peculiarities of time, place, and ongoing activity related to the situations and knowing created and displayed through developmental cycles that characterize work practice. Together these characteristics form what I am beginning to call a cultural home: situations where procedural and propositional knowing, and other representations of doing things, are appropriated within shared practice.[15] Extra-local technologies of doing like school math, or a design and technology activity like the design report, may be social engagement removed from, rather than peripheral to, the shared practice of a cultural home or practice originating in another cultural home like a school classroom. I am not suggesting that a procedure or information introduced into a practice cannot be appropriated or made relevant to those in the practice in some way. We can see this in how Ross and the others use and re-use engrained processes, tools, and procedures associated with manufacturing and engineering practice originating separately from their classroom. In many respects, this dissertation is about how students do this. However, proceduralization occuring outside a cultural home and represented as practice in another community may be problematic in the sense that any technicized form of doing something holds, as Lave (1993) says,

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15 Wenger (1990) devotes much of his dissertation explaining knowing as an activity in the social organization of the world. He argues that information requires a shared practice to become useful (p.95), and I have used his work to flesh out the idea of a"cultural home".

"potential for decontextualizing practice in situated ways". In other words, such practices have the appearance of providing access, but in practice may not. There is, of course, other talk and activity in the Design and Technology classroom, with the characteristic of "decontextualizing practice in situated ways". Assignments such as the design report, or school math were present. The idea of a cultural home orients our thinking about situatedness, and how appearances can mislead.

Summing up the Ross conversation

The Ross conversation provides us with a picture of the circumstances of how things are done in the electric car classroom. We see how emergent and engrained practices each afford resources for the other in making a drive train and attaching the front end. Whether too much power, a poor alignment, or a lack of information, shared practices also organize opportunities for resolving problems. Furthermore, shared practices–that is, co-participation–have an interpenetrating relationship with technologies of doing in various forms. We see this in how an assigned division of labour--a particular technology of doing--mediates an emergent division of labour by students who ignore it and work together instead. Lassitter organizes the students so that they will individually complete the systems that make up the car. But the requirements of practice, that is, the social and material requirements of putting together the front end and the drive train dictate a different division of labour, one that has them working together.

Other technologies of doing like school math affect how Boz feels about the status of "welding math." The Design Report assignment is a technology of doing that idealizes the way things are done. The potential for this idealized way of doing things to become accepted as the way things should be done at some point in the future is troubling. As a product of social practice the Design Report has the appearance of being situated in an emergent cultural home, as does school math. Both hold some potential in practice for fundamentally altering the timing, tempo and spacing of emergent actions, and understanding of people. Without subjects, or a "cultural home" however, the design report becomes another "design for compliance" (Franklin, 1999), and school math may limit an increasing participation in practice.

Taken together, we might see how technologies of doing, the requirements of practice, and co-participation have an epistemological significance as they effectively organize one's access to further participation, and understanding in practice. The significance of relations between co-participation, technologies of doing, and requirements of practice can be understood as providing a social and culturally organized context for access in practice, a topic taken up in more detail in Chapter VI.

This dissertation makes sense of the ways things are done by examining some of the interplay of social and material resources constituting classroom practice. This sense making includes examining procedures and information introduced into a practice and how students can appropriate and make them relevant in the context of their own lives. In the next conversation with Dan, I continue by examining one particular aspect of Dan's talk and sense making and in doing so, move closer to a social and cultural practice view of learning.

CHAPTER IV: SOCIAL ENGAGEMENT IN MAKING AN ELECTRIC CAR - PART TWO

Social life is inherited and always being changed
(Rosaldo 1993, p. 105)

Conversing with Dan

Introducing Dan

Dan is fifteen years old and in his second year of high school. His main interests are cars, snowmobiles and other machinery. He was born and still lives on the family farm about fifteen minutes north of town where his parents keep animals and make their main living. Like most of the other students at his school, he takes a bus every day. Dan is successful at school and has managed so far to achieve an average in the 80 s. Dan wants to get a job "in technology" as he put it. He will probably go to the local community college for some preliminary training in mechanics or as an electronics technologist--he's not sure yet. Dan is one of a number of "techie" regulars who "hang out" in the shop area of the school. His locker is across from the Design and Technology classroom and down the hall from the welding shop where most of the electric car fabrication is taking place. In his first year of high school, Dan took a number of compulsory tech credits through the transition years program. The transition years program at his school involves an introduction to Design and Technology knowledge and skills in a number of areas. Dan took the compulsory credits in this program as well as an extra tech course in the second semester. He now has all of his compulsory tech credits for graduation.

I use this conversation with Dan because he is present for all of the car making and is a willing participant. Dan is very forthcoming and liked to ask and answer questions. He is quite at ease with the extra responsibilities he has as driver and design spokesperson at the competition. His teacher, Mr. Lassitter depends on him in the way that many teachers come to depend on certain students for getting things done and taking care of day to day classroom details.

I begin this interview by asking Dan to tell me about this Design and Technology course and how it fit with the other courses he had been taking since arriving in secondary school last year. Dan makes a distinction between the tech courses and the non-tech courses he is familiar with. Dan tells me about taking the compulsory tech course that all Grade nine students are required to take. He says that he ended up in this particular course because *he liked the look of it*. He briefly compares this tech course with French and math which he says he likes to do, but that they and other mainstream courses are very different and repetitive. He tells me they are *like flipping on light switches all the time. You just keep turning it on and off. Same thing over and over and over again*. Dan is clearly interested in school activity in which he--in his words--*is going somewhere*. He then elaborates on what he means by *going somewhere* and doing the kinds of things in which he got to *take things apart and see how things work*. This course provides him with an opportunity to expand on his interest in planning for a *job in technology* as he puts it.

The following excerpts from our long conversation come after we have a chat about some of the activities I observe him doing. We talk about the kinds of things helpful for him in working out the problems and projects he works on. He identifies his teacher, Mr. Lassitter as an important part of that process. Here he tells me what he appreciates about Mr. Lassitter, saying Lassitter encouraged him to think differently. We join the conversation as he tells me about the teaching he has experienced in this class.

Ordinary patterns, taking risks, not knowing until you find out

> *He explains the way stuff wasn't working, for one thing, and what would work better. But he like left the nature, like left us to do most of the thinking. Like we could learn ourselves.*

Give me an example of that.

> *Um (pause), he'd let us decide how to put the steering system on, like why it wasn't working. He let us like, he let us alter the frame and like trust our judgement and stuff. Like it's like he acts like it's our project and not his, like he lets us do work on it. Like he doesn't take it over sort of thing.*

Hmm. So it belongs to you.

Yeah, basically. It belongs to us and he's helping.

Hmm. So he's sort of along for the ride but he's not running the show.

Yeah. I would say that. He offers like great insights in what he says is not working.

Can you think of some stuff?

I was thinking like of a couple of chain drives, he said that might not work because we'd lose a lot of power or the chains could snap or stretch or something, and they could like jump off. It would use too much energy and be too complex and like the gears could break and stuff like that.

Hmm.

So like sort of insights on how that works.

So sort of less is better.

Yeah. Keep it simple. Like you don't want something too complex or it won't, no one can figure out how it works.

Um hmm. And probably it won't work.

Yeah. I could think of a very complex circuit, it might not doing anything. It might do something but you don't know.

Yeah.

You don't learn so you try something.

Hmm. So you're saying that one of the things that was really helpful was how the so-called teacher acted in like the whole thing. He was sort of like, what was the word you used?

Ah, like sort of like an instructor but not like a teacher who tells you what to do. Like points you in the right directions and let's you go.

Ha. Okay.

Yeah. That's what he does.

So he might not be pulling you along, he might be pushing you.

Yeah. Pushes you to like discover new horizons and stuff.

Yeah, yeah.

Discover new stuff and try new ideas and tells you not to think of the ordinary pattern. Like, ah, my com-tech teacher last semester like boxed the Xs, one for each corner, one in the centre and one between each corner. We had to cross out, go through every X with four lines, and you could only cross over the lines once or something like that. You have to go across the three bottoms, out past the box, not through the middle one and the end one, down to the bottom one where we started and up through the middle one again. But he's like, he's trying to prove a point *that you have to like, people see what they see, but you're supposed to see beyond what you see. He tries to teach you to think differently than people have been telling you to think for like the last centuries or whatever.*

Right. So we have to do some, sort of, we have these ideas of the world, how the world works, and we have certain ideas of what rules are.

Yeah, like ah, like ah, like you're supposed to think of the unknown. Like Columbus thought, like we thought the world was flat, but like he had an idea that it wasn't. He was willing to take risks. So he went sailing across and he found something great. You have to take risks to discover something, like to make something great.

So in other words, push the edge, in this case, the fact that you could go outside the four or five sort of Xs, and leave that sort of confined area.

Yeah, leave your thoughts of ordinary people. Think your own way. Like don't think, like don't fit into the stereotype of people, like, that do nothing. Go make a new stereotype or something.

So tell me how this, um, how this project then, wasn't this project here, when they say you have to make a car to go, you know, really light, it has to be powered by a battery and it has to be all these things.

I think you're right.

Is that the same thing?

Yeah. I figure like he sort of chuckled to himself, like oh wow, we get to make a car.

Yeah.

And everybody saying, oh it looks great, it's like that's going to do really good, it's going to like kick butt. It's not how it looks, it's how it works.

Hmm. So I'm wondering about your idea around how you, what do call that where you have those Xs and you go beyond the Xs? Like the exercise.

Like where you could find sort of like people, ordinary think. Be willing to take risks and stuff. Like, just because someone says it doesn't work you might want to try it, even if it's never been done before.

Yeah.

Like people thought you couldn't fly to the moon. They thought it was made out of Swiss cheese or something.

(Chuckle)

You don't know until you try. Colonizing Mars. They don't know if that's possible. I think it is, but they don't know. They don't know until they try. Like, I like to watch these. The X-Files, like, questions the idea like extra terrestrials and stuff like that. There's no proof that they don't exist, there's no proof that they do. But some people believe. You believe what you want to believe. Like you don't know until you find out.

So how was the design of this car, the way you designed the car be a kind of um, way of forcing you to do things the way differently than they've always been done?

Ah, not really, because how many cars do you see built out of bike parts? Like, not many cars have like, have like a battery for power. They use gas or something.

Ah, okay.

Like fuel, so we need something else to power our cars or other modes of transportation or something.

Hmm. So it's not sort of ordinary then?

No, it's definitely not ordinary. I don't think you see many cars powered by batteries and going on three wheels.

With a recycling box in the back, right? (Chuckle)

Yeah.

That fits through doorways.

Yeah, not many cars can fit through doorways. The guy who invents a car that fits in a briefcase.

Oh yeah.

That was cool. I thought that was cool. But like carrying your car. If your car breaks down just open your briefcase and go for a ride

(Laughter)

To the nearest gas station.

(Dan Interview 2, p. 7)

I wanted Dan to expand a bit on what was happening with him as he worked through problems like the front end. I was aware of the pace of how things got done, but wanted to hear more of what he had to say. I felt that there was more to what I had observed than just breaking out of *ordinary patterns.* In this conversation, excerpt we chat about these problem solving and idea-getting processes in more detail. I asked him to tell me about some of the activity--like the front end construction--and he began by telling me that in his drafting class you couldn't cheat like he'd done in one of his regular courses last year.

You can't really. You can't cheat. Like you're drafting, right, they weren't, like exactly the same. Like if you like copying words, change them around a bit, change the words, but you can't like change drafting, or pictures or something. Like they just look different.

Or it doesn't matter in that scene?

Well if you're trying to cheat, like something like drafting, you couldn't cheat really. Like for written assignments in another course, you could *borrow some guys like assignment, like copy it, like change the words around and reword them and stuff, but you can't do that with a drawing.*

But isn't that what you're doing all the time in drafting? Aren't you taking other peoples' ideas and just sort of acting on them and running with them?

Yeah, like we add on, edit.

That's what I was getting at. Like it seems impossible to cheat because it's all sort of...

Oh yeah.

Everything's turned on it's head.

Everybody's work is everybody else's work basically.

Why do you say that? I mean, I suggested it but I'm wondering why you would agree with me on that?

Because like...yeah, you have to sit with everybody else, an idea to yourself isn't worth anything...like, if I had an idea to build a plane, I cannot build a plane for myself. Like I need other people to help me. And like they might see a problem that I don't, different viewpoints, different aspects, and stuff, like it just gives you a whole bunch of different ideas, different backgrounds, different ideas.

So where do you think those ideas that you have come from?

Real life.

Ah, so they don't come from yourself.

Real life and imagination and stuff like that. TV shows, like people's ideas like what they could build if they had this, if they had that. Like well what if you do have that, then you could do this. If you've got enough, like ideas it's like, if you've got enough knowledge on how stuff works then you could do what you want to do.

Yeah, right.

But if you don't, then you end up in a dead end. And you can't do anything if you don't know what to do.

Yeah, yeah, yeah. Hmm. So, it sort of means that you sort of um, when you do that kind of stuff you're not really by yourself, are you? It's like, even if you're...

Yeah, it's like a group effort. Everybody.

You're describing a different kind of group effort, aren't you? Yours is different.

Yeah, um, group effort. Oh everybody has input, the whole class. But a group effort, like you're all heading to one goal, but basically the same thing. This class, like everybody, like we come from different backgrounds so you try a different way, but they're all kind of in the same area. Like some guy might take a longer way from the direct course, but you all end up at the same point. And like the guys taking the direct course could get insights from guys taking long way or something.

Yeah.

Different directions give you different viewpoints and aspects, different ideas.

Okay. So that's sort like living in a bunch of people that sort of work together.

Yeah, it's like, I guess you could sort of discover the community or something like that.

Yeah. Yeah. The community.

Yeah. Like you might have to, like, knock down some guy's fence sometime to like plant a tree...like you just keep on improving stuff.

What do you mean you might have to knock down a fence sometime, but what kind of tree?

Oh, you get rid of some of that guy's idea, give him a new idea.

Oh, I see. I see.

Like my idea for something...like, they trashed that idea and came up with a completely new idea.

Yeah.

It happens. The job doesn't work, you just get a new idea.

And that new idea comes out of the sittings.

Yeah, talk. Like people think, well this could work, this could work and that could work.

Yeah.

Like, some people say, no that won't work, and keep adding on to it.

(Chuckle). So that becomes more than just you.

Yeah, it's like the whole class group, area, activity, whatever you want to call it. Everybody has input. Some guys might not be right, others might be more right, whatever. But that happens. You can't think about it.

Yeah, yeah. That's kind of neat. So when you think about the whole project, I mean to finish up, we think about the whole project. I mean, what do you take away from it? What do you get from it?

Well, you learn how to work with others. You learn decisive skills, you learn how to problem solve, you learn how to like others. There's a whole bunch of stuff you learn. How stuff applies in real life, like math. Like you're not going to go out and try to learn a whole bunch of math 'cause you don't think it will do anything. Ah, you just, if you learn something like first hand, you're more willing to learn it than if you like learn it from a text book. Oh wow, some guy flew to the moon. That sounds exciting. Like if you flew to the moon yourself it would be a lot more exciting than learning it from a textbook. If I built the rocket ship it'd be a lot more exciting than, *oh wow, here's the plans for a rocket ship. Like, it's still more exciting to do stuff first hand.*

Hmm. Do it yourself.

Yeah. Like, others telling you stuff like helps, and it might point you in the right direction, like if you're building something, but...Like I think it would be a fun, like I know it would be a lot more fun to build a car than it would be to hear like just, oh wow, you built a car, that sounds fine. Like when you hear about something you don't realize the challenges, the problems involved with it. You just think, oh wow, he did that? It took you five years to do that? Why does it take you so long? Like, I've built a rocket ship before, and it didn't take me five years. Why did it take you so long? Some people don't realize the problems with stuff like that.

But now you do? (Laughter)

And I do.

(Dan Interview 2, p. 19)

The Front End Session

Before turning to an analysis of the foregoing conversation excerpts, I provide a description that augments some of Dan's explanations of how things are done with his classmates. The front end of the car presents a challenging hurdle in the weeks leading up to the competition. Without attaching it, the car does not really look like a car. It has a boxy, triangular appearance without any of the identifying features of a car. After the decision is made to use a bicycle front end, the students try to put it together. The following account is from my fieldbook.

> Dan, Boz and Ross are in the welding shop trying to figure out how to make a front end work on the frame that sits up on the four stands. The group has already agreed that they will take a front end directly from one of the bikes in the pile outside the doors of the shop in the fenced-in materials area. There isn't any agreement, however, on how it will work. Mr. Lassitter is off somewhere and the four of us are left to work out some arrangement. Boz is impatient and wants to get moving on the welding. He has the "stinger" for the welder in one hand and is turning a set of welding goggles over and over in his other hand, clicking the eyepieces together in a repetitive and irritating manner. Eventually, Ross darts him a look and he stops it, choosing instead to sling them over the stinger, dangling them precariously close to the end of the tool so that there is some danger of them falling and smashing on the concrete floor of the shop. After snickering and fooling around for about ten minutes, Dan and Ross tell Boz to cut off the forks of a small bike from the pile. They debate where he should cut it and then Boz grabs the cutting torch and cuts both tubes quickly about ten inches from the headset where the handlebars are secured to the frame. While it cools down, the four of us begin a discussion about how it should be connected. Dan holds the front end up to the frame and asks the others what they think. Boz shrugs his shoulders and says something to the effect that it will do, and I ask him if there's enough leg room under the handlebars for the driver to sit down. Since Dan is the driver, they

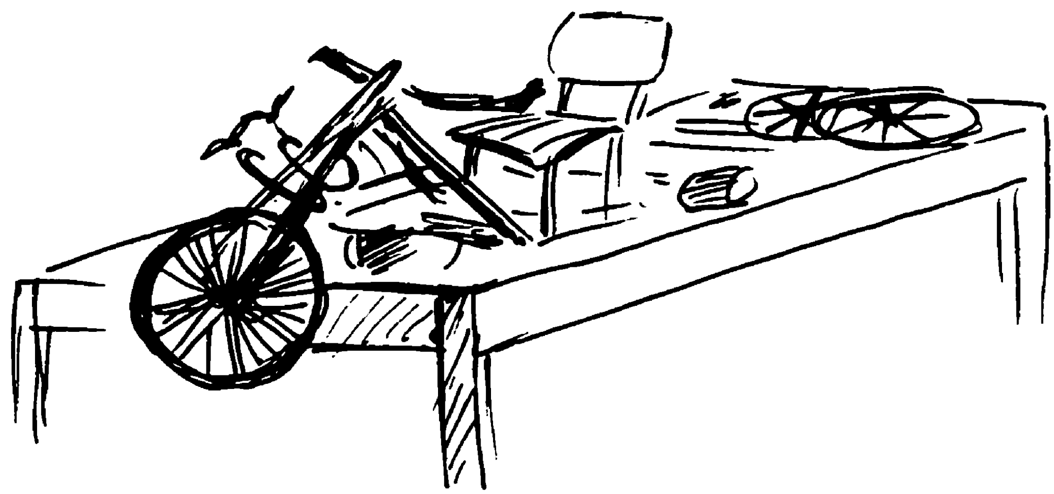
begin to take the frame down off of the stands so he can see if his knees fit under the handlebars connected to the front end.

Unfortunately, they haven't decided on a seat yet, so a discussion ensues about how high the seat should be. They end up sitting on the long metal workbench, and after ten minutes or so, we are interrupted by Dan's friend who comes to the door of the shop and beckons him to come out. Dan tells us he'll be back in a few minutes and leaves. The two of them sit there for a few minutes not doing much. Lassitter arrives with the welding teacher and they ask him what to do. Lassitter suggests that they look in the dumpster outside for something as he disappears into the woodshop next door.

After arguing for a few minutes about who is going to go into the dumpster, I volunteer and climb in and root around looking at all the metal scrap being thrown out. I comment that there's lots of neat stuff and Boz sticks his head over the edge and ends up jumping in with me. We find a couple of broken desks with seats attached. Finally, Ross jumps in too, and we manage to extricate a desk from the tangled mess in the bin. In the meantime Dan returns--without his friend--and waits as we dump stuff out onto the ashphalt enclosure outside the shop.

Boz immediately cuts the backrest and seat portion off the top-less frame and we have a seat complete with legs for the car. It takes another ten minutes for them to agree on where to cut the legs down so they will fit in the rather limited room available on the frame. In the end, they agree that the seat will fit over the motor and drive train which means the seat assembly will have to be removeable. Both

Boz and Ross realize the late bus will leave in a few minutes and they hastily take off leaving Dan and I to figure out what to do. Dan decides it's time for him to go as well so the upshot is that the front end doesn't get done.



Next day, Wednesday...We're back at it after school this time with Mr. Lassitter, Boz and Dan. They spend about half an hour holding up the bike front end to the frame, even clamping it at one point with a couple of vice-grips. Finally, they agree on an angle and Boz cuts the tubes off at the headset tube so that the frame members of the car butt up to it. With Dan and I holding the front end in position with clamps, Boz tacks the tube on with a couple of spot welds, burning through in one spot. He grunts in frustration and says that "It'll be okay". Lassitter by this time is out of the shop again, and we are left to play with the angle of the front end some more. Turns out, it's lined up pretty well and both Dan and Boz agree that it will do. They spend the remaining half hour sitting up on one of the benches looking at the frame and front end--among other things--commenting that it's beginning to look like something (Field book 3 , p. 27).

Everyday Relations of Dan

The front end construction relies on trial and error action in the midst of other activity: the arrival, disappearance, and reappearance of Dan in the middle of the work, sitting around, waiting for Lassitter, 'horsing' about. There is also serious talk about what was next: measuring, estimating, speculating about angles. All of this goes on as the front end gets cut, attached, and modified. Each action or "inaction" creates new circumstances and situations that need some attention and subsequent decision making. Problems are "stacked up" or "backlogged": establishing an appropriate angle for the front end means putting it on hold until the seat height can be figured out. But the seat height has to make allowances for the drive train which has not been done yet. Imagining and speculating what the drive train configuration will be like occurs. Each tentative solution comes to fruition after many different kinds of activity. Sometimes things ""just happen". Digging around in the dumpster is fun. Picking over the miscellaneous furniture and equipment throwaways of the school spring cleanup produces a seating arrangement that cuts corners and saves time. What appears trivial and a waste of time to the casual observer, in practice is not. A considerable amount of time is spent sitting around in contemplative silence. I can tell it is contemplative because the silences are often interrupted by someone else arriving or the school bell ringing, instances which felt almost intrusive. These moments are often followed by some obviously productive activity like searching the dumpster for parts or deciding to cut something in a certain place. Finding the seat, speculating, and then deciding on its positioning relative to the drive train and front end--neither of which were there--strikes me now as complicated as the work practice one might find on any shop floor or construction site.

Dan goes about the affairs of the shop and classroom as a committed and involved student who takes responsibility for his part in the putting together of a prototype electric car. We see this in the account of the Front End session where he and his classmates puzzle through the work that needs to get done. One gets a sense that this is an almost idyllic world of school, playing and working with ideas and tools in making an energy-efficient car powered by a battery. There does not seem to be any great pressure by Mr. Lassitter on the students. Dan works moderately hard, providing suggestions and support for the ideas, and work that needs to get done. Things do not happen very quickly. They are, after all, in their second year of secondary school and are just becoming familiar with many of the sophisticated tools and ways of doing things available to them.

Dan is convinced that the car is an innovative piece of work. They begin with a pile of junky bike parts gathered off the street from garbage put out for pick up. He is quite pleased with this and rejects my suggestion that the work may not have broken any new ground. He resists my efforts to criticize the car. Later, I realize that Dan was not particularly interested if the car "breaks new ground" or how it looks. He wants to win the race and looks do not matter. The only thing that does is how far it can go. The others feel the same way. Boz, for example, wants to *kick butt*, as he put it. Dan and the others are not interested in spending much time in putting together a design brief, or documenting the design processes building the car. Their main concern is to get it done and win the race.

In the previous chapter, I use the talk and action of Ross as objects of analysis in exploring how co-participation, technologies of doing and the requirements of working practice are productive of the way things are done in Electric car. I use these resources for introducing some basic epistemological assumptions informing this inquiry: The way things are done suggest that knowing is constituted in the everyday world by people acting together in relation to technologies, and the requirements of practice. I introduce some theory from cultural psychology (Bruner, 1996) for underpinning my use of these resources as culturally mediated, historically developing and occurring through practical activity (Cole, 1989). Whereas in the Ross conversation I pay attention to practical activity and what Ross has to say about it, in this conversation I pay more attention to what Dan has to say about what he is doing, particularly some comments *about practice* contrasted with some of his talk *in practice*. The analysis here focuses on the historically developing nature of Dan's social engagement in the context of his sense making in conversation with me. I conclude the Ross conversation by suggesting that the relations constituting them can be understood as providing a social and culturally organized context for access in practice, an issue discussed further in Chapter VI. Here I continue using the situated learning research of Lave (1988, 1997), Lave and Wenger (1991), Brown and Duguid (1996), activity theorists Keller and Keller (1993), and Engeström (1987,1993) for developing further, a social and cultural practice perspective on learning called 'distributed practice'. The development of this perspective conveys something of how these students act through each other and the material world they inhabit.

The Dan conversation and commentary takes up the discussion about the historical nature of coming to know something by examining further, the interplay of the resources contributing to distributed practice . In what follows, I take a look at what Dan has to say at the beginning and at the end of the foregoing conversation and situate his talk within Tech Ed. I then move to a discussion of what Dan has to say elsewhere in our conversation about how he acts through others and the material world of his classroom. I close by discussing how working knowledge and other resources in practice become a "design" for getting done what gets done.

The way things are done

Stock phrases

Reading the transcripts of my conversation with Dan, I find his comments somewhat confusing. I want a coherent picture and understanding from him about the way things are done and what they mean for him. I am puzzled, though, by what I take as a mixture of conflicting statements. Dan's sense making at the beginning and end of our conversation contrasts with what he says in the middle of it.

At the beginning of our conversation, Dan's comments about Lassitter come as a surprise to me, perhaps because I underestimate Lassitter's influence. The picture Dan describes of his teacher is quite flattering. He reflects on the nature of the teaching he experiences in the class. He says Lassitter *acts like it's our project and not his*. According to Dan, this happens as Lassitter exerts an influence that helps him figure out how things are or are not working. He describes Lassitter as a teacher who doesn't tell you what to do but one who *points you in the right directions and let's you go*. Moreover--as Dan continues--Mr. Lassiter *pushes you to discover new horizons and stuff.* Dan elaborates by describing a tech class where the teacher uses a pen and paper conundrum in an exercise about breaking out of patterned ways of thinking. The exercise helps Dan understand possibilities, *to see beyond what you see*. He appreciates Mr. Lassitter, because he feels encouraged to think and see things differently. Dan suggests that what is required is a way of looking at the world that is outside of the *ordinary patterns* of thinking about things. Dan introduces the notion of risk, saying that in order to find something great you have to be like Columbus who *was willing to take risks*. Dan makes another comparison with the idea of colonizing Mars, that it's important to check things out; *you don't know until you find out*. Right at the end of our conversation I ask him what he takes from being in the class and he replies,

> *You learn how to work with others. You learn decisive skills, you learn how to problem solve, you learn how to like others. There's a whole bunch of stuff you learn. How stuff applies in real life, like math. Like you're not going to go out and try to learn a whole bunch of math 'cause you don't think it will do anything. Ah, you just, if you learn something like first hand, you're more willing to learn it than if you like learn it from a text book. Oh wow, some guy flew to the moon. That sounds exciting. Like if you flew to the moon yourself it would be a lot more exciting than learning it from a textbook. If I built the rocket ship it'd be a lot more exciting than, oh wow, here's the plans for a rocket ship. Like, it's still more exciting to do stuff first hand .*
>
> (Dan Interview 2, p. 19).

Dan's talk at the beginning and end of our conversation appears similar to that of proponents in Tech Ed who call for better training of students in meeting workplace needs. The basic thinking concerns learning by doing as a way of providing relevant work experiences. Students who complete programs will have developed the capacities necessary for them to make a transition from school to work.[16] Initially, I associate his talk strictly with these vocationalizing influences. I think, ""here is a kid mimicking phrases like *problem solving* and *how stuff applies in real life*". But later, I am puzzled by the presence of other talk and explanations that strike me as very different from mimicry. His respect for Lassitter seems serious enough, and I think that I may have been confusing his talk with what I understand as rhetoric. It is obvious too, that other students I have been talking to also appreciate Lassitter in a similar fashion. Dan's talk is still there, however, and I am left wanting an explanation more robust than just attributing it to his strong connection with Lassitter and leaving it at that.

Dan's talk contrasts so vividly with what I have been witnessing on the shop floor, in addition to his explanations of what was happening in the middle of our

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These "stock phrases" are connected to recurring debates between liberalizing notions of Tech Ed on the one hand and as preparation for work on the other. These have been the subject of debate in other countries (Layton 1995) but less so in Canada. Despite this, there has been a number of shifts in Tech Ed policy and curriculum in most provinces. For survey of these changes see Kozolanka & Medway (1996). Kincheloe (1995) provides a critique of theories undergirding vocational education in the United States which have some relevance for Tech Ed in Canada and Ontario. The relevance of debates elsewhere and the language used in policy and curricular documents in this country are similar to Dan's talk conversation. There, he describes what it is like to work with others in a series of short statements like this one,

> *Because like...yeah, you have to sit with everybody else, an idea to yourself isn't worth anything...like, if I had an idea to build a plane, I cannot build a plane for myself. Like I need other people to help me. And like they might see a problem that I don't, different viewpoints, different aspects, and stuff, like it just gives you a whole bunch of different ideas, different backgrounds, different ideas.*
>
> (Dan Interview 2, p. 15)

We might see the contrast between this statement and others earlier and later in our conversation. I begin seeing them differently as I puzzle out contrasting statements and explanations in what he says in this conversation. For some assistance in understanding his contrasting statements, I turn to the literature associated with 'learning by doing' in Tech Ed. Dan's initial and final talk, as well as the discussion in the middle of our conversation resonates with current conceptual thinking within Tech Ed that situates coming to know as a socially influenced, active and individual phenomenon. My assumptions about the characteristics underpinning constructivist views in Tech Ed derive from recent work (Gradwell 1996, 1999; Hansen & Froelich 1994; Wilson 1997) in the field, construing knowledge as actively created in social contexts in the minds of individuals. This is the general thread of constructivism, a way of saying that human knowledge, the criteria and methods used in inquiry, including disciplines and cognitive structures of individuals, are constructed. A lack of consensus as to common characteristics of constructivism is reflected by a range of perspectives in the literature[17].

Dan's talk has something to do with solving problems and knowledge discovery on the one hand and other descriptions of how it happens on the other. He describes his dependency on *group effort* and how *an idea to yourself isn't worth anything* and the give and push of talking and working things out: *knock down some guys fence sometime to plant a tree.* He shows some awareness of my own understanding of how things get done as shared rather than occurring exclusively inside one's head and discovered "out there" in the world independent of relations between people and various contributing resources. But Dan also talks about *thinking of the unknown*, or to *take risks to discover something* as well as *problem solving*. This talk is more like the familiar phrases associated with design studies in Tech Ed. I find Dan's use of them in an almost offhand manner in our conversation to be interesting in the context of his other descriptions of how things are done. Although subtle, these phrases permeate his explanations to me in our interviews as well as the descriptions used by him and Ross in their Design Report, the assignment required by Lassitter at the end of the term. Although Dan's talk and explanations may be traced to conceptions

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17 There are many aspects to constructivism, a major contributing perspective in Tech Ed. Philips (1995) developed a framework helpful in comparing them and I conceptualize Tech Ed in view of Philip's analysis.

of constructivism common in Ontario Tech Ed, that literature does not provide an explanation for his contrasting talk and sense making. Additionally, reducing Dan's talk to conflicting versions of constructivist theory does not make sense given my interests here in exploring more than appearances in learning by doing. Accordingly, I turn to activity theorists and situated learning researchers who explore similar issues in work communities.

Keller and Keller (1993) assisted me earlier in understanding the requirements of working practice as an interplay of learning resources. Engeström's work derives from a similar tradition, the soviet socio-historical school (Leont'ev 1978; Wertsch 1991, 1985) and uses similar theoretical resources that underpin cultural pscychology and situated learning (Brown, Collins and Duguid 1989; Lave & Wenger 1991). Where cultural psychology is concerned more directly with issues of how mind is constituted by culture (Bruner 1990, 1996), activity theorists are concerned with examining the integration and continuous construction occurring between various components of activity systems. Where cultural psychology is concerned generally with units of study related to psychological processes as historically developing, culturally mediated and occurring through practical activity (Cole 1989), activity theorists pay more attention to historically developed actions as part of a broader systems of relations. Activity theorists draw our attention to contradictions which are identified as features of change in activity systems. We've already seen the value of using activity theory in the analysis of Ross's sense making in the front-end and drive train activity. There I use research by Keller and Keller for illuminating something of the interplay between individual action and craft standards. Here I continue using activity theory and situated learning in an analysis of what Dan has to say about some of the contradictions emerging from his sense making about getting things done.

Engeström (1993) has something to say about the presence of contradictions in communities of practice. Engeström identifies disruptions as inner contradictions mirroring contradictions characteristic of broader socio-economic formations. He describes these as tensions between exchange and use values. In similar fashion, Lave and Wenger acknowledge the notion of commoditization as "a major contradiction underlying the historical development of learning" suggesting it appears "typically in situations such as schooling where pedagogically structured content organizes learning activities" (p. 112). We see some threads of this in the account of the Design Report which calls for a display of learning rather than a knowing in practice, which I refer to later in this analysis as knowledgeability.

Lave and Wenger believe that a second contradiction is fundamental to the historical development of learning in practice. In their apprenticeship research, they find that a major contradiction exists between continuity and displacement in communities of practice. It goes something like this: We have some sense that peripherality is a way in which newcomers achieve access to an increasing participation within a community of practitioners. We see this in the Ross analysis. But Lave and Wenger (1991) tell us that an increasing and fuller participation also engenders a displacement of the practice as players move from peripheral to fuller participation. Peripherality provides access to eventual and longer-term continuity in the community at the same time as displacing those processes. Their conceptualization echoes the tension present in Dan's talk and use of these phrases in his sense making. As a peripheral player, his use of 'stock phrases' not only exhibits existing classroom talk and experience, it occasions and generates an emergent understanding in practice. Lave and Wenger comment,

> The different ways in which old-timers and newcomers establish and maintain identities conflict and generate competing viewpoints on the practice and its development. Newcomers are caught in a dilemma. On the one hand, they need to engage in the existing practice and its development over time: to understand it, to participate in it, and to become full members of the community in which it exists. On the other hand, they have a stake in its development as they begin to establish their own identity in its future (p. 115).

We have all experienced peripherality participating in one community of practice or another. The awkwardness is felt as one comes to know and use new language and ways of dressing, or specialized tools. These are all important in gaining access to a community of practice. But peripherality also carries with it a certain visibility of the practice that core members may be blind to. This initial visibility permits newcomers to offer a different view of the practice before achieving a more robust membership in it. At the same time as seeking a fuller membership, we engage in displacing the practices we seek to learn. Recent criticisms of hazing rituals in the military and of engineering school initiations provide everyday examples of how many newcomers refuse to engage in debilitating rituals.

My initial thoughts about Dan's use of 'stock phrases' as rhetoric, now becomes more than that as we explore his use of them in practice. Dan uses stock phrases for developing an expanded understanding of the way things are done. Examples from research in worksites help expose his use of them as a way in which institutionalized talk is mediated through experience, not exclusively the other way around. It turns out the opposite of Boz' experience with school math. There I use Franklin's social critique for seeing how technologies of doing can work their way into the everyday ways of doing and understanding. In this conversation and analysis, we have an instance of Dan exhibiting "stock phrases", and then situating them in new historical moments, generating an emergent understanding in practice.

In this conversation so far, we have taken a look at Dan's talk and use of 'stock phrases'. We did this with a view to gaining some sense of their use as more than mimicry on his part, or an ambiguous use and application of constructivist learning theory on mine. Informed by cultural psychology (Bruner 1990), activity theory (Engeström 1987), and situated learning (Lave and Wenger 1991) we see that disturbances like Dan's conflicting use of "stock phrases" provides a way for exposing something of the processes of how people and communities both exhibit their practices at the same time as generating new forms of them. Bruner (1990), for example, refers to the negotiated meanings that arise as people use narrative for exhibiting the canonical as they generate exceptionality in their lives (p. 47). Lave and Wenger theorize a similar interplay in their continuity - displacement contradiction. Table 6 illustrates the presence of this dynamic in this classroom.

Table 6: Exhibiting and generating practices

exhibit	peripherality & legitimacy			generate
	emergent	extra-local	individual	
↕				↕
	engrained	local	community	
generate	peripherality & legitimacy			exhibit

Lave and Wenger suggest that the continuity - displacement contradiction is "fundamental to the social relations of production and to the social reproduction of labour" (p. 114). It is an interrelated dynamic that continues emerging in this analysis. It begins with the introduction of engrained and emergent activity identified in the Ross analysis continuing through here in the context of Dan's use of "stock phrases". We continue next with Dan's talk and sense making regarding co-participation. As we do so, we move towards a social and cultural viewpoint on learning I call "practical negotiation" by taking a look at the emerging idea of a distributed practice.

Distributed practice

Towards the middle of our conversation, Dan tells me about some of the car making activity and what was happening there. There are two parts to this talk that interest me. The first is his explanation of how collaborative work unfolds for him. The second is hidden in the middle of that explanation and is a comment about relations between knowing and doing. First, there is Dan's explanation of the collaborative work in both the Design and Technology class as well as the after school work and how different they are from regular school. He says that it is impossible to cheat like he could in other subjects. He supplies one reason for this saying *everybody's work is everybody elses*. He elaborates, telling me how *an idea to yourself isn't worth anything* and he uses the example of building a plane by himself which he could not do. He says that other people in the class see things differently: *different viewpoints, different aspects, and stuff , like it just gives you a whole bunch of different ideas, different backgrounds*. At first I take these comments as more stock phrases about how working together is important. This in itself is not surprising, as one might expect a student to mimic the ethic prevalent within education generally and for design and technology education in particular. There is a degree of pressure--for example--on students in Tech Ed to develop personal qualities such as the ability to get along, to be punctual, to be able to work with others. This is another manner of commoditization of learning but one in which the identity of learners becomes an explicit object of change. Critical pedagogues like Simon (1992), and Simon, Dippo, and Schenke (1991) address this in an Ontario context of a particular type of work-study education. Lave and Wenger refer to this commoditization as a distortion of the self as object (p. 112). The general point is that schools exist as places which fashion the capacities of students so that they fit existing conditions of workplaces.

As I discuss earlier however, I think Dan's talk is about more than mimicking expected behaviour; or of "knuckling under" to a somewhat tacitly understood ethic preparing students for "job readyness". Here in the middle of our recorded conversation he elaborates on what he means by *group effort*.

> *Yeah, um, group effort. Oh everybody has input, the whole class. But a group effort, like you're all heading to one goal, but basically the same thing. This class, like everybody, like we come from different backgrounds so you try a different way, but they're all kind of in the same area. Like some guy might take a longer way from the direct course, but you all end coming up together and*

> *up at the same point. And like the guys taking the direct course could get insights from guys taking the long way or something* (Dan Interview 2, p. 17).

There is something significant to this analysis in Dan's idea of *group effort* and his sense of how the *group* structures the experience of its members. Cultural psychologists refer to activity that is historically developing, and culturally mediated as distributed cognition (Cole, 1990; Newman, Griffin & Cole, 1989; Salmon, 1993). Conceptions of distributed cognition vary, but the general thread has thinking influenced outside one's head through others, technologies, and cultural circumstances. A simple way that our thinking processes are distributed in the world outside of us was articulated by anthropologist Gregory Bateson in a popular story cited by Cole and Engeström (1993),

> Suppose I am a blind man, and I use a stick. I go tap, tap, tap. Where do I start? Is my mental system bounded at the hand of the stick? Is it bounded by my skin? Does it start halfway up the stick? Does it start at the tip of the stick? (p. 13).

On Bateson's view, the line between mind and body is indeterminate. We know from the actions of students like Ross and Dan that the tools of practice, be they physical ones like welders or conceptual ones like 'acceptable' weld joints, act as mediating instruments and signposts for practice. Keller and Keller help us understand similar relationships and how the requirements of work provide learning resources. Likewise, Bruner (1996) also tells us that the instruments and aids we use define our work in advance of completing it,

> The oar and the oarlock invent the rower; the catenary sail creates the up-wind sailor, the spirit level begets the horizontal measurer. At a more superordinate level, the assembly line gives birth to affordable automobiles (p. 152).

Bateson's questions, and Bruner elsewhere (p. 151), suggest the mind is an extension of the hands and tools and purposes to which they are used. They draw our attention to the popular notion of knowing as doing, a continuing theme here and later towards the end of this chapter, as I begin a discussion about knowledgeability as activity situated in the social and cultural organization of the world.

First, however, I shift thinking here from cognition distributed between people to the notion of practice not only distributed between actors, but between material resources in the form of technologies in various forms. To do so, I begin with the notion of context as a way of thinking about contributing resources constituting these classrooms. Lave (1988, 1993) and Engeström (1987, 1993) provide views of context as an "arena" or "system" of relations between people acting and the settings they are a part of. Both contend that context has been thought of in limiting ways that either delimit the contributions of social, societal and cultural aspects or,` the contributions of individual players. Both suggest that contexts are typically viewed as "containers" of behaviour, where social situations, interactions and the like are treated as entities separate from broader material and socio-economic practices. In Engeström's interpretation of Leont'ev, he would have us to view activity as systems or,

> arenas of our everyday life usually not *directly and visibly* molded by our actions. But they are constructed by humans, not by superhuman agents. If we take a closer and prolonged look at any institution, we get a picture of a continuously constructed collective *activity system* that is not reducible to series or sums of individual discrete actions, although the human agency is necessarily realized in the form of actions (p. 66).

Engeström's interpretation is relevant for the purposes of this analysis, because he draws attention to ways of thinking about the integration of "human agency" and broader "arenas" without reducing either to the other. He offers a critique of Lave's (1988) conception of "arena" in her math supermarket research. Engeström (1993) points out that Lave's analysis focuses more narrowly on the individual with the "arena" left "unanalyzed" as something separate from the actions of people (p. 99). My interest in exploring more than individual and cognitive aspects of understanding in practice attempts to avoid a similar problematic.

Engeström also provides a way of theorizing how the everyday features of institutions and individual actions reveal each through the other. The basic idea is that not only do people use technologies and exhibit their understanding of them, they are continuously renewing and generating new understandings, a common interpenetrating dynamic evident in much of the student talk and action presented here. Dan's use of "stock phrases" can be seen in this light. We might also see how Dan's explanation of *group effort* provides something of a social resource for thinking about context. If we think back to the Front End and Drive Train activities we see that in addition to co-participation, there are the requirements of work. Engeström reminds us of these and other resource; otherwise the "arena" is thought of as a separate entity or container for social interactions.

There are many ways people distribute their thinking separate from themselves. Leaving a hockey bag by the door so it won't be forgotten, or the widespread use of "sticky notes" serve as physical reminders of our thinking separate from ourselves "out there" in the world. But, not only are the use of sticky notes ways in which we "think" outside ourselves, at some point their use can become social practices common to a community of practitioners. This is common in how communities define and represent who they are to themselves and to others in many ways. Farmers and others wear baseball caps adorned with brand names, paddlers wear "Tilley" hats, and some of the students in Electric car wear "attitude"[18] shirts. They all carry their own messages, means of identification, and ways for connecting and dis-connnecting with others. My interest in conceptualizing this classroom context as distributed practice arises through my descriptions, and the sense making of Ross and Dan informed by a growing literature that theorizes similar circumstances as systems (Engeström, 1987), arenas (Lave, 1988), structuring activity (Brown, Collins, & Duguid 1989), situated activity (Lave & Wenger (1991), and communities of practice (Lave, 1988; Lave & Wenger, 1991; Wenger, 1998).

My shift in conceptualizing distributed practice as an integration of contributing resources is a conscious move away from distributed cognition as "intellectually shared resources" (Salomon 1989, p. xviii) between people. Although I am interested in the relations between people acting, I am also interested in their school worlds as more than containers within which they act. Besides, the contributions people play in the reproduction and transformation of themselves and the communities they are members of are educational considerations. Important as the idea of distributed cognition is to cultural psychologists interested in the interaction of culture and mind, I am more interested in using the notion of the self distributed more from the perspective of how a context

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18 Tilley Endurables is a Toronto-based clothing manufacturer which produces headgear popular with Canadian paddlers. "Attitude" apparel is clothing popular with adolescents. Shirts, for example, come with slogans intended to communicate a particular viewpoint

(which includes cognition) acts as a habitat, or an ecology that is broader than immediate social interactions.

In retaining a broad analytic focus on practices rather than discussing cognitive processes and conceptual structures, I understand Dan's expressions of *group effort* as part of what I'm calling "distributed practice". My use of the term is intended to draw attention away from a stricter, social "thinking through others" focus of distributed cognition and instead to an analytic focus on "thinking and acting through others and the material world." Returning for a moment to my expanding illustration of practice depicted in the previous tables, Table 6 is reframed here as a depiction of how practice is socially, culturally and historically constituted and distributed amongst an array of contributing resources.

<u>Table 7: A distributed practice</u>

exhibit	peripherality & legitimacy			generate
	emergent	extra-local	individual	
↕	[illegible]			↕
	engrained	local	community	exhibit
generate	peripherality & legitimacy			

Like Lave & Wenger's (1991) exposition of situated learning, distributed practice implies a move away from understanding and learning defined as a self-contained structure in the minds of people, but instead is spread out in a context of activity constituted through the participation of people where identities, and meaning come into being. Keller and Keller (1993) provide a cogent example of what I am beginning to call a 'social and cultural practice view' of learning in their account of "Thinking and acting with iron" (p. 125). Along with Engeström (1987, 1993), Lave (1988), Wenger (1990, 1998) and Franklin (1999) their use of activity perspectives in theorizing knowing as flexible processes of engagement in the world move us closer to this view of learning. This analysis extends their use of these perspectives to a nuanced situated learning view.

A situated learning view represents fundamental challenges to aspects of cognitive, behavioural and developmental psychology which underpin educational theories such as Deweyian problem-solving, a major contributing influence in Ontario Tech Ed classrooms. Bruner's (1990,1996) continuing critique of these major influences are based in an understanding that it is a mistake "to locate intelligence in a single head" (1996, p. 154). As people engage in activities of the everyday world, they find that they are connected to each other through technologies in the form of objects, processes, intentions, and knowledge that they have of, and about the world[19]. We have already examined a few of them so far. It makes sense to think in terms of practice as

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For a philosophical account of technological relations Mitcham (1994) provides a comprehensive analysis from a phenomenological perspective.

spread out or distributed in communities defined by the practices there. Communities of practitioners in effect hold things in common through various technologies of doing, working knowledges and co-participation. It explains in part why we see the son or daughter of an athlete becoming an athlete, or that the best fiddlers in the country come from Cape Breton. The work of becoming an athlete or a fiddler is tied into the processes and practices of those families and communities to the extent that doing things together creates what it means to stand in the world as an athlete or fiddler.

Distributed practice and knowledgeability

Dan's talk and action provides an opportunity for expanding on the idea of distributed practice as an integration of contributing resources. He says that knowing has something to do with having *enough knowledge* on *how stuff works*. *If you could do this, if you had that*, he says, *then you could do what you want to do*. Dan associates knowing with ways of doing things. Knowing, doing and thinking through others, are processes and practices involving *knocking down each others fences to plant a tree*, a somewhat awkward way he describes things working out through others building the car. He cites a course of action--a direction--as a way of explaining how things get done. He tells me that *different directions give you different viewpoints and aspects that you could sort of discover the community or something like that.*

Some of Dan's talk suggests that this is about following a problem-solving method. But his actions and other accounts reveal that idea-getting and problem solving are engrained in the practices generated through his participation with others. He is quite resistant to the notion of learning from a textbook. He tells me how he does not like to do any work following a recipe or prescription: *If I built the rocket ship it'd be a lot more exciting than, oh wow, here's the plans for a rocket ship.* He tells me that he and his classmates come to "do" things *not thinking* about them. His participation in the front end and drive train reconstruction emerge as mostly improvised activity in a material world of tools and engrained practices. Kicking around ideas involves just sitting sometimes and in other moments it means rummaging around in garbage bins until something presents itself as the way to go. His statement about *not thinking* fits with activity theory describing how craftspeople come to make things through mutually modifying relations with materials, craft traditions, and the self (Keller & Keller, 1993; Sorri, 1994).

Dan's insight and explanation of thinking and acting through others--which I theorize as constituents of distributed practice--are informed as well by examples in the literature. Both Lave (1993) and Wenger (1991) use the term "knowledgeability" in describing knowing as situated in practical activity: "When knowing is placed in an activity within the social organization of the world, then we have knowledgeability" (p. 101). Lave refers to it as well in her comments concerning the assumptions underpinning transmission and transfer theories of learning which imply a uniformity of knowledge. Lave raises the point that such theories don't acknowledge the influences of context in the constitution of knowing. The result being that knowing or "knowledgeability" is not recognised as a "flexible process of engagement with the world" (p. 13). Lave's (1997) use of the term implies that knowing arises through social relations multipally constituted through practical activity.

> Understanding-in-practice looks like a more powerful source of enculturation than the pedagogical efforts of caregivers and teachers. Social practice theory argues that knowledge-in-practice, constituted in the settings of practice, based on the rich expectations generated over time about its shape, is the site of the most powerful knowledgeability of people in the lived-in world (p. 32).

Distributed practice is informed by the development and use of knowledgeability. Where the Ross commentary addresses some basic epistemological issues connected to these contributing resources, this commentary moves the analysis closer to a discussion about the manner in which these students creatively occupy their classrooms. In this conversation, I focus rather narrowly on Dan's use of "stock phrases" as a way of exploring some of his developing knowledgeability. Knowledgeability is an apt term for describing the product of his talk and action. It not only acknowledges social interaction as a medium of development but also the broader "arena"--to borrow from Lave (1988)--constituted en route.

Summing up the Dan conversation

This conversation shows us the development of a knowledgeability generated through Dan's talk. It is a straightforward way of understanding his sense making about what it is he is up to. It is not easy. He is subjected to a layer of talking about what is happening in the classroom that originates outside of the work and practice he is experiencing. The meanings connected to these terms also originate separately so he also has to sift through them. When does he get an opportunity to do so? In our conversation surely, but beyond that, I have no way of knowing. The point is that it seems to be increasingly difficult for anyone to resolve problems that are not their own. I raise this question also in an earlier discussion about 'cultural homes'. Brown and Duguid (1996) suggest that problems originating separately from their historical and social locations as practice are problematic abstractions. Such extra-local versions of practice require a cultural home, that is, an enabling social and cultural context where such versions may be appropriated or owned by participants. We might see how Dan's conversation provides us with a picture suggesting that coming to "own" that which originates elsewhere is an enduring project of understanding and learning in practice. Coming to own one's experience emerges here as an object of analysis in my concluding chapter.

Dan's explanation of how things are done assists me in outlining a practice 'distributed' between him and others. It's a view that helps us see how working knowledge expressed in the tools, materials, craft standards, improvisations, that constitute distributed practice become a "design" for getting done what gets done. Cultural psychologists, activity theorists, and situated learning researchers refer to these as historically constituted designs for living.

In this conversation, I convey something of Dan's sense making regarding knowing through his use of "stock phrases". We see how he not only exhibits institutionalized features of practice but also how he generates and produces emergent ones. This interplay is characterized by contradictions common to learning in practice, contradictions theorized by those who study learning in workplaces. I introduce the idea of "knowledgeability" as a flexible process of engagement in the world and a way of describing how understanding in practice becomes a design for what it is to know. I conclude here by suggesting that coming to "own" problems in practice is an enduring project for learning. In the next chapter, what Lassitter the teacher has to say about pedagogy is the object of analysis, as I take a look at the pedagogic structuring of Electric car.

CHAPTER V
DISTRIBUTED PRACTICE AND PEDAGOGIC STRUCTURING

Pedagogy is never innocent. It is a medium that carries its own message
(Bruner 1996, p. 63)

Lassitter and pedagogic relations

Apart from outlining the institutional and organizational context in the introduction, there are few clues as to the pedagogic intentions of Lassitter, the teacher. So far, my analysis focuses on the structure of social practice rather than the structure of pedagogy as the source of learning directly. Paying attention to social practices rather than pedagogy follows in the wake of other situated approaches, specifically the work of Jean Lave (1988), Lave & Wenger (1991), and Etienne Wenger (1998) who question that learning is necessarily a result of teaching. Some further explanation is necessary on this point before proceeding with a look at the pedagogic structuring of the Electric Car.

The Ross and Dan conversations and analysis expose some instances where the workings of the social and cultural order of this classroom become apparent. Additionally, these same social and cultural infrastructures often provide resources for an expanding knowledgeability, sometimes not. I conceptualize this social and cultural order as distributed practice. While the talk and action organize the analytic categories, my conceptualization of distributed practice has its genesis in the research of activity theorists like Vygotsky (1962), Leont'ev (1981), and others who studied the interrelatedness of mind and social actions.

Distributed practice is a way of suggesting that the Vygotskian "zone of proximal development" is a collective rather than individual entity. In simple form, the zone can be described as the difference in performances of people alone contrasted with their performance in collaborative activity. However, while learning is conceptualized as a social act, it is nonetheless interpreted, usually by psychologists, as a step on the way to understanding cognition. My own take on the "zone" follows more closely along the lines of Engeström's (1987) view which centres around the disturbances and binds embedded in the differences between everyday actions of individuals, and the historical forms of activity that exist in social practices. We see this in Dan's use of 'stock phrases' where we have a lack of instruction and the presence instead, of a social practice. Thus, I orient my fieldwork less on pedagogic structuring as the object of analysis per se. Instead, I begin and maintain my attention on disturbances and disruptions in student activity and sense making. Brown & Duguid (1996) refer to similar fieldwork and analytic orientations as paying attention to the "demand side" rather than a "supply side" view of learning (p. 53).

Despite my disregard for pedagogy as a way of informing the talk and action so far, it is clear that pedagogic structuring in different forms makes its presence felt. Instruction is present in the use of assignments like the design report, as well as references to design processes in Tech Ed curriculum documents and, as we shall see, in what Lassitter has to say about his teaching.

When teachers choose a particular pedagogy, they also choose a conception of learners and learning, one that is more or less tacitly held. Teachers use approaches in tune with the prevailing spirit of the times and the culture in which they are situated. The prevailing spirit of this design and technology classroom comes as a response to industry and business interests calling for vocational relevance in school programs (cf. Ontario 1990). Where my earlier introduction of Broad-based Technology (BBT) provides a way for understanding the institutional context of this classroom, here I expand on it. I introduce some ideas connected to the notion of 'leaning by doing' and 'practical competence' as influential and powerful ways of thinking about these classroom activities.

The response of technology teachers emerges in what cultural psychologist Jerome Bruner (1996) says are the "folk pedagogies" they use (p. 44). We should examine these folk pedagogies so we may expose the tacit assumptions held by teachers about learners. We should also examine them so we can expose something of the prevailing spirit in which they are formed. Both are relevant questions when considering the talk, actions and sense making of these students. In what follows, we consider Lassitter's sense making in terms of what Bruner says about pedagogy, as well as what situated learning theorists have to say about social practice in sites where learning practice is the focus. Lassitter's ideas about teaching and learning are important because they form a pedagogic context for the social engagement I describe and analyze in the Ross and Dan conversations. What social theorists have to say is also important because, they focus our attention less on pedagogy and more on participation in social contexts and the learning in practice associated with it.

We now turn to a closer look at the pedagogic context of the Electric car classroom understood through what Lassitter has to say about his teaching in conversation with me. How Lassitter thinks about the pedagogic setting in which the car gets built, and how he understands it to be a way for experiencing actual practice, is important because as the teacher, he is primarily responsible for its organization as a learning resource. I begin by introducing Lassitter and present a series of excerpts from our second interview where we discuss his teaching. The interview excerpts are interspersed with a commentary about pedagogy and what situated learning theorists say in the context of the analysis I develop here.

Conversing with Lassitter

Introducing Lassitter

Lassitter has twenty years of teaching behind him, most of it as a Tech teacher, although he also teaches other subjects in the sciences. Where most Tech teachers enter teaching from one of the trades and earn a diploma in education, Lassitter has an engineering degree. His professional training as a civil engineer and a career as a designer in a paper mill preceded his teaching. He is the department head with two years to go before his retirement. This past year, his teaching involves two drafting courses in communications technology, a new introductory course for grade nine students, and now this grade ten design and technology class. Lassitter is very active in the school as a coach, in other extra-curricular activities as well as being very busy looking after his responsibilities as head. He has seen changes come and go in education, the most recent being the shift from independent disciplines in tech to a Broad-based Technologies (BBT) approach. As an experienced teacher, Lassitter has a strong grasp of teaching. As an engineer trained in designing and making machines in industry, Lassitter has things to say about design and classroom activities. First, he describes some of his early teaching experiences. These are followed by other comments that give us some idea of how he thinks about arranging his classrooms for teaching and learning.

A conversation and commentary about pedagogy

I went back to school and I came out with industrial physics because I was into this project design[20] *and the engineering part of it. It was interesting to get back into a school to sell industrial physics. Here tech was hammering and banging and you were sent kids who were good with their hands. "Oh, he's good with his*

20

Project Design" is the name of a "delivery system"and an implementation and management tool given to an initiative introduced by the Queen's Faculty of Education in the 1970's (Loney 1991). The intention was to orient tech teachers to systematic thinking about projects before and while they were made. "Project Design" reflected National Curriculum initiatives in the United Kingdom which gave design prominence as an main organizing feature in the new technical/vocational education there. "Project Design" preceded and influenced the present conceptualization of BBT in Ontario.

hands, they would say. He would do well in your course." So I've always had this kind of course with an emphasis on Tech design, where you're always designing and trying to streamline design and trying to streamline getting kids involved in projects and getting committed to a project and so on. And, I taught a lot of different courses that worked really well. Some of the best ones were construction projects where the kids actually got blueprints of houses. I went to a housing developer and they gave me bundles of old drawings and stuff. It was wonderful because they got a real house to design, they had the drawings, they got to read the drawings, and they got to trim up the house and make it the way it was drawn. And they thought that was pretty glamourous. Some of them were just enthralled with it. They left the class saying I'm going to be a contractor, and lo and behold they did. They got to be a contractor. So that worked well.

(Lassitter Interview 2, p. 2)

Lassitter tells me about the kind of student he is handed: students perceived to be capable in practical ways, an oblique reference to Tech Ed classrooms as traditional "dumping grounds" for those perceived as unable or unwilling to "make it" in other subjects (cf. Kozolanka 1993). We gain some idea of what Lassitter thinks is important; he gets his students working on projects that have connections to the real world of designing. It is the beginning of our conversation and Lassitter sends me a subtle signal that student activity in his classroom is tied to the kinds of things that designers do. This may well be the exception for drafting classes of the day where classroom activities are limited to reproducing drawings from texts with little connection to communities and students. In contrast, Lassitter describes his idea of a good learning situation; the students are enthralled, and they get to draw up the trim and other details for houses that actually exist somewhere. It is as close to authentic designing as one can get without actually sitting down with a client and working out their needs on paper.

There is a distinction, however, between the brief description of how he gets his students working on bundles of drawings scavenged from a contractor and the activities described and talked about in the preceding analysis. This activity seems to be organized more like instruction than the distributed practices of the Front End and Drive Train activities. The excerpt helps us see how Lassitter thinks about teaching early in his teaching career before design becomes a formal subject and organizing consideration in Ontario Tech Ed classrooms. He continues our conversation by talking about problem solving.

A living understanding of how an equation works

> *The next bunch of courses worked really well. I taught an aircraft physics course in grade 11. We built a model of an aircraft and then they flew them. We bought these little engines and then we'd go out and fly them. They were welded structures with Saran Wrap over the wings and stuff, and we tried a whole bunch of different things. And then they would control line fly them. They were very*

twitchy. Some of them would dive very quickly because we were not aircraft designers. But we learned a lot. I actually taught them computer programming during those courses too because it taught them how to marry solutions to the physics problems of lift and drag and so on. They would program the equation of a lift, which was a family of lines that was parallel on the curve of a wing. It was a series of lines and they had to program them in and then solve it. And they really had a living understanding of how an equation worked. I remember one kid came back to me after he'd graduated from university. He was working in a programming shop for some software designer and he said, those courses were the first time I ever realized you could solve problems by just muscling the solution through.

Elaborate on that more.

You put in a number and made a calculation and if it fell outside your limits then you adjusted it. You would have to adjust the equation of the lines with whatever the factor was and solve it again, and then see what your answer is the next time. If it's closer then use that one. And if it wasn't you would have to adjust and do it over again. So you could do all of that sort of thing in the programs that were on old TRS80s that we bought and they muscled those in.

So muscling something out sounds to me like you basically start working on the problem by doing it as opposed to, thinking...it sounds more like um, a practical kind of exercise rather than a theoretical one.

Find a solution and then see how it works. That was more or less what we did and then we would try to modify it. Like the scientific process or something.

So, scientific process or something...

Yeah, I wound up starting to teach some physics and science courses, and that worked fine. I didn't mind that. But then I noticed that these kids that were in these other courses were just a commitment level above the kids in the tech programs in their paper skills. Like they could produce anything. They could study anything and make anything look neat, and that was really interesting to me, but here was stuff that was so uninteresting in some ways because the physics, of course, we were studying the expansion of something when you heated it, well that's pretty uninteresting to a tech student. Sure it's hot. It gets bigger and won't fit in the same hole, and it breaks and swells when you heat it. So they know all that but these other people would study it and produce a lovely report. So what were you trying to do with these other students? And what were they trying to do? And it was interesting to me to step into this mark hungry group that was in physics, in these physics classes, and here were these other kids thirsting to basically do something. A lot of it of course was hammering and banging and something, but some of them really wanted to make things that were interesting. And making things that are interesting, of course, requires discipline, so the discipline is hanging out over there in the physics classes 'cause they'll discipline themselves to do very mundane tasks, and here you're trying to solve these significant problems and you've got undisciplined people. So. I think we try to encourage our youth,

youth with apparent skill to follow a science career, or just plain our youth, never mind whether they have skill or not. Science and mathematics. And yet surely technology is applied science and mathematics. I mean if it isn't that well, you know, what is it?

Um hmm.

They were really turned on to that. So there was an obvious example of applied science, because they didn't, they didn't know the force and rotational forces and so on that were going to come to bear on this project. And so they were interested in learning about those things, and they would have been interested in learning more about them had they been able to, had they had unlimited experimental capabilities. Which of course we don't have. And they get very interested in that and so then they start to ask, what if. And that sounds to me like applied science. They're very interested in applied science. Like, how will it bother me if I, you know, if something goes wrong, how will it bother me.

(Lassitter Interview 2, p. 4)

Lassitter describes a more recent class where he and his students build and test model aircraft using computer programs. He explains how they use computers for figuring out changes to the curve of a wing in order to improve lift and reduce drag. He calls it *a living understanding of how an equation works.* At first I do not completely understand what he means and ask him to elaborate. He continues by telling me how you have to adjust the lines according to what figure comes out of the equation. His explanations are quite technical and I can barely understand the details but I eventually understand his explanation when he says *find a solution and see how it works.*

Lassitter suggests that learning the ropes in these classes has something to do with engaging in the everyday activities of producing solutions to problems. This is not at all surprising. Engineers are trained in problem solving and producing workable solutions. It comes as no surprise that Lassitter orients his students to practice in a similar fashion. Lassitter has an intellectual hold on classroom activity influenced by his engineering training and experience. He conceptualizes the classroom action in terms of *problem solving*, and *muscling through solutions*. Thinking about Tech Ed as problem solving is a common enough view that is often associated with applied science [21]. Much has been written about technology conceptualized as applied science with the general argument holding that scientific principles are prior to, and primarily inform technological activity, rather than the other way around. Lassitter provides a number of clues as to how he thinks about the learning organization these activities provide. His students figure out the physics of making model airplanes fly. They calculate solutions by adjusting answers produced by using equations and computers. He says the curve of an aircraft wing *is a family of lines* which

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[21] Gardner (1995) provides a comprehensive historical and philosophical reflection which draws on phenomenological philosophical conceptions of technology that underpin my use of the term in this dissertation. Phenomenological views such as those posited by Ihde (1990) suggest that technology is ontologically prior to science, that science is the 'tool' of technology and has evolved into applied science as a result of technology.

tells us something about their relationship to each other. When one line is changed, then they are all affected. His students load the equations into a computer program and the dimensions of the wing are adjusted accordingly.

In the Ross and Dan analysis I use the term 'technology of doing' as a way of describing material, social, and institutionalized versions of activities present in their classroom. The use of the equation described by Lassitter can be thought of in a similar way. As a technology of doing, the equations provide a way of structuring how lift and drag problems are solved. I ask Lassitter if using the equations is a practical exercise or a theoretical one and he tells me it is a practical one. It certainly has the appearance of a practical exercise, but one which is "front loaded" as a didactic teaching scenario.

Bruner (1996) tells us that "didactic teaching is based on the notion that pupils should be presented with facts, principles, and rules of action which are then to be learned, remembered, and then applied" (p. 54). Equations are common in engineering practice providing procedures for working out problems. Knowledge is thought to exist "out there" waiting to be absorbed or delivered and people pass on what they "know" in the form of propositions to others. In curricular terms, the purpose is the maintenance and transmission of established knowledge (Kelly 1989; Pratt 1980), depending on how the subject matter is treated in a given situation. The emphasis is on information as knowledge without consideration for the position of the knower except as one who might "discover" the world and integrate it as schemata in terms of a persons' cognitive functioning. Table 1 depicts the assumed institutionalized relationships between these conceptions.

Table 8: Information processing pedagogy

curriculum as	content
education as	transmission
pedagogy as	didactic
knowledge as	propositional - 'what'

In Ontario, Tech Ed classes are often organized according to accepted design conventions (cf Wilson 1997; Kozolanka & Medway 1996; Ontario 1995; Hill 1994) which can be thought of as propositions to be applied in a similar fashion. Some activities in Lassitter's design and technology classroom used a similar instructional focus early on in the semester before the car was built. A certain amount of initial design activity was didactic in that students were expected to copy existing Front End designs to see how they functioned. A basic underlying assumption accompanying didactic approaches is that learners are ignorant of the procedures for solving problems or getting to solutions and accordingly, they need to be informed. Knowing is thought to be in the hands or heads of teachers, or in books, databases etc. Bruner tells us that "procedural knowledge, knowing how, is assumed to follow automatically from knowing certain propositions about facts, and the like" (p. 55). Lassitter helps us to understand that didactic teaching seeks to help people remember and apply certain principles in practice, an example of which Lassitter provides in this conversation. Engineers do not only teach didactically of course. Consider what Lassitter has to say in this next excerpt about another common engineering practice that finds its way into his teaching.

Reverse engineering

> *I wound up teaching, I would teach a welding course, mostly electronics and welding. I kept going in that direction 'cause I was heading toward the computer field. So we were headed toward interfacing eventually, but in the meantime I went through these aircraft physics courses, the construction courses, some welding courses and then some small engine courses. That was fascinating because you could really turn on people to become good record keepers by making them take apart the whole engine and draw every part in detail, and then put it back together again. Some of them used to come up with very neat records of part number 1, 2, 3 and they'd have all these parts and then they'd put them back together again.*

As it came off the engine.

> *As it came off the engine.*

So would this be a kind of, the equivalent of notation that you'd get in writing or music for example? So taking apart an engine has a certain kind of notation?

Where does that come from, the idea of notating or keeping a record of how it comes apart?

> *Probably the first year I ran the course, they were destroying the engines and never being able to find out where the hell the parts were.*

Like losing the parts or something.

> *Yeah, and not having any note of, you know, what part was that, you know, "Well I don't know. I just took it apart." Well they didn't remember what the part was so this was important for them that way. We didn't, we didn't do any design work then with them, although some of those kids went on and became sort of our school's repair guys 'cause they would repair a lathe. They'd take the lathe down and then they could actually, boom, boom, boom, here's the steps.*

Isn't that a kind of design from behind isn't it?

> *Um hmm. Sure it is.*

I mean, it's sort of like,

> *1950s Japanese design* (sic). (Chuckle)

You mean like industrial espionage kind of design?

> *Yeah.*

Same as the French were doing during the Industrial Revolution in England. Engineers would go off to England on espionage missions to see what was happening in factories and in the shops. And they would come back and say, "well I have a sketch of this machine that does this, this is what they put in one end and this is what comes out the other".

> *Well that makes sense to me that would have happened.*

In what way? Like how does that ring a bell for you?

> *First of all, I had a couple of students and one of them was very adept at doing reverse engineering when he was in grade 12. He was one of those kids who were at the leading edges of the computer industry at that time because they had lived with them all through public school, all through high school and they were way ahead of the industry. They became the industry and he was designing CAD programs and he was building them for a company, and he was just taking apart chips from all over the world and redesigning them. I had a big part in his technical training and he was just so far away ahead of me, where I was, but that's what they were doing. They were reverse engineering then and that whole company was founded on reverse engineering.*
>
> (Lassitter Interview 2, p. 8)

Lassitter gives me an account of his teaching that is different from his earlier descriptions of *muscling through solutions* and *problem solving*. It is also different from his description of a *living understanding of how an equation works* which is the way he describes the work of inserting equations into a computer program. In this excerpt he talks about kids taking apart engines, and lathes, and designing computer chips. He calls it *reverse engineering*, historical engineering practice common across cultures. According to Lassitter, *reverse engineering* is about taking things apart to see how they work, sketching the components as a record, and notating dissassembly sequences for reassembly.

Reverse engineering makes its way into other communities of practice as well. In Lave's (Lave & Wenger 1993 p. 72) work among Vai and Gola tailors in Liberia, production processes were initially reversed so that newcomers got an overview of the practice. Thus, apprentices worked on finished garments first--pressing them, then moving to attaching buttons and hemming cuffs--and so on, in a kind of backwards production process. Instruction is engrained within the social practice of tailoring rather than that of teaching tailoring. The master tailors provided various resources in the form of work practice with a division of labour structuring the initial and subsequent apprenticeship routines of tailors. The relevance of Lave's observations of this "formal" activity of apprentice tailors for the activity here is to illustrate imitation as a learning tradition that transcends cultures and disciplines.

When we perceive students as imitative learners, we provide examples of how we want learners to act. We commonly associate the imitative learning described by Lassitter with apprenticeships, where newcomers are thought to model masters and others in work communities. Bruner (1996) calls it "leading the novice into the ways of the expert" (p. 53). Learning "how" to do things has been the mainstay of Tech Ed pedagogy partly because of the apparent ease with which occupations can be reduced to their component parts, as found in skills profiles (Hill 1993, p. 420) and the like. In curricular terms, learning "how" pedagogy can be linked to the objectives movement in education (Tyler 1949) and the proceduralization of competence enacted in a community of practitioners. Social reproduction and the performance of social roles are one way of describing the purpose and outcomes of objectives-based instruction. Behavioural indicators such as the extent that someone is able to competently perform certain roles is an important consideration in a pedagogy based on imitation.

Bruner alerts us to some of the underlying assumptions in a pedagogy of imitation. He explains that when learning is equated with doing and knowing-how, competence is developed through habits and practice to the exclusion, Bruner suggests, of negotiation and argument. It is possible that an exclusive attention to mimicry can reduce opportunities for negotiation. Lave and Wenger (1991), for example, report on the apprenticeships of meat cutters who are denied opportunities for social engagement in certain core practices and instead, are limited to routine, repetitive tasks. The result is that they are denied opportunities for participating in, and producing new forms of their practice. Table 2 depicts the assumed institutionalized relationships related to imitative pedagogies.

Table 9: Imitative pedagogy

Curriculum as	Process
Education as	Transaction
Pedagogy as	Imitation
Knowledge as	Procedural - 'how'

Apprenticeships have been with us for some time and carry a certain amount of conceptual baggage as to their worth as models for contemporary schooling. Lave and Wenger (1991) warn that a narrow reading of apprenticeship as if it were organized the same everywhere is problematic. Their situated learning research on varied contemporary apprenticeships in diverse cultural settings shows how learning, or failure to learn, may be accounted for by a number of social factors. The backwards production reported by Lave and the *reverse engineering* cited by Lassitter assist us in seeing how teaching can be situated as a social practice rather than a second order representation about it.

Deeply getting involved

A bit later in our conversation, I ask Lassitter to elaborate on what he means by design processes. Instead of talking about design directly, he talks about what it takes to learn something. He tells me that it is something he learned before he began teaching when he understood learning to be about *deeply getting involved in a building project*. He is very explicit about what it takes. He does not talk about thinking about building something directly, he tells me that what it takes to learn is a matter of depth of involvement, an involvement that requires building. He continues telling me that it has something to do with going out and seeking information that he has a use for. As a teacher he hears kids in school saying the same thing; *what's the use of that?* Lassitter ties this to the Electric car activity saying that these kids knew what it is about. They do not ask *what's the use of this?* I suspect that what Lassitter describes has something to do with more than following a set of procedures for solving problems, like the equations for working out the drag and lift problems in the model airplane class. Rather, Lassitter suggests that learning the ropes has more to do with social engagement. Here is what he has to say:

> *Well, I have always felt, and almost since I was well, since I was teaching and before I was teaching, that learning by deeply getting involved in a building project taught you more about everything than just sitting and trying to take in learning from a whole bunch of areas because a deeply involving project sends you out seeking information from others in many ways. And I always thought that the sending out to get information and making connections was an important way for ME to learn anyway, and perhaps for a lot of other people to learn, 'cause I, early on I had to see a use for it. It is only AND I hear kids saying, "what's the use of that" "what's the use of that".*

What's it for.

> *Yeah, and I already knew what it was for because I was involved in the project, so it seemed to me that if you were sent on a project you knew why it was useful. And I think these kids that were in the Electric car course this year, they never said what's the use of this. They never said where do I go? 'Cause they started to pick up ideas from each other, like how are we going to solve that problem? Well then there's nothing that is useless if it pertains to the car. So, you go chasing the ideas.*
>
> (Lassitter Interview 2, p. 6)

This excerpt appeals to me because he seems to be talking about more than design and the importance of seeking out information for solving problems. I have the sense that he is suggesting learning takes more than getting involved in a number of areas and instead, requires a depth of involvement with places and people. Lassitter gives us a hint how he may have been thinking about shared practice as a learning resource. There were few references in our conversations about putting his students together for the sake of putting them together. Yet talking about design here, solving problems, dealing with a computer and an equation with the aircraft models, or following a procedure for notation of an engine dissassembly, all require the participation of fellow students. Attaching the front end to the car or piecing together the drive train all required more than one person as well. Dan's description of *group effort* and *knocking down some guy's idea to plant a tree* give us a hint that there was little activity in this classroom that did not require what Bruner (1996) calls "intersubjective interchange" (p. 56).

Intersubjective perspectives are basically developmental in curricular terms, where the emphasis rests with individual and social activity. Pedagogy is directed by broad principles and outcomes are thought of as understanding arising from active participation and reflection on experience. John Dewey (in Hickman 1990) refers to development in terms of citizenship and building a democratic community. For my purposes here, development in these contexts is referred to as "why" knowing issues beyond information and technique. "Why" knowing concerns the significance of artifacts and tools as the relate to the world beyond the artifacts and tools themselves. Table 3 depicts the assumed institutionalized relationships related to intersubjective pedagogy.

Table 10: Intersubjective pedagogy

curriculum as	development
education as	transformation
pedagogy as	intersubjective
knowledge as	questioning - 'why'

According to Bruner, intersubjective interchange involves the capacity of people to construct and negotiate meanings for themselves. In an intersubjective perspective, children and students actively engage in processes moving to maturity through interpretation and collaboration rather than exclusively as imitators and/or receivers of propositional knowledge. Intersubjective pedagogic perspectives assume learners are capable of reasoning and sense-making with themselves and others. As he puts it, "knowledge is what is shared in a discourse" (p. 57). This is a way of saying that knowledge is produced by knowing subjects engaging with each other and social situations. An intersubjective view of pedagogy assumes that learning is a way of being in the social world rather than a way of coming to know about it. There are instances of both in the Electric car. The experimental activity that preceded the building of the car may fit the latter. The end of our conversation provides an opportunity for taking a look at these differences further.

Design as social practice

At the end of our conversation, I asked Lassitter where the students got their understanding of gear ratios, something that they had to contend with when putting together the drive train.

Now about gear ratios, I'm wondering, did that come out of the business of playing around with the motors and the motor burning out and the direct drive and the chain not being okay for the big one, having to change it around. Did those questions come before or did they come after that?

No, they came before.

Oh.

Earlier on I had a series of motors around here and we actually built circuits for all of them to work on. Push button circuits, and I tried to transistorize them so that they got a couple of experiments. They got to do some experiments with high speed switches and I compared...anyway, that's how that got set up. They know speed and so on, but they didn't figure it out until later.

So it just led one thing to another, like kids being kids (chuckle).

Yeah, that's right, and of course the gear ratios, they have a bit of a gut feeling about it because they all know how drive a tractor and run snowmobiles.

So the shifting gears is probably something that came up fairly early, I expect.

Um hmm

Yeah. Okay.

But they didn't have an inherent solution to it all. We tried to get them to design things in one area and take the designs to the next. Very difficult process. And yet people have this impression, oh you can draw something and then go and build it in the shop. Oh my Lord. That's almost dream world sort of situation where you can design with discipline and then go and build it and you're a grade 9 kid. I mean, that's what we get told by our so-called leaders in the school. They say, well draw them and then go into the wood shop and build them. Oh my goodness me. Which do you do first? Go to the wood shop and then draw, or do you draw and then go to the wood shop? And *what's the machine? The closest thing that most kids have to knowing about technology is they have a computer at home and the car gets pulled up to a gas station every once in a while. I mean, that's technology to them. So how do you turn them into designers?*

Where something happens before the other?

Um hmm. They're never going to know the physics of it before, or they're never going to know how to design it before they've experienced it.

(Lassitter Interview 2, p. 8).

When I ask Lassitter where they learned about gear ratios, he surprises me. At first he attributes their familiarity to the preliminary work done in the design classroom before the cars were built. I have a hunch that the students pick it up during their work on the Drive Train. But after mentioning the design class activity, Lassitter tells me that they probably *have a bit of a gut feeling about it*, crediting their familiarity with machines as rural farm lads who know about tractors, snowmobiles and the like. Gear ratios and shifting gears are so well integrated into rural farm life that Ross, Dan and the others may have already had a strong socially constructed basis for understanding the drive train problems. I am not sure about this, but it is apparent from my conversation with Lassitter that although the students may have had some sense of how the gears worked, understanding the physics of it all may have been another matter.

We earlier witnessed something of how blacksmiths (Keller & Keller 1993) work with iron using both their individual knowledge and competence with tools and materials for forging an object mediated by craft knowledge connected to the tools, processes and other smithing practices. Bruner's fourth pedagogic perspective concerning history resonates with the smithing and this gear ratio account. This concerns the historically constituted nature of all knowing, whether in the form of propositional "what", procedural "how", or the capacity of people to address issues beyond information and technique, the"why" of knowing. The fourth perspective holds that people need to grasp the distinction between personal knowing on the one hand and what is taken to be known by the culture on the other. Bruner suggests that understanding the difference between the two may be a key to understanding the historical nature of knowledge. Given my developing sense of the historical nature of tools, artifacts, and related technologies of doing things that flow from this research, it is easy to understand all of Lassitter's teaching as having historical significance. Table 4 depicts the assumed institutionalized relationships related to pedagogies re-thought historically.

Table 11: Pedagogy as historical

curriculum as	**negotiation**
education as	**transmediation**
pedagogy as	**historical**
knowledge as	**knowledgeability - 'identity'**

Lassitter's question about design that ends our conversation underscores how what is known by the culture at large provides an important resource for understanding and mediating individual experience. The *gut feeling* for gear ratios attributed to the students provides a rich social context for their understanding of the physics that Lassitter would like to introduce them to. I suspect the answer to Lassitter's design question lies within the negotiated interplay of distributed practice I describe in the Ross and Dan analysis. These and related issues are addressed further in the next chapter.

A pedagogic context: Situated pedagogy

I experienced some difficulty in making connections between the four dominant conceptions of folk pedagogy explained by Bruner, and Lassitter's descriptions of his teaching. My difficulty arose not because I could not see connections but that there were many. *Reverse engineering* for instance, is not just a procedure, it is a way of doing things steeped in engineering practice and other communities of practitioners across cultures and disciplines. At the same time, it also can be understood and used as a way of imitating practice. However, stripped of its place as part of an enabling social context and lacking a cultural home, *reverse engineering* becomes a technology of doing originating separately from where it is used. Equations and formulas can be seen as examples of practice made into something they likely are not intended to be:propositional knowledge presented as technique rather than engrained in social practice. When put into action as social practice, they most likely cease to be merely propositional, but propositions situated within a cultural home, that is, an enabling socio-cultural context. The point to make is that pedagogies need to be situated as much as any technology or other contributing resource that is part of a distributed practice.

Bruner makes a general point about the four perspectives. As influential parts, he suggests they form a broad picture of pedagogy undergoing some change due to recent advances in learning theory. According to Bruner we must avoid emphasizing them as isolated.

> What is needed is that the four perspectives be fused into some congruent unity, recognised as parts of a common continent. Older views of mind and how mind can be cultivated need to be shorn of their narrow exclusionism, and new views need to be modulated to recognise that while skills and facts never exist *out* of context, they are no less important *in* context (p. 65).

Taken together, Bruner, Lassitter and the preceding analysis assist in understanding something of how this classroom is structured pedagogically and institutionally. Bruner provides an initial way of thinking about the actions described by Lassitter in pedagogic terms but it lacks, in many respects, a social and cultural setting. Lassitter doesn't frame his statements to me in terms of pedagogic theory. He does however, offer a sophisticated explanation of what he does by providing sketches of how his classrooms are organised around activities in different forms.

His version of pedagogy is situated in socio-cultural settings. Both Bruner and Lassitter contribute to an important assumption underpinning this inquiry; that learning is a way of being in the social world of practice rather than principally a way of coming to know about it, which is the enduring problematic of much school learning.

The limitations of presenting complex activities and sense making in the form of the preceding tables may seem obvious in the absence of their enabling constituent relations. However, I provide the table here in its entirety as a guide for understanding the relationships between their respective pedagogic (Bruner, 1996), curricular, educational (Kelly, 1989) and knowledge (Stairs and Kozolanka 1995, 1997) assumptions[22].

Table 12: An overview of what, how, why and who pedagogy

curriculum as	content	process	development	negotiation
education as	transmission	transaction	transformation	transmediation
pedagogy as	didactic	imitative	intersubjective	historical
knowledge as	propositions (what)	procedures (how)	questioning (why)	identity (who)

22 With the exceptions of the last column and the bottom row, the theoretical resources contributing to the construction of this table originate with those cited.

CHAPTER VI
TOWARDS A SOCIO-CULTURAL PRACTICE VIEW OF LEARNING

Learning as coming home...
(Bateson 1994, p. 195)

Reprise

In the preceding narratives, commentaries and analysis, I have looked at various classroom activities, talk, and sense making of tech ed students. I have also included descriptive accounts of my own sense making in trying to work out something of how things are done in the everyday world of Electric car. I have drawn from studies of how apprentices and others learn in their respective communities of practice, particularly the research of anthropologist Jean Lave (1988,1990,1996,1997), and social theorists Etienne Wenger (1991,1998), and Ursula Franklin (1990,1999). I have leaned mostly on perspectives closely associated with situated learning and related social theory [(Brown, Collins & Duguid 1989; Lave & Wenger 1991; McLellan 1996).] However, I have also used elements of activity theory [(Chaiklin and Lave 1993; Engestrom 1987,1993)] and to a lesser extent, phenomenology [(Mitcham 1994, Ormiston 1990)] for assisting me in situating the actions, sense making and material resources in ways that illuminate my broader project, moving towards a social and cultural practice view of learning.

I continue moving towards my conclusions here by resuming something of the unfolding analysis undertaken in the Ross and Dan conversations. In that analysis I use the Front End and Drive Train activity for arguing for a view of knowing as a social and cultural process of flexible engagement carried out within distributed practice. I focus attention on the way things are done and find that technologies of doing in many forms are an integral constituent of everyday practices in that classroom. When knowing is associated with participating in social relations technologically constituted, then the epistemological significance of technologies warrants attention. Access to participation and understanding the technologies of doing that constitute classrooms accordingly, become important considerations for teaching and learning. In this concluding chapter, I revisit distributed practice as forming a social and culturally organized access in practice by outlining some elements of the practical negotiation enacted by these students. I conclude by offering some comments about significance and related matters arising from the inquiry.

Revisiting distributed practice: A social and culturally organized access

In the Ross and Dan conversations, I spent some time examining what they were doing as they built an Electric car. It became apparent that their actions were a combination of improvised as well as prepared or "engrained" action. Furthermore, these processes were not exclusive of each other, that is, I discovered that engrained processes often required some improvisational work. Likewise, their improvised actions involved engrained ways of doing and acting. Their work regularly depended on tools, materials, and established ways of doing things that made their way into the way things were done in the classroom setting. I cited some examples from activity theorists showing how work activities such as those in the Electric car are historically constituted by people like Ross And Dan exercising judgement, improvising as they go. It was the first instance in the inquiry where I documented actions that appeared initially as contradictory, but in retrospect I understand and reframe as complementary practices.

During the Ross and Dan commentaries, I began putting together a picture of these apparent contradictions in ways that now make more sense to me. Their talk and action provide moments illuminating how the social and cultural infrastructures organize and constitute the way things are done in their classroom. Taken together, I conceptualize these infrastructures as distributed practice; co-participation, the requirements of working practice, and technologies of doing. Distributed practice is constituted in a context of legitimate and peripheral participation characterized by an interplay I call practical negotiation.

Revisiting distributed practice

Describing the interplay of co-participation, the requirements of practice, and technologies of doing took up most of the commentary in the Ross and Dan conversations. First, co-participation is the term I have been using for thinking about shared practice and how the relations between students organize opportunities for learning. A snapshot of co-participation or actions can be seen in descriptions like the drive train reconstruction as they kibbitz, jostle, and otherwise "feel" out what gets done. Dan also provides us with a simple yet convincing description of co-participation as he oscillates between stock phrases like *problem solving* and his use of other phrases like *everybody's work is everybody elses*. The concept of co-participation is a way of calling attention to just how much happens in what seems to be an "accidental" manner. However improvised and accidental co-participation may seem, it also exists in these classrooms as constituent parts of an engrained infrastructure that includes what I call the requirements of working practice.

When examining the talk and action of Ross, Dan and the others, we can see how the requirements of working practice exist as a manner of "social conditioning" enacted through co-participation. The requirements of making the Electric car provide as many cues as Lassitter does directly. It is the students who form a link between established historical knowledges engrained in tools, procedures and maxims, rules and routines of, in this instance, metal fabrication. The Front End could be fastened to the frame with bolts, but instead, they weld it on. They attach it to the Electric car frame the same way it was attached to the bicycle they took it from. I do not remember if Lassitter told them to weld it on or not. Either way, the requirements of doing the job are enacted by them. The students form a living link between established ways of making and doing, and emergent ones embodied in their actions. In this instance, copying a production procedure well established in practice. Keller and Keller's (1993) blacksmithing example cited earlier, helps us understand how reforging a handle draws on the smith's conceptual representation of what a skimmer should be like, informed by the canons associated with the "general standards of aesthetics, style, and function" (p. 139) constituting blacksmithing. Yet the skimmer produced by the blacksmith Keller is unique, as is the Front End of the Electric car.

The third resource contributing to distributed practice examined has been technologies of doing. My first interview with Boz helped me make connections between the research of those who have studied people doing math while working and shopping, with others who show how technologies can supplant those ways of doing things. Indeed, conceptualizing technology as a way of doing something (Franklin 1999) proved to be a revelation. I began understanding my earlier reading in the philosophy of technology (Heidegger 1977; Mitcham 1994; Ormiston 1990) as theorized versions of what I was witnessing in these classrooms. Understanding school math as a "technology of doing" directs my attention to the manner in which Boz downgrades his own lived experience despite his competence at welding math. This is an issue I take a look at in the next section about ownership and negotiation after revisiting the ideas of peripherality and legitimacy as ways of looking at learning and practical activity differently.

Coming to this inquiry, I knew there was merit in checking out appearances when it came to figuring out how students were socially engaged. I think of peripherality as a way of understanding how the students in this classroom often appear like they are not participating when they are. I suspect that few people gain a full membership in a community or classroom immediately as the talk and action of these students show. Ross and Dan's appropriation of the division of labour provide them with an opportunity for engaging not only peripherally but also legitimately. Lave and Wenger (1991) surmised from their research with apprentices that legitimizing the peripheral participation of newcomers is an important facet for developing competence. Legitimacy creates conditions for their belonging. Here in Electric car, the appropriation of the division of labour afforded a move to a more or less peripheral participation legitimized by Lassitter through a combination of neglect and tacit approval. Peripherality serves as a way of taking the measure of a person's trajectory of participation differently than just accepting appearances. Like peripherality, legitimacy in different forms like belonging can serve as an analytic lens for identifying conditions under which learning takes place. It is to the idea of learning conceptualized in terms of ownership and negotiation that we now turn.

Ownership and negotiation

Ownership of meaning

Based on seeing and hearing what the Electric car students do and say, and supported by a growing awareness of the epistemological significance of technologies, I am wary of any technology of doing that separates knowers from the peculiarities of ongoing activity. In a discussion about observational practice in the Ross conversation, we looked at the differences between practices removed from, rather than peripheral to, their sense of history and identity. I called the time, space and situations where these synchronous processes are supported as their cultural home. As a way of conceptualizing "situatedness", a cultural home contrasts with social relations removed from, or marginalized rather than peripheral and connected to the synchronous processes rooted in a shared history.

At the conclusion of the Ross conversation, I raise the idea that people in communities are constantly having to contend with practices originating separate from the cultural home they exhibit and generate for themselves. I call some of them extra-local versions of technologies. Wenger (1990) suggests that the authoritative meanings accompanying such versions of practice also originate separately. This fits with the general idea of situated representations I introduce later in the Dan commentary where Franklin (1990,1999), Wenger (1990), Lave (1988), and Scribner (1984) demonstrate how representations of practices can work their way into the discourse of a community, even supplanting the way things are commonly done in them.

Franklin, for example, discusses how prescriptions by process have a tendency of pushing out other ways of doing things. Wenger uses the term "proceduralization" (p. 93) for describing a relation between separate communities where understanding is set aside for the purposes of simplifying the processes it describes. Scribner (1984) and Lave (1988) explore the everyday use of math in a milk packing plant and supermarkets respectively, finding that they have little to do with the math people learn in school. The common thread in these examples is that despite everyday accounts of how things get done, what they call prescriptions by process, proceduralizations, and situated representations, have a continuing presence in communities in which they may be initially irrelevant. My presentation of school math, the design report, the division of labour, and stock phrases fit this description. There are others as well. Next, we revisit each in the context of the access afforded through them to an increasing participation and learning, or not learning in practice.

<u>Negotiating school math with Boz</u>

Boz does not see himself as someone who can *calculate math and whatnot*. He uses this perceived inability to tell me that he is *not very smart*, despite his obvious competence at calculating what I have been calling "welding math". This is an instance of a technology of doing--school math--supplanting other ways of legitimately thinking about what math can be. Boz sees his welding math as different and *nothing as complicated* as his school math. It shows how the way things are done can become displaced by representations of how things are done. School math in this instance is invoked and given a privileged place in this thinking about his self worth and abilities. School math arrives from another community with its own authoritative meanings in place. The project of learning in this circumstance, becomes one of reconciling the extra local meanings with the local ones enacted by Boz. Doing so, is the gist of what I am calling practical negotiation. So, what does Boz do?

What Boz has to say about school math suggests that it is something of an enigma for him. Further, he uses it to de-legitimize his welding math–and his own experience--in a poignant statement about *not being very smart*. When he privileges 'school math' over "welding math", school math is recognised as a dominant form of knowledge over a form developed within what I have been calling a cultural home. In many respects, school math marginalizes his participation rather than providing room at the periphery of practice from which he might puzzle out links between different ways of thinking about it as a resource for learning.

Brown and Duguid (1996) are helpful in understanding what I call extra-local technologies and their use. They suggest that it is as important not to cut off individual learners from social practices in a community as much as it is important to not isolate technologies, like the school math is in this instance (p. 52). Isolating school math from its constituent resources originating elsewhere do nothing for Boz. Situating and connecting school math to the social and material resources in that classroom could provide opportunities for Boz to look beyond it to its enabling periphery. As it happens, Boz exhibits the presence of an extra-local technology (of doing) in his talk but does not generate a revised understanding of it in practice. Although distributed practice here seems like it affords a social periphery, it may be one lacking in opportunities for him to situate his experience with school math in the context of welding or some other interest. Peripheral and legitimate participation may not be enough.

Negotiating the design report with Ross and Dan

The design report assignment provides another opportunity for taking a look at practice that I earlier suggested was removed from, rather than peripheral to, a cultural home. Although the Ross and Dan conversations, analysis, and commentaries provide a number of instances which suggest knowing is produced through an interplay of resources I call "distributed practice," the Design Report itself does not reflect much of what goes on there. Where I argue that knowledge production is a social relation and made up of practice distributed among material and social resources, the Design Report by contrast, presents an idealized account of the ways things are done. When complex social processes like distributed practice are presented unproblematically as technical relations as they are in the design report, versions of knowing are promoted that have little to do with knowing subjects, and with the lived ambiguities of practice. Reading the design report gives one the impression that making the car depends primarily on technique rather than a complex interplay of contributing resources situated in an emergent cultural home.

The organization of the design report is one way in which idealized versions of the way things are done can enter a discourse about practice. After Wenger (1990), I suggest that the ownership of meanings that accompany any technology rest with the subjects and circumstances that produce it. In this case, the design report originates separately from the circumstances where it is used by these students. But they are presented as representing the way things are done.

Introducing technologies of doing isn't altogether a problem for any practice that is renewing itself; it is common enough for practitioners to appropriate and use technologies that originate outside their practices. A practitioner might say "Oh, that's the way YOU do it, here let me try." All one has to do is take a look at the introduction of new technologies into any community be it an indigenous one, (Stairs 1994; Pacey 1984) or an industrial site (Noble 1995). There is much evidence of communities both renewing themselves, and being constrained by, technologies in various forms. In such circumstances, there is always potential for complexity in the form of any technology of doing to be reduced to a prescription for the way things are done and accordingly, what it is to know. Thus, how the content in any technology of doing is organized becomes problematic for both sustaining and reformulating practice. This is especially a problem when such designs are held up to be models for the ways things should be done and then used to organise practical learning for students.

There are, however, other ways of understanding the design report as a learning resource. As my analysis of the design report unfolded I became less comfortable with the notion that it was meaningless for learning. With the aid of time, and hindsight, I can speculate about the social engagements of these students in the context of what other researchers have to say about similar circumstances. In both my initial and subsequent thinking well into this project, I had thought of assignments like the design report as suspect from a learning perspective. In their research on workplace learning, Brown and Duguid (1996) describe how people manage to supercede didactic instruction at the same time as learning rich, complex work skills.

Brown and Duguid's work has been concentrated on workplace learning, where they find that what is taught is not necessarily what workers learn. Although they acknowledge significant differences between workplaces and classrooms, their work suggests that there are overlooked commonalities that situated approaches to inquiry in their work sites illuminate for classrooms. They use an appropriation metaphor in describing how learning is made possible and how knowledge comes to be "stolen" within work communities. Through "acts of sense-making" (p. 49) stolen knowledge emerges as players actively assimilate and appropriate the events, circumstances, and interactions of the workplace. They cite Rabindrath Tagore (1989) as a way of illustrating their point:

> A very great musician came and stayed in [our] house. He made one big mistake...[he] determined to teach me music, and consequently no learning took place. Nevertheless, I did casually pick up from him a certain amount of stolen knowledge (p. 45).

The "certain amount of stolen knowledge" was appropriated as Tagore watched and listened to the great musician interacting and playing for others outside the immediate context of their classes together. Tagore's engagement--somewhat vicariously--with the social practices of musicianship within and beyond the "teaching" enabled his learning. Brown and Duguid use the ideas of assimilation and appropriation in describing the dialectical nature of learning experiences. This resonates with Wenger's (1998) thesis outlining four dimensions of educational design. Wenger describes one dimension between the designed and the emergent--between teaching and learning--as something more robust than simple cause and effect. He describes the interaction between the two as an interplay where each serves as a resource for the other, where teaching acts as an object around which learning may organize itself.

The source of Tagore's stolen knowledge is organized around the teaching of music but not necessarily directly connected to it. Knowledge is "stolen" when explicit aspects of distributed practice are appropriated or "owned". In the same vein, I have come to see that the relevance of the design report for learning, is that as an explicit design for learning, it carries with it certain implicit understandings that may remain invisible. Franklin (1999) also refers to relations between explicit and implicit aspects of learning. Franklin tells us that most implicit learning occurs "by the way" as groups work together developing "social understandings, coping skills, ranging from listening, tolerance, and cooperation to trust, or anger management" (p. 170). The implicit value of the Design Report may be in its systematic attention as a device for reflecting on practice rather than its worth identifying some explicit features of design.

Wenger (1998) makes a similar argument suggesting that instruction does not cause learning directly. Rather, it contributes to the creation of contexts where it's possible for learning to take place. He says that there is an indirect relation between teaching and learning; that what is taught may or may not be what is learned. This follows the line of thinking in his earlier collaboration with Lave (Lave and Wenger, 1991) and Lave's earlier work (1988). Wenger (1998) says that, "to the extent that teaching and learning are linked in practice, the linkage is one not of cause and effect but of resources and negotiation" (p. 266).

Wenger also sheds some light on the problematic nature of attempting to cover all of the details of practice in a particular educational design. Likewise, Brown and Duguid suggest that the need exists for knowledge in practice to be "stolen" because its nature is not all explicit but implicit as well. This accords with the view that it is just not possible to list, reduce, and otherwise break down all the complex ways of acting and doing things. Rather, "stealing" knowledge becomes an issue of access to, and negotiation of, available resources. This includes resources that are both explicit and implicit in terms of their significance for learning. The requirements of the Design Report are exhibited by these students but there is little suggesting that there is any emergent understanding connected to its use as a learning resource. It could be that practical negotiation of the Design Report means compliance at the expense of an emergent understanding in practice. While giving the appearance of learning in practice, it may be something different.

Negotiating a division of labour with Ross

In the Ross conversation, we follow two aspects of classroom practice within a division of labour and use them as objects of analysis in speculating about the forms of his social engagement. In the Electric car classroom both the initial assignment of individual responsibilities and the unilateral decision making by

Lassitter can be construed as denying peripheral access to participation. But in practice, Ross and the others ignore the assigned responsibilities and instead work collaboratively. In appropriating this aspect of the work process assigned to them, Ross takes practice and re-presents it in his own terms. Instead of a practice mediated entirely through Lassitter's participation as the instructor, we have one mediated also through co-participation among students. As Hanks (1991) suggests in the introduction to Lave and Wenger, "the differences of perspective among the co-participants mediates learning between them" (p.15). We saw hints of this in my accounts of the drive-train reconstruction as well. The way things are done in puzzling through that reconstruction are characterised by mutually modifying relations between students, their teacher and various material aspects of practice. Thus, the initial assignment and subsequent appropriation by Ross and the others can easily be construed as ways in which Ross "exhibits" the influences of particular ways of doing things in this case, an assigned division of responsibility, and then "generates" a new, emergent, transformed practice.

The second aspect of the division of labour--the decision making by Lassitter--also provides an opportunity in expanding on how Ross responds and appropriates the division of labour for his own purposes. Instead of accepting Lassitter's assigned tasks, Ross and others generate a locally "designed" division of labour. I consider that one could view the decision making by Lassitter in different ways. It can be seen as a way in which Lassitter denies Ross access to participation or it can be construed as providing a necessary "observational outlook" for him to peruse and survey practice.

I speculated earlier that the front-end decision making by Lassitter has the appearance of didactic instructional practice rather than one mediated in-situ by students. The question I now ask is, what manner of participation? Does that didactic instruction provide a periphery for perusing practice? Or, a premature exposure to core production processes? What about the Design and Technology classroom early in the semester? Although the early Design and Technology classroom exercises have the appearance of providing access to a peripheral participation by constructing models and prototypes, I now see that it exists in a distinct and different kind of community, an instructional one.

However, given Wenger's (1998) comments about relations between the designed and the emergent and the indirectness of relations between teaching and learning, it is possible that the preliminary work in the Design and Technology class may create subsequent contexts for learning. The following incident about the Front End assembly is a subtle one and common enough in most classrooms. Its significance had not occurred to me until I began to understand the importance of increasing participation as a way of understanding how students like Ross appropriate and own the circumstances of their experience.

The assembly of bearings in a bicycle frame where the handlebars and front forks meet--the head set--is a somewhat complicated arrangement, and a rusty one at that. Taking one apart is something new for Ross, but he does so the same night he welds the front-end to the frame; kind of like homework. He returns with it the next day, wire-brushed, clean, and ready to be put back together. But he does not know how to reassemble it. So he asks and I help him put it together, which we do while Dan stands by watching. I show him how to tighten the headset so the bearings will remain free to move. Although Ross suggests that *Lassitter did all the decision making,* he continues appropriating many of the subsequent circumstances, using them for his own purposes. While Lassitter's decision making may appear initially as an impediment to a peripheral and increasing participation for Ross, it can be construed differently when seen as part of his broader and ongoing participation.

The same observation about increasing participation may apply to the preliminary work in the Design and Technology classroom. As explicit practice, it holds some potential for providing access to implicit learning resources latent in the social periphery of the overall practice of car building. As a researcher interested in the social engagement of students in classrooms, the presence of a rich social and material periphery may be a more relevant indicator of enhanced access rather than unwarranted assumptions about the qualities attached to the effects of a particular activity. In order to become useful as learning resources, activities require a cultural home. This is to say that when processes are used in the context of their social and historical locations as practice, then they are situated in a cultural home. When practices originate extra-locally, they require a negotiation.

There is a sense of negotiation in how Ross acts. Wenger (1990) suggests that negotiatedness is a process that arises as situations and knowing are created within contexts of activity. Situations and knowing are not separate entities where one is applied to the other. Ross' appropriation of the division of labour goes against the grain of rule-based theories of learning that link condition and action as cause and effect: what initially has the appearance of a lack of access when viewed through rule-based theories of learning becomes something else when viewed as an act of appropriation. Wenger tells us that "The person is part of the situation to be resolved and the process is one of constructing within the situation a vantage point that transforms it into its resolution" (p. 112). Ross takes the decision making by Lassitter further than any perceived limitation it seems to pose. What makes this incident interesting is that it represents an increasing participation for Ross, one that shows an increasing movement beyond participating in observational and other peripheral ways. In the end, Ross generates his own homework project through which he constructs within the situation, a way of acting and responding to the requirements of working practice.

Ross exhibits the historically developing nature of practice through his use and appropriation of technologies of doing such as these two aspects of a division of labour. A fundamental tenet of situated learning is that mastery and knowing resides in the organization and social relations of a particular community of practice rather than solely in the heads of individuals or the sole experience of a master or teacher (Lave & Wenger 1991, p. 94). In the instances raised through these observations and my conversations with Ross, some aspects of a division of labour are transformed into other subjective forms. An emergent division of labour is negotiated and situated in new historical moments. This reveals the capacities of students like Ross to both exhibit and generate the social practices of classroom life. This interpenetrating dynamic is referred to here as practical negotiation.

<u>Negotiating stock phrases with Dan</u>

I use Dan's talk about his actions for conceptualizing knowing as a practice distributed between him and others. I suggest that the resources contributing to distributed practice exist in an interplay of historically constituted social relations. Engeström (1993) describes this interplay as "continuous construction" (p. 67) where we not only obey rules, but we reformulate them, where we use instruments and renew them. We witness something of Dan's reformulation and use of the assigned division of labour with Ross. In an examination of his use of "stock phrases", I outline how his talk at first appears contradictory, and how it seems to be at odds with his descriptions of *group effort*. However, when viewed as an interplay between exhibiting talk introduced into the practice from elsewhere on the one hand, and generating emergent talk and understanding on the other, we gain some idea of what it means for him to own his experience. This ownership is a conscious appropriation of talk originating in a cultural home removed from this classroom and his experience.

Lave and Wenger's (1991) notion of continuity-displacement contradiction as a necessary contradiction provides a way for understanding the interpenetrating dynamic between exhibiting "stock phrase" and generating an emergent understanding of them. Lave and Wenger (1991) suggest this dynamic is foundational to learning in practice. Earlier in this analysis, I characterize the interplay between practices originating in different places as a struggle for ownership of meaning. This occurs when authoritative interpretations that accompany designs, proceduralizations, prescriptions by process, or any situated representation are transported into a community of practice. Dan's use and reformulation of "stock phrases" in his conversation with me shows something of an emerging ownership of the meanings associated with his experience.

Wenger (1998) also tells us that access to new forms of identification and negotiability emerge as important considerations for coming to own one's experience or for appropriating meaning that originates elsewhere. This is the problem associated with technologies originating in other cultural homes or with pedagogic structuring removed from, rather than peripheral to, an emergent cultural home. Wenger suggests that when a practice is "stripped of its social complexity", there is "little material with which to fashion identities that are locally differentiated and broadly connected" (p. 269). So, issues of access not only relate to opportunities for negotiating these dynamics, but also for dealing with designs which have been "stripped of their complexity" as social practices generated elsewhere. These issues remain the enduring challenge of negotiating practice in this Electric car classroom. And by extension, I would venture to speculate that the same dynamics might be found in other settings as well.

Practical negotiation: Appropriating and owning one's experience

In political terms, school math, the design report, the division of labour, and stock phrases provide ways for the playing out of power relations (Franklin 1999, p. 16; Wenger 1990, p. 100). I suggest earlier that a relevant question under such circumstances is who gets to "own" a particular design or technology of doing. How students own their own experience within distributed practice is a measure of their access to an increasing participation and understanding in practice. If we conceptualize knowing as social engagement in changing processes of activity–knowledgeability--as we see here in the Electric car, this suggests that access to those resources remains an important issue. Although their research is not about the social engagements of students directly, Franklin, Wenger, and

Engeström have provided me useful ways for thinking about Ross and Dan's social engagement as a form of negotiation.

Through the research of Franklin, Lave, Wenger, and Engeström, I have begun seeing that the technologies of doing that work their way into the ways things are done are social and material practices. This helps me understand how the contributing resources to distributed practice can be mutually constituting rather than existing separately as technologies, or co-participation, or the various requirements of working practice, as social practices all are constituted in relation to knowing subjects. The importance of these theoretical resources for my analysis is twofold. First, they demonstrate ways of making connections between broader influences and local talk and action without reducing one to the other. Second, they provide a way of thinking about contradictions as both a product of social engagement as well as a means of negotiation. This is the gist of a social and cultural practice view of learning I call practical negotiation. Ross and Dan show us how they not only exhibit some of the features of institutional life, but generate them as well.

Appropriation or owning one's experience in practice has something to do with the extent that students like Boz, Ross, and Dan are able to not only use, but eventually understand, something of the broader significance of what they are doing. Lave and Wenger refer to "the transparency of the socio-cultural organization of practice"

(p. 91) in describing how people make visible the significance of various technologies. Franklin (1999) tells us that gaining control is especially difficult when processes are prescribed, because control of the process rests in the hands of the people usually in other locations who design the procedures. I characterize coming to own ones experience as a struggle for the control of meanings associated with developing competence in a practice.

Putting together all of the above, this inquiry is about the ways in which students become socially and culturally capable of through processes of negotiation. They create an emergent sense of self in practice by appropriating and otherwise owning various technologies of doing such as school math, the design report, a division of labour, and stock phrases and many others beyond what has been examined here. The talk, action and sense making of these students help us understand that technologies and their use in practice provide us with a realm through which we can discuss issues related to understanding, and thus, the organization of coming to "know".

The actions and sense making of these students help us to see that knowing is a flexible process of participation in a social and material world. Access to increasing participation means access to knowing, because learning resources within a distributed practice, whether in an occupation or a classroom, are a social and cultural organization for enabling or denying access in practice. We examined some of these contributing resources throughout this inquiry, principally what I have called technologies of doing. They import ways of doing things into this classroom that are problematic because they also bring with them authoritative meanings from elsewhere. This becomes contested territory that students negotiate. Their negotiation is a way in which they come to appropriate and own their experience in what I call their own cultural home. In all this, I portray learning as very much a product of social practice exhibited and generated by these students. I address this learning as a matter of negotiation by knowing subjects without reducing one to the other. Distributed practice is about the interplay between complex social relations, technologically constituted. Coming to understand, negotiate, and own them becomes in effect, both the object and the means of their practical negotiation. These activities are at the heart of the claim in this dissertation.

Matters arising

Learning happens

At the outset I problematize the notion of "learning by doing" as a general way in which progressive practice in schools is thought to occur. Then, I focus on the Electric car classroom and how some students experience and make sense of it. I focus relatively little on how pedagogy is theorized. This reflects the premise that learning "happens", no matter what pedagogic form provides the learning context. We know this from the early work of Suchman (1988) and later by situated learning researchers like Lave and Wenger (1991) as well as Brown and Duguid (1996).

This inquiry illustrates their claim in a classroom: what Ross, Boz, and Dan learn to varying degrees are the rudiments of negotiating the institutional and organizational arrangements of which pedagogy plays only one part. They respond actively to the conditions and circumstances of their classroom, rather than directly to conditions set down externally. The conditions of social practice provide part of the "design" for getting done what gets done.

The thesis examines some learning by doing practices that provide as well as deny access to continuing participation and understanding. We find that sometimes, learning by not doing was also relevant. I surmise that access may have less to do with specific practices than it does with opportunities for ownership and appropriation in what I have been calling a cultural home. To be amenable to learning, any practice needs a rich social periphery so that learners may situate themselves, and how things get done, in the context of the broader social practice of which they seek to become a part. For pedagogues, this suggests many questions including; Are there alternatives to premature participation in core production processes? Can learners be supported in moving to the social periphery where practice may be observed and experienced for extended periods of time? Does movement to the periphery sequester or marginalize students there? Can students experience an appropriate level of "neglect" by teachers so that learning may be mediated by differences in perspective among co-participants?

One of my central analytic foci is the notion of technologies and their presence constituting classroom life. Conceptualized simply as modes of practice and the way things are done, they have become a way for examining classroom life from the perspective of learners and learning. While doing so, I have expanded common use of the term technology to include more than objects, to understanding in the form of processes, how we think and what we know. Thinking of technology as understanding in many forms has been a way of connecting knowledge to experience. This provides a way for seeing through them to their social construction, rather than as naturally occurring or without the "social mortgages" (Franklin, 1999, p. 17) associated with their use. Questions arising from the recognition of the technologically constituted nature of social relations in this classroom concern the social infrastructures at work including: do the technologies-in-use provide access to an increasing participation? Are there opportunities for situating, appropriating, and owning technologies of practice in their new cultural home? Can technology teachers use this negotiated interplay to enhance the mediation between individual knowing and knowing situated in the culture at large in craft standards, procedures, canons, maxims, rules, etcetera?

This inquiry also marries in practice, two somewhat disparate but not totally incompatible theoretical traditions. The first is activity theory conceptualized in societal and institutional dimensions, the other, phenomenology, more in temporal terms concerning issues of being and meaning making. I bring the former into the analysis with an emphasis on the historically constituted nature of practical activity. I use the second through an attention to technologies as the ways in which things are done. Both come together in my conceptualization of this classroom as contested territory negotiated by students as they alternately exhibit and generate reality, a reality that includes defining who they are in relation to the subject matter of technology education. One implication of this view of learning is that the boundary between context and players is blurred collapsed by the theory. This creates an important beginning point for further research into how knowing-in-practice becomes a design for living and a way of producing the self and the broader world of which we are a part.

This last point of course, concerns identity and its formation. This inquiry has stopped short of fully exploring issues related to the formation of the self as it relates to these students and their learning trajectories through what is a small part of their schooling. It does, however, provide a research platform outlining some of the underlying social processes, relations, and organization common to classrooms and the lived experience of students in them which provide clues to further investigation.

Learning with both hands

As a part time canoe builder, I'm surprised by the difficulty many people have in understanding the idea that most canoes are built around a form. This isn't generally a problem when thinking about the use of fibreglass and similar materials that look and feel like plastic. Most of us are familiar with the idea of taking a mold and applying plaster to it so the idea of doing the same with a fibreglass or plastic canoe isn't difficult. Wooden canoes however, are another matter. When I mention that the cedar canvas canoes I like to build are built on a "form", people get this puzzled look on their faces and ask for an explanation. I then describe the form as being the shape of a canoe only much sturdier. The ribs and planks are bent over the form and left to dry after which it is lifted off the form, the ends are closed in, seats, thwarts and decks are added and it is ready for canvassing. The usual response is something like "So that's the way you do it" and that is the end of it.

I suspect that it is hard for people to get around the idea that not only is it possible to bend wood but, we are conditioned to think of what is possible because of our greater familiarity with contemporary materials like fibreglass. Although we may know what a cedar canvas canoe looks like, "seeing through" the complexity of building one is hard to do. This inquiry has been something like canoe building.

I began all this by revealing some of my assumptions regarding the centrality of "learning with both hands"" and my interests in how students in classrooms come to understand themselves and the world. I also began with the idea that appearances of students in classrooms can be deceiving. I introduced the idea of "seeing through" the complex ways that things are done at the beginning, and it has remained a tacit organizing idea throughout. In many respects, my main goal has been exposing something of the workings of the socio-cultural order of this classroom through a collaborative sense making effort between the students there and myself. It has been an interpretive descent into the centrality of "learning with both hands", discovering along the way that there is something more to the way things are done.

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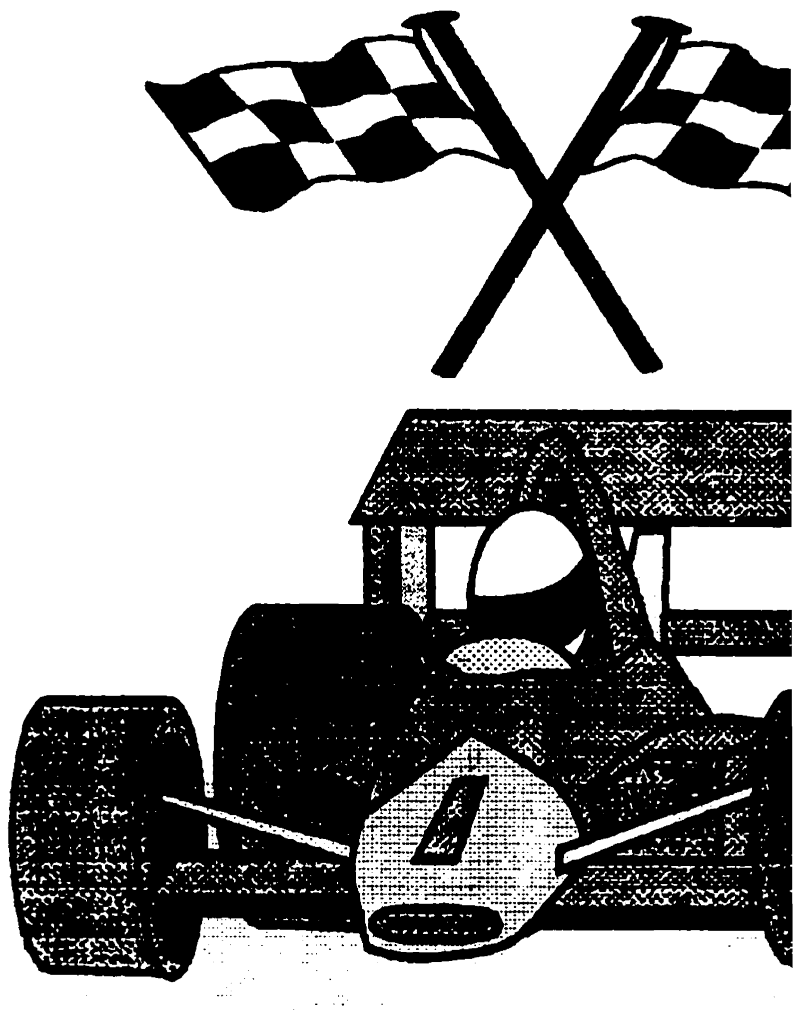
C.CT

ELECTRIC REPORT



TECH

Outstanding

BY: D[redacted]

&

[redacted]

AF	40/40
GOP	5/5
Dwg	20/22
Circ	5
Drill	1/3
	72/80

CAR DESIGN EVALUATIONS

Fundraising:

successes:-We sold tickets for a raffle at a dollar a piece for 3 $50 gift certificates donated from Canadian tire.
-We were able to raise $210 with the tickets over 6 days.

weaknesses:-The raffle should have been started earlier so that there was more time to raise money.
-The design of the ticket did not give a space in which to record the phone numbers of the ticket purchasers.
-More publicity would have made it easier and more successful in raising money.
-In addition to the raffle, more ways of raising money should have been used to increase the money made as well as how quickly the money was raised.

design:-To raise enough money to pay for the hotel room in Kingston so that less money would have to come out of our own pockets.

improvements:-The raffle tickets could be made and distributed sooner so that there would be more time to sell them.
-We should make more publicity for the car as well as sell the tickets at stores.
-We should alter the design of the raffle tickets to create room to record the phone numbers of the buyers.

Car Criticism

Design: To evaluate the car and find flaws in it so changes could be made or the design could be modified.

Successes: In the limited time we had from when the car was finished to the race it was done to the best of their abilities.

Weaknesses: Our abilities to detect problems weren't that great so they missed things and they didn't have that much time to look at the car.

Improvements: We could have practice to improve our abilities and had the car done earlier to give them more time to look at it.

Construction

Design: The design of this was to build a car that would last thelongest on one car battery and that would be practical to use.

Successes: Our car was very successful For what we built it for. It lasted the longest by far in the race and was the fastest too. We also had cargo space so it could be used for practical uses. The frame held up very well and the steering worked well too. Also our brakes worked excellently.

Weaknesses: Most of the weaknesses of our car are minor and not too important but there is one major problem. When power is applied the car does a 'wheelie' which is dangerous. Also the drive wheel was too weak and folded over after only a short time because there was too much torque. We didn't add any safety features to the car which was not very practical. Another thing that was more for luxury than anything else was a body to keep out of the rain, wind, etc.

Improvements: Some improvements that could have been made would be adding a frame for comfort so it isn't just a fair weather vehicle. We should have had a gradu ated increase of speed with either two buttons with different speeds or a tension gear. This would solve the problem of the 'wheelie'. We could have made it a two wheel drive which would spread the torque out and maybe stronger wheels wouldn't be needed.

Sponsorship:

successes:-We were sponsored by [redacted], [redacted], and [redacted]. These sponsors gave us access to spare parts and the ability to change our minds to a certain extent of the design of the car.

weaknesses:-More sponsors would have been helpful.

design:-To give us access to the parts necessary to complete the car as well as the ability to change our minds.

improvements:-We could obtain more sponsors.

Technical Support:

successes:-We formed a pit crew which stayed after school for several weeks to construct the car.

-We created the car to the best of our ability with the amount of time given.

weaknesses:-There were few people involved in the actual construction of the vehicle so only 1 to 2 jobs could be done at a time slowing the production process.

[redacted]

design:-To create the car both as quickly and efficiently as possible.

improvements:-A larger construction team may be able to build the car faster so that it would be created with time to spare leaving more time to be spent on the looks.

Construction:

successes:-The vehicle was constructed on time and held together afterwards.
-The motor had more than enough power to propel the car forward.

weaknesses:-The tires were very weak and tended to warp on the corners.
-The motor did not accelerate, it jumped immediately to full speed,this proved to be very stressful on the tires as well as to powerful for a static start. On a static start the car jumped out of control.
-The car was not completed until the last second so little time was able to be spent on the car's looks.
-The car had no special safety features.

design:-To create the most efficient car possible for an endurance race.
(3 view drawing of frame shown on diagram A.)
(Drive wheel circuit on diagram D)

improvements:-We could give the car an "shell" or outer body because in the marking of the car many marks were awarded for the appearances of the cars.
-Search for a way to have the car accelerate so that it does not kick into full speed.
-Stronger wheels should be used to reduce warping.

Education Elements:

successes:-We learned how to use various tools/machines.
(eg. welders, plasma cutters, etc.)
-We definitely learned **patience!**
-We learned how to work as a team to solve problems by looking them over and reasoning them out.
(giving suggestions, listening to other opinions etc.)
-The importance of planning out what you are going to do *before* you do it.

weaknesses:-There was little time to create the car so maximum time was not able to be spent on exploring and looking over how everything on the car works and is put together.
-Some of the time was spent fooling around so little progress was ever made at these times.

design:-This was designed to give the students a better understanding of the design process and also to provide hands on experience of how the design is followed through.

improvements:-The project could be started earlier and more time could be focused on the car.

√

Communication:

successes:-Every one in the group contributed ideas for the car and most were given careful consideration.

weaknesses:-Not all of the ideas which were given were thoroughly looked over.

design:-To allow all the students to look over all the problems and think of ways to overcome them working with others by both giving and taking suggestions.

improvements:-All given suggestions should be thoroughly looked over so that the problem can be faced from any different angles.

Spare Parts

successes:-We had a spare motor, tire tubes, break cable, wires, battery, and axle.

-We had access to other spare parts from [redacted], [redacted]n, and [redacted]a.

weaknesses:-We had no way of replacing the drive wheel had it broken and there were no other spare parts than listed above.

design:- To allow us to replace any heavily damaged or destroyed parts.

improvements:-We could get more spare parts so other parts of the car may be replaced.

Testing:

successes:-We made it twice around the school track.
-The car held together.

weaknesses:-The chain came off the gears.
-We burned out the motor on the first lap.
-The brake lights were not hooked up.
-There was not enough power on the first motor to start the car going from a dead stop. This design was dropped (circuit on diagram B) and a new one for the larger motor was used (circuit on diagram C).
-More speed was needed.

design:-To ensure that the car would work and look for any problems with the car which we could fix.
-To demonstrate to the contributors to the raffle how the car looks and works.

improvements:-We should wait until the scheduled test time to test the car.
-We should be more prepared for the test demonstration. (finish car sooner.)

Car Criticism:

successes:-We criticized the car to the best of our ability.

weaknesses:-We do not have the design knowledge needed to properly .evaluate the car.

design:-To find strengths and weaknesses in the car so that we are able to search for ways to improve it.

improvements:-we could obtain a better understanding of design so that a more complete and thorough evaluation may be done.

By:[redacted]
& [redacted]