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A STUDY OF CRITICAL THINKING AND ADAPTATION TO TECHNOLOGY

by

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Abstract

A STUDY OF CRITICAL THINKING AND ADAPTATION TO TECHNOLOGY

by

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Adaptation to a new technology is described among workers in two public transportation facilities in a working-class suburban borough of a metropolitan city in the U.S. The process is conceptualized as critical thinking (CT) within activity systems, as the workers dialectically engage with the socio-cultural and technological context. An association is found between CT and adaptive computer use.

Data on workers' (n=125) use of a database of bus maintenance activities were obtained from the computer system. Adaptive use was operationalized as broad use of affordances within the system. The workers widely utilized the options within the system, but the range of usage declined over five months, indicating that the range of affordances used by the group narrowed over time. Great variability across individuals was observed in use of the system with many workers showing patterns opposite to the declining trend.

Questionnaires (n=40) assessing attitudes towards the computer system and the workplace indicated cautiousness and skepticism, as well as optimism toward the new

system. Factor analysis yielded four attitude factors, three of which were associated with adaptive computer use outcomes.

Indicators of CT were examined in interviews (n=18) during early implementation of the system. The coded segment consisted of dialogue about four dilemmas: two about the new system, one about bus maintenance, and one hypothetical moral dilemma. The workers' responses were counterprobed following a modified Piagetian clinical interview method. A coding was developed for seven elements of CT: Identification of assumption, Negation, Contradiction, Reinterpretation, New Solution, Evaluation, and Metacognition. An average of 1.75 elements per utterance were found in the 1,249 coded utterances. Factor analysis revealed a highly intercorrelated cluster of the first five elements. The hypothetical dilemma elicited higher rates of selected CT elements than the other dilemmas.

The hypothesized relationship between CT and adaptive computer use was supported by the results showing that high levels of four of the seven elements, as well as scores based on combinations of elements, are associated with sustained adaptive computer use. This finding is interpreted as evidence of a dialectic process of adaptation where an initial critical engagement leads to an adaptive outcome.

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Chapter 1: Introduction and Literature Review

Development is often a dialectic process where struggle leads to adaptation. This study will document one such process observed among a group of blue-collar workers facing the arrival of a new computer technology to their workplace. Many theoretical concepts, including critical thinking, activity, discourse, context, dialectic, and adaptation. will be invoked to frame the observed phenomenon, which, in turn, will test the utility of such theoretical constructs in explaining the reality. The observations collected to illustrate the workers' struggle with the new computer system consist of field notes, interviews, questionnaires, and computer files. The goal is to identify indicators of "critical thinking" in the data and, following the idea of a dialectic process, to show that critical thinking is associated with adaptive computer use patterns.

People's adaptation to new technologies is an opportunity to study a process of development in an activity context, where individuals engage in thinking, talking, and acting in a concrete physical and social setting where they face a challenge to existing cognitive and socio-cultural organization. Such activity contexts consist of dialectic relations between acting persons, personally experienced settings, and culturally, politically, and socially defined arenas (Lave, 1988). Activity theory framework (Leont'ev, 1974; 1986; Kozulin, 1986) places goal-directed activity in real-life settings where physical, historical, semiotic, cultural, and social surroundings enable or constrain thinking, speech, and action. Many researchers have found this framework useful for analyzing activities in technological contexts (Nardi, 1996).

By bringing in the notion of critical thinking this study seeks to identify moments of diversion from socio-cultural determinism among individuals who engage in dialectic with the socio-cultural context. Among theories of adult development, "liberative" models, which emphasize adults' ability to challenge existing frameworks and expectations and to create culture in addition to being shaped by it, can be distinguished from ontogenic and sociogenic models (Levenson & Crumpler, 1996). Bakhtin's (1986) analysis of the relationship between an individual speaker with a voice and a socio-culturally determined language suggests that discourse can be analyzed to study the dynamics between an individual agency and the socio-cultural context.

One objective of this study is to expand the traditional cognitivist definition of critical thinking which best applies to academic contexts. Language and thought among people with limited formal education has been characterized as particularistic, contextual, local, and metaphorical (Bernstein, 1972), and as containing contextualized common-sense wisdom (Geertz, 1983). Building on existing definitions, the following expanded definition of critical thinking was formulated during the proposal phase of this study:

Forms of thought, discourse, and activity which, in a given context, attempt to:

1) identify and question assumptions,
2) resist, contradict, challenge, and negate existing ideas, arguments, and activities,
3) evaluate the quality of ideas, arguments, and activities of others and one's own, and
4) as a result create novel ideas, arguments, and activities.

As computer technologies are becoming an integrated part of the everyday life of an increasing number of people, social science researchers are challenged to incorporate the role of technology into their paradigms of human behavior and social organization

(Menser & Aronowitz, 1996). When information becomes a highly valued commodity, people's work will increasingly involve information management, even for many workers who have been traditionally perceived exclusively as manipulators of physical objects. The fusion of workers' knowledge of their work with new information technologies exposes old assumptions, requires new solutions, and initiates processes of critical thinking in the workplace (Marsick, 1990). Several observers of contemporary society have identified technological change to be one of the most important topics of critical thinking (Landow, 1997; Feenberg, 1991; Marsick, 1990; Gadzella, Hartsoe, & Harper, 1989).

Dialectic of Adaptation

The term adaptation is applied here to describe a process of development in adults who encounter a new technology. In *Psychology of Intelligence* Piaget (1947/1981) characterized intelligence as adaptation, and defined adaptation as "an equilibrium between the action of the organism on the environment and vice versa (p 7)". This study conceptualizes adaptation as a non-linear dialectic process within activity systems.

The concept of *dialectics* encompasses a non-linear developmental process that involves contradictions and negations as an integral part of the whole. Hegel developed his idea of dialectics based on different elements of ancient philosophy, including the Platonic and Socratic dialogues, and Heraclitus's idea that everything moves (Gadamer, 1976). The concept of dialectics essentially involves movement, interaction, contradiction, self-contradiction, qualitative change, and emergence. Many developmental psychologists, have applied the notion of dialectics in their theories (e.g. Lawler, 1975; Riegel, 1975; Basseches, 1984; Piaget, 1947/1981). A fundamental theoretical question that motivated the design of this study is the underlying dialectic between individual agency and social constructionism.

Lave (1988) discusses the central role of dialectics in understanding the relationship between persons, activity and context. She sees cognition as a dialectic between persons acting and activity settings. Dialectical analysis, according to Lave, can avoid environmental determinism. "Conceived in dialectical terms, central aspects of activity include its self-generative and open character, whose structuring grows (dialectically) out of conflict." (p145) Contradiction and conflict have crucial roles in analysis of activity, social practice, and social order. Instead of claiming that the person and the setting are in contradiction, she says that arenas of activity involve contradictions of political economy and socio-cultural structuring. If activity is seen as dialectically constituted it becomes unpredictable, because social practice can be reproduced, transformed, or changed.

The idea of dialectics has also been criticized (Foucault, 1972; Latour, 1996a, Merleau-Ponty, 1973). Foucault warns against a formalistic use of dialectics:

> "Dialectic is a way of evading the always open and hazardous reality of conflict by reducing it to a Hegelian skeleton, and 'semiology' is a way of avoiding its violent, bloody, and lethal character by reducing it to the calm Platonic form of language and dialogue" (p114-115)

Activity in Context

Context literally means "in text", and like a word gains its meaning from the surrounding text, a person engaging in discourse and activity will look meaningful only when situated in a particular context. Lave (1988) in her studies of cognition in everyday contexts, provides a further analysis of what context means. She differentiates between arena and setting as different aspects of context, and treats setting as a repeatedly experienced, personally ordered and edited version of the arena. In her example of grocery shopping, the setting is generated out of a person's grocery shopping activity, and at the same time, the setting generates that activity. Activity is dialectically constituted in relation with the setting. Arenas, like the supermarket, are realizations of dialectical relations among semiotic systems, social structure, and political economy. According to Lave, context is not a list of environmental components, nor an intersubjective construction, nor a knowledge structure, nor a realization of political economy, but it is a relation between acting persons, settings, and arenas.

Lave (1988) emphasizes that conflict is the source of dilemmas and that a problem solver in a real context is emotionally engaged in the solution of a dilemma. Processes of resolving dilemmas are correspondingly removed from their assumed universalistic, normative, decontextualized nature. Menser and Aronowitz (1996) suggest that technology is perhaps "the most effective category for problematizing culture". A new computer system is a technological arena that elicits various conflicts in terms of semiotic systems, social structure, and political economy. Each user of the system generates a personal setting of computer use activity.

The ideas of activity theory first emerged among psychologists in the Soviet Union (Leont'ev, 1974; 1986; Kozulin, 1986). Activity as the unit of analysis demands attention to what people (subjects) do in concrete settings, what seem to be their goals (objects), and how their physical, historical, semiotic, cultural, and social surroundings enable or constrain them. The unit of activity can be contrasted with stimulus-response behaviorism, as well as with mentalistic, decontextualized, universal units (e.g. cognition, intelligence, memory, mind) which populate Western psychological analyses. Leont'ev

(1974) describes activity as a structure directed towards a *motive* (or an *object*), and consisting of *actions* with conscious *goals* which are realized through different modes called *operations*. Engestrom (1996) depicts an activity system as a continually constructed relationship among *subject*, *object*, and *tool*. Following Vygotsky's (1962) initial conceptualization, activity theorists have problematized the definition of *unit of analysis* (Zinchenko. 1985). What counts as an *action* or a *tool* in a given case has to be carefully specified in each particular context of study.

Individual Agency in Context

For Lave (1988) a person acting in setting becomes the unit of analysis. According to her account, the thinking person is constituted in relation with other aspects of the lived-in world. Lave expresses discontent with cognitivist, normative, rule-based models of good thinking, because they conceal non-determinant aspects of everyday activity. Lave does not seem to need a mentalistic notion of a person with intentionality who consciously resists determinacy. Activity is transferred by means of active reproduction of settings, activities, and selves, and change and improvisation can be part of the process:

> "The constitutive order and everyday practice together reflect and constitute the distribution of power and interest such that, in general, reproduction of activity in setting is much more likely than its transformation or change. There are other limitations on variability as well. Resolutions to contradictions normally take a small number of culturally generated forms that are better described as partially appropriated and partially invented by persons-acting, across occasions." (p188-189)

According to Lave (1988), creative novelty, major contributions to knowledge, expertise, and other valued forms of cognition do not take place at the level of cognitive processes, but instead, they are constructed in dialectical relations of everyday practice.

Different theoretical models of change and development portray varying accounts of the individual agency. When attitude change is studied in a traditional social psychology framework, persuasion and shifts in attitudes are generally explained in terms of some external variables (e.g., source of information, group pressure), universal laws of thinking (e.g., attributional biases), or personality types (e.g., rational or intuitive style of thinking) (Potter & Wetherell. 1987). Traditional developmental models generally pay more attention to the cognitive processes within the individual than modern social psychology models. Piaget's theory, for example, depicts an individual who experiences disequilibration, equilibration, assimilation, and accommodation when encountering the environment (Chapman, 1988). Cognitive developmental theories have been criticized for being decontextualized, while socio-cultural approaches emphasize the determining role of social and cultural context. Many socio-cultural theorists propose some mechanism of cultural transmission, such as the zone of proximal development (Vygotsky, 1962), scaffolding (Bruner, 1983), or apprenticeship (Rogoff. 1990).

Bakhtin's (1986) theoretical arguments provide a helpful framework for exploring the relationship between the individual and the social and cultural-historical conditions. The individual consciousness, in Bakhtin's view, is deeply embedded and rooted in the particular socio-cultural and historical conditions. His linguistically inspired account of the individual as a speaker with a voice, presents a fundamental tension between all utterances arising from the culturally determined forms and frames, and every utterance being unique and unrepeatable.

Bakhtin (1986) lists greetings, farewells, and congratulations as examples of speech genres. If forms of utterances such as questions or assertions are considered generic forms of speech, Bakhtin's claim that genres fundamentally shape our consciousness has important implications to our conception of critical thinking. Critical questioning what one is learning may be a generic form of dialogue that is internalized from external social dialogue. It is also important to recognize the developmental dimension of generic forms of speech. According to Bakhtin, the better our command of a genre, the more we reveal our individuality in our utterances.

Discourse as Activity

Lotman (1989) draws attention to the potential of dialogue as a generator of new meaning. The processes of collaboration and struggle during communication drive the creation of meaning, and these processes can occur between individuals or within an individual. According to Lotman, "thought is dialogic in nature". Within the socio-cultural and discourse approaches to psychology, the concept of intersubjectivity, generally referring to overlapping subjectivities, is seen as the basis for communication. Matusov (1996) points out that these traditional notions of intersubjectivity overemphasize agreement over disagreement. He says that breaks in understanding do not necessarily lead to a lack of intersubjectivity, but that diversity and dispute are important for creating new meanings. According to Matusov, intersubjectivity consists of a dialectic between understanding and misunderstanding.

The views of dialogue discussed above see discourse as a site of individual agency in context. Vygotsky (1962), who is seen as the originator of activity theory, extensively discussed the unique role of language in human life, and viewed speech as a special mediator of human activity. Viewing speech as action highlights the role of language as a psychological tool for accomplishing activity goals, in contrast to seeing language primarily as an abstract system for mapping symbols to meanings (McNeill, 1985; Wertsch, et al., 1995; Resnick, et al, 1997).

The concept of discourse has become very popular in the practice of psychological theorizing and research (e.g. Potter & Wetherell, 1987; Shotter & Gergen, 1989; Harre & Gillett, 1994). Literature on rhetorics, argumentation, and persuasion (Billig & Sabucedo, 1994; Antaki, 1994; Myerson, 1994; van Eemeren & Grootendorst, 1992; Brown, 1987) provides conceptual frames for analyzing arguments in discourse. The modified clinical interview method of "counterprobing" used in the present study (Piaget, 1929/1951; Saltzstein et al, 1997) is an attempt to use particular discourse techniques as a research method.

Billig and Sabucedo (1994) discuss the postmodern revival of the ancient rhetoric tradition. According to their analysis, both science and common sense are rhetorical activities. A rhetorical analysis may be helpful in bridging forms of critical thinking found among the workers and those found in academic discourse. According to Billig and Sabucedo, thinking is based on rhetorics:

> "...the rhetorical position emphasizes the argumentative nature of thinking. It sees the ordinary thinker as a rhetorician, using rhetoric to persuade others and to argue. Thinking is not viewed as an essentially wordless process, or even as an individual one. Instead, it is a social activity, for thinking is to be found in discussions and arguments. When thinking takes place in isolation, for example, an individual deliberating upon an issue, then it resembles an internal debate, which is itself modeled upon public argumentation." (p123)

Billig and Sabucedo (1994) look for the essence of thinking in rhetorical activities like criticism and justification, and not in computations and information processing. Rhetorics are historically constructed, not universal. The post-modern consciousness can be described as a "pastiche" of commonplace moralities and scientific concepts that have entered the popular culture. Billig and Sabucedo argue that the "pastiche" ensures contradictory elements necessary for critical thinking. For example, religious arguments can provoke values embedded in science.

Adult Cognition

Levenson and Crumpler's (1996) recent overview of prominent theories of adult development categorizes different theories into three types, which they call ontogenic, sociogenic, and liberative models. The liberative models are especially interesting in terms of critical thinking, because they emphasize increasing freedom from biological (ontogenic) and social (sociogenic) determinism. Topics that can be seen as achievements from liberative perspective include: overcoming self-deception, enhanced awareness of the sources of one's own and others' behavior, increasing ability to recognize and resists social pressure, and reduction in cognitive biases. Levenson and Crumpler (1996) characterize the liberative models the following way:

> "Adult development is thus not merely a product of biology and social adaptation, but also involves individual choice and personal commitment to change. ...The liberative perspective requires that, for optimal adult development to occur, the individual must deconstruct the existing framework or at least not be constrained by expectations about how one should act or feel. ...Humans create culture, as well as being shaped by it." (p146-147)

Some theorists of cognitive development take Piaget's theory as their point of reference, and describe adult cognition as "post-logical" or "post-formal". Koplowitz (1987) does a comparison between pre-logical, logical, and post-logical forms of thinking, which all can all be included in the repertoire of an individual adult. Pre-logical thought involves such characteristics as one-step causality, emotional responses over logical analyses, and openness to manipulation by others. Logical thought considers linear causality, and generally employs abstract logical analyses. Post-logical thought, in contrast, acknowledges the possibility of cyclical causality, uses logic contextually, tolerates paradox, and considers the systemic level. Koplowitz (1987) also proposes a fourth rare form of thought he calls "unitary". In unitary thought cause and effect are seen as all-pervading, and logic is only one possible tool for communication. Most definitions and ways of measuring critical thinking are at the level of logical thought. In the framework of post-logical and unitary forms of thought it may be possible to conceptualize critical thinking based on principles other than abstract logic.

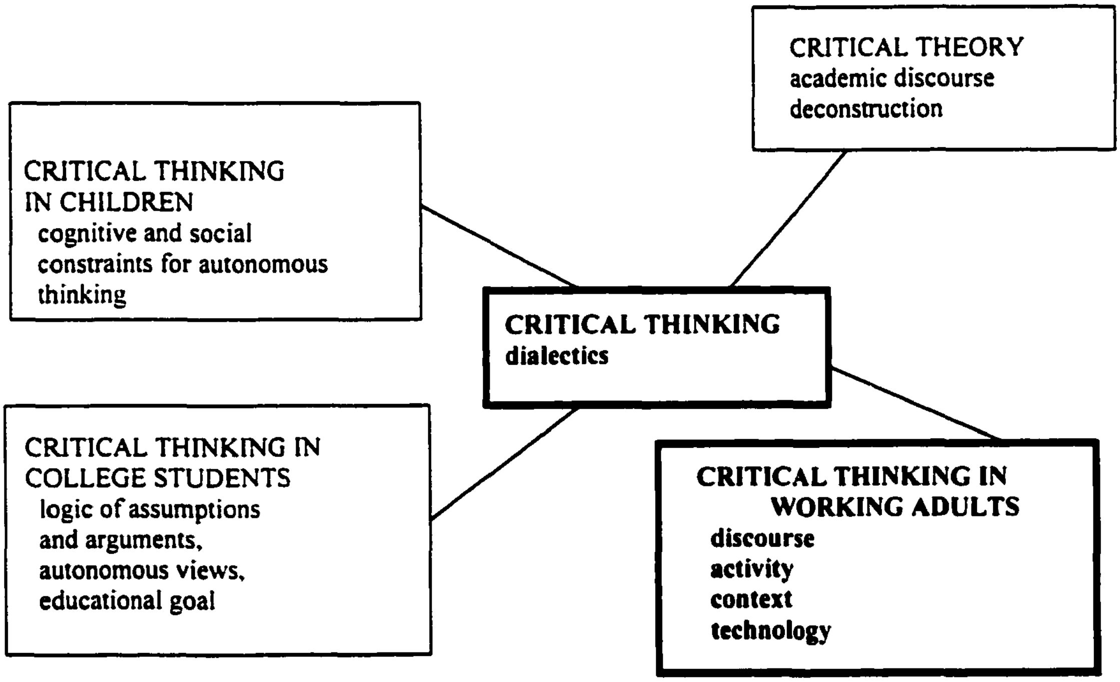
Accounts of Critical Thinking

Figure 1.1 was constructed for the proposal of this study to map and analyze developmental locations of critical thinking. Dialectics is placed in the center of the map, because most definitions of critical thinking are, at least implicitly, based on a notion of a dialectical process. The definitions found in the literature emphasize such processes as questioning, challenging, and criticizing, which essentially refer to "an informed negation" of something. Children are presented in Figure 1.1 as a separate group, because due to their cognitive immaturity, and their subordinate social position in the world, they are generally not considered capable of autonomous critical thinking (e.g., Piaget, 1932).

As shown in Figure 1.1, college students are another group of interest, because most of the research on critical thinking has been done with college student populations. Their critical thinking is generally considered a worthy topic of study, because critical thinking has been identified as one of the main goals of formal education (see e.g.

Brookfield, 1987; Shor, 1996). Critical thinking in college students has generally been operationalized as an ability to evaluate the logic of assumptions and arguments, and secondarily, as an ability to maintain autonomous views. Another location of critical thinking mapped in Figure 1.1 is the academic community. This refers to recent postmodern and critical academic theories, which reflect a pattern of dialectics and deconstruction that is also inherent in a general definition of critical thinking.

Figure 1.1. Where is critical thinking?



Several authors have encouraged research on critical thinking that is "ecologically valid" and contextually embedded (Brookfield, 1987; Mezirow,1990;1991; Basseches, 1984, Marsick, 1990). Most of the existing research views critical thinking as independent of context or domain, and treats college students as the norm for people in general. Study of critical thinking in schools does not provide the same immediacy of real problems as the study of critical thinking in the workplace. Viewing academic critical thinking abilities as "portable" from school to the world of work is an example of the more general mismatch between the agendas of school and work (Glick, 1995).

Numerous theorists and researchers have provided their own definitions of critical thinking. Most seem to agree on some core elements of the definition. Table 1.1 presents a selection of definitions of critical thinking found in the literature.

Table 1.1. A selection of definitions of critical thinking

Klaczynski, et al. (1997): "Effective critical thinking is a function of two components. First, students must possess the rudimentary competencies to perform specific cognitive operations. For example, students must have the ability to detect logical flaws in both their own reasoning and that of others. Second, students must conquer the metacognitive challenge of evaluating evidence independently from their goals and beliefs."
Kuhn (1993): "...the ability to justify what one claims to be true."
Chaffee (1988): "...our active, purposeful, and organized efforts to make sense of our world by carefully examining our thinking, and the thinking of others, in order to clarify and improve our understanding."
Brookfield (1987): "...involves calling into question the assumptions underlying our customary, habitual ways of thinking and acting and then being ready to think and act differently on the basis of this critical questioning."
Ennis (1987): "...reasonable reflective thinking that is focused on deciding what to believe or do."
Kitchener (1986): "...application of reflective judgment."
O'Neill (1985): "...the ability to distinguish bias from reason and fact from opinion."
Halpern (1984): "...thinking that is purposeful and goal directed."
Annis & Annis (1979): "...considerable overlap in the lists of suggested abilities making up critical thinking such as identifying central issues, recognizing underlying assumptions, evaluating evidence, and drawing warranted conclusions,..."
Garrett & Wulf (1978): "...the ability logically to assess whether statements are proposed correctly."
Scriven (1976): "...assumption hunting."
Hullfish & Smith (1961): "...creation, use, and testing of meaning."
Dressel & Mayhew (1954): Critical thinking processing abilities: problem solving, selecting pertinent information for solution of problems, recognizing stated and unstated assumptions, formulating and selecting relevant and promising hypotheses, drawing valid conclusions, judging the validity of inferences

Young (1980) pointed out that philosophers, psychologists, and educators each have claimed the concept of critical thinking, and emphasized different aspects of the concept. According to Young's analysis, philosophers have focused on the logical and rational foundations of thought, psychologists on the cognitive structures, and educators on appropriate curricula. Annis and Annis (1979) propose two models of research in critical thinking, the mental paradigm (unified general mental process), and the logical paradigm (composed of various specific abilities).

There are other concepts that are closely related to the general concept of critical thinking. For example, Habermas (1979) introduced the term "emancipatory learning", which can be defined as " that which frees people from personal, institutional, or environmental forces that prevent them from seeing new directions, from gaining control of their lives, their society, and their lives." In his theory of critical education, Paulo Freire (1970) talks about "conscientizacao", or "learning to perceive social, political, and economic contradictions, and to take action against the oppressive elements of reality". Basseches (1984), and Riegel (1975) use the term "dialectical thinking" which for both of them describes a form of thinking found in mature adults.

Other closely related concepts include "reflection" or "reflective thinking". According to Mezirow (1991), reflection is "the process of critically assessing the content, process, or premise(s) of our efforts to interpret and give meaning to an experience." He is one of a group of theorists who draw on Dewey's (1933) definition of reflection as "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusion to which it tends."

What is the relationship between critical thinking and intelligence? Some overlap seems to exist in common definitions of these two elusive but popular constructs, although definitions of critical thinking generally highlight only some aspects of what is typically counted as intelligence. Both intelligence and critical thinking are traditionally seen as general and decontextualized abilities, although the notion of general decontextualized intelligence has been questioned, and alternatives have been proposed (Gardner, 1983; Sternberg, 1985). Addressing the relationship between his theory of multiple intelligences and critical thinking, Gardner (1993) observes that "particular domains of human competence seem to require their own brand of critical thinking" (p44).

Measures of Critical Thinking

Some operational definitions of critical thinking are provided by currently available standardized measures. A list of sub-tests for three widely used measures illustrates how designers of the tests conceptualize critical thinking. Table 2.2 presents a summary of sub-tests for the Watson-Glaser Critical Thinking Appraisal (Watson & Glaser, 1980), the Cornell Critical Thinking Test (described in Thompson & Melancon, 1987), and the Curry Test of Critical Thinking (described in Thompson & Melancon, 1987).

The selection of sub-tests in Table 1.2 illustrates the emphasis on logical and academic features of critical thinking in the standardized measures. All the above measures are administered in written booklets that include examples of arguments and dialogues, typically on academic topics, and multiple choice measures of responses.

These measures have been found to correlate with academic achievement (e.g., Royalty, 1994; Garrett & Wulf, 1978), standardized intelligence tests (e.g. Watson & Glaser, 1980), creativity (Gadzella & Penland, 1995), and formal education in logic (Annis & Annis, 1979). They have been found to produce close to chance performance in "low ability" groups, and in populations with reading and other academic impediments (Frisby, 1992; Gadzella, Hartsoe, & Harper, 1989). Although the available standardized measures of critical thinking are clearly not appropriate for the population of working adults in the present study who generally do not have strong reading skills, and whose academic exposure consists of high school education which took place years or decades ago, some elements of these measures were adapted to the instruments and coding schemes of the present study.

Table 1.2. Summary of sub-tests in three standardized critical thinking measures

Watson-Glaser Critical Thinking Appraisal	Cornell Critical Thinking Test	Curry Test of Critical Thinking
Inference	Is simple generalization warranted	Fact and opinion
Recognition of assumptions	Is hypothesis justified	False authority
Deduction	Is reason relevant	Making an assumption
Interpretation	Reliability of authority	Inadequate data
Evaluation of arguments	Does statement follow from premises	Improper analogy
	Identification of assumptions	
	Relevance of information in deduction	

The standardized measures claim to represent a general or "domain-independent" ability of critical thinking, which, therefore, would not necessarily capture "contextualized" aspects of critical thinking which may be fundamental for critical thinking among working adults. Interestingly, the claim for generalizability of critical thinking as a "domain-independent" ability has become a subject of debate among the community of researchers who use the standardized measures (Norris, 1992). For example, when Royalty (1994) found that undergraduate class standing accounted only for .02 proportion of the variability in scores on the Cornell Critical Thinking Test, he concluded that the pursuit of specific domains during the college curriculum did not meaningfully generalize to "domain-independent" problems in the critical thinking measure.

All three standardized measures of critical thinking outlined in Table 2.2 generally attempt to capture how well the subject can evaluate the quality of arguments. Identification of assumptions, which also tends to always be central to definitions of critical thinking, appears as one core element in all three standardized measures. Two of the three tests include an aspect of evaluating authority, and one also emphasizes the differentiation between fact and opinion. Those two tests seem to acknowledge how critical thinking is embedded in authority and power relationships, and is, at least partly, a social and interpersonal phenomenon.

Various components of formal logic, such as inference, deduction, generalization, premises, analogies, and hypotheses are considered by the designers of these standardized measures to be the essence of critical thinking. Notions of relevance and appropriateness are also included as sub-components in all three standardized tests. Relevance and appropriateness can be interpreted in several different ways, including social appropriateness, linguistic and discourse appropriateness, and appropriateness to context. Relevance and appropriates introduce a context-sensitive dimension to the objective logical analyses. Most of the research on critical thinking has been conducted with the kinds of standardized tests described above. Alternative ways of measuring critical thinking have been identified, although not commonly used. For example, Ennis and Norris (1989) list the following forms of measuring critical thinking: interviews, naturalistic observations, "think aloud" paradigms, essay tests, and multiple choice tests.

One recent example of experimental approach to critical thinking as objective logical reasoning is a research by Klaczynski, Gordon, and Fauth (1997). Their dependent measure of critical thinking consisted of three types of academic-logical reasoning: law of large numbers (or relevance of sample size on conclusions), covariance reasoning (or relevance of possible third variable effects), and evaluation of validity of scientific evidence. They claim that these types of reasoning are frequently applied in everyday decisions, such as career choice. In their research, college undergraduates were asked to evaluate the quality of arguments related to their own career choices (e.g. Accountants have many family problems).

According to Klaczynski et al. (1997), critical thinking consists of cognitive operations and a metacognitive ability to evaluate arguments independently from one's own goals and beliefs. They found in their research that individuals are more likely to think critically when facing arguments that contradict their goals and beliefs, and they are less likely to think critically when facing arguments that support their goals. They explain this with a "depth of processing" model which states that deep level of processing is elicited by belief-threatening information. Belief-enhancing or belief-neutral information, on the other hand, are processed on a relatively shallow level, because they are easily assimilated to existing belief systems. Klaczynski et al. (1997) list specific metacognitive skills that are important in critical thinking because they enable independence from one's own beliefs and goals. Their list includes monitoring the flow of one's thinking, reflecting on prior thinking, maintaining alertness against inconsistency, and deciding how to allocate processing resources.

Klaczynski et al. (1997) found that intelligence (as measured by an intelligence test) did not predict the ability to reason independently of one's goals and beliefs. The verbal ability component of the intelligence test was a modest predictor of the cognitive operation component of critical thinking, but did not predict the metacognitive objectivity component. They also found that individuals who self-reported a rational information processing style (as opposed to an intuitive style) were more likely to be "objective" in their critical thinking.

Critical Thinking in Workplace

The study of critical thinking in working adults does not adhere well to the standardized measures which imply an academically oriented definition of critical thinking. Some studies have been conducted among working adults, but the specific approaches and methodologies vary across studies. Brookfield (1987) outlines a theory of critical thinking in adulthood where the workplace is included as one of the important contexts for critical thinking in adults, in addition to such other contexts as relationships and political involvement. He also points out that, according to some opinions, the workplace in general, and especially blue-collar work, does not provide many opportunities for critical thinking. He quotes such writers as the adult development theorist R. Gould (1980) who claims that "the workplace is not organized for human development and hence inevitably conflicts with the transformational process".

Brookfield (1987) suggests that there may be limitations to critical thinking opportunities among white-collar workers as well, because their work is also often constrained by various external factors. Citing Lipsky's (1980) description of the work of "street-level bureaucrats", such as teachers, social workers, and the police, Brookfield points out that many public service practitioners are especially constrained by norms and rules that do not leave room for individual decision making.

According to Brookfield (1987), the preconditions for critical thinking among workers include some level of democracy and a special situation or event that prompts critical thinking. Types of occasions may be major failures or disasters in the workplace, or perceptions of anomalies, discrepancies, and crises. On such occasions, the conditions are set for a dialectical analysis of contradictions, oppositions, and diverse possibilities. Schein (1985) has developed a specific technique for uncovering assumptions in the workplace which involves interviewing workers about critical incidents in the history of the organization. Examples of such critical incidents include the oil crisis of the 1970's, incidents of fraud or embezzlement, or events in the history of unionization.

Discrepancies between theory and actuality, and responses to unforeseen situations occur daily in most areas of work. Most workers, according to Brookfield (1987), are "theorists", because they constantly balance out their private, intuitive, and contextual "theories in use" and the publicly agreed upon "espoused theories" of rules for appropriate practice. Brookfield says that developing the "theories in use", and making them more explicit is one of the most important forms of critical thinking in the workplace. "Theories in use" involve a contextual awareness of the workplace life that is often possible to achieve only through long experience with the work tasks. Schon (1983) describes "critical reflection in action", which corresponds to "theories in use", as an "artistic" process, because it is intuitive, improvisational, and creative. Scribner's (1986) description of "practical intelligence" in the workplace also includes an element of critical thinking, because it involves active problem formation, flexible modes of solution, and sensitivity to context.

Argyris (1982) uses the term "double-loop learning" for the type of thinking through which workers publicly identify, question, and change assumptions underlying workplace organization. He has identified an interesting form of double-loop learning involving what he calls "nested paradoxes". Nested paradoxes are forms of reasoning that work in the short term, but lead to unproductive consequences in the long term. The question of "cannibalizing" buses for parts can be characterized as nested paradox in the context of the bus depots. Decisions are frequently made in the bus depots whether to take parts out of a bus that is waiting for a repair for another bus that could be sent out to service.

Existing research on critical thinking in the workplace has focused on managers and executives. Brookfield (1987) lists several well known principles of management, which directly reflect the concept of critical thinking, although they are not usually labeled as such. His list includes strategic planning, effective decision making, creative problem solving, situational leadership, entrepreneurial risk taking, research and development activities, and organizational team building. Research has shown these concepts to be related to high organizational performance.

A study by Lowy, Kelleher, and Finestone (1986) shows that "high learning" managers were characterized as recognizing and responding well to contextual complexity, ambiguity, and change. Isenberg (1983) points out that successful managers need to abandon the search for certainty or total success before taking action, in other words, be reflectively skeptical. Such managerial concepts as "acting thinkingly" (Weick, 1983) and "action learning" (Marsick, 1990) also draw on the idea of critical thinking, while they bring the connectedness of action and thought into focus.

Marsick (1990) points out that critical thinking is becoming important in organizations, especially among management, when they are facing today's turbulent economy and ground-breaking technological developments. She applies Mezirow's (1990; 1991) concepts of reflective and transformational adult learning in the context of the workplace. The three major components of workplace learning that she explores are: reflection on experience, relationships between personally constructed meanings and social consensual meanings in the organizational culture, and transformations of personal frames of reference.

Marsick illustrates the concepts of workplace learning with examples of an action learning program for managers where work on real-life problems and reflection seminars are combined. The real-life problems include, for example, decentralization, corporate identity, new markets, and the impact of new technology. Action learning programs are based on the ideas of Revans (1982) who distinguished "P" (programmed knowledge) and "Q" (questioning insight) types of learning. Action learning consists of a dialectic between acting and reflecting on the consequences of action.

The reflection component of action learning consists of different processes of challenging assumptions, benefiting from differences in perspective, and reformulating problems. Challenge is always part of the reflective process, and while it comes from the facilitators and group members in the action learning exercises, it can ultimately be internalized as part of one's private thinking process. Marsick illustrates a deep level of self-challenge by quoting a manager who often asks himself, "Why am I working like this today? Why is my organization like this today?" One of the goals of action learning is to link the reflection and action into one's "personal theories of action".

Brook (1989) describes critical reflection among the managers of a large service corporation facing changes mandated by government deregulation. She interviewed twenty-nine managers, who were nominated as critically reflective by their peers, and found three types of critical reflection: reflection-in-action, reflection on ethical issues, and strategic planning. She found that critical reflection was facilitated by increased responsibility, participation, and openness. Empathy, perspective-taking, intuition, monitoring thought processes, and identifying discrepancies were identified among the components of critical reflection. A pattern of questioning within the family and personal transformations such as intercultural encounters, personal illness, divorce, and failure at work, were frequently found to precede the ability to think reflectively. The managers described deep personal insights gained through critical reflection such as "I must have the courage of my convictions" and "There are more realities than one".

Another interesting study of critical thinking among working adults, although not directly in the context of workplace, is Kuhn's (1993) investigation of scientific and informal reasoning. She included such expert groups as parole officers and teachers in her sample, and asked the subjects to reason about problems both in their respective areas of expertise (criminal recidivism and school failure) and other areas. Kuhn found that expertise in a subject domain area did not predict higher levels of reasoning and critical thinking in problems in that area. Her finding suggests that experience in a specific context does *not* increase the ability to think critically about problems in that context. Instead, critical thinking ability seemed to be a domain-independent general ability, and was it found to be correlated with general educational level.

Blue-collar Thought and Language

A need for contextual study of thinking, especially among working adults has been stressed by a number of researchers (Scribner, 1986; Marsick, 1990; Lave, 1988). According to Brookfield (1987), blue-collar work is usually described as execution of simple sets of routine, dull, pre-determined activities, and therefore does not generally invite critical thinking. The only exception is some form of workplace democracy where workers are sharing decision making and/or profits. When democratic participation and worker control are a norm in a workplace, there will be many opportunities for critical thinking and stimulation of adult development in general (Basseches, 1984). Labor unions are identified as one of the most important forums for critical thinking among blue-collar workers.

Worker collectives or cooperatives where decision making and profits are regulated by workers, exemplify, according to Brookfield (1987), most significant learning and critical thinking opportunities many workers will ever experience in their lives:

> "They need to recognize which of the norms governing workplace organization should remain from the precollective era, and which are inappropriate to a worker collective. They need to be ready and able to restructure administrative procedures around assumptions that are very different from those under which they formerly labored. They need to abandon the hierarchical patterns of communication they are familiar with and devise democratic ways to come to collective decisions." (pp. 147)

Brookfield also warns about the "folly" that results from inviting workers who are accustomed to the traditional hierarchical organization of the workplace to participate in management: "Without adequate preparation for this assumption of control, these workers, not surprisingly, tend to fall back into traditional patterns of dependent or disobedient behavior." (pp. 149)

When critical thinking is studied in the workplace, it is only presumed to take place among the management. Brookfield (1987) describes the reasons for lack of research on blue-collar critical thinking:

> "Blue-collar work is generally perceived as routinized and adaptive; workers are seen as responding to directions imposed from above regarding how and when to work, and the nature of the work tasks they will be performing. The presumption seems to be that critical reflection is the prerogative of managers, executives, and professionals. This might be because theirs are considered the only jobs in which such capacities are needed or in which opportunities for this kind of analysis exist. Or it might be because they are thought to be the only kinds of workers able to engage in such sophisticated cognitive operations as identifying and challenging assumptions or exploring alternatives." (pp. 144)

Brecher and Costello (1980) would not agree with Brookfield's description of blue-collar work. They describe different more or less subtle strategies of resistance that workers everywhere apply as manifestations of their critical thinking.

> "Unfortunately for employers, however, workers are not just tools; even after they go to work they remain human beings, pursuing their own ends, their own satisfactions and their own freedom. Worse still, they retain their human ability to think and to relate to each other directly, even though they are only supposed to follow orders and relate through management." (pp.59)

Brecher and Costello (1980) point out that the choice of strategies varies from individual to individual, from those who want to please the employer, to those who what to stay out of trouble, to those who defy the management's power. They describe a specific category of workers' strategies as "guerrilla tactics", when outright confrontation is replaced by secret underground methods. For example, workers have ways of controlling the pace of work, the functioning of machines and tools, and the variability of work assignments. Brookfield's (1987) notion of critical thinking is limited to explicit reflection on practices that typically are in line with the goals of the organization and the employer, and therefore, "guerilla tactics" are not included in his description.

There may be forms of thinking that are characteristic of people of the working class, but before an attempt to describe those forms of thinking, we must recognize that the definition of working class or blue-collar work is not straightforward. If we follow the Marxist definition of working class as "that class which does not own or otherwise have proprietary access to the means of labor, and must sell its labor power to those who do" (Braverman, 1974), most of the population would be counted as working class. "Blue-collar workers", who are sometimes called the "old working class", are typically defined by their engagement in manual labor. As Scribner (1986) and others have pointed out, however, the distinction between manual and mental labor can be artificial and misleading.

Bernstein (1972) makes a case for the determining force of social class in forms of language and thought:

> "Without a shadow of doubt, the most formative influence upon the procedures of socialization, from a sociological viewpoint, is social class. The class structure influences work and educational roles and brings families into a special relationship with each other and deeply penetrates the structure of life experiences within the family. The class system has deeply marked the distribution of knowledge within society. It has given differential access in the sense that the world is permeable. It has sealed off communities from each other and has ranked these communities on a scale of individious worth...Historically and now, only a tiny percentage of the population has been socialized into knowledge at the level of the meta-languages of control and innovation, whereas the mass of the population has been socialized into knowledge at the level of context-tied operations." (pp. 163)

Lave (1988) presents a summary of Bernstein's (1972) characterization of language and thought in different social classes. Orders of meaning in the upper class tend to be universalistic, explicitly principled, context-free, and use a public form of metalanguage, whereas orders of meaning in the working class are characterized as particularistic, implicitly principled, contextual, and local. Speech codes in upper class are elaborated, reflexive, changeable, and include articulated symbols, while working class speech codes are restricted, not reflexive, not changeable, and include condensed symbols. The mode of thought in general is characterized as rational in upper class, and as metaphorical in working class. These descriptions, if true, would predict less critical thinking, or at least very different forms of critical thinking, in working class compared to upper class.

Some Marxist theorists have used the concept of class consciousness to indicate a particular form of critical thinking in the working class. Braverman (1974) defines class consciousness as a "state of social cohesion reflected in the understanding and activities of a class". It is important to note that class consciousness generally refers to a force residing in an entire group of people, and is not located in the thoughts and beliefs of an individual. Furthermore, it does not function on the level of psychological consciousness, but is mediated by practical activity (Lukacs, 1968; Feenberg, 1981).

Gramsci emphasized the development of class consciousness on the mental level by proposing that the philosophy of praxis as an intellectual approach should be diffused among the masses in order to create a counterhegemony (Billig & Sabucedo, 1994). According to Gramsci: "All men are philosophers, because ordinary language, and ordinary common sense, contains philosophy." (pp. 134 in Billig & Sabucedo, 1994).

As reviewed above, the case has been made for limitations of critical thinking among blue-collar workers, as well as specific forms of critical thinking characteristic of working class. If critical thinking is defined in academic-logical terms, blue-collar workers are expected to have limited critical thinking abilities. But if the definition of critical thinking is expanded to discourse and activity in context, it can capture such phenomena as "guerilla tactics" (Brecher and Costello,1980), or class consciousness (Lukacs, 1968; Feenberg, 1981).

According to Geertz's (1983) observations, recent anthropology is committed to demonstrating that 'simpler' peoples do have such 'advanced' cultural systems as science, art, and philosophy, and that they find intrinsic interest in knowledge. However, defenders of the "proposition that every people has its own sort of depth", Geertz included, usually admit that 'colloquial' wisdom differs from systematized and studied wisdom. According to Geerz, someone with common sense "is not just using his eyes and ears, but is, as we say, keeping them open, using them judiciously, intelligently, perceptively, reflectively", and applying lessons learned in the school of hard knocks when dealing with everyday problems. Common sense is not tied with high IQ, and in fact, the world is "full of high-IQ morons". Common sense is a serious subject of modern philosophy, as exemplified by Wittgenstein's interest in ordinary language, Husserl's phenomenology of everyday life, and American pragmatism.

Geertz (1983) lists five characteristics of common sense that he has deducted from his analyses of common sense across cultures. Common sense everywhere seems to be natural, practical, thin, immethodical, and accessible. By 'natural' he refers to an air of 'of-courseness', and by 'practical' to a general sagacity. Common sense is 'thin' in a sense that "important facts of life lie scattered openly along its surface, not cunningly secreted in its depths". In contrast to such 'professional complicators of the world' as poets, intellectuals, and priests, ordinary folks with common sense try to avoid complicating the obvious. 'Immethodicalness', or a lack of uniformly structured system, is the attribute most relevant here, and will be discussed further below. Finally, 'accessibility' means that common sense is democratically distributed, and any person, regardless of expertise or intellectual talent, can grasp and embrace common-sense conclusions.

In his discussion of the immethodicalness of common sense Geerz notes: "Common-sense wisdom is shamelessly and unapologetically *ad hoc*. It comes in epigraphs, proverbs, *obiter dicta*, jokes, anecdotes, *contes morals* – a clatter of gnomic utterances – not in formal doctrines, axiomized theories, or architectonic dogmas." Other examples he lists include polished witicisms, didactic verses, animal fables, or embalmed quotations. Interconsistency among pieces of wisdom is not of concern. Geertz inlcudes the following examples: "Look before you leap," but "He who hesitates is lost"; "A stitch in time saves nine," but "Seize the day." There is no need for these contextually applicable pieces of knowledge to gather in a universally structured system.

Adaptation to Technological Change

Technological change has been identified as one of the major contemporary topics of critical thinking (e.g., Landow, 1997; Feenberg, 1991; Marsick, 1990; Gadzella, Hartsoe, & Harper, 1989). The definition of "technology" has been one of the questions provoking critical analysis of technology. The nature of technology has preoccupied prominent philosophers (e.g., Marx, 1939/1973; Heidegger, 1977). The boundary of technological and non-technological has inspired quite creative explorations among academics (Ihde, 1990; Haraway, 1991; Stone, 1995; Latour, 1996b).

Feenberg (1991) discusses the blurred lines between what is political, social, and technical: "Since the technical limits of political action are not self-evident, drawing the lines between the social and the technical is a political, and not a technical affair." Menser and Aronowitz (1996) argue that technologies are deeply embedded in most, if not all, aspects of modern and post-modern life:

> "Both subjectivity and agency are wrapped up (knotted) in technological system…Sociality, politics, perception, experience - not to mention love and friendship ('You never call me anymore!') …have been challenged or changed by technology."(pp. 21)

Menser and Aronowitz proceed to present an analysis of the complex and intertwined relationship between technology, culture, and science. According to their analysis, technology is a complex object of criticism:

> "As such, technology *challenges* us in such a way that it has displaced both its users and critic-users (there is no simple separate category 'critic'). The objects of our critiques have become impure, confused, indistinct, 'fuzzy' in the

> way in which even mathematics has accepted 'inexactness' as sometimes closer to the way things really are." (pp. 9)

Menser and Aronowitz (1996) point out that at least since the 1950's, there has been a concern about the "massification" effects of technology on culture, and about the fate of the independent and rational individual of the enlightenment tradition in the mass-media techno-culture. But according to Menser and Aronowitz, this type of technophobia by many culture critics and social analysts has proven largely unwarranted in the face of vast diversity of content in such technologies as television, publishing, and the internet. They also discuss the possibilities of the internet as a democratic arena, and the anarchist counterculture of computer hackers as examples of forces against the "massification".

Selfe and Selfe (1994) discuss the politics of computer interfaces. They show how social, political, and economical borders in the society and in the world are reproduced in computer design. They describe computers as "linguistic contact zones", which are "social spaces where cultures meet, clash, and grapple with each other, often in contexts of highly asymmetrical relations of power." Selfe and Selfe warn us about an overoptimistic view of computer technology as always a tool for democratic and engaging activities. They urge critical reflection on technology.

> "Computer interfaces, for example, are also sites within which the ideological and material legacies of racism, sexism, and colonialism are continuously written and re-written along with more positive cultural legacies". (pp. 484)

Selfe and Selfe use the example of computer interface design to show how ownership and opportunity are mapped in the interfaces, just like they are mapped in other social and cultural artifacts. Interface design is not ideologically innocent or inert.

Markers of the values of modern capitalism and class privilege are embedded in such common symbols or metaphors as "desktop", "folder", and "file".

> "The interface does not, for example, represent the world in terms of a kitchen counter top, a mechanic's workbench, or a fast-food restaurant - each of which would constitute the virtual world in different terms according to the values and orientations of, respectively, women in the home, skilled laborers, or the rapidly increasing numbers of employees in the fast-food industry." (pp487)

In interface design, rationality and logic are presumed to be universal and basic ways of knowing. Feenberg (1991) discusses how the design of technology is "an ontological question fraught with political consequences." Values of capitalism are reflected in information technologies as information is increasingly a commodity and a product. The text-as-commodity is owned by an author who can be protected by a password (Selfe & Selfe, 1994; Landow, 1997).

Critical approach to technology, according to Selfe and Selfe, consists of "remapping and renegotiating the borders". They list three specific forms of critical thinking regarding technology: encouraging critical awareness of technology issues in general, involvement in software design, and customizing computer interfaces.

Landow (1997) discusses the relationship between critical theory and technology. He focuses on "hypertext", or open-ended, interactive electronic network of text, as a form of technology that, according to him, can embody ideas of critical theory, and be theorized by critical theory. Hypertext questions such traditional ideas as center, margin, hierarchy, and linearity. To some extent Midas, the new computer system arriving to the bus depots, can be conceptualized as hypertext. The new computer system does give the bus maintainers power to create input, which makes it a text with multiple authors. Landow, however, reminds us that hypertext is not necessarily democratic by definition:

> "This pattern of relative empowerment, which we must examine with more care and some skepticism, appears to support the notion that the logic of information technologies, which tends toward increasing dissemination of knowledge, implies increasing democratization and decentralization of power. Technology always empowers someone. It empowers those who possess it, those who make use of it, and those who have access to it." (p273)

Part of the democratizing effect of information technologies, according to Landow, resides in the technologies' tendency to homogenize language. This democratization happens at the expense of some particular languages, as Landow himself, as well as Selfe and Selfe (1994) have noted. Anything that cannot be translated into an electronic form is at risk of being marginalized or abandoned.

Technological democracy is often at odds with technological plurality. But Landow (1997) argues that plurality and indeterminacy are still maintained in the content of the technology, even though the language on a basic level is homogenized. Distributed and decentered structure of information technologies, and the opportunities they provide for interactivity may outweigh the homogenizing tendency. Feenberg (1991) uses a democratic metaphor to describe technology itself:

> "Technology is not a destiny but a scene of struggle. It is a social battlefield, or perhaps a better metaphor would be a parliament of things on with civilizational alternatives are debated and decided." (pp.14)

A discussion of politics of hypertext has to start from the question of access (Selfe & Selfe, 1994; Landow, 1997; Feenberg, 1991). Technologies such as the Midas system in the bus depots allow for various possibilities of regulating access and levels of access. Technologies make partial access possible, and sometimes users do not know what they cannot access. Another related political issue is the question of authorship (Landow, 1997). Our notions of intellectual property and copyright were developed prior to the multiple-authorship hypertext era when the prototypical text was a book that was considered written by one author.

Landow (1997) argues that, in the midst of all the political battles, technologies do also have a special potential to realize human possibilities and transform consciousness. This aspect of technology is important for an account of critical thinking in a technological context. Landow uses Lyotard's notion of information technologies as "prosthetic aids" which increase the range of possibilities for human activity. Technologies like writing enable a distancing between the reality and a representation, and therefore, make transformations of consciousness possible. Feenberg (1991) also discusses the communicative and reflexive dimensions of information technology which create a "textualized" work process that increasingly blurs the distinction between mental and manual labor. The workplaces of blue-collar workers are becoming increasingly "symbolically mediated", which means that new forms of continuous learning and development become part of their work.

Feenberg (1991) outlines the possibilities of a more socialist application of technology in the society. He constructs a middle-ground between the thesis of technology as a neutral tool, and the thesis of technological determinism by asserting a notion of ambivalence and agency in the concrete applications of technology. Although the development of technologies in this society has been guided by the capitalist ideology, they also embody alternative paths of future development. While optimists have seen technologies, like computers, as tools for eliminating routine and painful work, and for more democratic participation, and pessimists have seen them as tools for universal surveillance and control, and for eliminating jobs, Feenberg argues for the "ambivalence of computers".

Feenberg (1991) locates the ambivalence of technologies in the "connotations" of technologies, as opposed to formal "denotations", and in the possibility of production that resists "reproduction" of existing practices. The technological ambiguity of choices shows on the level of active involvement with practical problems, where abstract values are realized in concrete facts. Although Feenberg (1991) wants to emphasize the ambiguous possibilities of technology, he also describes the ways in which capitalism is designed into existing technological applications. Such principles as total control of workers and strict division of labor are embedded in technological choices. Feenberg describes how a hegemony is created by the transformation of socio-cultural values into socio-cultural facts, and how this transformation occurs in the areas of ideology (embodied in laws), economic realities, and technological applications. Feenberg's citations include Foucault and Marcuse, who, according to him, see society as a "gigantic machinery regimenting its members."

Marcuse (1964) claims that technological rationality has become the definition of rationality. Feenberg (1991) paraphrases Marcuse the following way:

> "Not only is technical progress distorted by the requirements of capitalist control, but the 'universe of discourse', public and eventually even private speech and thought, is limited to posing and resolving technical problems...There is no place for critical consciousness in this world: it is 'one-dimensional'"(pp.70)

This analysis provides a possible angle to challenge the notion of critical thinking as an academic-logical privilege. Lukacs (1971) associates formal rationality with capitalism and dialectical reason with socialism. To Lukacs, formal rationality and dialectical thinking are two different modalities of thinking, and one of the problems with formal rationality is its tendency to decontextualize.

Feenberg (1991) advocates a gradual and contextualized, but informed and systematic process of resistance and change workers can achieve in ambiguous technological applications. He refers to de Certeau's (1984) theory of strategies and tactics, which defines strategies as the institutionalized means of control embodied in social and technological systems, and tactics as the often subtle and covert ways in which the dominated respond to strategies. The direction of change that Feenberg suggests is toward a humanistic social democracy: "Workers' control is *uniquely compatible* with changes in technology and the division of labor that further the actualization of human potentialities at work." (pp.39) He also points out that old industrial technologies (machinery) completed the separation of manual and mental labor, but that new technologies (computers) sometimes have a tendency to blur the division of labor.

According to Feenberg (1991), democratic and safe work and environmental concerns are not "extrinsic to the logic of technology". In order to accomplish a new direction for technology, Feenberg recommends an alliance of technical elites with the underlying population, because workers usually do not contribute to the design of technology:

> "Given the authoritarian structure of the industrial enterprise, workers have no direct influence on the design of technology, but instead manifest their wishes in union strife. Because they do not participate in the original networks of design choice, workers' interests can only be incorporated later through a posteriori regulations that sometimes appear to conflict with the direction of technical progress. But workers are not so much opposed to the advance of technology as they are to a system in which they are the objects rather than the subjects of progress." (pp.191)

The lack of alliance among management, technological staff, unions, and workers at the Transit Authority was demonstrated during the planning and design stage in the implementation of the Midas system in the New York City Transit Authority (Glick et al., 1996). The present study will describe some of the later impact of the initial top-down design process on users at two Transit Authority bus depots.

Few applications of theory or empirical studies were found concerning the intersection of critical thinking, technology, and work. An exception is the work by Nurius (1995) in the field of human services. She writes about the importance of critical thinking as a meta-skill for integrating training, practice, and technology, and an orientation to the computer more as a medium of thought and expression, and less as a machine. She says that critical thinking is not a "silver bullet solution", but that it has to be an ongoing process that helps human service professionals determine the availability, appropriateness, viability, and sustainability of types of information technologies relative to specific needs, resources, and contexts.

> "Creative thinking about what computer tools, theoretically, *can do* needs to be combined with understanding the resources required to implement that vision to enable a realistic evaluation of whether the benefit (e.g. improved service) justifies the investment and is sustainable. To this end, I will organize my remaining points around three aspects of critical thinking:
>
> 1. the ability to mentally move back and forth between concepts, language, functions, and so forth of multiple frameworks (understanding dimension)
> 2. the ability to use constructively critical observations in recognizing weaknesses and engaging in problem solving (application dimension)
> 3. the ability to create; to move beyond what is to see and contribute to what could be (generative dimension)" (pp.114)

Nurius (1995) reports results of a survey study of Seattle human service agencies which found that what agency heads mostly valued in social workers was their "conceptual understanding of the computer functions". Specific software functions were learned relatively quickly, but "ability to get on board in terms of understanding" and "attitudinal comfort" took longer to develop and were "sorely needed as a starting point". Nurius suggests that the crucial abilities listed above should be integrated into training in human services, and more specifically, as part of the research training.

Nurius (1995) also discusses a specific aspect of computer technologies that is relevant in the context of the system studied in the present research, namely, the tendency of forcing the representation of reality into a "categorized" form. Categorical data, such as yes/no and checklist systems, are easier for a software system to handle than multifaceted, contingent, qualitative data. Nurius is concerned that categorized data, coupled with cognitive tendencies in human information processing to represent categorically, will simplify the workers' conceptions of their clients and their problems. This concern is parallel to the problems the bus maintainers have in representing complex repair activities in terms of simple codes on the computer system. Nurius also points out, however, how collecting great amounts of easily manageable electronic data can ultimately help in the construction of *more accurate* representations of reality. For example, some intuitive stereotypical assumptions about the clients can be checked against the electronic data, and thereby, the computer system is used as a tool for critical thinking.

A body of empirical studies has emerged during the past decade addressing issues related to adaptation to computer technologies. Many of these studies (e.g., Ballance & Ballance, 1996; Coffin & McIntyre, 1999; Brosnan, 1999) use standardized scales developed to measure computer-related stress (Hudiburg, 1989), attitudes (Nickell &

Pinto, 1986; Todman & Dick, 1994), self-efficacy (Hill et al., 1987; Murphy et al., 1989), anxiety (Heinssen et al., 1987). A major limitation of this line of research, in addition to "decontextualized" scales, is the reliance on self-reports of computer use as dependent variables.

Rationale

The motivation for this study stems from observations of hundreds of workers adapting to a new computer system. These early observations pointed to a non-linear process where full adaptation seemed to require some resistance. Manifestations of the workers resistance has been described elsewhere (Kindred, 1999). This study was designed to systematically document the observations in two settings and to conceptualize a dialectic process of adaptation. As discussed above, others have applied the concept of dialectics to study developmental processes.

Review of literature on activity theory suggests that it can be a useful framework for research seeking to analyze thinking, talking, and acting in concrete physical and social settings. Several researchers studying technologies in the workplace have recently started adopting an activity theory approach. The review also points out that discourse can be conceptualized as activity, and that analysis of discourse can be used to highlight the dialectic between an individual with an agency and the socio-cultural context.

Literature on adult development describes advanced reflective forms of cognition that emerge in adulthood. Many of these forms are conceptually similar to what is described elsewhere in the literature as "critical thinking". Traditional definitions and measures of critical thinking are clearly tailored for academic environments, and critical thinking among college students has been studied extensively. The importance of critical thinking in the workplace has been noted, and some research has been conducted on critical thinking among management, but no systematic research was identified addressing critical thinking among blue-collar workers. The language and thought of blue-collar workers has generally been characterized in the literature as context-bound. One objective of this study is to engage the workers in contextualized discourse, and identify elements of critical thinking in their responses.

As reviewed above, technology has been identified as an important topic of critical thinking. Far from a neutral tool, technology has been shown to be a thoroughly political arena of activity. Social science researchers have started paying attention to the fact that our lives are increasingly permeated by technologies, but the role of critical thinking in adaptation to technology has not yet been addressed empirically.

Several types of methods will be applied in this study to capture how bus mechanics in two bus depots adapt to a new scheduled maintenance computer system. Indicators of critical thinking will be identified in interviews, questionnaires, and field observations. It is hypothesized that critical thinking during early implementation of the new system will be associated with adaptive computer use patterns. Successful implementation of the computer system requires adaptation on the part of the workers. Therefore, the adaptation patterns described in this study have potential practical implications for attempts to implement new technologies in the workplace.

Research Questions and Hypothesis

A set of research questions was formulated for the proposal for this study. These then evolved into a set of aims and hypotheses. The research questions are presented below in the format they appeared in the proposal, while the aims and hypotheses listed below reflect a later and more specific formulation of the questions.

Research Questions

1. How does technology elicit critical thinking, and how does critical thinking affect the way technology is used?
2. What are some aspects of discourse and activity displayed by the workers that can be categorized as critical thinking?
3. What aspects of discourse and activity correspond to different elements of the dialectical process of critical thinking, such as identification of assumptions, resistance, negation, and emergence of new forms?
4. Is critical thinking among the workers limited to context specific and local issues and activities?
5. Is it possible to operationalize a definition of critical thinking that captures local and context-specific forms of dialectical discourse and activity?
6. Are indicators of critical thinking related to use patterns of the computer system, such as sustained creative use and utilization of a wide range of possibilities afforded in the system?
7. What theoretical frameworks best account for processes of critical thinking identified in this context?

Aims and Hypotheses

1. To describe a process of adaptation to a new technology, and to place the process within layers of cultural, social, and technological context.
2. To describe computer use patterns over several months among a group of workers.

3. To describe the workers attitudes towards issues related to the new computer system and their work.

   Hypothesis 1: Questionnaire responses will form factors corresponding to components of attitudes and elements of critical thinking. (Please see Table 2.1. for the eight expected clusters.)

4. To use measures of attitudes to predict computer use patterns.

   Hypothesis 2: Initially critical attitudes predict constructive computer use patterns.

5. To describe markers of critical thinking in the workers' discourse during interviews, to examine relationships among the markers, and to propose a revised definition of critical thinking based on the results.

6. To examine the relationship between context-specificity and level of critical thinking in interview discourse, by comparing critical thinking elements in discourse across four dilemmas varying in context-specificity.

   Hypothesis 3: Context-specific dilemmas elicit more critical thinking than a hypothetical moral dilemma.

7. To use markers of critical thinking in discourse to predict computer use patterns.

   Hypothesis 4: High levels of critical thinking predict adaptive computer use patterns.

Chapter 2: Methods

Setting and Participants

The participants are maintenance workers in two public transportation maintenance facilities in a largely working class suburban borough of a metropolitan city in the North-Eastern United States. The two depot facilities are part of a system with a total of seventeen bus depots across the city area which each house about 100-200 buses and 50-150 maintenance workers. This study describes the two depots at a time of a radical transition caused by the implementation of a computerized maintenance information system, and more specifically, the maintenance workers' adaptation to the new computer system. A more detailed description of the setting based on field observations is included in Chapter 3.

Due to minimal demographic diversity in the setting, all individuals who participated in the questionnaires and interviews were white middle-aged men. The slightly more ethnically diverse group of 125 workers, capturing all workers with bus maintainer titles in the two sites, was included in the observations and computer use measures. The workers, whose average age was 44 years ranging from 27 to 70, have high-school-level formal education and careers in bus maintenance ranging from about five to over thirty years. Their work activities can generally be classified as "skilled labor". They are unionized and display a strong sense of working class identity.

Computer use measures over the first five months into the implementation of the system were obtained for 125 workers. Questionnaires were completed by 40 workers, 20 at each site. These 40 are a subgroup of the 125 with computer use measures. The questionnaire group had an average of 14.6 years with the company, 10.9 years in their job title, and 8.8 years in their current depot. Questionnaires were distributed to all workers at the two sites, but only 40 were returned to the researcher, either personally or via mail. Eighteen workers in the questionnaire group also participated in the interviews, eight at depot A and ten at depot B. Participation in the interviews was constrained by supervisors who were instructed by the manager to designate potential interviewees. After two months of interviewing and eighteen interviews, even the most cooperative supervisors declined to allow any more of their workers' time to be spent on interviews. Two persons designated by their supervisors declined to participate.

Participant Consent

The procedures for obtaining consent from the study participants was reviewed and approved by the Internal Review Board of the City University of New York Graduate School. Each participant signed an informed consent form prior to responding to questionnaires and interviews. The informed consent materials explained that the information would be kept confidential, and that only the researcher would be able to associate participants' identities with their responses. In a study occurring in a workplace it was especially important to assure the participants that their employer would not have access to information provided by individuals.

The City University of New York research group conducting the computer training workshops had secured a permission from the New York City Transit Authority to analyze computer use data obtained from the organizations' managed information system. This agreement was communicated to all of the individual bus depots. Individual users' identities were not to be revealed in reports based on the computer data.

The present study was part of a larger set of studies by the research group on workers' computer use patterns.

Design and Timeline

The data collection was designed to occur at the time of the implementation of the new computer system. The duration of data collection was from one month prior to the implementation, when field observations started, to five months after the implementation when last computer use data were obtained. Figure 2.1 below presents a time line for the data collection.

Figure 2.1. Time Line for Data Collection

Month prior	Month 1	Month 2	Month 3	Month 4	Month 5
	Questionnaires n=40				
	Interviews n=18				
	Computer use measures n=125				
Field observations					

A larger number of questionnaires and interviews was anticipated in the proposal for this study, but the sample size was reduced because of complications during recruitment. The supervisors acted as gatekeepers for allowing workers to participate in interviews. After several weeks of interviewing, the supervisors gradually stopped cooperating with the researcher, and declined to identify potential interviewees.

Field observations were distributed over a period of five months, consisting of a total of 48 visits to the research sites. The questionnaires and the interviews were collected during early implementation. The questionnaires were distributed to the workers during the first week of implementation and received back over a two-month period. The interviews were conducted during the first two months. The computer use data were downloaded monthly from the system over the first five months. Questionnaire and interview based measures obtained from participants during early implementation were associated with the same participants' computer use patterns over five months. The entire interview sample was included in the questionnaire sample, and the entire questionnaire sample was included in the computer use sample.

Field observations

This researcher's immersion in the general setting of bus depots began over two years prior to the specific data for the present study were collected. General field observations of similar settings were conducted as part of a larger project involving conceptual training workshops and shop-floor computer support in fifteen other bus depots that implemented the same computer system. During the two years, the researcher worked as a leader of conceptual training workshops with hundreds of workers, and spent time on the shop floor observing and helping the workers use the computer system, and getting generally acquainted with bus mechanics and their work and the specific technology of the new computer system. The phenomenon, which this study conceptualizes as "dialectic adaptation" to the new computer system, was initially observed during the work in other bus depots, and the present study was designed in an effort to document the phenomenon more in detail.

Materials for the interviews and the questionnaires were designed based on prior observations in other bus depots. Specific conflict issues arising from the new technology were identified from the observations and conversations with workers in other depots, and used in the structured part of the interviews for the present study. Three of the conflict issues were presented to the interviewees in the form of a story about a bus mechanic who is facing a dilemma. Two of those dilemmas were specifically about a conflict regarding an aspect of using the new computer system, and the third one was about a non-computer related conflict issue in a bus depot. The observation-based materials used in the interviews and the questionnaires are discussed in detail below in sections describing the instruments.

The field observations at the two sites were conducted over a period of five months starting one month before the depots started using the computers and continuing four months into the implementation. Since the two sites are located only about five miles apart, virtually all visits consisted of spending some time at both sites. During the month prior to implementation and the first month of implementation, the sites were visited about three times a week, and during the following three months, about twice a week. Field notes were collected during a total of forty-eight field visits, which occurred literally during all hours of day and night, including overnight shifts.

The perceived role of the observer in a field setting affects what is available for observation, and often alters the activities in the setting in subtle ways (Emerson, Fretz & Shaw, 1995). This researcher entered the bus depots as a lead trainer in workshops designed to introduce the new system. The training was conducted in small groups and the researcher established friendly relationships with some of the workers during these pre-implementation workshops. The nature of the training is described in detail elsewhere (Kindred, 1999). When the training staff entered the depot it was explained to the workers that the trainers come from the university, and that one of their interests is to do research on the implementation of the new system. The purpose of the present study was explained to the participants separately.

Many of the workers became accustomed to seeing the researcher at their workplace, greeting her friendly, offering their time for brief conversations, and sometimes asking technical computer use questions, but some continued to display suspicion towards the researcher even after several months of visits. This is probably explained by the researcher being somewhat of an intruder in the depots, and by her role not always being clear to everyone. Some workers may have thought that the researcher would report their comments to the management.

Specific field work techniques described in the literature on ethnography (e.g., Lofland & Lofland, 1995; Emerson, Fretz & Shaw, 1995) were applied during the observations. Contacts were initiated with "gate-keepers" including managers, supervisors, and union shop stewards, informing them about the general purpose of the observations. The researcher followed the casual bus depot dress code, and carried a small note book and a pencil in her pocket, writing brief notes on the shop-floor only when absolutely necessary for memorizing. Some field notes were written between observations in the bus depot's ladies locker room, but most notes were written immediately following the visits to the sites.

The observations were generally guided by questions related to the specific topic of the proposed research. Information was obtained describing the various layers of context around the mechanics' activities, including their relationship to the overall organization, the basic functioning of a bus depot, specific physical work settings, interactions and talk among people, the social organization of the depots, examples of specific work activities, activities at the computer terminals, indicators of their attitudes towards the computer system, and markers of critical thinking in talk, activity, and artifacts.

After the field work phase, the field notes were read, analyzed, and organized according to a general outline of topics. This outline included the following three major sections: The Environments and Cultures, The People and Their Activities, and The Computer System and Its Use. The major sections were further divided into sub-headings, and the notes under each heading were written into narrative form. These sections combined constitute the description presented in Chapter 3.

Measures of computer use

The new computer system is managed through a relational database where data from all 17 bus depots are stored. Monthly queries that extracted and downloaded the data entered by all bus mechanics in the two depots were conducted over five months. Every time a person enters information into the system, they have to be "logged in" under their own pass-number and use their own secret password, making it possible to associate data with individual users.

Measures of how the workers use the computers were previously developed in the research group studying the implementation (DiBello & Chamberlain, 1996). The assumption was that a broad use of codes reflects a deep understanding of the intended purpose of the computer system, the intended purpose being the accumulation of a scheduled maintenance database. In research conducted in other depots it was found that participants trained in the conceptual basis of the scheduled maintenance system were using a broader range of codes than those who were not conceptually trained (DiBello & Chamberlain, 1996).

Measures of how the range of affordances within the system is utilized were also designed for the current study. Use of the system on a great level of specificity is necessary for the idea of accumulating an accurate bus maintenance database to be used for planning scheduled maintenance. Specificity also becomes important on a more immediate level of communicating repair activities to others who will be working on the same bus. At the same time, it is much easier to fill out work orders on the computer by using less specific generic information, and it requires more effort to look for specific and accurate information. However, a worker who understands the underlying purpose of the database should be compelled to use a broad range of specific codes, at the cost of more effort and trouble spent learning the computer system.

The workers are required to use different types of codes to close out a "symptom" on the computer after each repair job is finished. In addition, they have an option of typing in any comments or notes about the work that was completed. Several different aspects of the workers computer use will be described in Chapter 4, with a specific focus on following up the use of two particular kinds of codes over time. (The structure of the work order and all different types of codes are described in Chapter 3.) The two types of codes used for the outcome measures include the repair code which describes the repair action (e.g., removed, cleaned, tightened), and the component code which refers to the specific part of the bus that was repaired (e.g., steering arm, brake light bulb, right front tire). The system provides lists of 50 repair codes, and approximately 2,800 component codes. The code-based measures reflect how widely the workers utilized the entire ranges of possible codes.

It was initially planned that monthly aggregates of code use would be used to measure use patterns over time. However, wide variation among workers was observed in the number of symptoms closed per month (See Chapter 4)[1]. Therefore, a revised strategy was applied, whereby symptoms completed by individual workers were aggregated into consecutive groups of 30 symptoms. For each worker in the sample, consecutive sets of 30 symptoms were defined during the first 5 months' data, up to 10 sets per person. This made it possible to examine changes in code usage from set to set.

Two measures were obtained for each set of 30 symptoms, a repair code measure and a component code measure, which represent how broadly the total universe of codes was utilized in the set. The number of different repair codes used was obtained for each person's each set and this number was divided by the total number of possible repair codes (50), resulting in a measure of "percentage of the total universe of repair codes utilized within one set". Component code use was tracked by measuring how many different component codes were used at least once during each set of 30 symptoms. In addition, the number of times each mechanic typed in comments was studied during months two and five.

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[1] It was also determined that it is more important to examine the code usage curves in relation to how many times each person used the computer, instead of curves based on chronological time. In other words, specific number of "trials" at the computer for each person was considered more important than how long the computers had been in the bus depot.

Questionnaires

A self-administered questionnaire was designed during the pilot work to serve as a method of gathering some attitudinal data from a larger sample of workers than could be interviewed. It was also expected that the questionnaire format would elicit attitudes that workers may not want to express verbally to an interviewer. A copy of the questionnaire is included in Appendix 2A.

The questionnaire consists of twenty-four items that were designed in eight categories reflecting different aspects of the workers attitudes towards the new computer system and their work, as well as some elements of critical thinking. Items in the eight categories are listed in Table 2.1. As Table 2.1. shows, the eight categories consist of two based on components of attitudes (Rajecki, 1990), two based on components of critical thinking, three based on specific conflict issues, and one set of popular opinions identified in the fieldwork. A validation analysis of the categories, based on clustering of answers within item categories, was performed by examining intercorrelations among items and by conducting a factor analysis of the responses (See Chapter 5).

Table 2.1 Originally Proposed Questionnaire Item Categories

Category	Questionnaire items
Knowledge and confidence Cognitive component of attitude	I know my way around in the Midas system. It is difficult for me to learn the Midas system. I know a lot about computers.
Feelings and evaluations Affective component of attitude	Overall, I like my job. I feel curious about the Midas system. I am nervous about the Midas system. I don't care about the Midas system. Overall, I think the Midas system is a good system.
Questions, suspicions, and doubts Negation element of critical thinking	I have many questions in my mind about the Midas system. I do not trust the Midas system. I doubt that the Midas system will ever work.
Authority and agency Social element of critical thinking	I sometimes openly question decisions made by my superiors. I usually respect authorities. I always question what I hear in the news. I am in control of my work.
Perspective Specific conflict issue 1	I care about the "big picture" of what is going on in my depot. Midas will change the operation of bus maintenance.
Accountability Specific conflict issue 2	I am the only person responsible for my work. My superiors are responsible if something goes wrong with a bus.
Interdependence Specific conflict issue 3	The quality of my work always depends on other people's work. Other people in the depot depend on how I do my work.
Popular opinions collected in field-work Examples of specific discourse	Midas is there just for accounting purposes. Midas is there just to watch the workers. The maintainers' input will be heard through Midas.

The social psychology literature typically defines attitudes as "learned predispositions to respond cognitively, affectively, and behaviorally to a particular object in a particular way." (Rajecki, 1990). The cognitive component of attitudes is captured in the category of "knowledge and confidence". Confidence was combined with knowledge because a self-report questionnaire is a better measure of confidence in one's knowledge than objective level of knowledge. The affective component of attitudes is included in the category of "feelings and evaluations".

The category of "questions, suspicions, and doubts" corresponds to the negation element of critical thinking, and the category of "authority and agency" to the social dimension of critical thinking. Some of the items (e.g., "I always question what I hear in the news.") were modeled after existing standardized questionnaires for measuring attitudes toward authority in general (Rigby, 1987).

The categories of "perspective", "accountability", and "interdependence" were identified in the fieldwork as conflict issues in the particular context of this study. The same three issues are also presented in the interviews in the form of stories involving dilemmas. The last category of "popular opinions" consists of three typical statements describing workers attitudes toward the new computer system. These statements were often heard during early field observations, and provide specific examples of discourse among the workers.

After answering seven general background and identification questions, the participants were asked to answer each item on a five-point scale from strongly agree to strongly disagree. This answer scale was selected based on feedback from the workers during pilot testing. Initially, a simple scale (yes, maybe, no) was presented in the pilot questionnaires, but the pilot group insisted on changing it into a "typical market research" scale ranging from strongly agree to strongly disagree. The twenty-four items were arranged into a random order by alternating computer system related items and other items. The full questionnaire is included in Appendix 2A.

Interviews

A semi-structured interview protocol was designed for individual face-to-face interviews with a sub-sample of the mechanics. The purpose of the interviews was to elicit discourse data that can be coded for elements of critical thinking. Rather than a method of collecting information from the respondents, these interviews are a form of discourse activity which can be analyzed for patterns of interactive speech (Mishler, 1986). The interviews are seen as conversations, although not as "naturally occurring conversations", because as Mishler (1986) points out, a conversation between a researcher and a participant is always artificial and asymmetrical. The parts of the interviews that involved open-ended questions often resembled casual conversations. but a pre-determined structure was replicated in all interviews during the segment that was coded for this study.

An interview method modeled after Piaget's (1929/1951) *method clinique* has been developed by Saltzstein and collaborators (Saltzstein et al, 1997) for moral judgment interviews with children. The method involves systematic challenging of the interviewee's responses with "counterprobes", which consist of arguments opposing the interviewee's statements. In Piaget's (1929/1951) *method clinique* the counterprobes served to test for the stability of ideas discussed by children. Piaget encourages interviewers "to probe all around the suspect answer to see whether or not its roots are solid" (1929/1951, pp. 19). Saltzstein et al. (1997) used counterprobes in moral judgment interviews, and systematically analyzed children's responses to the counterprobes. The children heard stories where a protagonist was experiencing a dilemma between telling the truth and keeping a promise, and their responses to the dilemmas were systematically counterprobed. It was found that children's ability to resist counterprobes varied across age groups and dilemmas.

To explore why particular children resisted or yielded to the counterprobes, qualitative analysis was applied to the interviews (Millery & Steinmayer, 1999). This analysis identified elements in the children's discourse (e.g. negation, evaluation) that resembled categories discussed in the literature on critical thinking. By presenting a dilemma that creates a tension between alternative answers, and by counterprobing the interviewee's responses, these interviews had triggered responses with a variety of elements of critical thinking. Parts of the qualitative coding of the children's interviews were later adapted to the coding scheme of the present study.

Based on the experience of analyzing the children's interviews, it seemed that the general method of presenting dilemmas and systematic counterprobing could be applied in other contexts to elicit discourse rich in critical thinking. Two years of leading training workshops with bus mechanics familiarized the researcher with their discourse patterns, especially with their conversations about the new computer system. These conversations seemed abound with elements of critical thinking. The method of presenting dilemmas and counterprobing was adapted for the context of the bus mechanics. In addition to probing for critical thinking, the structured interview made possible a design where segments of the interview can be compared across interviewees.

The interview protocol (see Appendix 2B) consisted of the following segments:

1- Brief conversation on how participant is doing with the computer system

2- Administration of questionnaire[2]

3- Discussion of selected questionnaire responses

4- Structured dialog about three context specific dilemmas and one hypothetical dilemma

5- Additional comments about the computer system and evaluation of the interview.

Three context-specific dilemmas and one hypothetical moral dilemma were designed for the interviews (see Appendix 2B). The three context-specific dilemmas present conflicts identified during pilot fieldwork. One is about a mechanic deciding whether to "borrow" a part for a repair from another bus (Part story), another one is about a mechanic deciding whether to type in comments on the computer against his supervisor's request to close out (Note story), and the third one is about a mechanic deciding whether to ask for help to find a specific code on the computer (Code story). The hypothetical moral dilemma is about a man deciding whether to tell the police about his friend's stealing (Stealing story). The content of the four dilemmas is summarized in Table 2.2.

The context-specific dilemmas were presented first, in a counterbalanced order. The hypothetical moral dilemma was always presented last due to concern for logical flow of interview content. The interviewer read the dilemma and asked the participant what he thinks the protagonist should do. The participant's answers were then systematically counterprobed. For example, if the mechanic opted for using a general

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[2] Most interview participants filled out their questionnaires during the interviews.

code in the code story, he was counterprobed with "But what about the fact that the people who look at the code later will not have specific information?"

Table 2.2. Four dilemmas

Name Type Conflict issue	Summary of Content
Note dilemma Context-specific Accountability	A mechanic wants to enter notes on the computer about an additional problem he found in a bus. Should he continue even when his supervisor wants him to get off the computer?
Code dilemma Context-specific Interdependence	A mechanic cannot find a specific component code. Should he use a general code or bother someone to get help?
Part dilemma Context-specific Perspective	A supervisor asks a mechanic to take a part from another good bus because the necessary part is not available. Should mechanic take the part?
Stealing dilemma Hypothetical moral Truth vs. Promise	A friend tells the protagonist that he is stealing money from his job. The protagonist promises not to tell anyone. Should he tell the police upon being questioned?

The interviews, which varied in length from 20 minutes to over one hour, were audiotaped and transcribed. Different types of transcription techniques have been developed for linguistic data, depending on the purpose of the transcripts (Edwards, 1993). The transcription here generally followed standard English orthography, supplemented with some modifications for pronunciation in spoken dialect, such as "cause" for "because", and "gonna" for "going to". Long pauses were marked (approximately longer than 5 seconds), as well as some audible non-verbal events (e.g., laughter, coughing). Turns of talk were marked by starting a new line in the transcript and indicating the speaker's identity.

Interview coding

The development of the coding system started with listening to all interview audiotapes accompanied by reading of the interview transcripts. The proposal for the study included a preliminary list of elements of critical thinking which guided the identification of examples of different elements in the interview transcripts. The nine coding categories listed in the proposal included: Identification of assumptions, Questioning of assumptions, Resistance, Contradiction, Challenge, Negation, Evaluation of self, Evaluation of others, and Creation of new. These categories reflect the definition of critical thinking outlined in the proposal.

The initial nine categories evolved into fifteen, and eventually into the seven used for the final coding presented below. Several categories discussed in the proposal remained in the final coding system, including Identification of assumptions (now includes questioning of assumptions), Evaluation (now includes evaluation of self, other, object, or something abstract), Negation, Contradiction, and New Solution (previously called Creation of new). Metacognition and reinterpretation were new categories identified in the data.

The more elaborate initial version of the coding system was applied to six entire interviews, including parts of the interviews outside of the structured segment. The initial system had fifteen different elements, including an attempt to code for categories of content (e.g., computers, bus, Transit Authority, etc.). A process of selections and combinations among the fifteen categories resulted in the final coding system of seven elements. The data presented below is restricted to using the final coding system on the segment of the interviews discussing the four dilemmas.

The unit of analysis of the interview coding is an interviewee utterance, which typically corresponds with a turn of talk. One utterance expresses one idea, thought, argument, or topic. Occasionally, several utterances are included in one turn of talk, or one utterance continues across two turns of talk. (For further details on utterance boundaries, please see Coding Manual in Appendix 2C.) The interview segment discussing the four dilemmas was divided into utterances, and all utterances by the participant were coded. A high interrater reliability (95% agreement, see below) was achieved for defining utterance boundaries. This unit was chosen in order to have a reliable unit of coding, and does not suggest that critical thinking somehow naturally appears in units of utterances. When elements of critical thinking were identified there was typically only one occurrence of a particular element per utterance, making utterance the best reliably identifiable unit of analysis for the elements.

Each interviewee utterance within the segment was coded for the presence of each of the seven elements of critical thinking. The total number of coded utterances ranged from 48 to 105 per person. The seven elements are briefly described in Table 2.3, and a complete Coding Manual is included in Appendix 2C. An example of applying the coding system to one conversation about the Note story is included in Appendix 2D.

It should be noted that the coding approach developed for this study breaks down the definition of critical thinking into small individual elements. One limitation of this approach is that it does not capture the dynamic flow of thought, which often moves between elements and integrates several of them. Many of the elements are coded regardless of the content of the utterance . For example, negation is defined as "a statement denying something", and "something" can refer to any content. Many of the coding choices, including the "small element approach" and the use of linguistic markers regardless of content, were made in the interest of developing a coding system that is less ambiguous and more reliable.

As described above, traditional tests of critical thinking include many of the same elements included here. The traditional tests typically present arguments in written booklets, followed by multiple choice questions. They do not attempt to code for elements of critical thinking in conversation. This study retains a bridge to the more traditional critical thinking research by coding for many of the same elements that the traditional tests operationalize into multiple choice questions. Study of critical thinking in conversation also broadened the scope of the definition of critical thinking. For example, reinterpretation, which involves responding to the interviewer's utterance, was added as a new coding category identified in the data.

Table 2.3 Seven Elements of Critical Thinking[3]

Element of Critical Thinking	Definition	Examples
Identification of assumption	Awareness of an assumption made by someone. May involve questioning of the assumption. An assumption is a statement for which no proof or evidence is offered (Halpern, 1996).	"They are only concerned about the next day, how many buses they can get." "You can't ask people to have a positive reaction and you're threatening their livelihoods." "Guys help each other out here."
Evaluation	Opinion or feeling about the quality of something or someone.	"These are odd questions." "I don't like my job, I love my job."
Negation	A statement denying something.	"I don't know anything about computers". ." "It is really useless."
Contradiction	Two or more incompatible elements in one utterance or in adjoining utterances. May involve pointing out a contradiction.	"It hurts one way and it doesn't hurt another way." "Sure it makes sense to get help, but it's just not realistic."
Reinterpretation	Re-interpreting, re-casting, clarifying, adding to or re-emphasizing what the interviewer said.	"To us, 'Go and find the part' means go to the stock room." "It depends on the problem."
New solution	A statement that arrives at a new solution to a problem, or suggests a new way of doing something.	"We would have more useful codes if the workers could add a code to the system every time there is no good code." "I would put in the general code and then I would put in my notes exactly what part I changed-- if there's no code for it."
Metacognition	Reflecting on one's own or someone else's thought process.	"I think..." "I know that..."

[3] The order of presentation of the elements follows a largely random order in which they evolved during the coding process. The order does not imply any type of hierarchy among the elements. Possible hierarchical relationships among the elements are addressed in the discussion in Chapter 6.

Interrater reliability coding

Six of the eighteen interviews were coded for interrater reliability by a second coder. Those six interviews included a total of 404 coded utterances, or 32.3% of all 1249 coded utterances included in the study. Reliability statistics were obtained for agreement on utterance boundaries and the coding of each of the seven elements. There were 21 disagreements between the two coders regarding utterance boundaries within the 404 utterances, yielding a 94.8% rate of agreement. Table 2.4. summarizes the reliability results for the seven elements of critical thinking.

Table 2.4. Summary of Interrater Reliability of Coding for Seven Elements

Element	% agreement	Cohen's Kappa
Id. of assumption	86.1	65.0
Evaluation	94.3	86.5
Negation	93.1	85.9
Contradiction	96.0	74.3
Reinterpretation	89.1	68.8
New solution	95.0	71.0
Metacognition	95.8	85.9

Statistical analyses

1. Computer use patterns over time

The composition of the computer use data file is described in Chapter 4. A variety of descriptive statistics, including percentages, ranges, means, and standard deviations, are employed to depict the workers' computer use patterns. The unit of analysis for the two code-use measures is a set of 30 consecutively completed symptoms. Changes in code use patterns over time are described by plotting curves of measures in consecutive sets. Use of repair codes is shown in terms of the proportion of the total universe of 50 possible repair codes used in each Set, and use of component codes is shown in terms of the number of different component codes used in a Set. In addition to descriptions on the sample-level, examples of individual workers' code use "curves" over time are also included. Comment use is shown in terms of percentage of symptoms with comments during Months 2 and 5. Conditional proportions describe change in comment use frequency from Month 2 to Month 5. Pearson correlation is used to test for associations among the three different computer use measures, and t-test is used to compare computer use between the two depots.

2. Questionnaire responses

Means and standard deviations, as well as percentages, are used to describe the workers' responses to the questionnaire items. Differences between the two depots are tested by means of t-tests. Pearson correlation is used to examine associations among questionnaire items. A factor analysis of the 24 questionnaire items is performed to find possible item clusters.

3. Elements of critical thinking in interviews

Means, standard deviations, and ranges are used to describe numbers of utterances in the coded interview segment. Interrater reliability of the interview coding is examined by means of percentage of agreement and Cohen's Kappa. Simple frequencies, numbers per utterance, and numbers per person, as well as ranges and standard deviations of frequencies per person, are used to describe occurrence of the seven elements of critical thinking. Individualized rates per utterance are obtained by dividing the frequency of each element in one coded segment by the number of utterances in that segment. Means, standard deviations, and ranges are used to describe the distributions of individualized rates per utterance of the elements.

A GLM repeated measures procedure is used to test whether the individualized rates of the elements vary significantly across the four stories. Pearson correlation and factor analysis are used to examine associations and clustering among the seven elements. In addition, Pearson correlation is used to test for associations among the questionnaire factors and the critical thinking elements in the interviews.

4. Associating interview and questionnaire data with computer use data

The dependent variable of computer use patterns consists of the three computer use measures described above (repair code use, component code use, comment use). The repair code use measure is designated to be the primary outcome variable. Code use measures for each Set of 30 symptoms and comment use measures for each Month are treated as separate dependent variables.

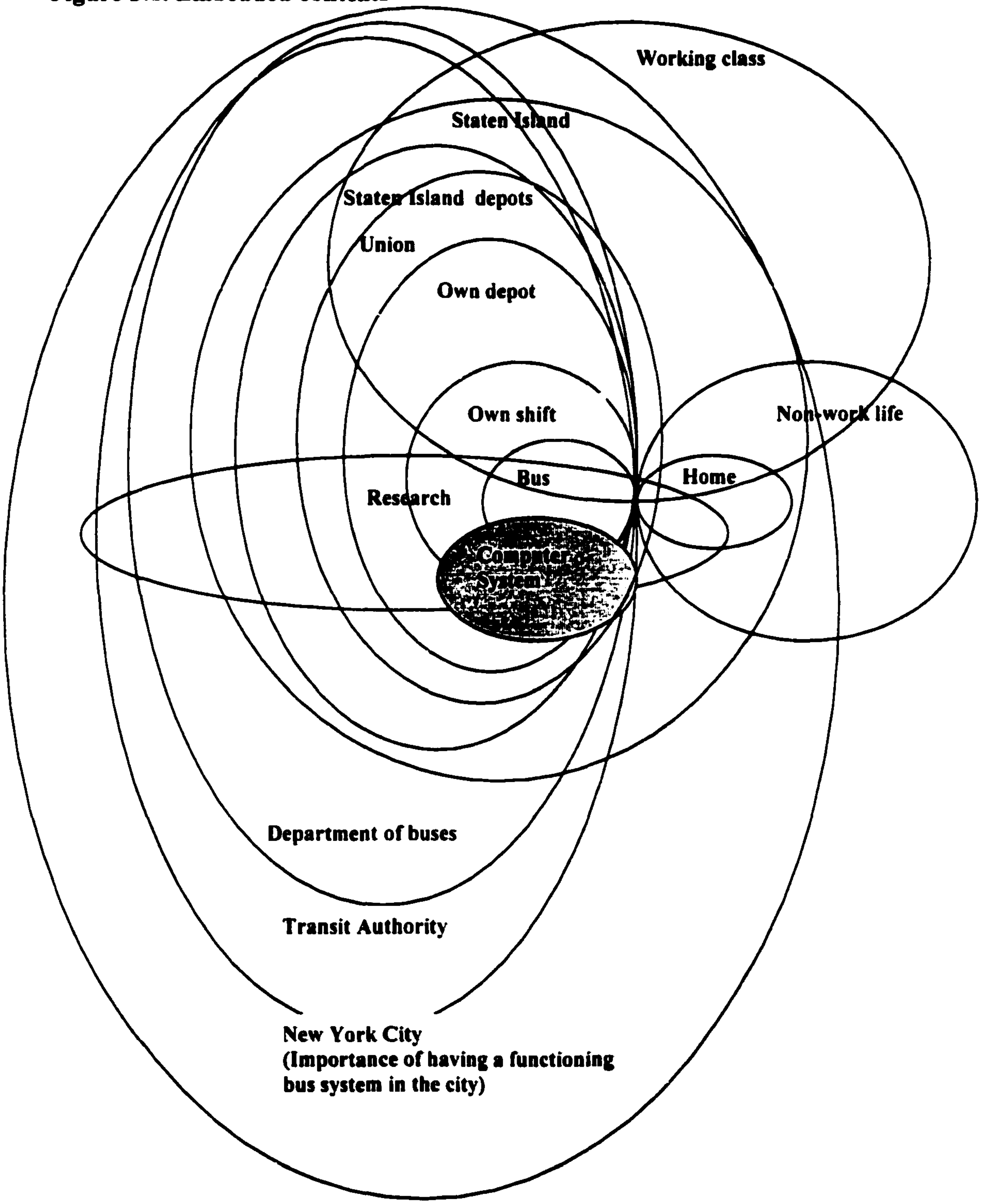
A total of seventeen questionnaire and interview based measures collected during early implementation of the new system serve as the independent variables. These include socres on four questionnaire-based factors and frequencies of the seven elements of critical thinking, as well as measures based on combinations of elements. Two types of statistics are used to test for the association between the independent and dependent variables. First, Pearson correlation coefficient is obtained for each pair of independent and dependent variables. Second, participants are divided into three equal size groups (low, medium, high) based on the independent variables, and differences among the means of the three groups on the dependent variables are tested in one-way analysis of variance.

Chapter 3: Observations of activity in embedded contexts

One of the goals of this study is to describe how a process of adaptation to a new technology is embedded in different levels of cultural, social, and technological context. This Chapter attempts to place the subject of the study within various contextual spheres that create the arenas for the activities under observation. Several theoretical perspectives have influenced the organization of the field-work-based description in this Chapter, including psychologically oriented anthropology (D'Andrade, 1984; Schneider, 1976), activity theory (Lave, 1988; Leont'ev, 1981), and ecological theory of human development (Bronfenbrenner, 1979).

Theories that view context as embedded and intersecting levels (Bronfenbrenner, 1979) or "galaxies" (Schneider, 1976) were found useful for organizing the multiple layers of context encountered in the field work observations. Figure 3.1. is a graphic presentation of some of the most salient layers of cultural context in the bus mechanics' lives that were either directly observed or often discussed by the informants. The figure was constructed in an effort to illustrate the complexity of intersections and nesting among different spheres of relevant context. These spheres constitute the arenas for the activity systems engaging the bus mechanics.

Figure 3.1. Embedded contexts



The figure was used as a map for organizing information gathered about the context of the study and the notes collected during field observations. Some relationships displayed in the figure represent the logic of embedded hierarchies within the work organization. For example, the Staten Island depots are part of the Department of Buses, which, in turn, is part of the Transit Authority. "Working class" and "non-work life" were identified as spheres because they became distinct topics of conversation between the researcher and the informants. "Home" emerged as a special circle within the "non-work life" as affectionate references to family life during the interviews indicated that these men view their homes and families as the basic foundation for their existence. A different type of sphere that also brings a sense of meaning and purpose to the mechanics' lives is the "importance of having a functioning bus system in the New York City area". The bus mechanics feel that through their work activities they have a critical role in the New York City community.

The context where the researcher had her point-of-entry into the world of bus mechanics was clearly marked as a training and research context. The purpose of the researcher's presence was explicitly communicated to the study participants. It is important to understand that this context of research is also experienced by the mechanics as a particular kind of context, and that it has a powerful impact on what the researcher comes to know about the other contexts of the participants' lives. D'Andrade (1984) concludes his discussion of investigator-informant relationships by stating that "Context is usually a social relationship - that is, the meanings people have for each other". Description of the contexts of bus mechanics' lives was obtained through the context of research, which includes observations and interviews, and which is constrained by how the mechanics viewed the researcher. Although most mechanics seemed to develop a pleasant relationship of mutual respect with the researcher, there were many who continued to display intense suspicion. One mechanic communicated this to the researcher during a brief field interview by stating: "People think you're a spy."

Different spheres of context presented in Figure 3.1, and systems of activities within these spheres. are described in the narrative below. The narrative is divided into the following segments: Staten Island and working class, The Transit Authority and The Department of Buses, Operation of a bus depot, The Staten Island depots, Mechanics' work settings and artifacts of critical thinking, Bus repair as an activity and a representation, The computer system, Adaptation to the system.

Staten Island and working class

Staten Island is a largely working-class suburban borough of New York City. Because it is an island only accessible by a few toll bridges, many people choose to both live and work there. The mechanics who described their work histories explained how they often had to work in depots located in other boroughs early on in their careers, but after a few years of seniority they became eligible to "pick" to work in one of the Staten Island depots. They generally seem to have firmly established their lives and families in Staten Island, where they feel "at home" among other "white-ethnic" working-class families.

Ira Shor (1996) has written extensive descriptions of people in the same Staten Island communities in his book *When Students Have Power*, which is a study of one class he thought at College of Staten Island. Table 3.1 presents a list of characteristics used by Shor to describe his students.

Table 3.1. Characteristics of Staten Island working class (Shor, 1996)

working-class look
predominantly white ethnic
few books at home
no-one in their family ever attended college
traditional
family-oriented
homophobic
hardworking
pride on the job in doing their work well
knowledgeable about their jobs
quick learners when it matters to them in real contexts
wise about earning a living
smart but not sophisticated or academic
intelligent but not belletristic, scholastic, bohemian, or cosmopolitan
media-drenched but not well informed about events (TV more than newspapers)
unpredictably literate about special subjective interests
shrewd and manipulative when they need to be
largely unimpressed by professors and intellectuals
not easily persuaded
not pushovers
bad diet and poor health
enjoying good stories, a good laugh, and comradery
resilient (the world doesn't owe you a living)
their fate is to sell their labor every day to make ends meet
little or no authority on the job or in the halls of government

Shor further observed that his working-class Staten Island students have "little or no power to control the decisions that affect them at work and in their communities", and that they are "occupying a very narrow political spectrum from dominant/aggressive conservatives to marginal/moderate liberals, but are often cynical about 'politics' as a waste of time and a feedbag for corrupt officials". One of Shor's insightful conclusions of his observations is that "They tend to be achingly traditional and proudly insubordinate at the same time."(p2)

The field research for the present study largely confirms Shor's observations. His list of terms presented above could, indeed, be a description of the bus mechanics. However, there is one interesting difference. Shor says that his college students do not "claim working class identities". The bus mechanics, on the other hand, like to be identified as "workers", they often talk about problems facing the working class, and belonging to a labor union is part of their identity. One of the differences to Shor's students is that the mechanics have never attended college. Shor's book describes how people from the same communities adjust to college education, and how this leads to a disappearance of a working-class identity.

The typical bus mechanic in this study is a white man in his 30's or 40's who lives with his wife and children in a small house in Staten Island. These workers tend to come from working class families that have been in the United States for several generations after they immigrated from Italy, Ireland, or any of a number of countries. Their formal education consists of high school, which is a requirement for the job, and sometimes a limited amount of technical training. They largely learned their specific job skills while working, although they were likely to have entered the job with at least some knowledge of vehicles and their repair. Many of them were interested in cars and other mechanical devices since childhood. Learning to repair buses and becoming a bus mechanic occurs in a community of practice where legitimate peripheral participation enables apprentices to gradually gain the identity of a master of the trade (Lave & Wenger, 1991). Being a bus mechanic with the T.A. is considered a life-long career-choice.

Excerpt 1:

J: "When you take a look around you-- your blue-collar worker in general, okay is-- how many places have mechanics, okay, that stay there 20 years, 25 years, 30 years? You go into a dealership today-- a car dealership. If you have somebody there 10 years-- astronomical, wow. Okay, here the average thing, I would venture to say, is 15 plus, okay. Why? What kept these people here all these years?"

Researcher: "I know. I keep asking that."

J: "Again, because of the atmosphere that was here, okay. Now, the minute you change atmospheres, everything else--"

The mechanics generally see themselves as average members of the American working class and good productive citizens who strive to provide comfortable lives for their families.

Excerpt 2:

V: "Just a little piece of the pie, okay. The American workers say we're all satisfied with a piece of the pie. We just want to be able to pay our mortgage and our rent, food on the table, put your kids through school-- the normal American dream."

They work hard to maintain the stability and security of their life style. This makes them suspicious and hostile towards anything radically new, including the new computer system invading their workplace. The uneasiness about historical change is illustrated in the following excerpt:

Excerpt 3:

V: "When I first came on the job I used to say: 'I have a good job'. I went from saying 'I have a good job' to 'I have a job' to-- 'I'm lucky I have a job'. So, now that's within a quarter of a century. What's the next quarter of a century going to bring for the worker?"

<u>The Transit Authority and The Department of Buses</u>

The New York City Transit Authority (T.A.) operates one of the largest and most complex public transportation systems in the world. It runs 24-hour bus and subway service which is used by approximately six million people daily[1]. The TA reported that

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[1] The figures presented in this section were originally obtained from the 1997 Insiders Guide to the TA Department of Buses, and updated based on information presented on the TA website in February 2000.

in 1997 customers paid for 72% of the bus and subway operating expenses, and 28% was tax-subsidized. Important functions of the public transportation system in the city, compared to private means of transportation, include easing the congestion of traffic and reducing air pollution. During interviews, several mechanics expressed that these functions of public transportation give them means of contributing to important causes in their community. They felt that millions of people, including their own family members, are counting on them to make sure that the bus system operates.

The Fifth Avenue Coach Company started the first motor bus service in the city in 1907. The T.A. was established in 1953 to manage the subway system, which had started in 1904, and the bus routes that were then operated by the New York City's Board of Transportation. The administrative structure of the T.A. has changed over the years. During 1953-1971, the top management consisted of several commissioners, and starting in 1971, one Chief Executive Officer (called "President" since 1980) has been in charge of the highest level management. The current (as of February 2000) President has been in office since 1996. Twelve department heads constitute the next highest layer of top management. The T.A. has over 42,000 employees in 27 major departments and divisions. The employees belong to 21 different local labor unions and supervisory organizations.

The Department of Buses, which is one of the major departments of the T.A., provides 24-hour bus service to about 1.4 million riders daily. Its 203 local and 31 express routes total 1,671 miles, and its17 bus depots located across the city house over 4,000 buses. The annual budget of the Department was $805 million in 1997. The Department has about 12,000 employees, including close to 2,000 bus mechanics. About

97% of the employees are unionized. Middle management in the Department consists of 450 managers and 300 supervisors.

The overall style of the Transit Authority operation easily reminds an observer of the military. Ranks are strictly observed and maintained, and signified by "uniforms"; people sometimes give and receive "direct orders"; and formal disciplinary structures are in place to control a largely male body of workers considered potentially rebellious. At the same time, the T.A. is an intense active political battlefield where every decision regarding spending and receiving money, purchasing, appointing people, and locating the infrastructure is negotiated semi-publicly in front of politicians and taxpayers. The "machinery" of the T.A. is slow and complex compared to privately owned corporations, making it often look inefficient and confused.

Operation of a bus depot

A bus depot is a 24-hour operation that never stops even for holidays or bad weather. There are three shifts of workers, the day shift 7 a.m.- 3 p.m., the "mid-trick" 3 p.m. to 11 p.m., and the "hawk" from 11 p.m. to 7 a.m. Most of the managers are present only during the day shift, although one superintendent is always in the depot. Not having managers around makes the later shifts desirable for workers, despite of the atypical work hours. Authority relations in bus depots are in a constant state of tension, although the specific conflict issues vary from time to time.

As illustrated by the following two excerpts from interviews, the mechanics often feel that they are mistreated and under-appreciated by their superiors. Both comments were triggered in a conversation regarding reasons why many workers do not care about the "big picture" of what happens in the depot.

Excerpt 4:

P: "The reason they say that [they don't care about the big picture] is because it is the way management is now treating us-- the way they now treat us, okay, they're treating us right now, like-- we're a junkyard dog, okay. And they just want to beat me to death. That's not my attitude, okay. My attitude is I am no longer a parts-changer. Okay, we have gone into high tech buses, okay. Computerized rear doors, transmissions, engines, okay. I'm a technician, okay. I'm a technician. I'm good at what I do, okay. I like myself, therefore, I want the respect, okay. I'm not getting it. Nobody is getting it, okay. You want to treat me like a junkyard dog? I'll be a junkyard dog. That becomes my attitude, okay."

Excerpt 5:

R: "So how is-- how is somebody supposed to feel? We've taken this person. We've smacked him on the right side of the head, the left side of the head, now on top of the head, and now you want me to care about the big picture? I can't. I can't. You've knocked me down to the ground and you spat upon me."

A typical shift has two foremen (line supervisors), and about 15 - 40 workers, depending on the size of the depot. The major categories of workers include the maintainers (mechanics), mechanics' helpers, and cleaners. The present study focuses specifically on the mechanics who mainly are the front-line users of the new computer system. Most mechanics have the title of BMB (Bus Maintainer B), and some are BMA's (Bus Maintainer A). The difference is that BMA's specialize to body work, while BMB's do any other kind of repairs in the bus.

The purpose of a depot is to maintain a fleet of about 100-200 buses, which involves repair of broken buses, as well as storage and coordination of available buses. Buses go in and out of the depot 24 hours a day, although the main "pull-out" occurs right before the morning rush hour around 6 a.m., and most buses are "pulled in" during the evenings. For the day shift, decisions have to be made about which buses will have to stay in for repairs, and there never seem to be enough buses for the pull-outs. At night, most buses are stored in the depot, but due to tightness of space, it is impossible to access more than a few for repair work. Since the operation never stops, it is very difficult for the people who work in the depot to step back and evaluate their coordination efforts. Instead, each day feels like a chaotic effort to scramble enough buses together to be sent out on the road.

The Staten Island depots

The city started operating bus service in Staten Island in 1947. The two Staten Island depots, located about five miles apart, operate a total of over 400 route miles within and outside Staten Island. The two depots have a total of about 800 employees who have their own union, Local 726. The union has a strong presence at the depots: meetings are held at least weekly, flyers are posted to keep members updated, and a shop steward at each depot is assigned to union duties for about half of his work hours.

Depot A, which measures 126,000 square feet, was built in the late 1940's as the first depot in Staten Island. It is located in an industrial area filled with auto-body-shops, furniture whole-sale shops, and other similar small businesses. It operates about 200 buses running 13 local routes and 6 express routes. Depot A has a total of about 500 employees: 350 of them are bus drivers and 60 of them are bus mechanics. Due to tight space, most buses are stored in an outside yard next to Depot A. The slightly deteriorated yellow-brick-building is rather dark inside, and always has a strong smell of oil and diesel fume. The inside walls and floors are covered with dark oily dirt. Pigeons are always flying around inside of Depot A, and the mechanics also feed a couple of regular depot cats.

Depot B, which was built in the late 1970's, and located next to a large shopping mall, and residential areas, is larger and newer than Depot A. It measures 244,000 square feet, housing close to 300 buses, which run 7 local routes and 12 express routes. The two-story red-brick building is better ventilated, and considerably cleaner, than Depot A. On top of the high noise level present in both depots, a "classic rock music" radio station always plays from the loudspeakers on the shop floor of Depot B. About 560 employees work at Depot B, including 400 bus drivers and 80 bus mechanics. The Staten Island Division Office, where local top managers have their offices, is located on the second floor of Depot B.

Mechanics' work settings and artifacts of critical thinking

Besides bus storage areas, the depots have designated areas for fueling, washing, tire changes, and part storage. The buses to be repaired or inspected are constantly driven in and out of the repair area on the shop floor where they can be taken up on a lift if necessary. It is difficult, at first, to spot the workers in dark blue uniforms under or inside buses, but wherever there is a bright red tool-box cart, there is likely to be a mechanic nearby. Individual mechanics have their own tool-box carts that are often quite personalized with funny stickers, family pictures, and warnings against intruders and tool thieves.

Social interactions among the workers intensify during break times. Both depots have a designated area where most mechanics spend most of their lunch and other breaks. They gather in these areas, eat, talk, and read newspapers and magazines. In one of the depots the lunch area is not a separate room with walls, but rather an area defined by a group of tables and benches and partly bordered by buses that separate the area from the general shop floor. In the other depot, a room adjacent to the shop floor and the locker room functions as the break area. After a few visits the mechanics seemed accustomed to the researcher's presence in the lunch area, and served her coffee and offered her cigarettes and parts of their lunch sandwiches.

Pieces of text are sprinkled all over the two depots. Anywhere one looks there are written messages painted or posted on surfaces, including walls, buses, tool carts, and bulleting boards. The biggest signs on the wall include: "Anti-freeze accumulation area", and "Safety first - injuries last!". The buses are covered with large advertisements, often portraying huge pictures of sexy underwear models that make people in the depot look miniscule.

The break areas are especially dense with items that can be characterized as "artifacts of critical thinking". The most popular topics of analysis include politicians, T.A. bosses, women, sports, body and muscles, cars, and dogs. One of the depots has a big banner hanging on top of the break area: "Crazy people working here". The mechanics like to collect their favorite magazine and newspaper clippings, stickers, photographs, and post cards together and make them into collages that accumulate over time. One of the depots has some of its' collages on break area tables under glass. In addition to arranging the collected items, the mechanics write and draw their comments on them, and the comments are not always "politically correct".

The free-associative collages easily connect such items a sticker supporting MIA's and POW's in Vietnam, newspaper article "Diesel fuels - protect your lungs", a picture of someone's dog, and a picture of President Clinton with his pants down. Global and local labor politics are represented by stickers: "Don't send my job to Mexico", and a picture of one of the top T.A. managers with added monster-teeth and a bubble saying "I buy the bus, you fix it in book time, if you don't you're out." The new computer system has earned its place in the collage with a cover page of the User Manual, where the system's name "MIDAS" is translated into "Many Idiots Doing A-hole Stuff".

An interesting artifact of critical thinking towards the Midas system was also encountered in a "Midas sucks" button that one of the supervisors was wearing. He started wearing it soon after the system came into the depot, but stopped after a couple of weeks. A week later there were some technical problems with connecting to the system, and he was seen wearing the button again. Another example of a wearable artifact of critical thinking was a t-shirt the mechanics had specially made at one of the depots. Across the front of the chest it read "Yukon Correctional Facility" (Yukon is the name of one of the depots).

The artifacts described above show how evidence of critical thinking can be identified outside of people's minds and words. These artifacts were part of the everyday environment of the mechanics who may have found it easier to express some of their attitudes, for example, by semi-anonymously posting items in a collage than verbalizing their ideas directly to others. Activities "crystallized" in physical objects often communicate people's individual or collective opinions and critical analyses. Objects. such as those described in the bus depots, can be counted as evidence of critical thinking activity.

Bus repair as an activity and a representation

A bus is a large and technically extremely complex object. The approximate size of a bus is as follows: length 40 feet, height 10 feet, width 102 inches, weight 27,000 pounds, number of seats 40, maximum passenger capacity 70. The average cost of a bus is $245,000, and the average age is 8.5 years. Further complexity is introduced by differences among several different models of buses that are in operation.

The notion of "bus repair" captures a vast diversity of tasks that require varying amounts of muscular strength, specialized expert knowledge, practice, patience, creativity, communication, concentration, manual dexterity, willingness to get dirty, endurance, ability to decipher manuals and diagrams, trust on one's instinct, ability to work alone, ability to work with others-- only to mention a few. Some mechanics specialize into one or more specialty areas, such as A/C, wheel chair lifts and rear doors, electrical work, or breaks.

The mechanics are confident about their abilities to repair buses. They generally approach each job assigned to them as a "professional challenge", much like a physician would approach a patient. Bus repair activities are broken down into relatively clearly defined units, which are reflected on the work orders that mechanics receive from their supervisors. In activity theory terms, a "job" described in a work order represents all the required characteristics of an activity: a subject, an object, a tool, a motive, and an outcome. Although most jobs are clearly defined and obvious, there are also buses that come in with mysterious symptoms requiring extensive diagnostic probing. The mechanics reported liking the mix of clear-cut jobs and challenging jobs.

If a work order is conceptualized as a unit of activity, critical questions arise concerning the computer system: Is it possible to accurately represent bus repair activities in a computerized database? Do the units provided by the computer system correspond to the units of bus repair activities? Does the system allow for descriptions of difficult and ambiguous repair activities? What parts of the activities are excluded from the computerized descriptions? In addition to the design of the system, an answer to these questions is found in the way the mechanics choose to utilize affordances in the computer system. In other words, are the mechanics able and motivated to represent their repair activities accurately on the computer? A match between real repair activities and what is represented in the computer system is critical for the accumulation of an accurate maintenance database that can be used for planning of activities. Mechanics looking for codes to fill out their work orders and typing in notes are struggling to make this match between reality and representation.

<u>The computer system</u>

The new computer system implemented in the two research sites is a scheduled maintenance information system custom designed for the New York City Transit Authority Department of Buses. Its name MIDAS stands for the Maintenance Information Diagnostics and Analysis System. Similar maintenance information systems based on the same core program are used in other organizations with varying success. Other users of these systems have often reported difficult problems with obtaining accurate data on the shop floor. Instead of using data entry clerks, which is the typical strategy, the Transit Authority decided to have the mechanics who work on the buses enter information directly on the computers.

The Transit Authority also decided to offer all mechanics a conceptually organized and activity based training workshop that explored the logic and the possibilities of a scheduled maintenance system in bus depots. The workshop has been described in detail by Kindred (1999). In the workshops, teams of workers played a game where they operated miniature bus depots with and without the help of scheduled maintenance systems, as well as received preliminary instructions for using the computers. All workers who participated in the present study went to their training workshops prior to or at the very beginning of the implementation of the computer system on the shop floor. During the interviews, some references were made to the training, mostly using an example from the game to refer to a real life activity in the depot, or questioning the relevance of the conceptual and activity-based training method.

Scheduled maintenance information systems, which originally emerged in nuclear and airline industries, are designed for gathering historical maintenance information and for planning a schedule of preventive maintenance activities based on the historical data. For example, if the engine of a bus typically starts failing around 100,000 miles, engine overhauls can be scheduled at every 90,000 miles for all buses. Preventive maintenance is especially critical for parts of the bus that involve potential safety hazards, for example breaks, but it can also improve the unpredictable and often chaotic flow of work in the depots, as well as decrease the occurrence of expensive break-downs on the road when the bus goes out of service, passengers are stranded, and the bus has to be towed into the depot.

The computer system ideally gathers specific information about all break-downs and repairs during the life-history of each bus. This information can then be used to analyze general patterns of breakdown, but it can also be utilized in the diagnosis of a problem in a particular bus. It can also be useful to the supervisors who can look at the status of the buses in the fleet on the computer while deciding on day-to-day priorities and distribution of work assignments. For the managers, a centralized information system can be an extremely powerful tool providing a wealth of information.

There are varying levels of access to the different "areas" of the computer system, and rules of access are highly contested among the users of the system. Access, which is controlled via private passwords, is of two types: access to view information, and access to change information. Only a few computer experts in charge of the system have completely universal access. The highest level managers in the central T.A. office can view everything, and managers in individual depots are allowed to view everything in their depots. Certain aspects of financial information and functions used to aggregate and analyze data and generate reports are reserved for managers only. The supervisors have control over their own "work assignment sheets" which they use to distribute tasks and workers, but a manager has to "sign off" on each work assignment sheet before is closed.

The mechanics have access to fill out and change information on "work orders" assigned to them on the work assignment sheet, and access to view other work orders. Although most mechanics do not believe it, official communication channels claim that the supervisors and the managers cannot erase or alter any information that a mechanic enters into a work order. Everybody across ranks can view bus histories and individual work orders.

The mechanics' day-to-day involvement with the computer system consists of filling out work orders on jobs that they were assigned to do. (See Table 3.2 below for the main parts of a work-order.) They type in their user-id and their secret password, and the work-order number, which they get from their supervisor. A work order includes one or more "symptoms" that describe what seems to be wrong with the bus (e.g., "noisy", "leaking"). Each symptom is associated with a specific "system" (e.g. hubs and wheels, engine, breaks) and "component" (e.g., left front tire, rear door bearing, oil filter). The supervisor usually gets the symptom either from a bus drivers' report or from an inspection report. When he enters the symptom code on the work order that he creates, the supervisor may or may not enter the system and component codes.

The mechanic will fill out the rest of the information in the work order. (A picture of a symptom screen of a work order is shown in Appendix 3A.) Even if the supervisor already entered a preliminary system and a component, the mechanic is responsible for checking them and changing them if necessary. In addition, the mechanic has to enter a "defect code" and a "repair code". The defect code (e.g., "worn out", "out of adjustment") differs from the symptom code by indicating what underlying problem, according to the mechanics' diagnosis, is causing the symptom. The repair code indicates what the mechanic did to fix the problem (e.g., "replaced", "adjusted"). The mechanics can choose their codes from master-lists of codes that include approximately 100 defect codes, 50 repair codes, and 2,800 component codes. In addition, space is provided in the work-order for the mechanics to type in comments and notes on the work they completed.

Table 3.2 Parts of Work Order

Part of work order	**Example**	**Function**	**Person Responsible**
SYMPTOM	Noisy	Apparent problem in bus	Supervisor
SYSTEM	Break system	General area of bus	Mechanic (Supervisor)
COMPONENT	Lining - left side	Specific part of bus	Mechanic (Supervisor)
DEFECT	Worn	Diagnosed problem	Mechanic
REPAIR	Replaced	Repair activity	Mechanic
NOTES	"Also found missing bolt"	Additional information	Mechanic

Adaptation to the system

When the computers arrived to the bus depots some of the mechanics had already gone to their training workshops, and everybody had ideas about the changes the computers would bring to the depots. These two depots were also the last two of a total of nineteen depots in the Department of Buses to be introduced to the computers, and stories from elsewhere had been heard in Staten Island. According to the mechanics, the stories were both favorable and unfavorable.

Four computer workstations were installed on the shop floor of each depot. Based on other depots' experiences with bringing these delicate machines into rough and dirty depot environments, special "booths" had been built for the computer units. Supervisors had their own terminals in their offices, and the four terminals for the mechanics' use were placed on the shop floor in the proximity of the bus repair area. When the system first went into operation, small groups of mechanics were observed hunched over the terminals trying to understand how the new machine works. One mechanic described the gradual social process of learning the system the following way:

Excerpt 6:

R: "Well, we're getting used to it. A lot of people never played with a computer in their life so-- it's all new. And it's still new because you're not sitting there all day doing stuff. It's like ten minutes here, ten minutes there.

Researcher: "That's right."

R: "And you don't really sit there and take time to play with it because there's other things that got to be done."

Researcher: "Right, right."

R: "That's why you pick up some from this guy, some from that guy. Before you know it you know a lot of different things to do and you get through your work orders easier, faster.

Special computer counselors were on call in the depots for 24 hours during the first two weeks. The counselors helped each mechanic fill out their first work orders. In a few weeks, most mechanics had learned the basic functions, and now seemed to prefer working at the terminal alone. The time spent at the computer varied from about two to fifteen minutes, and great variations were observed in the time spent scrolling through code lists looking for accurate codes. Another factor contributing to time variation was whether the mechanic decided to type in comments about his job. Even some of the slowest typists insisted on typing in very specific messages. After a few weeks of using the system, several mechanics commented that the system does not seem to be hurting the workers, but that it is making managers "nervous". One worker described how the managers are "jumping up and down and pulling their hair out", because the new system is "exposing their dirty laundry".

The process of accommodation to the new system was observed across many of the intersecting spheres of context shown in Figure 3.1. The decision to have the new system installed came from global "actors" much beyond the local depots. Actor-network theorists (Bijker & Law, 1997) describe similar networks of global and local actors where "intermediaries", such as resources and products, are exchanged in the process of developing technologies. The adaptation among the local actors was constrained by forces imposed from the global actors. For example, the union did not have the power to stop the arrival of the computers, but they were able to negotiate issues of access to various areas in the system.

Non-work experiences with computers partly determined who became the local leaders of computer learning, although a few complete computer novices also learned very quickly and assumed leadership roles. One mechanic gave an emotional account of being surprised when he became aware that people were coming to him for computer advice, not because he was a computer expert, but because he had happened to discover an alternative procedure for easily getting out and back in to one's work order.

Although the mechanics feel confident about approaching mechanical devices in general, computers were a new territory for most of them. They saw computers as machines designed for the educated middle and upper classes. This is an example of the contextual layer of "working class" playing a role in the adaptation process. Many of them had purchased computers for their children, partly as an effort of upward class-mobility in the information society. Several mechanics reported getting personally more interested in computers in general as a result of using the system at work.

The arrival of the computer system triggered much resistance among the workers. In addition to simple refusals to cooperate with the new system, many of the mechanics displayed more complex forms of criticism. These included analyses of what is good and bad about the new system and why people are resistant towards it, and what are the best strategies of adjusting to the new system, given that it is arriving to the depots. One of the mechanics provided a description of the dialectic of complaints and new ideas, the same basic idea that this study is applying to the process of adaptation:

Excerpt 7:

Researcher: "Somebody said this is one of those places where everybody complains but nobody ever leaves."

P: "Exactly. Okay, but it's human nature to complain. I think-- I think it's healthy to complain."

Researcher: "Yes, I-- I agree--"

P: "Because a-- along with complaints come new ideas-- fresh ideas."

Researcher: "That's actually what I'm trying to show in this study in a way. I like the way you put it. That we brought these computers into a place where there's a lot of resistance a lot of criticism, and you know, suspicion, but maybe that-- some of that-- is helpful in making this work. Because you need to have that, you know--"

P: "Negativity."

Researcher: "Well, some of it can be good, you know--"

P: "Yeah, well negativity-- yeah it can be good. Again, provided you don't let it get out of hand."

Chapter 4: Patterns of computer use

One of the goals of this study was to develop methods of studying how users utilize a large networked computer database system, and how utilization of the system changes over time. The system adopted by the bus depots functions under the assumption that the bus mechanics enter accurate and specific information about all work they do into the computers, because that is the only way of creating and sustaining a valid data base of maintenance information for communication and planning purposes. Entering specific information requires that the mechanics utilize the full range of options presented by the system. Productive users of the system choose accurate codes from pre-existing lists of codes and type in additional comments when necessary. This chapter presents data on three different indicators of the bus mechanics' computer use over time. These indicators were designed to capture what proportion of the total affordances in the system was utilized, and how the utilization levels were sustained over time.

Data file

Computer use data were downloaded from the managed information system of the organization. The relational database, where all bus maintenance data entered by the users are stored, consists of several linked tables of data, including a table where each row represents a symptom (a perceived problem in a bus), and the columns provide information about the symptom. These columns include date, defect code (an underlying problem in a bus), repair code (a repair action), system code (an area of the bus consisting of several components), component code (a specific part of the bus), employee pass number, and bus-number. Other tables in the database provide detailed information about, for example, each employee, each bus, or each bus component. Data from different tables can be linked via unique identifiers, and relational database queries can be conducted to obtain data on selected items.

Relational data base queries were performed once a month for five months to gather data on all work orders processed by the two participating bus depots. The final merged data set included a total of 26,829 symptoms in 7,937 work orders[1], and 31 variables for each symptom. The initial symptom file was grouped by employee pass number, and symptoms closed by individuals who were not mechanics were discarded[2], yielding a file containing 24,454 symptoms closed out by 125 mechanics in the two depots.

Individual mechanics' code use patterns over time were examined within consecutive sets of 30 symptoms closed by each mechanic.[3] Two indices of code use were obtained for each set of 30 symptoms. There were three mechanics who closed less than 30 symptoms during the five months. After symptoms closed by those three mechanics were excluded, the remaining symptoms were grouped by employee and ordered by date, and then categorized into consecutive sets of 30, up to a maximum of ten sets[4]. This procedure yielded a total of 699 sets of 30 symptoms closed by 122 different

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[1] Several related symptoms are often included in one work order. The primary unit of analysis in the analyses of code use below is the symptom, because symptoms are closed by the mechanics one-by-one, and different codes are used to close out symptoms within the same work order.

[2] Sometimes a mechanic's helper, a computer support person, a supervisor, or a manager closes out a symptom. All those symptoms were excluded from further analyses.

[3] The initial plan was to analyze monthly indices of code use, such as number of different repair codes used per month. Sets of 30 consecutive symptoms per person were chosen, instead of monthly usage, for two reasons. First, numbers of symptoms closed in one month varied widely from person to person. And second, the number of times of computer use was determined to be a more accurate outcome measure than the length of chronological time the computers were in the depot. Sets of 30 symptoms, as a measure, reflect the amount of experience using the computer accumulated over varying periods of time. In other words, one mechanic may have completed his first 30 symptoms in one week, while another mechanic may have completed his first 30 symptoms over two months.

[4] Ten sets was chosen as the cut-off point because very few workers had more than ten sets within the five months.

workers. Any symptoms left over after each mechanic's last complete set of 30 were discarded from the file. In the final file of 699 sets (20,970 symptoms), the number of sets for each mechanic ranged from one to ten. Table 4.1 below presents the distribution of numbers of sets among the 122 workers. The table shows, for example, that there were 18 workers with 10 sets of 30 symptoms, 3 workers with 9 sets of 30 symptoms, etc.

Table 4.1. Composition of data file:
Numbers of workers with different numbers of sets

Number of sets of 30 symptoms included in data file	Number of workers
10	18
9	3
8	11
7	15
6	15
5	14
4	20
3	13
2	7
1	6
Total	122

Indices of Computer Usage

The purpose of obtaining data files from the organization's data base was to find indicators of individual workers' computer use patterns over time. The rationale behind the indicators chosen here was to find measures that can capture how broadly a worker utilizes the options provided within the system. The broader the range of usage, the more carefully and specifically the worker is filling out his work orders. Usage of a broad range of options leads to specific and accurate database of bus maintenance information. Therefore, the more options a mechanic utilizes, the more productive user of the system he is.

Although the indicators of code use are described below for the entire sample, it is important to understand that the goal was to design accurate measures of individuals' code use. For instance, the decision to use sets of 30 symptoms as the unit of analysis was made in the interest of designing the best individual-level measures for testing hypotheses that involve predicting individual code usage patterns. Month-based measures may have been more simple for describing overall usage in the whole sample, but only set-based measures will be shown below because they will be used as outcome measures in Chapter 7.

The indicators of computer use selected for this study focus on repair code use, system/component code use, and use of comments. The mechanics are responsible for "closing out" all symptoms assigned to them by entering information on the computer describing the work completed to address each symptom. The symptom code for each symptom is previously entered by the supervisor. The mechanic enters a defect code, a repair code, a system code, and a component code[5]. The mechanic selects the appropriate codes from predefined lists of codes, and can also type in comments about the job. Please see Appendix 3A for a picture of the symptom screen that users see on the computer screen.

[5] Sometimes the supervisor enters the system and/or the component, but the mechanic is responsible for verifying these codes and changing them if necessary to match the job that was completed.

<u>Repair code use</u>

The repair code describes the repair action completed to address a problem in the bus. The list of 50 possible repair codes includes such actions as, "straightened", "removed only", "adjusted/aligned", and "fumigated". The fieldwork observations showed great variability in the care and time the mechanics took to select an appropriate repair code. Some mechanics settled on virtually always using one code, such as "completed", even when another one would have clearly been more appropriate for the job. These field work observations were supported by analyses of the computer data, as shown below.

The sample of 20,970 symptoms, which is defined above, indicates that the 122 mechanics in the two depots used 48 of the 50 possible repair codes at least once during the first five months. The most popular codes were "change out (replaced)", which was used 29.6% of the time, and "completed", which was used 22.6% of the time. These two codes are very general, and although many times they are correct, there is often a more specific repair code available. The other 46 codes accounted for the remaining 47.8% of the symptoms. Appendix 4A shows the number of times each repair code was used in this sample of 20, 970 symptoms.

In order to examine how broadly each mechanic utilized the possible range of repair codes, and to analyze patterns of usage over time, a summary-measure of repair code use was developed for this study. This measure reflects what percentage of the total universe of 50 repair codes was used in each set of 30 symptoms. As described above, consecutive sets of 30 symptoms were defined for each of the 122 mechanics. For each set (n=699), it was computed how many repair codes, out of the possible 50, were used at least once in the set. The number of different repair codes utilized within a set ranged from 1 to 15, M = 7.28, SD = 3.01.

In terms of "percentage of total repair code universe utilized", the entire sample of 122 mechanics used 96% (48 of 50) of the repair code universe within the first five months. The percentage of repair code universe utilized within a set of 30 symptoms ranged from 2% to 30%, with an average usage of 15%. Table 4.2 shows proportions of repair code universe used by set. Both the total proportion of repair code universe utilized by the sample, and the mean of individual utilization percentages, decline in later sets. It may be misleading, however, to examine these whole-sample-based indicators over time because the sample size also declines radically in the later sets. The workers who completed the highest numbers of symptoms within the five months may be a select group that is not representative of all workers. It is necessary to keep this limitation in mind when examining repair code usage over time for the whole sample (Figures 4.1. and 4.2.).

Figure 4.3 presents examples of repair code usage curves over time for three individual workers. Field observations, as well as analyses of the computer data, showed that different types of work assignments were generally equally distributed among the mechanics. There also did not seem to be great variation over time in the nature of work assignments received by one mechanic. Therefore, any fluctuations in individual mechanics' code use over time are likely to be due to variations in the way the computer is utilized, and not to variations in work assignments. The first example in Figure 4.3. is a worker whose repair code use resembles the declining pattern over time found for the overall sample. The second example illustrates a worker who used an increasing proportion of the repair code universe over time, and the third example shows a worker whose usage increased and then declined.

Table 4.2. Proportions of repair code universe utilized by set

Set	Number of workers[6]	Percentage of repair code universe utilized by all workers	Range of individual repair code utilization percentages	Mean of individual repair code utilization percentages	Standard deviation of individual repair code utilization percentages
1	122	88	2 - 30	16.8	5.7
2	116	78	2 - 24	15.7	5.1
3	109	82	2 - 30	15.1	6.0
4	96	82	2 - 26	14.7	5.4
5	76	84	4 - 24	14.5	5.4
6	62	74	2 - 26	13.5	6.0
7	47	68	2 - 26	13.3	6.6
8	32	58	2 - 24	11.0	6.4
9	21	44	2 - 20	8.3	5.1
10	18	42	2 - 24	8.0	6.3

[6] The number of workers declines in later sets because data were available only for five months, and some workers completed very few sets of 30 symptoms within the first five months.

Figure 4.1. Percentage of repair code universe utilized by whole sample

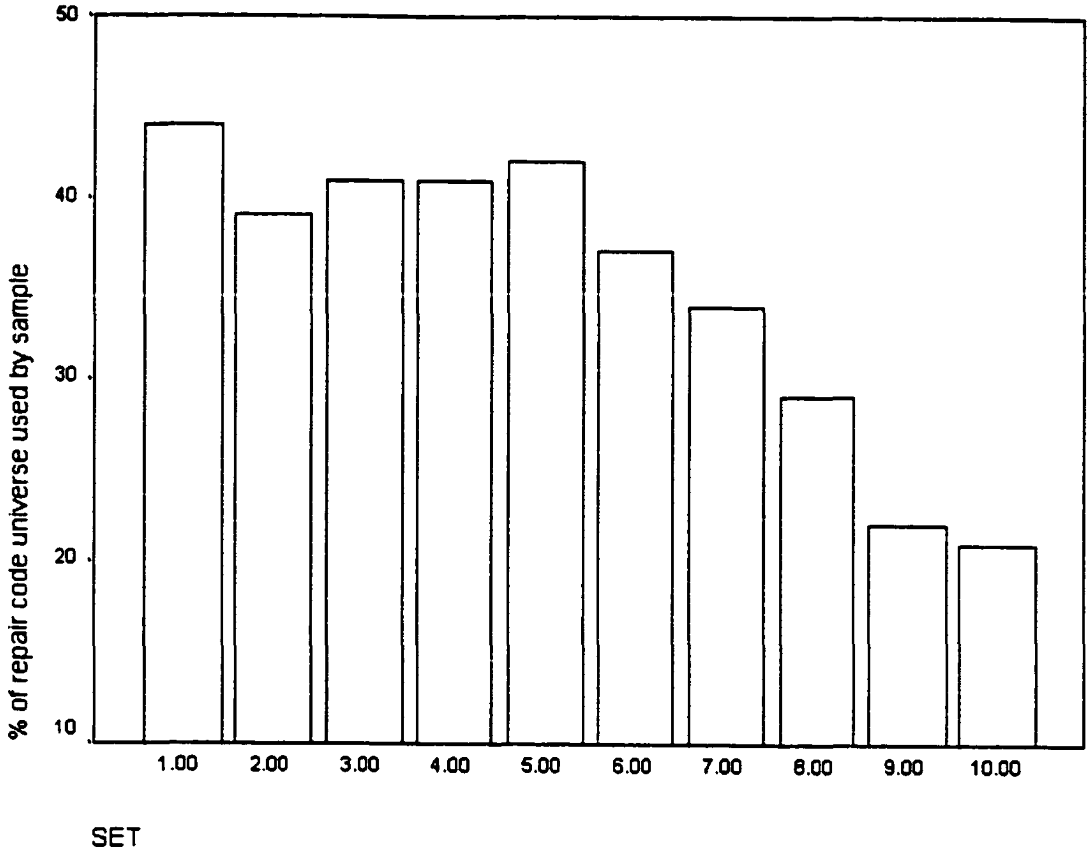


Figure 4.2. Mean of individual percentages of repair code universe utilized by set

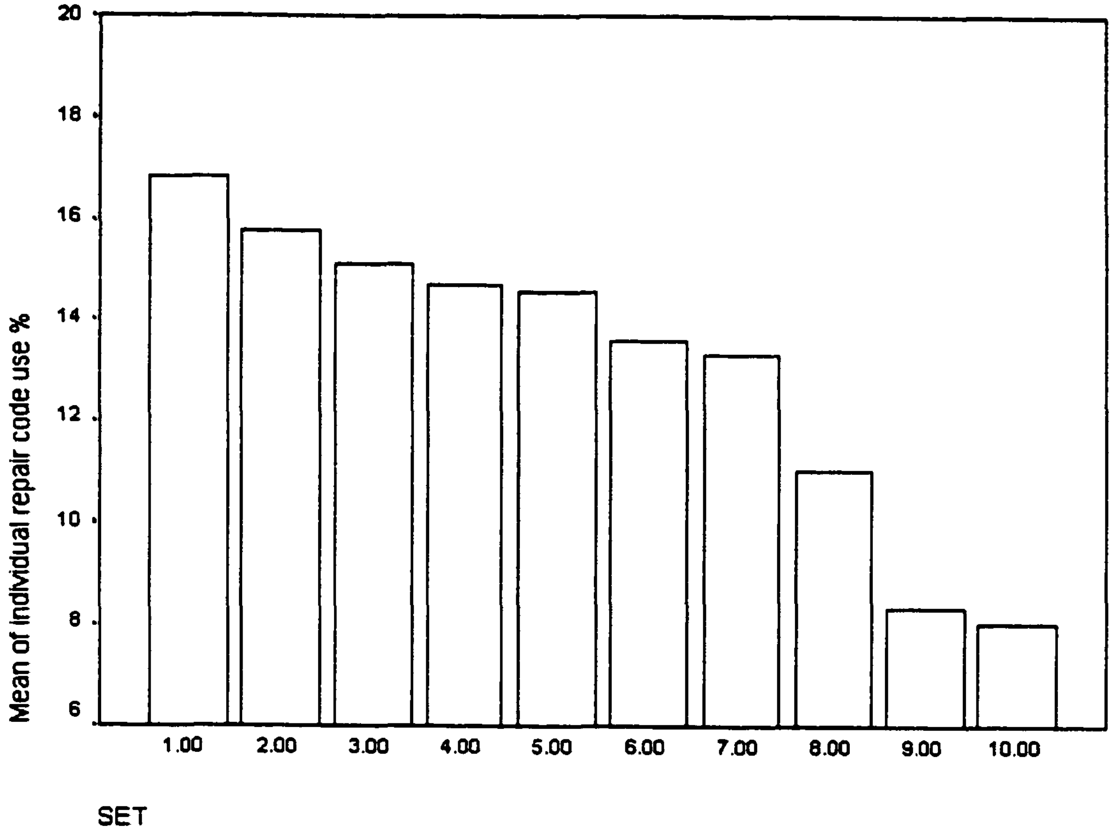
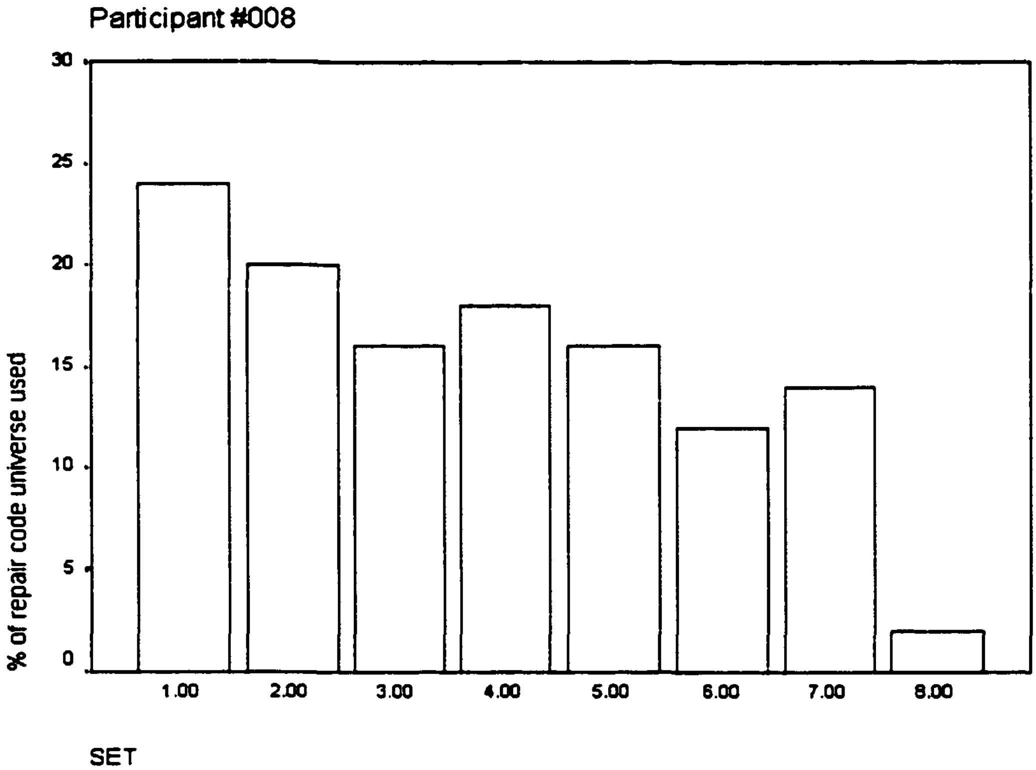
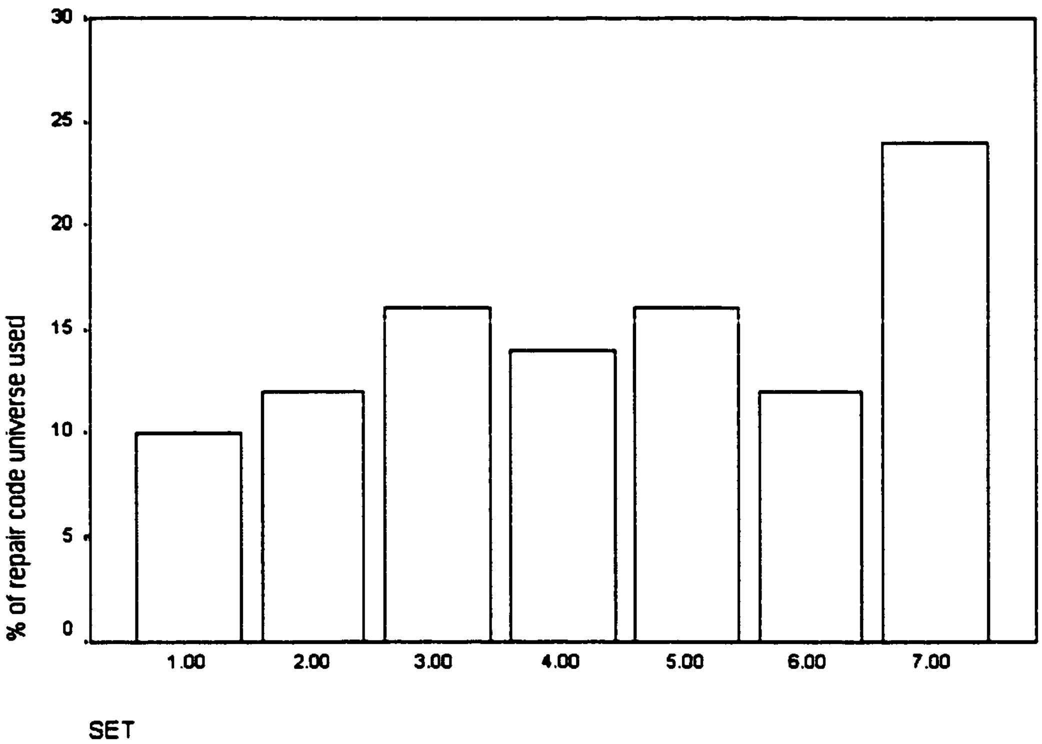


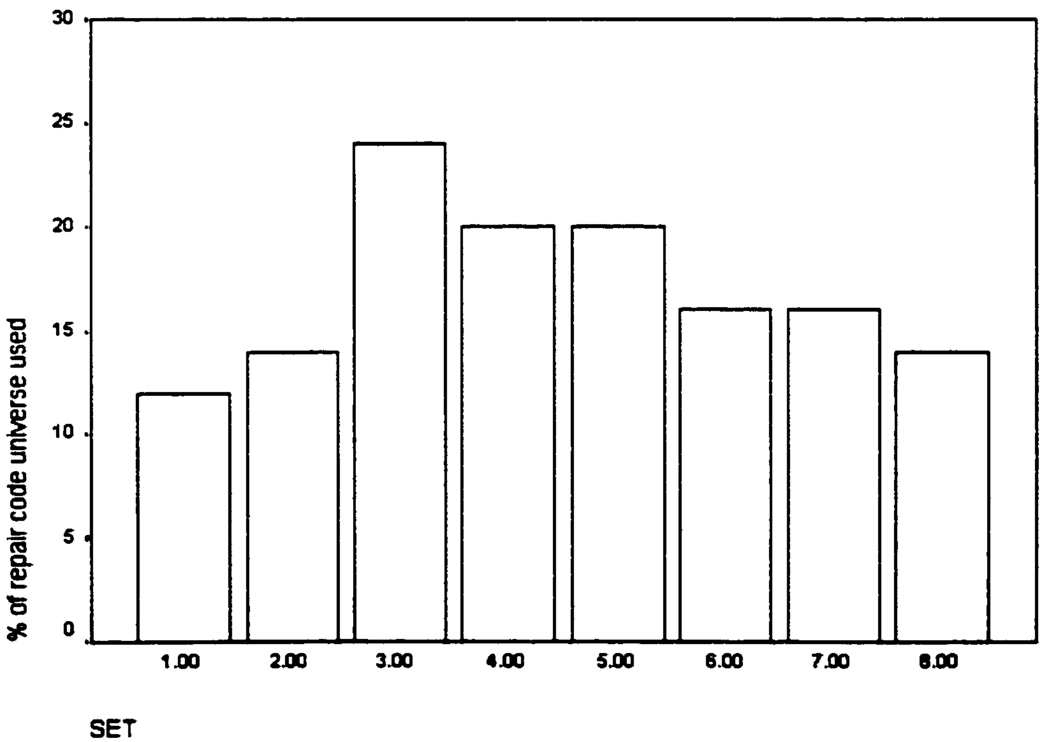
Figure 4.3. Examples of individuals' utilization of repair code universe



Participant #004



Participant #003



Component code use

The component code refers to the specific part in the bus that was repaired. The approximately 2,800 different component codes stored in the database are categorized into about 20 different systems. For example, within the system called "hubs and wheels" there is a component code for "right front tire". Sometimes the supervisor enters a system and/or component when he creates a symptom, but even in those cases, the mechanic is responsible for checking the system and component codes, and changing them if necessary. The mechanic enters the correct code by choosing it from a list organized by sub-system of the bus.

In the file of 20,970 symptoms described above, the 122 mechanics used 1,423 different component codes (approximately 50% of the total number of possible codes). There were seven component codes that were used more than 500 times each, and those seven were related to various types of scheduled inspections[7]. Other popular codes included those referring to entire systems in the bus, for example, "air-conditioning system" (used 493 times), "hubs and wheels" (used 214 times),"engine" (used 186 times), and "brake system" (used 150 times), and a selection of particular specific components, for example, "four wheel reline" (used 244 times), "air dryer" (used 170 times), and "driver's seat" (used 145 times). On the other hand, there were 320 different codes that were used only once each in the entire data set, 227 codes that were used twice, 145 codes that were used three times, and 100 codes that were used four times.

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[7] Scheduled inspections involve entire systems of the bus. Specific component codes are reserved in the component list for this type of inspections, and when scheduled inspections are performed, the mechanics are required to use these special codes, instead of regular component codes.

Although there are several limitations to the approach of looking at code use by combining different systems[8], this approach was adopted to give a rough idea of the patterns of component code usage over time. It is assumed here that variability accounted for by such factors as degree of specialization into particular systems of the bus among certain mechanics, will remain relatively stable over time, and therefore, changes in individuals' component code use over time are likely to be due to changes in their use of the computer.

Table 4.3 shows indicators of component code use for the entire sample by set. The number of different component codes used appears to decline sharply over time from 771 different codes used by 122 workers in their combined first sets, to 92 different codes used by 18 workers in their combined tenth sets. However, the limitations described above for interpreting repair code use over time apply here as well. In fact, much of the decline in the number of different component codes used is likely to be due to declining sample size in later sets.

The mean number of different component codes used per individual (Fifth column in Table 4.3.) is a more accurate indicator for the whole sample over time. This indicator declines over time as well, from 19.3 in the first set to 7.7 in the tenth set. It is possible, however, that decline in this indicator occurs partly because there are fewer mechanics with high numbers of sets, and the group of workers with the most sets is a select group that, for some reason, uses a more limited range of codes. Figure 4.4. shows a graphic

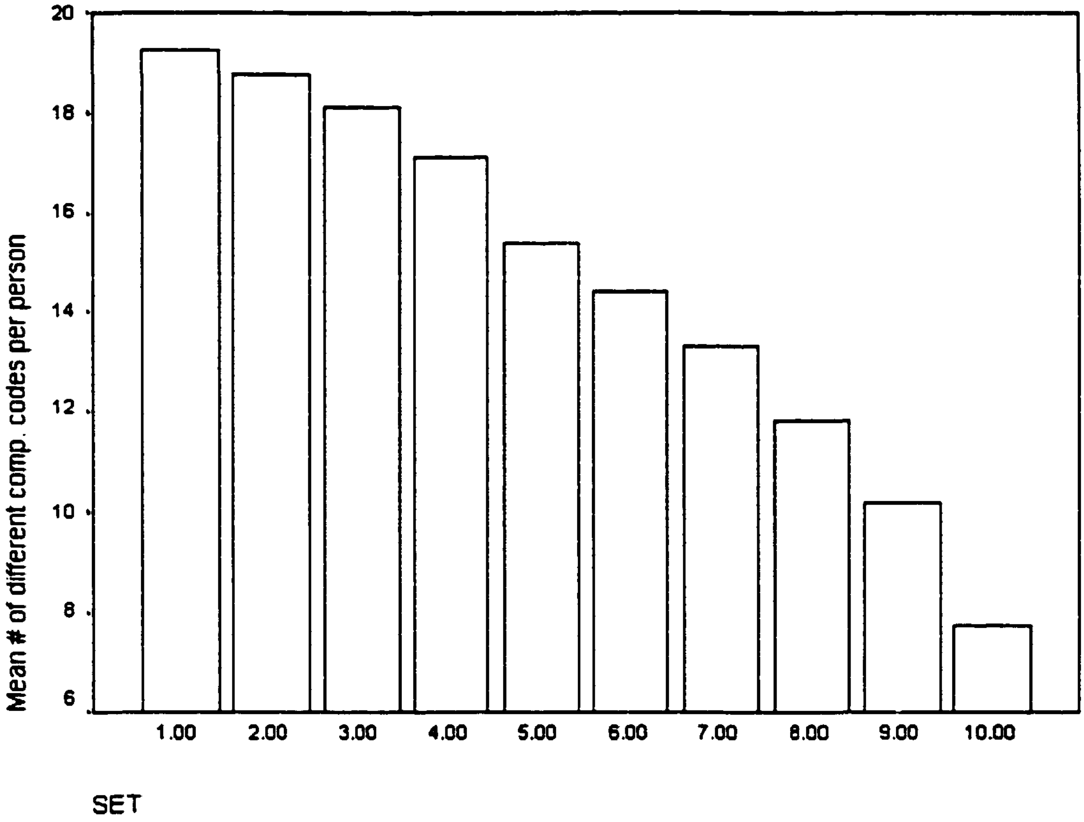
[8] The limitations include the fact that the type of the particular job and the nature of the particular system constrain the range of possible codes that can be used. In addition, there is some degree of specialization among the mechanics (see Chapter 4), and the range of codes a particular mechanic uses is partly determined by their system of specialization. For example, if a mechanic does inspections 50% of his time, his range of component code is likely to be narrower than if he did inspections only 10% of his time. This is because fewer component codes are available for inspections than for other types of jobs.

presentation of the decline over time in the mean number of different component codes used per individual. Three examples of individuals' component code use over time are presented in Figure 4.5. The first worker started out with a wide range of component codes, which then declined in later sets. The second worker's range of component code use widened towards later sets, and the third example shows a worker whose code range declined after four sets, but then gradually increased again.

Table 4.3. Component code use by set

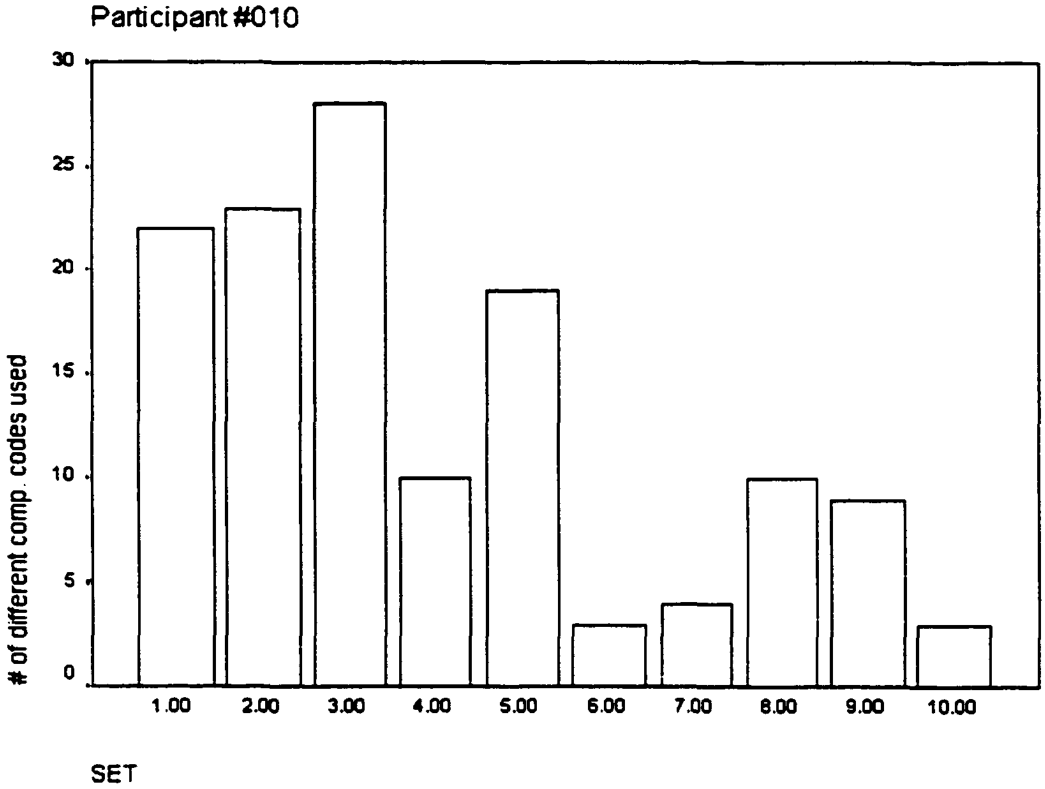
Set	Number of workers[9]	Number of different component codes used by all workers	Range of number of different codes used per individual	Mean number of different codes used per individual	Standard deviation of different codes used per individual
1	122	771	1-29	19.3	7.5
2	116	760	1-29	18.7	7.5
3	109	719	1-30	18.1	7.3
4	96	652	3-29	17.1	7.4
5	76	537	5-28	15.4	7.0
6	62	448	3-26	14.4	6.9
7	47	361	3-27	13.3	6.9
8	32	228	2-26	11.2	7.2
9	21	152	2-27	10.2	7.8
10	18	92	2-24	7.7	6.0

Figure 4.4. Mean number of different component codes used per person by set

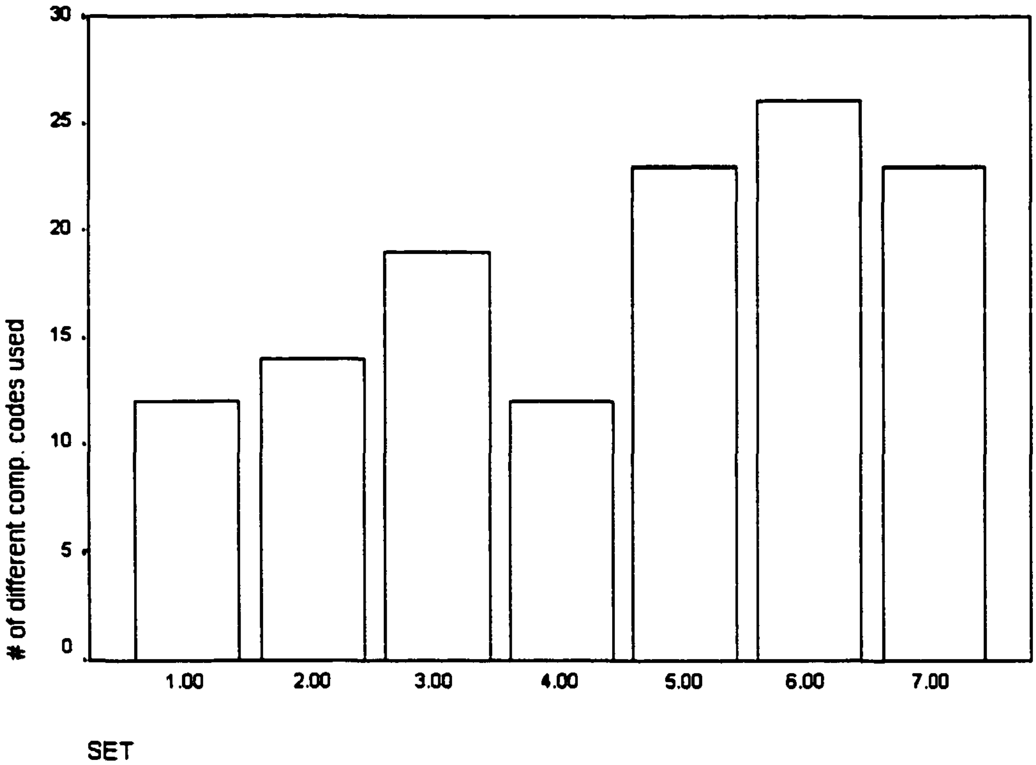


[9] The number of workers declines in later sets because data were available only for five months, and some workers completed very few sets of 30 symptoms within the first five months.

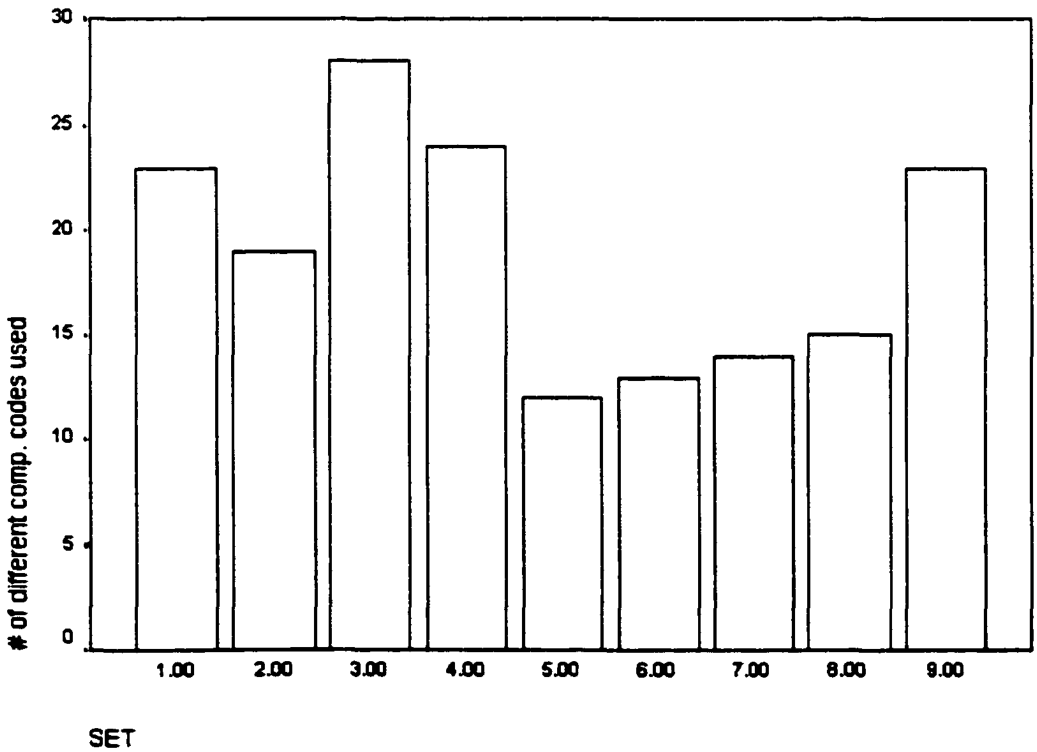
Figure 4.5. Examples of individuals' component code use by set



Participant #011



Participant #002



Use of comments

The mechanics are allowed to type comments on the computer about symptoms they complete. The field observations suggested that there is great variability among the workers in their comment use: some like to use them almost all the time and write long descriptions, and others almost never use them. Below is an overall description of the mechanics' utilization of this optional function of the computer system. Appendix 4B shows examples of actual comments typed in by mechanics in the sample.

In the relational database where all maintenance data are archived, there are separate data tables for comments and notes. These tables were queried and downloaded for selected months during the first five months in the two depots. It was determined that a month-based measure of comment use would be preferable to a set-based measure.[10] Months two and five were chosen to illustrate comment use patterns. Month one was excluded, because computers were phased in during that month, and many mechanics were still learning the basic functions of the computer. Month two illustrates comment use after a one-month initial learning period, and month five, the latest month available, illustrates how comment usage is sustained three months later. Table 5.4. shows comment use frequencies for months two and five. Overall, comments are used by the mechanics in the two depots in slightly less than one in three symptoms. The rate of comment use decreases from 30% in month two to 26% in month 5.

[10] Comment use data are not subject to some of the same constraints as code use data. The goal with the comment use data is not to describe how widely a universe of options was utilized. As described above, set-based measures were developed for code use data in order to capture how the range of options is

Table 4.4. Comment use frequency in months two and five

	Total number of symptoms	# of times comments were used	% of comment use
Month 2	5278	1588	30.1
Month 5	6276	1654	26.4

Individual mechanics' rates of comment use ranged from 0% to 100% during both months two and five. Table 4.5. presents distributions of individuals' comment use rates for months two and five. The proportion of individuals who use comments less than once in four symptoms stays relatively stable from month two to month five. Month five, compared to month two, shows a much higher proportion of individuals in the 25-49% range, and very few highest frequency comment users. It appears that the overall decline in comment use is accounted for by a drop in the number of highest frequency comment users. Figure 4.6. is a presentation of likelihoods of individuals' moving from one frequency group to another between months two and five.

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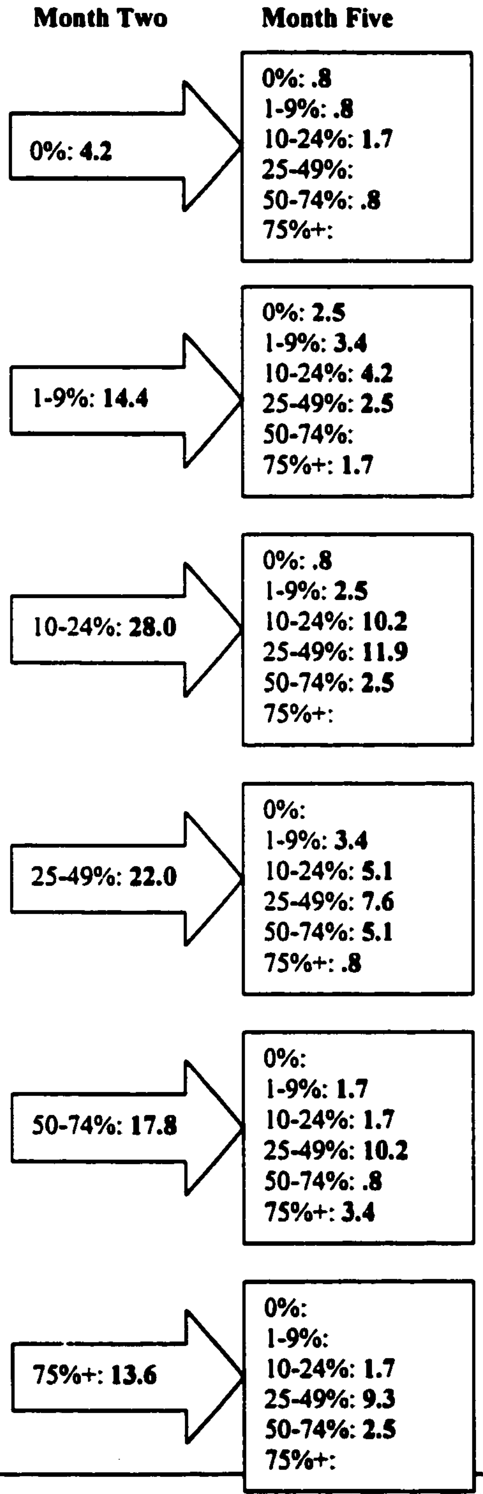
utilized within a set number of symptoms. For frequency of comment use, it is sufficient to examine how

Table 4.5. Distribution of comment use rate for months two and five

Percentage of time comments were used	Month two		Month five	
	Number of mechanics	Percentage of mechanics[11]	Number of mechanics	Percentage of mechanics[12]
0%	5	4.0	5	4.2
1-9%	18	14.5	15	12.6
10-24%	33	26.6	29	24.4
25-49%	27	21.8	49	41.2
50-74%	24	19.4	14	11.8
75%+	17	13.7	7	5.9
Total	124	100	119	100
Mean rate of comment use	37% (S.D.= .28)		32% (S.D. = .23)	

many times comments were used in 0proportion to total number of symptoms within a month.

Figure 4.6. Change in individuals' comment use from month two to month five (n=118)[12]



[11] The total percentage may not add up to exactly 100 due to rounding error.

[12] The bolded numbers are proportional likelihoods of belonging to a subgroup, presented in percentages. They add up to 100 across month two arrows and across month five boxes. Month five numbers are conditional likelihoods, in other words, each five month box represents the distribution for a group with a

Figure 4.6. shows how individual mechanics' comment use rates change from month two to month five. The overall pattern suggests that lowest frequency users in month two tend to increase their use, and highest frequency users in month two tend to decrease their use, leading to less overall variance in month five comment use rates. As Table 4.5 shows (bottom row), as the average rate of comment usage goes down from .37 in month two to .32 in month five, the standard deviation also decreases from .28 to .23.

Correlations among three measures of computer use

All three computer use measures are highly correlated with one another. For example, Set 1 percentage of total repair code universe utilized and Set 1 number of different component codes used have a correlation of .658 (p=.000; n=122). The repair code measures for each of the ten Sets correlate significantly with the component code measures in respective Sets. The comment use measures are also significantly, although not quite as highly, correlated with the repair code and the component code measures. Appendix 4C shows tables of correlations among the computer use measures.

Comparison of computer use between two sites

Almost no differences were found between the two sites in computer use measures. T-tests were performed for each of the measures, and the only significant difference by depot was found in Month 2 comment use. Mechanics in Depot A used comments more than half of the time during Month 2 (M=.5290; n= 54), while mechanics in Depot B used comments only one-fourth of the time during the same month (M=.2481; n=70; t=6.402; 2-tailed p=.000). No other significant differences between the two depots

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particular month two value. The month two percentages differ from those presented in Table 4.5 because slightly different samples. Only those with data for both months are included in Figure 4.6.

were found in computer use. All means and t-tests for depot-comparisons are listed in Appendix 4D.

Summary of computer use patterns

Overall, mechanics in the two depots as a group utilized a large proportion of the options afforded by the system to describe their work. Ninety-six percent of all possible repair codes were used at least once during five months, and comments were used about 25-30% of the time. However, only about half of the existing component codes were utilized within five months. This may be partly because some bus components on the list are almost never repaired.

Great amount of variability among mechanics was observed for all indices of computer use. When code use was examined within sets of thirty symptoms completed by individuals, there were individuals who used the same repair code every time, and others who used fifteen different repair codes within 30 symptoms. Similar variability was observed in component code use. Use of comments within one month also varied from 0 to 100% of the time.

Each of the three highly intercorrelated computer use indices show that the proportion of the full range of options utilized declined over time. The mean of individual repair code utilization percentages showed a linear decline from 16.8 in set one to 8.3 in set ten, and the mean number of different component codes used per individual declined linearly from 19.3 in set one to 7.7 in set ten. Comment use declined from 30% of the time in month two to 26% of the time in month five. This declining pattern was observed for the sample as a whole in both depots, but as shown above, each usage measure indicated some individuals with stable or increasing usage patterns over time.

Chapter 5: Workers' attitudes

This chapter describes what self-administered questionnaires revealed about the workers' attitudes towards different aspects of the new computer system and their work in general. Questionnaire responses were collected from the workers during early implementation of the new computer system to provide a description of the general tone and range of attitudes. The questionnaire method was chosen in order to reach a group of workers that was larger than the interview sample, and to allow for a medium of responding that is more private than face-to-face interview dialogue. Pilot testing of the questionnaire showed that the participant took answering the questionnaire items seriously, offered suggestions for improving the questionnaire, and generally thought that the questions were "good". These impressions were confirmed during the administration of the final questionnaires.

Completed questionnaires were received from 40 workers, 20 at each bus depot. The 24 items in the questionnaire were designed to reflect eight categories:

1- Knowledge and confidence (cognitive component of attitude)

2- Feelings and evaluations (affective component of attitude)

3- Questions, suspicions and doubts (negation element of critical thinking)

4- Authority and agency (social element of critical thinking)

5- Scope of Perspective (context specific conflict issue 1)

6- Accountability for work (context specific conflict issue 2)

7- Interdependence of people (context specific conflict issue 3)

8- Popular opinions collected in field-work (context specific discourse)

The full questionnaire is included in Appendix 2A, and the specific items are also listed in Table 5.1 below (Table 2.1. in Chapter 2 lists the items within each of the eight initial categories). Each of the 24 items was answered on a five-point scale ranging from strongly agree to strongly disagree - a response scale selected based on participant feedback during pilot testing. Means and standard deviations for the 24 items are listed in Table 5.1.

Table 5.1 Means and Standard Deviations of Questionnaire Responses

(Response categories: 1=Strongly disagree; 2=Disagree; 3=Not sure; 4=Agree; 5=Strongly agree.)

Questionnaire Item	Mean	Std. Deviation	N
I know a lot about computers.	2.30	1.18	40
I don't care about the Midas system.	3.00	1.18	40
Overall, I like my job.	4.10	1.06	40
I do not trust the Midas system.	3.03	1.40	39
I usually respect authorities.	4.13	1.02	40
I have many questions in my mind about the Midas system.	3.20	1.20	40
I care about the big picture of what is going on in my depot.	3.53	1.28	40
Midas is there just to watch the workers.	2.88	1.11	40
I always question what I hear in the news.	3.31	1.20	39
I feel curious about the Midas system.	3.38	1.17	40
The quality of my work always depends on other people's work.	2.35	1.46	40
The maintainers' input will be heard through Midas.	3.10	1.13	40
It is difficult for me to learn the Midas system.	2.26	.91	39
I am the only person responsible for my work.	3.53	1.43	40
Midas is there just for accounting purposes.	2.98	1.14	40
I know my way around in the Midas system.	2.44	1.23	39
Other people in the depot depend on how I do my work.	3.58	1.28	40
I doubt that the Midas system will ever work.	2.80	1.16	40
I sometimes openly question decisions made by my superiors.	3.64	1.25	39
Overall, I think the Midas system is a good system.	3.41	.91	39
I am in control of my work.	3.88	1.20	40
I am nervous about the Midas system.	2.18	1.10	39
My superiors are responsible if something goes wrong with a bus.	2.95	1.30	40
Midas will change the operation of bus maintenance.	3.15	1.16	39

The questionnaire answers suggest that early on in the process of implementing the new system the workers, on the average, did not feel very confident about their knowledge about computers and the new system, but were optimistic about their prospects of learning it, and had relatively positive attitudes towards it. Almost two-thirds of the respondents (62.5%) disagreed or strongly disagreed with "I know a lot about computers" (M = 2.30), and only 23.1% agreed or strongly agreed with "I know my way around the Midas system" (M = 2.44). However, only 5.2% agreed or strongly agreed with "It is difficult for me to learn the Midas system" (M= 2.26), and only 10.3% agreed or strongly agreed with "I am nervous about the Midas system" (M= 2.18).

Half of the workers (51.3%) agreed or strongly agreed with "Overall, I think the Midas system is a good system" (M=3.41), and 55.0% agreed or strongly agreed with "I feel curious about the Midas system" (M=3.38). The mean response for all remaining items regarding the new system were close to "Not sure", or between 2.80 and 3.20, indicating some ambiguity among the workers as a group. These items included "I don't care about the Midas system", "I do not trust the Midas system", "I have many questions in my mind about the Midas system", "Midas is there just to watch the workers", "The maintainers' input will be heard through Midas", "Midas is there just for accounting purposes", "I doubt that the Midas system will ever work", and "Midas will change the operation of bus maintenance".

Regarding their work in general, the mechanics tended to like their job (M=4.10), be in control of their work (M=3.88), and care about the "big picture" of what is going on in their depot (M=3.53). They generally seem to have a sense of independence and responsibility for their work. Almost two out of three (62.5%) agreed or strongly agreed with "I am the only person responsible for my work" (M=3.53), and only one in three (32.5%) agreed or strongly agreed with "My superiors are responsible if something goes wrong with a bus" (M=2.95). They do not tend to agree with "The quality of my work always depends on other people's work" (M=2.35), while most say that "Other people in the depot depend on how I do my work" (M=3.58).

The field work suggested that the mechanics often question and criticize authority. This impression was at least partly supported by the questionnaire responses. The item "I sometimes openly question decisions made by my superiors" showed the following distribution of responses: 30.8% strongly agreed, 30.8% agreed, 15.4% were not sure, 17.9% disagreed, and 5.1% strongly disagreed (M=3.64). A more general critical thinking item "I always question what I hear in the news" also indicated that many mechanics are critical thinkers: 12.8% strongly agreed, 43.6% agreed, 12.8% were not sure, 23.1% disagreed, and 7.7% strongly disagreed (M=3.31). A somewhat contradictory distribution was obtained for "I usually respect authorities": 42.5% strongly agreed, 40.0% agreed, 7.5% were not sure, 7.5% disagreed, and 2.5 strongly disagreed.

Attitude differences between two sites

Against expectations, some significant differences in the questionnaire answers emerged between the two depots. Two-tailed T-tests were performed on the mean answers to each item by depot. Significant differences were found for four of the 24 items. Workers in depot A had more respect for authorities (M = 4.55) than workers in depot B (M = 3.70; t = 2.88, 38df, p = .007), but were <u>less</u> likely to say that their "superiors are responsible if something goes wrong with a bus" (M = 2.35 for depot A, and M = 3.55 for depot B; t = -3.26, 38df, p = .002). Depot A workers also expressed more concern for the "big picture" than depot B workers ($M = 4.25$ for depot A, and $M = 2.80$ for depot B; $t = 4.31$, 38df, $p < .001$), and more curiosity towards the Midas system than depot B workers ($M = 3.80$ for depot A, and $M = 2.95$ for depot B; $t = 2.44$, $p = .020$).

These differences suggest that issues of authority and responsibility differ somewhat between the two depots. Depot A workers respect authorities, but they do not feel that authorities are always responsible. Depot B workers show less respect for authorities, but also want their superiors to be responsible if something goes wrong. Depot A workers also show more concern for the "big picture" than depot B workers. As a result of the questionnaires showing differences between the two depots, relevant field notes were revisited. Regarding authority and superiors, the field observations of most workers in both depots seemed to fit depot B pattern described above. Workers in depot A had very similar complaints about their superiors as workers in depot B. However, the observations did indicate that the communication between managers and workers was generally more open in depot A, while managers in depot B were seldom observed speaking directly with the workers.

Factor analysis of questionnaire responses

One of the research questions concerned clustering of the questionnaire items. The goal was to reduce the questionnaire data into a manageable number of factors, which could be used as predictors of computer use patterns. As described above, the questionnaire was initially designed based on eight categories of items. A factor analysis of the twenty-four items was performed to examine whether any of the eight initial categories would statistically form item clusters, and to reveal any other groupings among the items.

Prior to the factor analysis, a correlation matrix was obtained showing all bi-variate correlations among the items (Appendix 5A). An initial examination of the correlation matrix showed, for example, that the three items designed to reflect "Knowledge and confidence" did have significant correlations with one another (Table 5.2.). Several items indicating attitudes towards the new system also showed significant correlations. "Overall, I think the Midas system is a good system" had a negative correlation with "I do not trust the Midas system" (Pearson r = -.416, 2-tailed p < .01, n=38), with "Midas is there just to watch the workers" (Pearson r = -.537, 2-tailed p < .001, n=39), with "I doubt that the Midas system will ever work" (Pearson r = -.486, 2-tailed p < .005, n=39), and with "I am nervous about the Midas system" (Pearson r = -.339, 2-tailed p < .05, n=39). Among items about the mechanic's work and workplace, "Overall, I like my job" correlated highly with "I care about the 'big picture' of what is going on in my depot" (Pearson r = .528, 2-tailed p < .001, n=40).

Table 5.2. Correlation matrix of three items in "Knowledge and confidence" group

	Know computers	Midas difficult	Know my way in Midas
Know computers		r = -.457** 2-tailed p = .003 n = 39	r = -.434** 2-tailed p = .006 n = 39
Midas difficult	r = -.457** 2-tailed p = .003 n = 39		r = -.431** 2-tailed p = .006 n = 39
Know my way in Midas	r = -.434** 2-tailed p = .006 n = 39	r = -.431** 2-tailed p = .006 n = 39	

** Correlation is significant at the 0.01 level (2-tailed)

A factor analysis of the twenty-four items was performed by using Principal Component Analysis as the extraction method, and Promax with Kaiser Normalization as the rotation method. The initial analysis produced a nine-factor solution that was examined for conceptual consistency and component patterns. In this initial solution, most items had split variance among two or more components, and many of the last components did not form conceptual clusters. In subsequent analyses, the number of components was limited to eight, seven, six, five, and four. Each of these solutions was examined for component patterns and conceptual consistency among the component items. The four-factor solution, shown below in Table 5.3 was finally chosen as the best solution, because each component grouped items that shared conceptual meaning, and fewer items had split variance among components. The four-factor solution also provided a manageable number of factors that could be used to predict computer use patterns.

Factor 1 was labeled as **"Negativity towards the new system"**. Low scores on "Overall, I think the Midas system is a good system" clustered with high scores on "I do not trust the Midas system", "I doubt that the Midas system will ever work", "Midas is there just to watch the workers", and "I am nervous about the Midas system". The second factor reflects a general attitude towards one's work and workplace, and was labeled as **"Positive regard for one's job"**. Those high on this factor had high scores on "I care about the 'big picture' of what is going on in my depot", "I am the only person responsible for my work", and "Overall, I like my job", and low scores on "My superiors are responsible if something goes wrong with a bus".

Table 5.3. Pattern Matrix of Four-factor Solution[1]

Item	Component			
	1	2	3	4
Overall, I think the Midas system is a good system.	**-.819**			
I do not trust the Midas system.	**.768**			
I doubt that the Midas system will ever work.	**.675**			
Midas is there just to watch the workers.	**.669**			
I am nervous about the Midas system.	**.627**		.394	
I am in control of my work.	-.367			
I care about the "big picture" of what is going on in my depot.		**.855**		
I am the only person responsible for my work.		**.719**		
I usually respect authorities.		.605	-.353	-.392
Overall, I like my job.		**.552**	-.305	
My superiors are responsible if something goes wrong with a bus.		**-.524**	-.443	.313
I don't care about the Midas system.				
I have many questions in my mind about the Midas system.			**.693**	
The quality of my work always depends on other people's work.	.322		.664	
The maintainers' input will be heard through Midas.			**.629**	.369
I feel curious about the Midas system.		.379	**.488**	
Midas is there just for accounting purposes.			**.484**	
Midas will change the operation of bus maintenance.	-.337	-.347	**.441**	-.396
I sometimes openly question decisions made by my superiors.	.383		-.388	
I know my way around in the Midas system.				**.775**
It is difficult for me to learn the Midas system.	.370			**-.689**
I know a lot about computers.				**.623**
I always question what I hear in the news.		-.364		.535
Other people in the depot depend on how I do my work.				-.453
Total variance explained:				
Initial Eigenvalues/ Extraction sums of squared loadings total	4.068	2.990	2.664	2.417
% of variance	16.948	12.458	11.099	10.069
Cumulative % of variance	16.948	29.406	40.505	50.574
Rotation total	3.661	3.264	2.888	2.812

[1] Key items in each component that also form a conceptually meaningful group are indicated in bold

The third factor showed an interesting combination of attitudes that reflects some level of ambiguity towards the new system. It was labeled **"Careful optimism towards the new system"**. Those high on this factor had high scores on the following key items: "I have many questions in my mind about the Midas system", "The maintainers' input will be heard through Midas", "I feel curious about the Midas system", "Midas is there just for accounting purposes", "Midas will change the operation of bus maintenance". The fourth factor corresponds with the initially proposed category of **"Knowledge and confidence"**. High scores on " I know my way around in the Midas system" are associated with low scores on "It is difficult for me to learn the Midas system", and high scores on "I know a lot about computers".

Relationships among the four factors are shown in a correlation matrix below (Table 5.4). The first two factors show a moderate negative correlation (-.28), indicating that those who have more negative attitude towards the new system have less positive attitude towards their job. Other correlations among the factors are negligible.

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numbers in the component column.

Table 5.4. Correlations among four factors

	Negativity towards the new system	Positive regard for one's job	Careful optimism towards new system	Knowledge and confidence
Negativity towards the new system		-.277	-.077	-.091
Positive regard for one's job	-.277		.051	.051
Careful optimism towards new system	-.077	.051		.042
Knowledge and confidence	-.091	.051	.042	

Summary of questionnaire results

Self-administered paper-and-pencil questionnaires tailored for the specific context of study were found to be a viable medium of collecting data from blue-collar workers regarding adjustment to computers, and their work in general. During the early implementation of the computer system, the mechanics in the two depots, on the average, expressed that their knowledge about computers and the new system is limited, but that they feel optimistic about learning the new system. Attitudes towards the new system were largely positive, combined with some level of ambivalence. The mechanics also mostly expressed positive attitudes towards their work in general. Some differences were found between the two depots for items regarding issues of authority and responsibility.

Items designed to measure critical thinking in general indicated a relatively high proportion of "critical thinkers" among the workers. Over half (56.4%) agreed with "I always question what I hear in the news", and 61.6% agreed with "I sometimes openly question decisions made by my superiors". Interestingly, 82.5% also agreed with "I usually respect authorities".

Some of the originally proposed categories of items were confirmed empirically by the factor analysis. "Knowledge and confidence" (Factor 4) corresponds with the originally proposed group of three items. The three other factors revealed by the factor analysis combined items from two or more of the originally proposed groups. Factor 2 (Positive regard for one's job) incorporates the original group called "Accountability for work", and adds two closely related items from other categories ("Overall, I like my job", and "I care about the 'big picture' of what is going on in my depot"). Affective items were merged with negation items in Factor 1 (Negativity towards the new system). It included two items from the original "Feelings and evaluations", two items from "Questions, suspicions, and doubts", and one "Popular opinion" item. Factor 3 (Careful optimism towards the new system) incorporated items from four of the eight original categories. A moderate negative correlation was observed between Factors 1 and 2. The factor structure generally provides a confirmation that the items in the questionnaire conveyed their intended meaning. The factor analysis also provided a method of reducing the questionnaire data into four factors, which are revisited in Chapter 7 as predictors of different computer use patterns.

Chapter 6: Elements of critical thinking in discourse

The goals of the study included describing markers of critical thinking in the bus mechanics' discourse, and examining the definition of critical thinking in light of the findings. Semi-structured interviews were conducted to obtain samples of discourse between individual workers and the researcher. A coding system was developed for seven elements of critical thinking, and applied to selected segments of the interviews. The interviews included dilemmas varying in context-specificity and familiarity, making it possible to compare frequencies of critical thinking across different types of dilemmas. It was hypothesized that contextually familiar dilemmas would elicit more critical thinking than a hypothetical moral dilemma.

Overview of interview method

Eighteen interviews were conducted during the first two months of the computer implementation, eight in depot A, and ten in depot B. Participant selection, as well as other additional details regarding the method, are discussed in Chapter 2 (Methods), and only an overview is provided here. The interviews varied in length from 20 minutes to over one hour, partly because some workers were pressured to return to work quickly, while others engaged in longer conversations with the researcher about issues raised during the interview. Most interviews were conducted in empty supervisors' offices, and two were conducted in a bus.

The length and content of the open-ended segments varied across interviews, but all participants responded to the same structured segment which consisted of three context-specific dilemmas related to the new computer system and bus maintenance (Part Story, Note Story, Code Story), and one hypothetical dilemma (Stealing Story). The participants' responses to the dilemmas were systematically challenged with counterprobes. (See Appendix 2B for the dilemmas and the interview protocol.)

Overview of coding

The coded segment consists of conversations about the four dilemmas. Table 6.1 presents the numbers of coded utterances for the four dilemmas. The total number of coded utterances in the sample of 18 interviews was 1,249, and the number of coded utterances per individual ranged from 48 to 105 (M=69.4). A GLM Repeated Measures analysis was conducted to test whether the number of utterances varied by dilemma. The overall multivariate test with four levels of the within-subjects factor "Dilemma" approached statistical significance (F=2.774; df 3,15; p=.078). Two within-subjects contrasts were significant: The dilemma about typing comments on the computer (Note Story) elicited significantly more utterances (M=20.1) than the dilemma about looking for a precise code (Code Story) (M=15.9; F=6.131; p=.024), and the hypothetical moral dilemma (Stealing Story) (M=15.7; F=6.427; p=.021).

Table 6.1. Number of coded utterances by dilemma

	Average number of utterances per individual	Standard deviation of number of utterances per individual	Range of number of utterances per individual	Total number of utterances by all participants (n=18)
Part Story	17.7	3.58	9-24	318
Note Story	20.1	6.54	10-35	362
Code Story	15.9	5.72	7-27	287
Stealing Story	15.7	6.24	6-28	282
Total	69.4	15.55	48-105	1249

Seven different elements of critical thinking were selected for the final coding: Identification of assumption, Evaluation, Negation, Contradiction, Reinterpretation, New solution, and Metacognition. (See Chapter 2 and Appendix 2C for detailed definitions of the elements). Each utterance was coded for presence of each of the seven elements, which are not mutually exclusive. In other words, one utterance can have anywhere from 0 to 7 elements. For example, "I don't know the answer" has a Negation element and a Metacognition element.

Frequencies of elements

A total of 2,188 critical thinking elements were identified in the sample of 1,249 utterances, or an average rate of 1.75 elements per utterance. Frequencies for each element are presented in Table 6.2. The most frequent elements were Negation (identified 596 times) and Evaluation (413 times). These two were followed by Identification of assumption (352 times), Metacognition (287 times), and Reinterpretation (256 times). Contradiction (131 instances) and New solution (153 instances) were the least frequently identified elements.

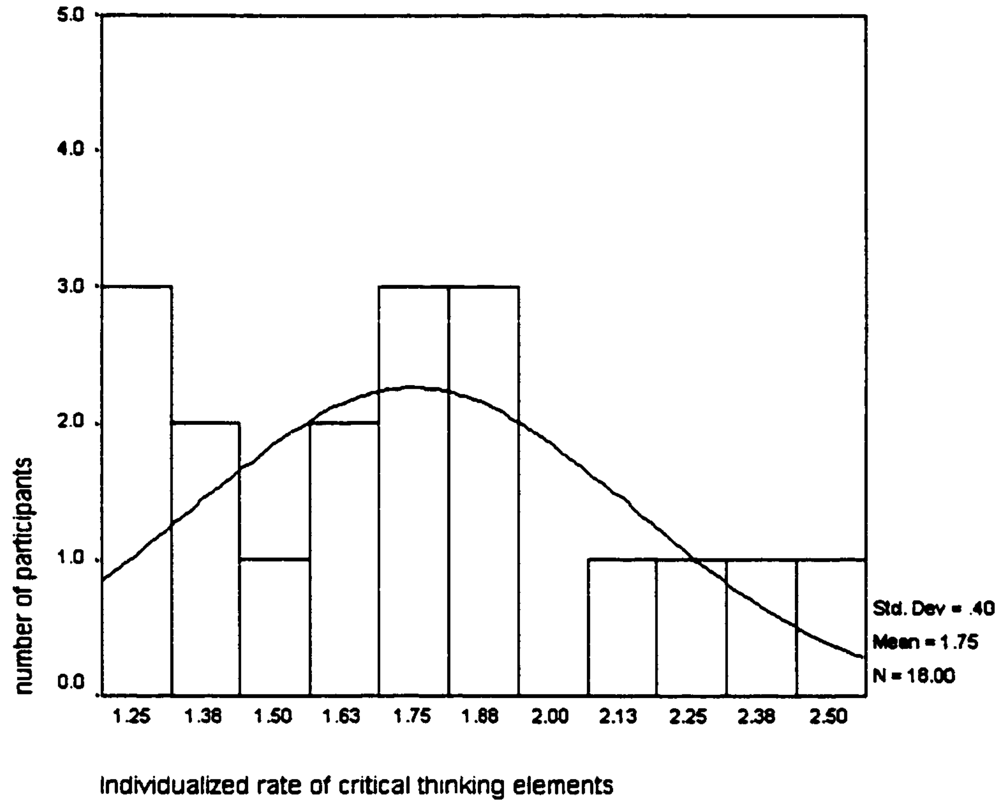
The third column in Table 6.2 shows how many times each element appears per utterance in the sample of 1,249 utterances, and the fourth column shows the number of elements divided by the number of participants. Numbers in the fifth through the ninth columns describe variability across individuals in frequencies of the elements. The total number of elements identified varied from 83 to 265 per person (M=121.6, S.D.=44.27). The rate of each element per utterance was obtained for each participant individually, by using the number of utterances by that participant as the denominator. The mean of these individualized rates among the 18 participants is presented for each element in the seventh column. The individualized rate for all elements combined varied across individuals from 1.21 to 2.52 (M=1.75, S.D.= .369). The distribution of the individualized rate of all elements combined is shown in Figure 6.1. Among the seven elements, the greatest variability across individuals was observed for Metacognition (range: .02 - .56, M= .222, S.D.=.118).

Table 6.2. Frequency of critical thinking elements in coded segment

Element	Frequency	Rate per utterance (n=1249)[1]	Mean number per person (n=18)[2]	Standard deviation of number per person[3]	Range of number per person[4]	Mean of individual rates per utterance[5]	Standard deviation of individual rates per utterance[6]	Range of individual rates per utterance[7]
Identification of assumption	352	.282	19.6	6.26	10 - 32	.289	.100	.13 - .55
Evaluation	413	.331	22.9	11.51	8 - 61	.322	.098	.15 - .58
Negation	596	.477	33.1	10.43	23 - 64	.476	.079	.33 - .61
Contradiction	131	.105	7.3	4.66	2 - 20	.106	.061	.03 - .26
Reinterpretation	256	.205	14.2	5.12	8 - 24	.209	.071	.11 - .35
New solution	153	.122	8.5	4.03	3 - 20	.124	.052	.04 - .25
Metacognition	287	.230	15.9	10.50	1 - 44	.222	.118	.02 - .56
Total of all elements	2188	1.752	121.6	44.27	83 - 265	1.748	.396	1.21 - 2.52

[1] Total number of times the element was identified divided by total number of utterances (n=1249).
[2] Total number of times the element was identified divided by number of participants (n=18).
[3] Standard deviation of the distribution of frequencies across individuals.
[4] Lowest and highest individual frequency.
[5] Each individual's frequency of element was divided by that individual's number of utterances to obtain individualized rates per utterance. This column presents the mean of these individualized rates.
[6] Standard deviation of the distribution of individualized rates per utterance.
[7] Lowest and highest individualized rate per utterance.

Figure 6.1. Distribution of individualized rates of critical thinking elements



Comparison of elements across dilemmas

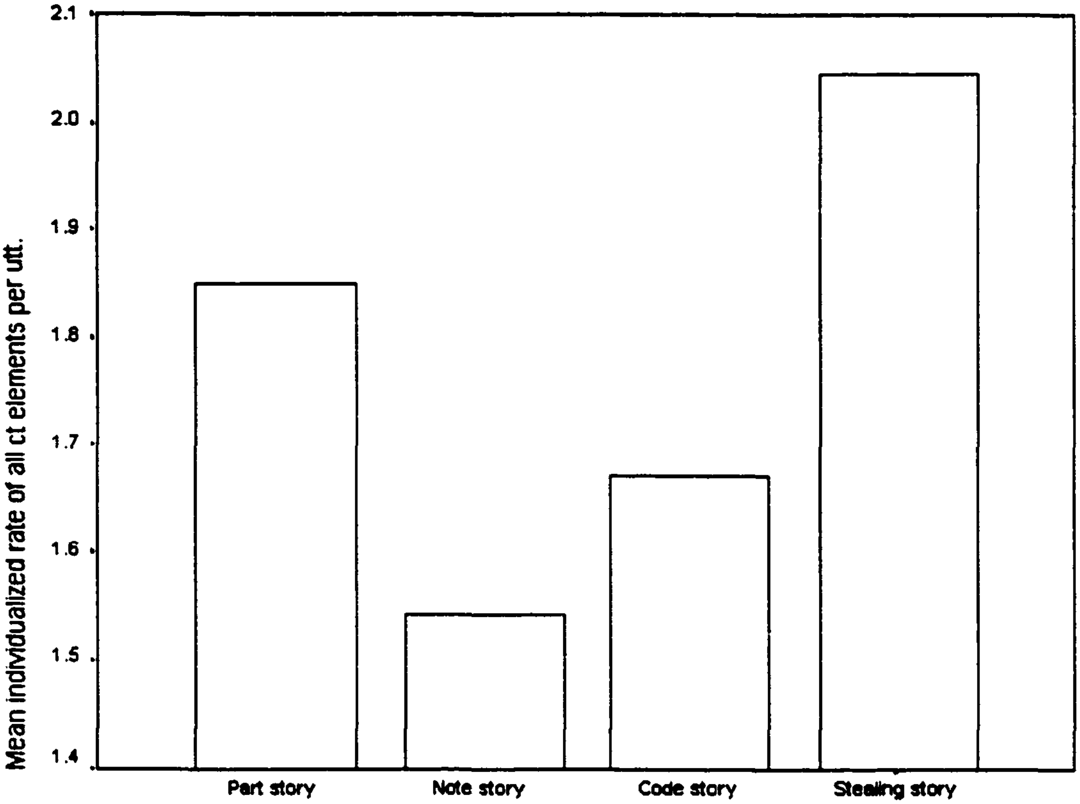
Hypothesis 3 predicts that context-specific dilemmas elicit more critical thinking than a hypothetical moral dilemma. This hypothesis was derived from accounts in the literature characterizing blue-collar workers' thinking as context-bound (e.g., Bernstein, 1972). To address the hypothesis, comparisons were planned between the hypothetical moral dilemma and the three context-specific dilemmas regarding situations that bus mechanics encounter on a daily basis. Individualized rates of critical thinking elements were used in the comparisons across dilemmas (Stories), to control for number of utterances. As explained above, individualized rates are obtained for each person separately by dividing the frequency of the element by the number of utterances. This procedure of obtaining individualized rates was followed within each Story. For example, if person A had ten utterances in response to the Part Story, and he had two instances of Metacognition within those ten utterances, his individualized rate of Metacognition for the Part Story is 2/10 or .2.

Table 6.3 presents average individualized rates of critical thinking elements by Story. The same information is presented graphically in Figures 6.2 to 6.9. A GLM Repeated Measures procedure was used to test for significant differences across stories. The within-subject factor "Story" had four levels (Part, Note, Code, Stealing). Separate analyses were performed for the rate of all seven elements combined and the rate of each element individually as dependent variables, resulting in a total of eight Repeated Measures analyses. The results of the Repeated Measures analyses are summarized next to each Figure (Figures 6.2 - 6.9.) and listed fully in Appendix 6A.

Table 6.3. Average individualized rates of critical thinking elements by dilemma

Element		Part story (Context: bus maintenance)	Note story (Context: computer)	Code story (Context: computer)	Stealing story (Context: unfamiliar)
Identification of assumption	Mean	.412	.249	.248	.242
	(S.D.)	(.188)	(.145)	(.127)	(.161)
Evaluation	Mean	.303	.253	.343	.445
	(S.D.)	(.188)	(.111)	(.126)	(.179)
Negation	Mean	.466	.427	.439	.607
	(S.D.)	(.150)	(.126)	(.106)	(.172)
Contradiction	Mean	.189	.058	.062	.118
	(S.D.)	(.103)	(.062)	(.075)	(.146)
Reinterpretation	Mean	.184	.238	.200	.189
	(S.D.)	(.106)	(.117)	(.127)	(.128)
New solution	Mean	.118	.164	.121	.103
	(S.D.)	(.083)	(.096)	(.088)	(.103)
Metacognition	Mean	.178	.152	.259	.341
	(S.D.)	(.148)	(.108)	(.165)	(.185)
Total of all elements	Mean	1.849	1.542	1.671	2.044
	(S.D.)	(.601)	(.398)	(.414)	(.646)

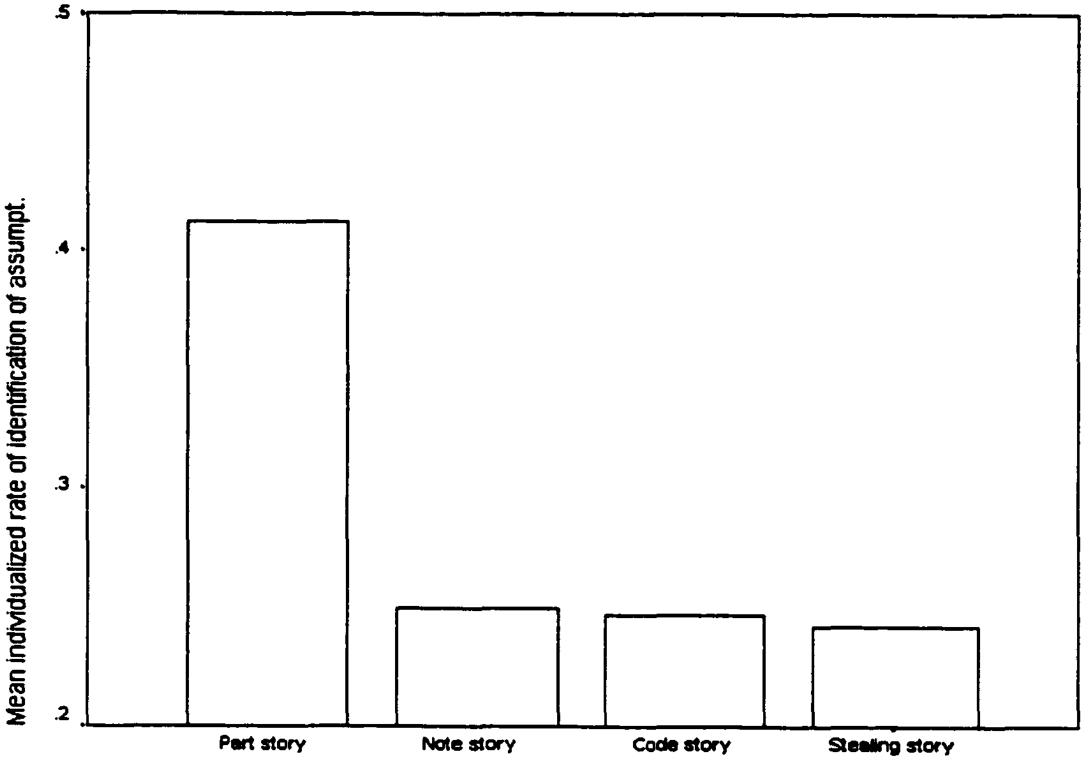
Figure 6.2. All critical thinking elements combined: Mean rate per utterance by story



<u>Multivariate within-subjects test:</u>
F = 3.015
p = .063

<u>Contrasts significant at .05-level:</u>
Stealing > Note
Stealing > Code
Part > Note

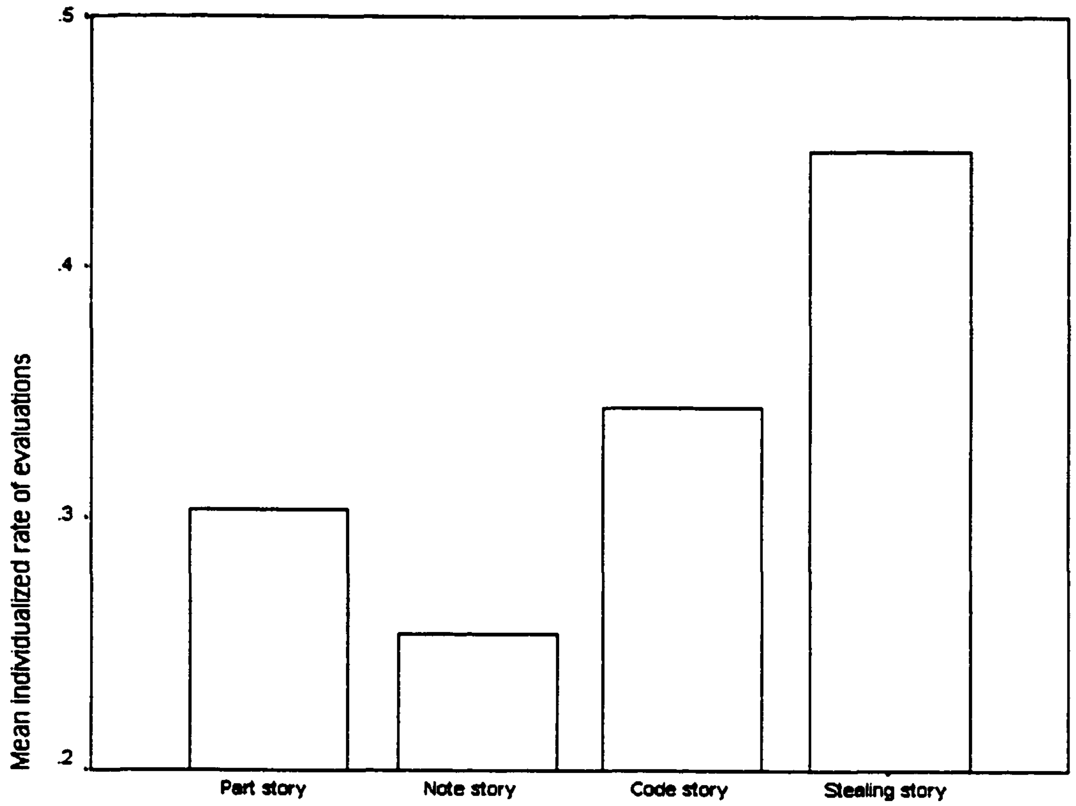
Figure 6.3. Identification of assumption: Mean rate per utterance by story



<u>Multivariate within-subjects test:</u>
F = 7.891
p = .002

<u>Contrasts significant at .05-level:</u>
Part > Note
Part > Code
Part > Stealing

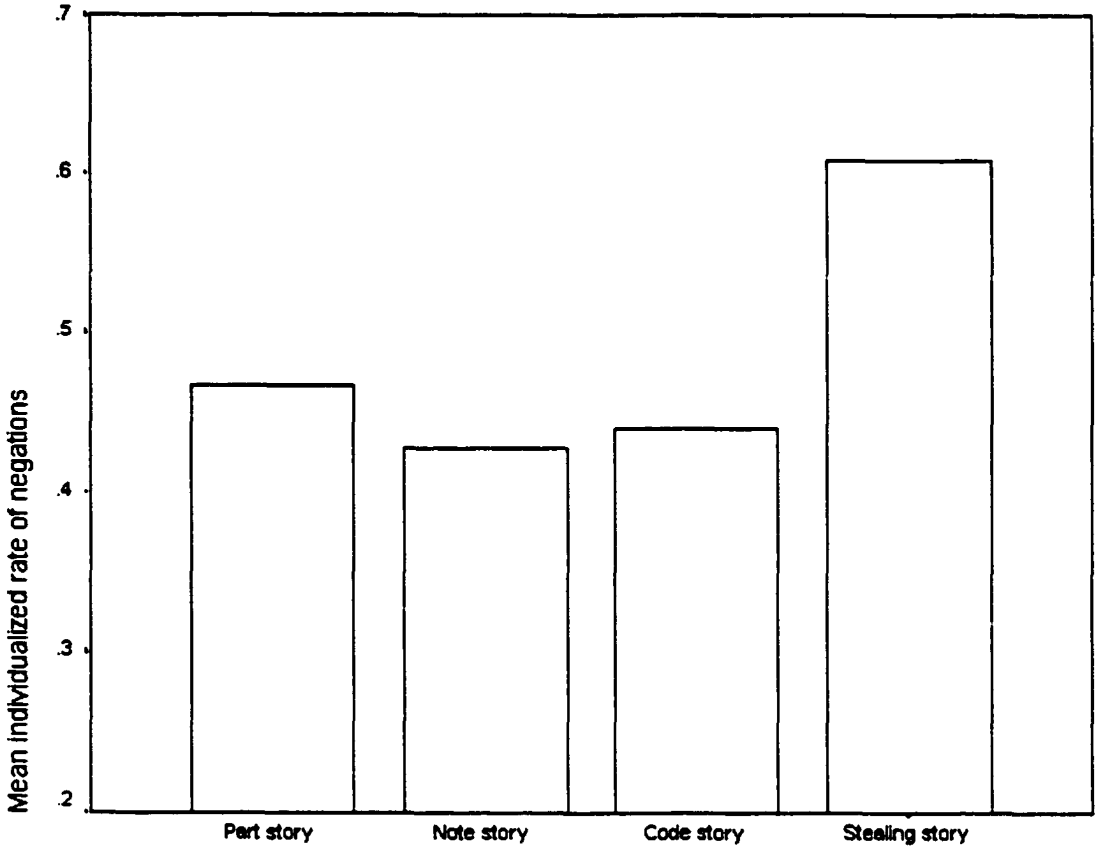
Figure 6.4. Evaluation: Mean rate per utterance by story



<u>Multivariate within-subjects test:</u>
F = 6.713
p = .004

<u>Contrasts significant at .05-level:</u>
Stealing > Note
Stealing > Part
Code > Note

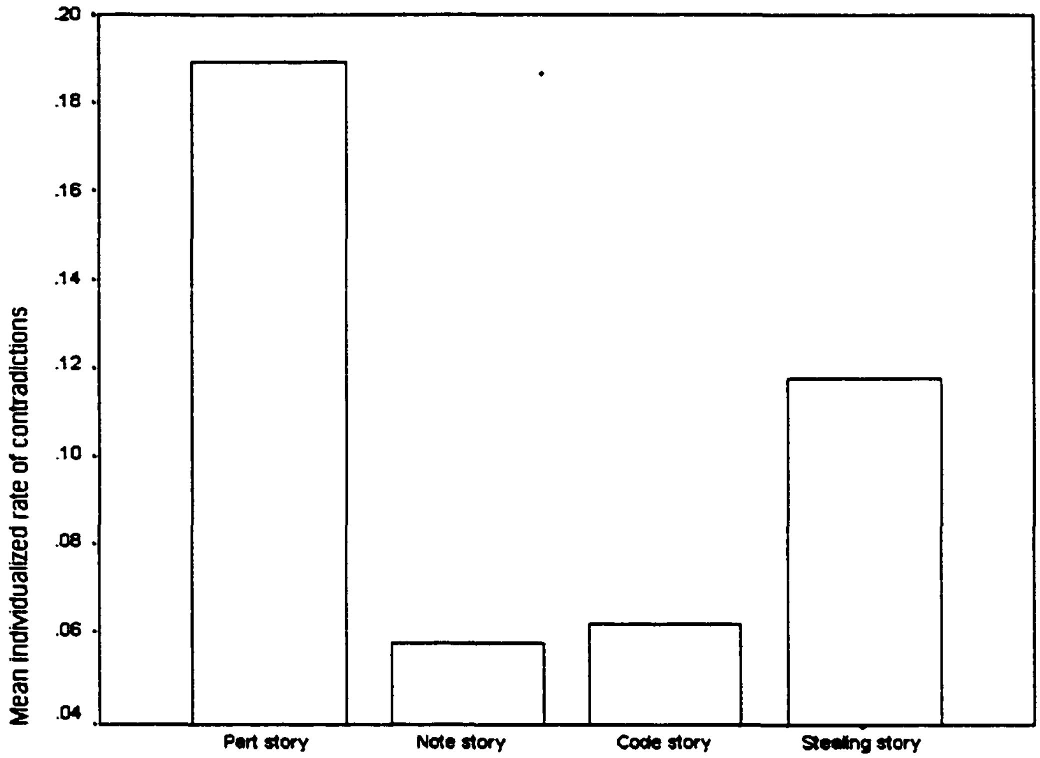
Figure 6.5. Negation: Mean rate per utterance by story



<u>Multivariate within-subjects test:</u>
F = 3.724
p = .035

<u>Contrasts significant at .05-level:</u>
Stealing > Note
Stealing > Code
Stealing > Part

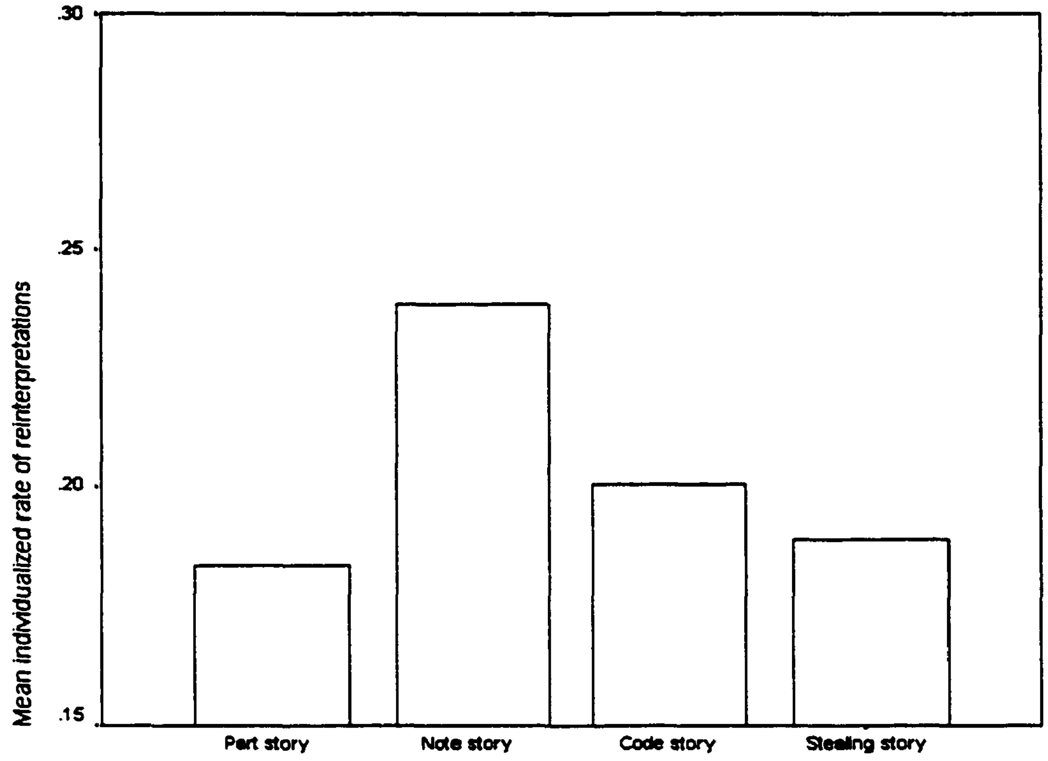
Figure 6.6. Contradiction: Mean rate per utterance by story



<u>Multivariate within-subjects test:</u>
F = 7.641
p = .002

<u>Contrasts significant at .05-level:</u>
Part > Note
Part > Code
Part > Stealing
Stealing > Code

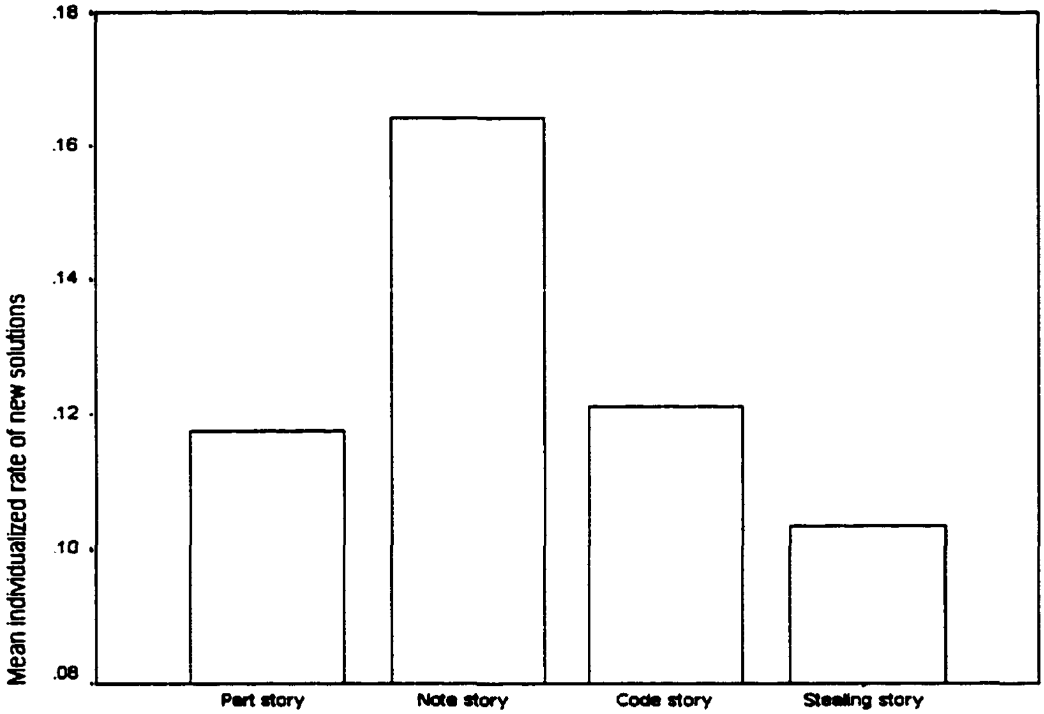
Figure 6.7. Reinterpretation: Mean rate per utterance by story



Multivariate within-subjects test:
F = 1.010
p = .416

No Contrasts significant at .05-level.

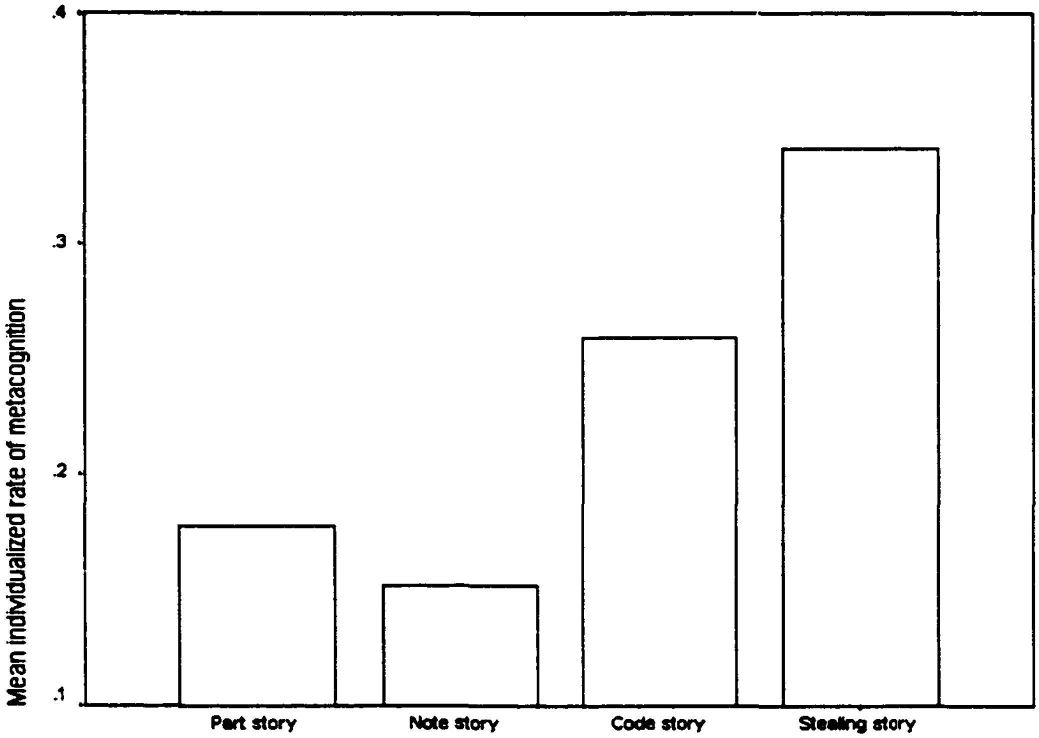
Figure 6.8. New solution: Mean rate per utterance by story



<u>Multivariate within-subjects test:</u>
F = 4.024
p = .028

<u>Contrasts significant at .05-level:</u>
Note > Part

Figure 6.9. Metacognition: Mean rate per utterance by story



<u>Multivariate within-subjects test:</u>
F = 16.282
p = .000

<u>Contrasts significant at .05-level:</u>
Stealing > Note
Stealing > Part
Code > Note
Code > Part

Opposite to what Hypothesis 3 predicted, the hypothetical moral dilemma elicited higher rates per utterance of all critical thinking elements combined than the three contextualized dilemmas (Figure 6.2). The average rate per utterance in the hypothetical Stealing story was 2.04, which is significantly higher than the rate in the Note story (M=1.54; F=10.234; p=.005), and also significantly higher than the rate in the Code story (M=1.67; F=6.926; p=.017) . The difference between the Stealing story and the Part story approached significance (Part story M=1.85; F=3.742; p=.070). In addition, the rate in the Part story was significantly higher than the rate in the Note story (F=5.897; p=.027).

In closer examination, this finding that seemingly contradicts Hypothesis 3 holds only for some of the seven critical thinking elements. Patterns somewhat similar to the overall rate were obtained for Evaluations (Figure 6.4), Negations (Figure 6.5), and Metacognitions (Figure 6.9), where the rates in the Stealing story were higher than in most of the other stories. But some of the other elements showed completely different patterns. The highest average rate for Identifications of assumption were found in the Part story (M=.41). It is significantly higher than the rate in the Note story (M= .25), Code story (M= .25), and the Stealing story (M= .24). The Part story also had a significantly higher rate of contradictions (M=.19), than the other stories (Note story M=.06; Code story M=.06; Stealing story M=.12). Please see Appendix 6B for the statistical significance information on these comparisons.

The four stories had very different "profiles" of frequencies of critical thinking elements. These differences call for a closer analysis of content differences among the four stories. Each of the three context-specific stories presented a unique type of conflict.

The Note story is about worker-supervisor communication, while the Code story addresses relations among workers, and the Part story views the worker's actions in the context of the entire system. The Note story and the Code story are context-specific, but they are about the new computer system which is an unfamiliar context. The Part story is the only story presenting a context-specific and historically familiar situation. The Part story had particularly high rates of Identification of assumption and Contradiction, but this may be due to any of a number of characteristics of that story, including a conflict involving the system, and historically familiar context.

Correlations among seven elements

When the seven elements of critical thinking were defined it was assumed that they are all related to one underlying construct of critical thinking. The validity of this assumption was tested by obtaining bi-variate correlations among all elements. Table 6.4 presents a correlation matrix of Pearson correlation coefficients among the seven elements, using individualized rate per utterance in the total coded segment as the measure.

As expected, there are high positive correlations among several of the elements. Ten of the twenty-one possible correlations among the seven elements reach statistical significance, although the sample size is small ($n=18$). The highest correlations are observed between Reinterpretation and Negation ($r=.81$, $p<.01$), Reinterpretation and Contradiction ($r=.70$, $p<.01$), and Contradiction and Negation ($r=.70$, $p<.01$). In addition, Negation is significantly correlated with three other elements (Evaluation, New solution, Metacognition). Four of the six correlations between New solution and the other elements are significant, as well as the correlation between Evaluation and

Metacognition. Some exceptions were observed to the strong overall associations among the elements: Identification of assumption is not significantly correlated with any of the others, and Metacognition only correlates significantly with Evaluation and Negation.

Table 6.4. Correlation matrix of seven critical thinking elements in coded segment

	Identification of Assumption	Evaluation	Negation	Contradiction	Reinterpretation	New Solution	Metacognition
Identification of Assumption		-.177	.399	.358	.306	.177	-.235
Evaluation	-.177		.606**	.335	.334	.506*	.613**
Negation	.399	.606**		.697**	.814**	.538*	.489*
Contradiction	.358	.335	.697**		.695**	.535*	.393
Reinterpretation	.306	.334	.814**	.695**		.620**	.391
New Solution	.177	.506*	.538*	.535*	.620**		.423
Metacognition	-.235	.613**	.489*	.393	.391	.423	

** Pearson r is significant at the 0.01 level (2-tailed).
* Pearson r is significant at the 0.05 level (2-tailed).

A factor analysis was performed to find out whether there are several underlying components among the critical thinking elements. The results of the factor analysis are presented in Table 6.5. Principal Component Analysis was used as the extraction method, and Promax with Kaiser Normalization as the rotation method. As Table 6.5

shows, two factors were identified among the seven critical thinking elements. The first factor has high loadings on five of the seven elements (Reinterpretation, Negation, Contradiction, Identification of assumption, New solution). The second factor incorporates Metacognition and Evaluation, and presents a highly negative loading for Identification of assumption. This suggests that Metacognition and Evaluation are separate from an underlying construct encompassing the other five elements. The first factor, which excludes Metacognition and Evaluation, may be preferable to a measure of overall critical thinking that simply sums all seven elements.

Table 6.5. Factor Analysis of Critical Thinking Elements: Pattern Matrix

Element	**Component**	
	1	**2**
Reinterpretation	.854	
Negation	.849	
Contradiction	.830	
Identification of assumption	.744	-.713
New solution	.626	.328
Metacognition		.797
Evaluation		.778
Total variance explained:		
Initial Eigenvalues/ Extraction sums of squared loadings total	3.748	1.515
% of variance	53.538	21.638
Cumulative % of variance	53.538	75.177
Rotation total	3.444	2.243

Relationship of questionnaire responses and critical thinking elements

To compare the four factors identified in the questionnaires with the interview-based critical thinking measures, the factor analysis of the questionnaires was re-run by substituting sample means for missing values in the questionnaires. This was necessary because three of the eighteen interview respondents had a missing value in their questionnaire, reducing the sample size to only fifteen. The results of the second version of the factor analysis were essentially the same as in the original version, identifying the same four factors. Only the second version, however, provided questionnaire factor loadings for all eighteen interview participants.

No statistically significant correlations were found between the four questionnaire factors and the rates of the seven critical thinking elements. The negative correlation between the rate of all seven critical thinking elements combined and questionnaire Factor 1 (Negativity towards the new system) approached statistical significance ($r = -.416$, 2-tailed $p = .086$). A borderline significant positive correlation ($r = .463$, 2-tailed $p = .053$) was observed between the rate of Evaluations and questionnaire Factor 2 (Positive regard for one's job).

Summary of findings regarding critical thinking in discourse

High frequencies of critical thinking elements were identified in the coded segment of the interviews. The overall rate of all elements combined was 1.75 elements per utterance. Negations were found in almost half (.477) of all utterances, and Evaluations were found in one in three (.331) utterances. The rate of identifying assumptions made by others, which is generally considered a high level critical thinking skill (Halpern, 1996), was remarkably high at .282 per utterance. At the same time, Metacognitions, which are defined as reflection on one's own or someone else's thought processes, were expressed by the mechanics in only .230 times per utterance, although the category included such common expressions as "I know" and "I think". In one -fifth of the utterances (.205), the interviewee reinterpreted the interviewer's previous question or comment (Reinterpretation). Contradictions (or identifications of contradiction) appeared in 10.5% of the utterances, and New solutions were discussed in 12.2% of the utterances.

Wide variability across individuals was found in rates of critical thinking elements. For example, the individualized rate per utterance for Metacognitions varied from .02 to .56 per utterance (M= .222, S.D.= .118), and the rate for Identification of assumptions varied from .13 to .55 per utterance (M= .289, S.D.= .100). The individualized rate per utterance for all elements combined ranged from 1.21 to 2.54 (M=1.748, S.D.= .396).

Hypothesis 3, predicting that context-specific dilemmas will elicit more critical thinking than the hypothetical moral dilemma, was not supported. The hypothetical moral dilemma elicited a higher rate of critical thinking (all critical thinking elements combined) than the context-specific dilemmas about familiar conflicts. This pattern, however, did not apply to all of the specific elements. For example, particularly high rates of Identification of assumptions and Contradictions were found in the Part story, which is about a familiar context, but not computer-related. If the finding showing the highest rate for the hypothetical story is valid, it suggests that blue-collar workers' level of critical thinking is not associated with context-specificity, at least when their responses are actively probed. Further analysis of differences in the content of the four stories is a possible avenue for finding explanations for the differences across stories in rates of different critical thinking elements.

Correlations were high among most of the seven elements of critical thinking. A factor analysis revealed a strong primary factor which included Reinterpretation, Negation, Contradiction, Identification of assumption, and New Solution, but excluded Metacognition and Evaluation. Compared to a measure combining all seven elements, the primary factor may be preferable as a measure of general level of critical thinking. The rates of critical thinking elements per utterance did not significantly correlate with any of the four questionnaire factors.

Towards an expanded definition of critical thinking

What implications do the findings described above have on the definition of critical thinking? The following initial definition of critical thinking was presented in the proposal for this study:

> Forms of thought, discourse, and activity which, in a given context, attempt to:
>
> 1) identify and question assumptions,
> 2) resist, contradict, challenge, and negate existing ideas, arguments, and activities,
> 3) evaluate the quality of ideas, arguments, and activities of others and one's own, and
> 4) as a result create novel ideas, arguments, and activities.

The primary factor identified empirically in the sample of discourse included the following elements: Reinterpretation, Negation, Contradiction, Identification of assumption, and New solution. Evaluation and Metacognition were combined into a secondary factor, and excluded from the primary factor. This suggests that the third component of the initial definition (evaluate the quality of ideas, arguments, and activities of others and one's own) may be somewhat separate from the other components.

The original definition of critical thinking was revised to include only those five elements that were part of the component identified by the factor analysis. The redefinition also involved reordering the five elements into a logical sequence that generally meant proceeding from simple to complex elements. Negation and reinterpretation were judged to be more elementary than identification of assumption and contradiction. As in the original definition, New solution maintained its place as the last element.

The reorganization of the five elements (underlined below) lead to the following revised definition of critical thinking:

Forms of thought, discourse and activity which:

1) negate, and reinterpret existing ideas, arguments, and activities

2) identify assumptions and contradictions

3) and as a result, create new solutions

The definition of critical thinking is discussed further in Chapter 8.

Chapter 7: Critical Thinking and Computer Use

Following the idea of dialectical process of accommodation to new technology, it was predicted that critical attitudes and high levels of critical thinking in discourse will be associated with constructive computer use patterns (Hypotheses 2 and 4). This Chapter examines how questionnaire and interview-based measures, obtained during early implementation of the technology, relate to measures of sustained constructive computer use. Three measures of computer utilization were developed for this study (Chapter 4).

The three measures, obtained for each individual, include:

1 - Percentage of total universe of repair codes utilized per set of 30 symptoms

2 - Number of different component codes used in a set of 30 symptoms

3 - Typing of comments during months two and five (percentage of total symptoms)

Before the actual analyses, statistical tests were performed to examine whether the outcome measures differ between those who are in the questionnaire and interview samples and those who are not. The mean outcome scores of different sub-samples were compared by using t-tests. For the repair code and component code measures, a separate comparison was done for each set of 30 symptoms, and for the comment measure, a separate comparison was done for each month. No significant differences were found in any of the outcome measures between the questionnaire sample and those who did not participate in the questionnaire, or between the interview sample and those who were not interviewed.

Among the three highly correlated computer usage measures discussed in Chapter 4, the use of repair codes was selected to be the primary outcome measure.[1] The presentation below focuses mainly on the repair code measure, and results regarding the two other computer use measures are discussed briefly.

Questionnaire factors and computer use

As discussed in Chapter 5 above, four distinct factors were identified in the workers' questionnaire responses:

1 - Negativity towards new system

2 - Positive regard for one's job

3 - Careful optimism towards new system

4 - Knowledge and confidence

A graphic presentation of the relationship between each questionnaire factor and repair code use over time is shown in Figures 7.1 to 7.4. For descriptive purposes, factor scores on each factor were divided into three equal-size groups (low, medium, high). Mean percentages of utilizing the total repair code universe in each set of 30 symptoms were obtained for each group. In addition to testing for significant differences between the mean scores of the three groups, correlations were obtained between each questionnaire factor and the repair code measure in each set. Only sets one through eight were included, because the sample size became too small in Sets 9 and 10. (There were only 8 mechanics in Set 9 and 7 mechanics in Set 10 who had both questionnaire and repair code use data). The correlations are presented in Table 7.1. Statistically

[1] As discussed in Chapter 5, the component code measure has more severe statistical limitations than the repair code measure. The comment use measure was not chosen because use of comments is optional, and some mechanics never used them. Furthermore, all three computer use measures correlate highly with one

significant correlations, as well as statistically significant differences between means, are indicated in Figures 7.1 to 7.4.

Table 7.1. Correlations between questionnaire factor scores and repair code measure

		Percentage of repair code universe used							
		Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8
Factor 1: Negativity towards new system	Pearson r	-.007	.035	-.128	-.140	.148	-.205	-.468*	-.497
	n	40	40	38	37	33	28	20	11
Factor 2: Positive regard for one's job	Pearson r	-.029	.085	-.041	.196	.009	.278	.476*	.680*
	n	40	40	38	37	33	28	20	11
Factor 3: Careful optimism towards new system	Pearson r	-.169	-.120	-.187	-.057	.238	.470*	-.102	.362
	n	40	40	38	37	33	28	20	11
Factor 4: Knowledge and confidence	Pearson r	-.066	-.189	.073	-.029	.079	.255	.238	-.010
	n	40	40	38	37	33	28	20	11

* Correlation is significant at the 0.05 level (2-tailed)

another, which justifies selecting only one of them as the primary outcome measure (See correlation matrix in Appendix 4D).

Figure 7.1. Repair code use over time by groups based on questionnaire factor 1 (Negativity towards new system)

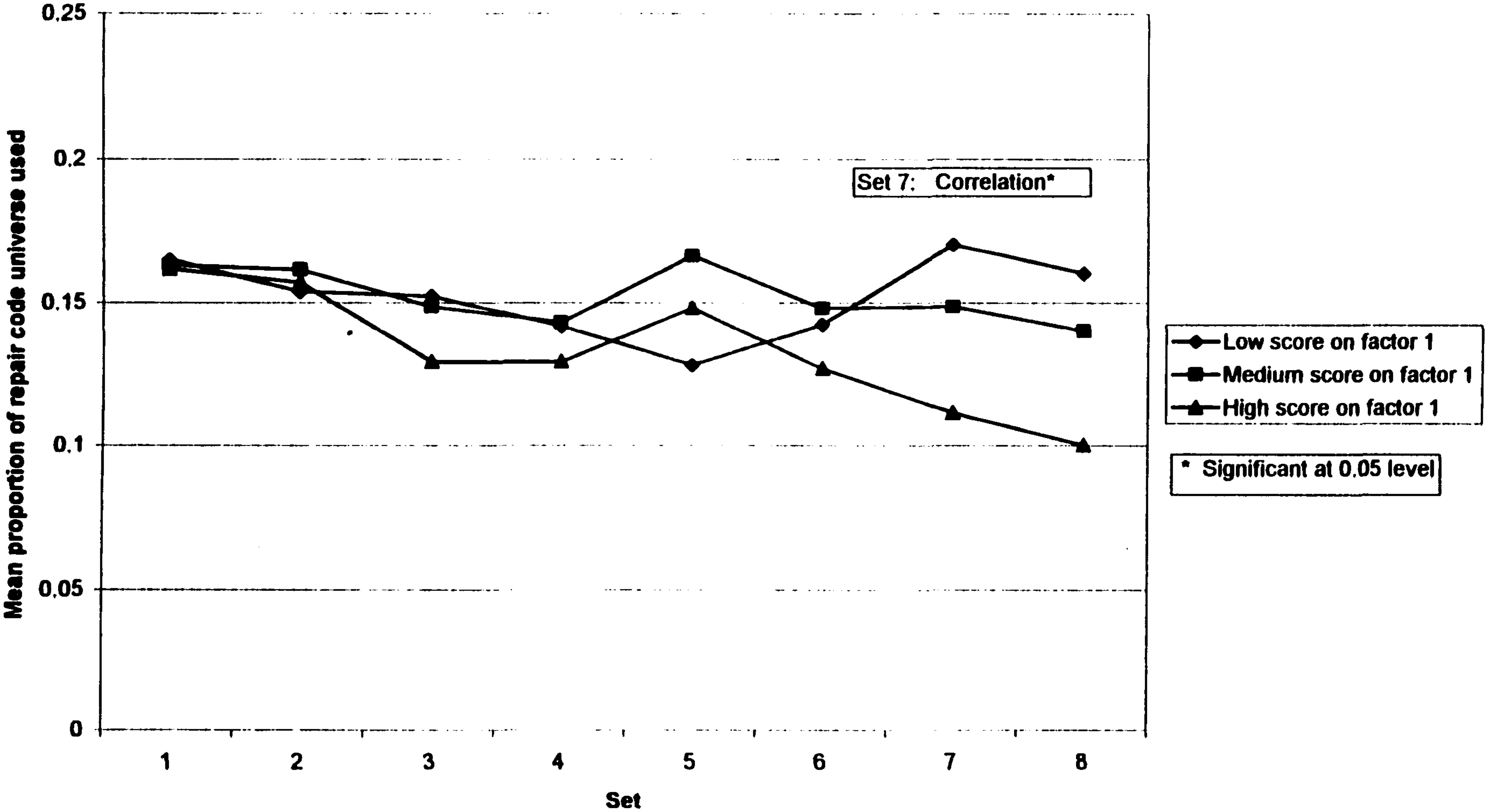


Figure 7.2. Repair code use over time by groups based on questionnaire factor 2 (Positive regard for one's job)

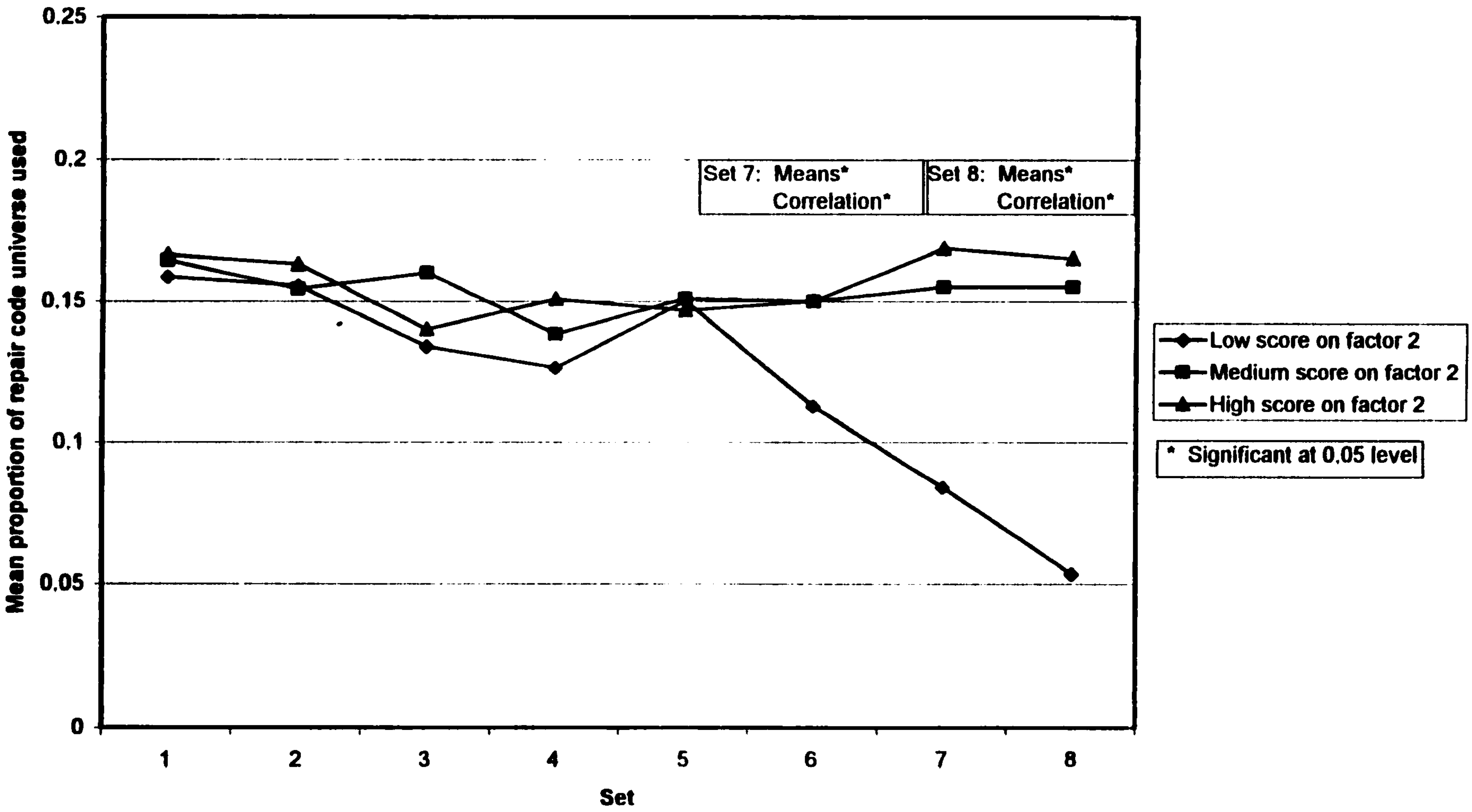


Figure 7.3. Repair code use over time by groups based on questionnaire factor 3 (Careful optimism towards new system)

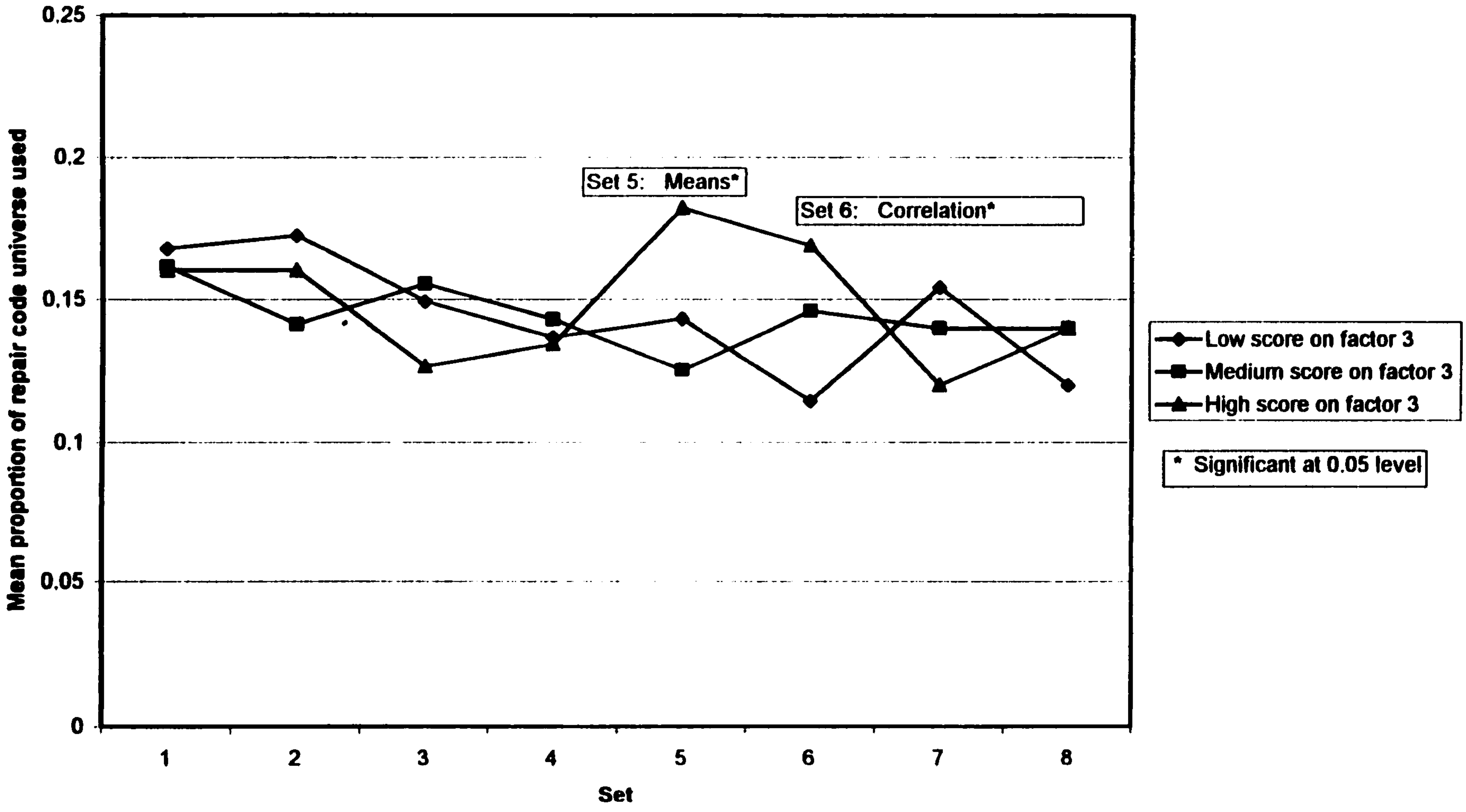
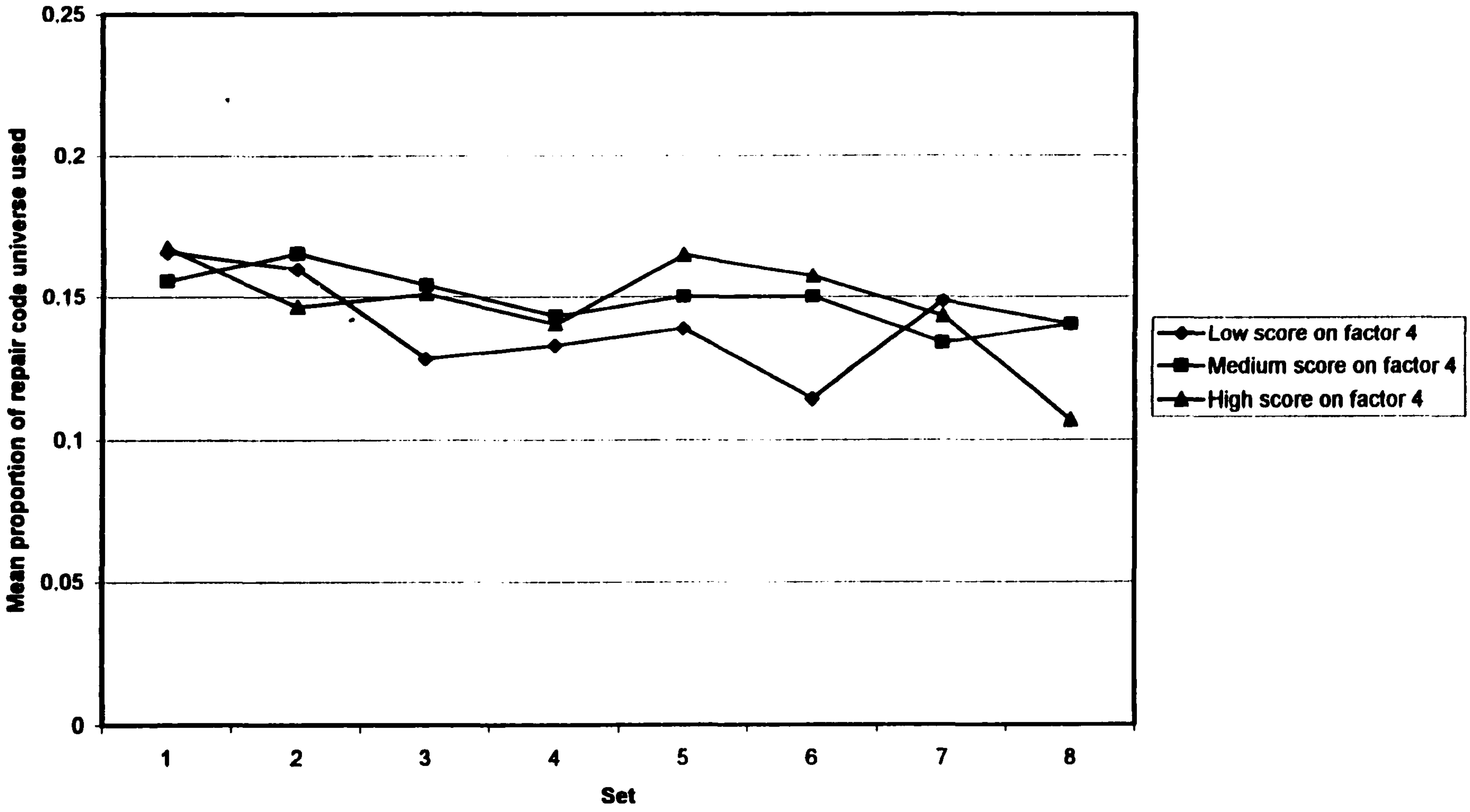


Figure 7.4. Repair code use over time by groups based on questionnaire factor 4 (Knowledge and confidence)



Among the four questionnaire factors, Factor 2, "Positive regard for one's job", is the strongest predictor of sustained constructive repair code use (Figure 7.2). High scores on this factor significantly predict high level of repair code use in the seventh and eighth Sets, which occur after the mechanics have used the system more than 180 times (30 symptoms times six Sets is 180). There is a significant positive correlation between the score on Factor 2 and repair code use in Set 7 (Pearson r = .476, n=20, 2-tailed p = .034), and in Set 8 (Pearson r = .680, n=11, 2-tailed p = .021). Set 7 means of the three groups based on factor scores on Factor 2 (low M = .084, medium M = .155, high M = .169) are also significantly different (F = 4.308; df 2,17; p = .031). The same pattern is found for Set 8 means of the three groups (low M = .053, medium M = .155, high M = .165; F = 8.295; df 2,8; p = .011).

Factor 1, "Negativity towards new system", also predicts some differences in repair code use (Figure 7.1). High scores on this factor (more negativity) are associated with low levels of repair code use in Set 7 (Pearson r = -.468, n=20, p = .037). The mean repair code scores of low, medium, and high groups on factor two are not significantly different in any of the Sets.

High scores on Factor 3, "Careful optimism towards new system" predict high repair code use in Sets 5 and 6, but the effect of this factor disappears in Sets 7 and 8 (Figure 7.3). The only significant correlation is observed for Set 6 (Pearson r = .470, n=28, p = .012), and the only significant difference between low, medium and high groups on Factor 3 is observed for Set 5 (low M = .143, medium M = .126, high M = .182; F = 3.955; df 2,30; p = .030). Factor 4, "Knowledge and confidence" is not significantly related to repair code use in any of the sets (Figure 7.4).

Similar analyses were performed with the component code measure and the comment measure as dependent variables. No statistically significant associations were found between any of the four questionnaire factors and those two measures of computer use.

Elements of critical thinking and computer use

Seven elements of critical thinking, and their combinations, were discussed in Chapter 6. These elements were observed in interviews conducted with eighteen workers during early implementation of the new computer system. The relationships among interview-based variables and computer use variables were examined following a procedure similar to the one described above for the questionnaire factors. The primary outcome measure, again, is percentage of repair code universe used in a set of 30 symptoms. Only sets one to five were included, due to declining sample size in later sets.

The following thirteen interview-based variables were used to predict computer use:

1- Score on the primary factor identified in factor analysis of critical thinking elements

2- Rate of all critical thinking elements per utterance (seven elements combined)

3- Identification of assumption rate per utterance

4- Evaluation rate per utterance

5- Negation rate per utterance

6- Contradiction rate per utterance

7- Reinterpretation rate per utterance

8- New solution rate per utterance

9- Metacognition rate per utterance

10- Rate of all elements in Part story

11- Rate of all elements in Note story

12- Rate of all elements in Code story

13- Rate of all elements in Stealing story

Figures 7.5 to 7.17 show graphs of repair code use by levels of each interview variable. For descriptive purposes, workers were, again, divided into three equal sub-groups on each independent variable. The graphs show repair code usage curves for the three sub-groups. In addition to testing for significant differences between sub-group means, correlations were obtained between interview variables and the computer use variable (See correlations in Table 7.2).

Table 7.2. Correlations between interview variables and repair code measure

Interview variable		Percentage of repair code universe used				
		Set 1	Set 2	Set 3	Set 4	Set 5
Interview factor	Pearson r	-.128	.224	-.122	.349	.667*
	n	18	18	16	15	13
All critical thinking elements combined	Pearson r	-.061	.271	-.078	.458	.675*
	n	18	18	16	15	13
Identification of assumption	Pearson r	-.075	.020	-.204	.007	.040
	n	18	18	16	15	13
Evaluation	Pearson r	.029	.413	.037	.554*	.689*
	n	18	18	16	15	13
Negation	Pearson r	-.055	.462	-.014	.598*	.807*
	n	18	18	16	15	13
Contradiction	Pearson r	-.310	-.038	-.360	.175	.383
	n	18	18	16	15	13
Reinterpretation	Pearson r	-.036	.255	.106	.372	.711*
	n	18	18	16	15	13
New solution	Pearson r	-.022	.032	.053	.156	.644*
	n	18	18	16	15	13
Metacognition	Pearson r	.061	.054	.003	.351	.393
	n	18	18	16	15	13
Part story total	Pearson r	.044	.463	-.025	.571*	.730*
	n	18	18	16	15	13
Note story total	Pearson r	-.169	.073	.062	.263	.561*
	n	18	18	16	15	13
Code story total	Pearson r	-.015	.161	-.119	.189	.329
	n	18	18	16	15	13
Stealing story total	Pearson r	-.024	.234	-.141	.420	.643*
	n	18	18	16	15	13

* Correlation is significant at the 0.05 level (2-tailed)

Figure 7.5. Repair code use over time by groups based on interview critical thinking factor

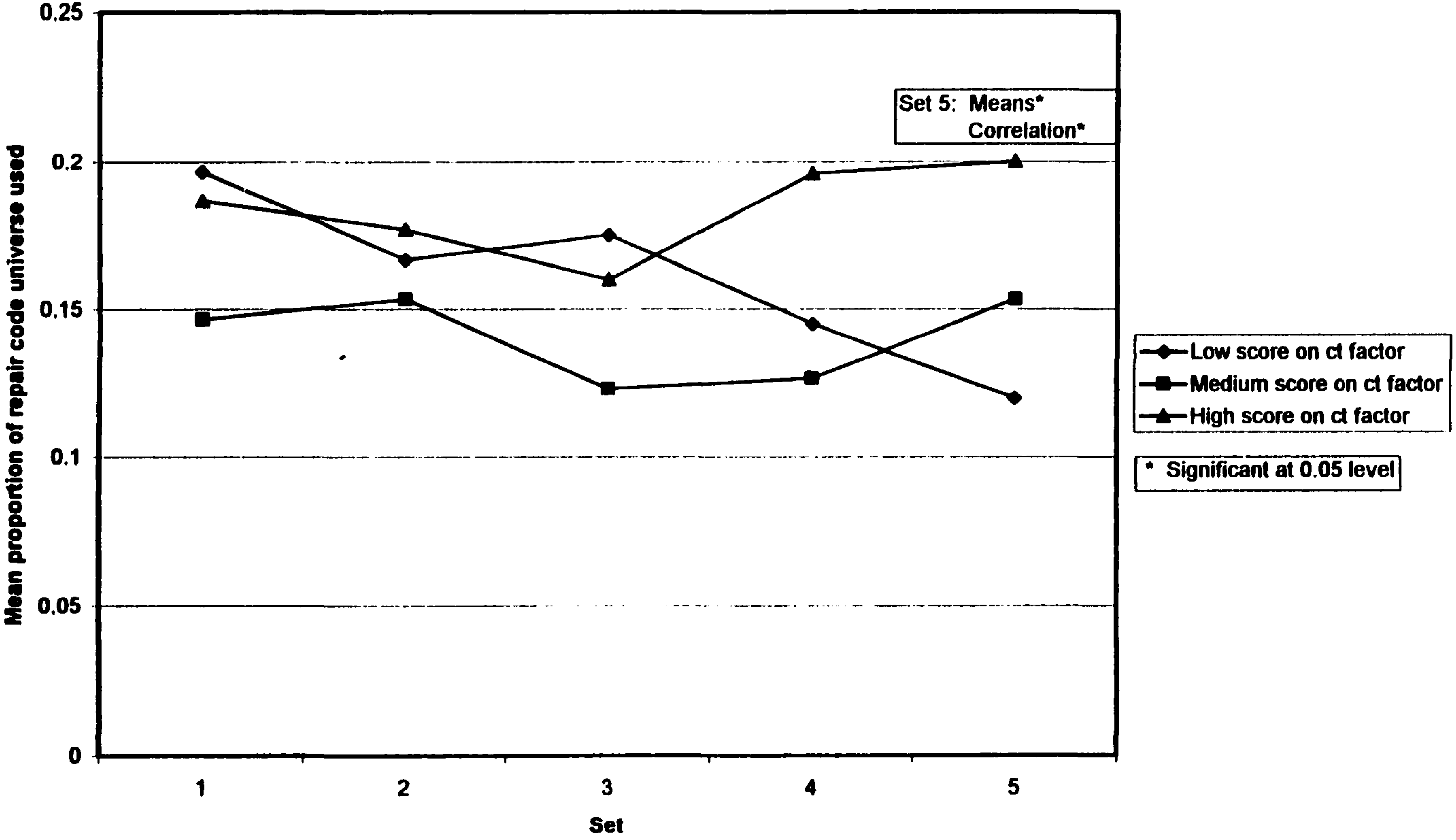


Figure 7.6. Repair code use over time by groups based on total of all critical thinking elements

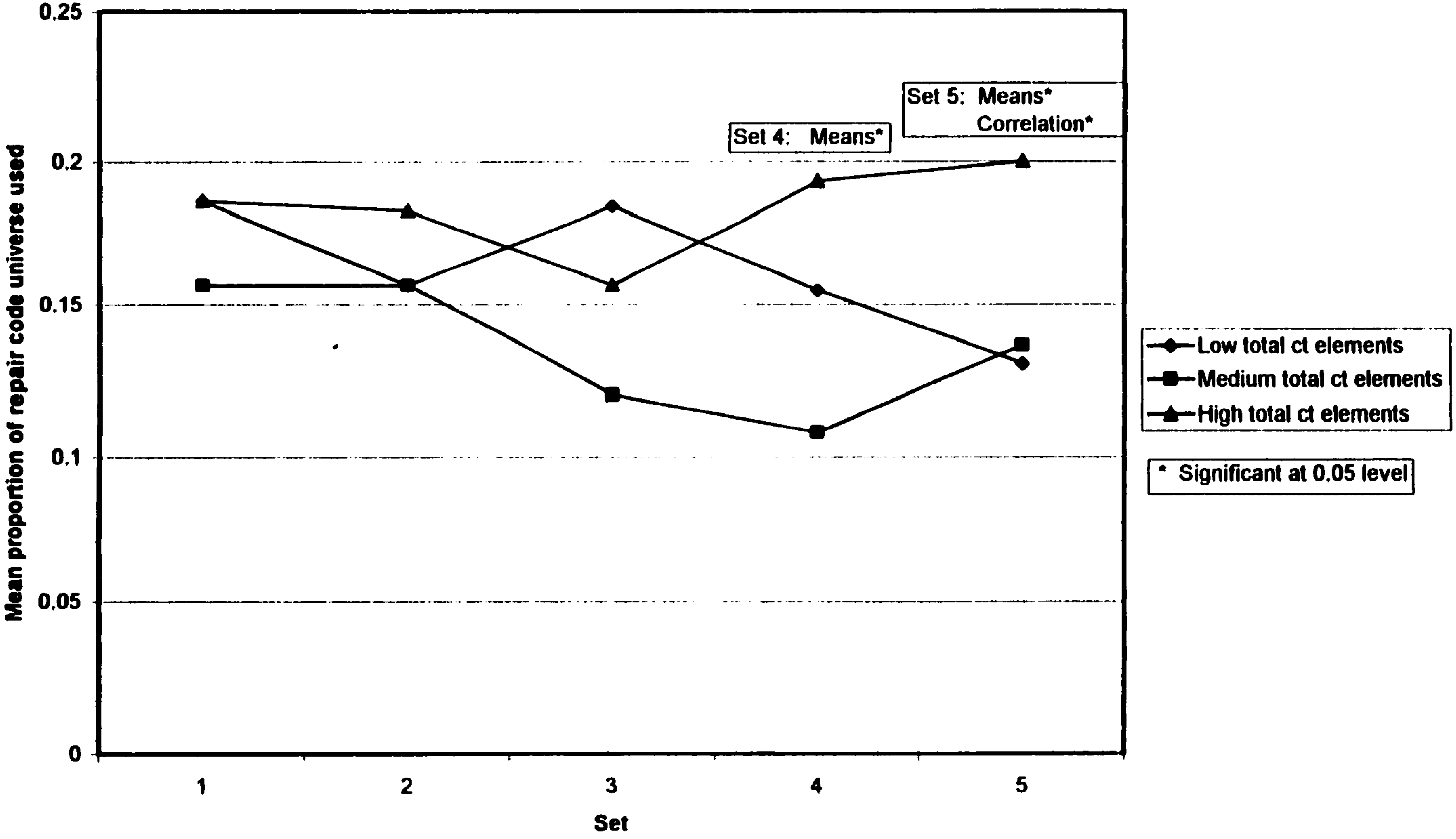


Figure 7.7. Repair code use over time by groups based on identifcations of assumption

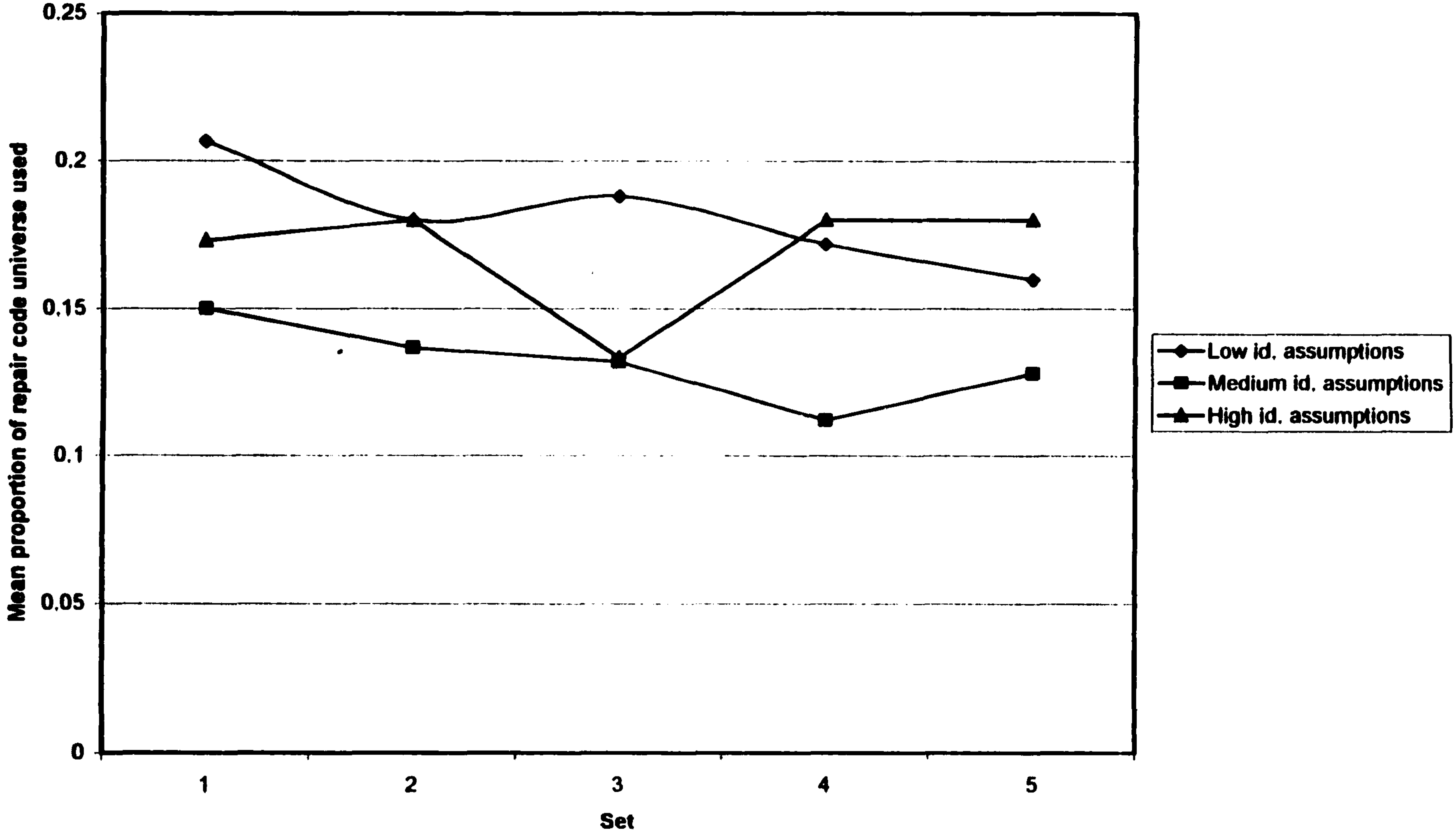


Figure 7.8. Repair code use over time by groups based on evaluations element

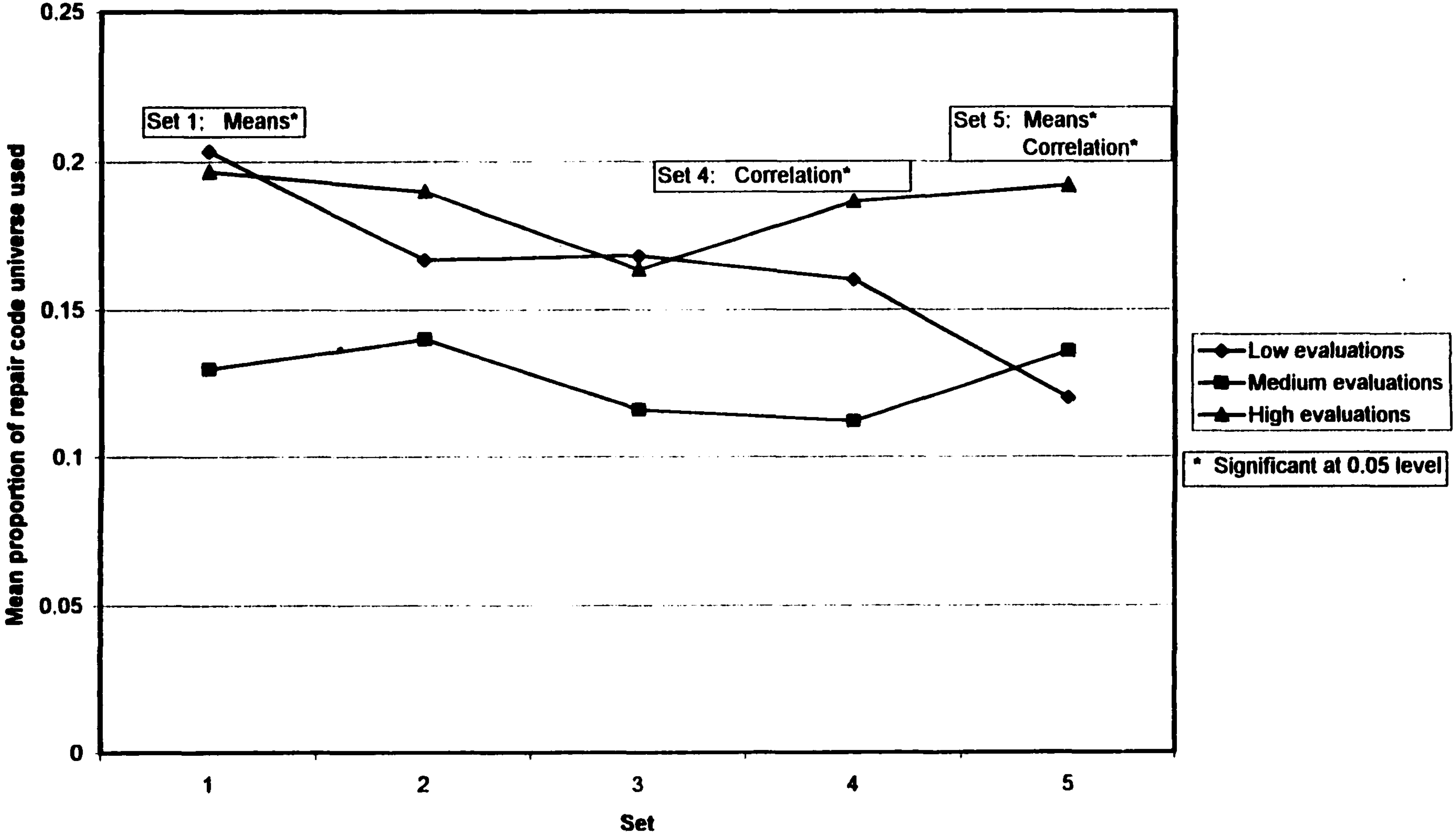


Figure 7.9. Repair code use over time by groups based on negations element

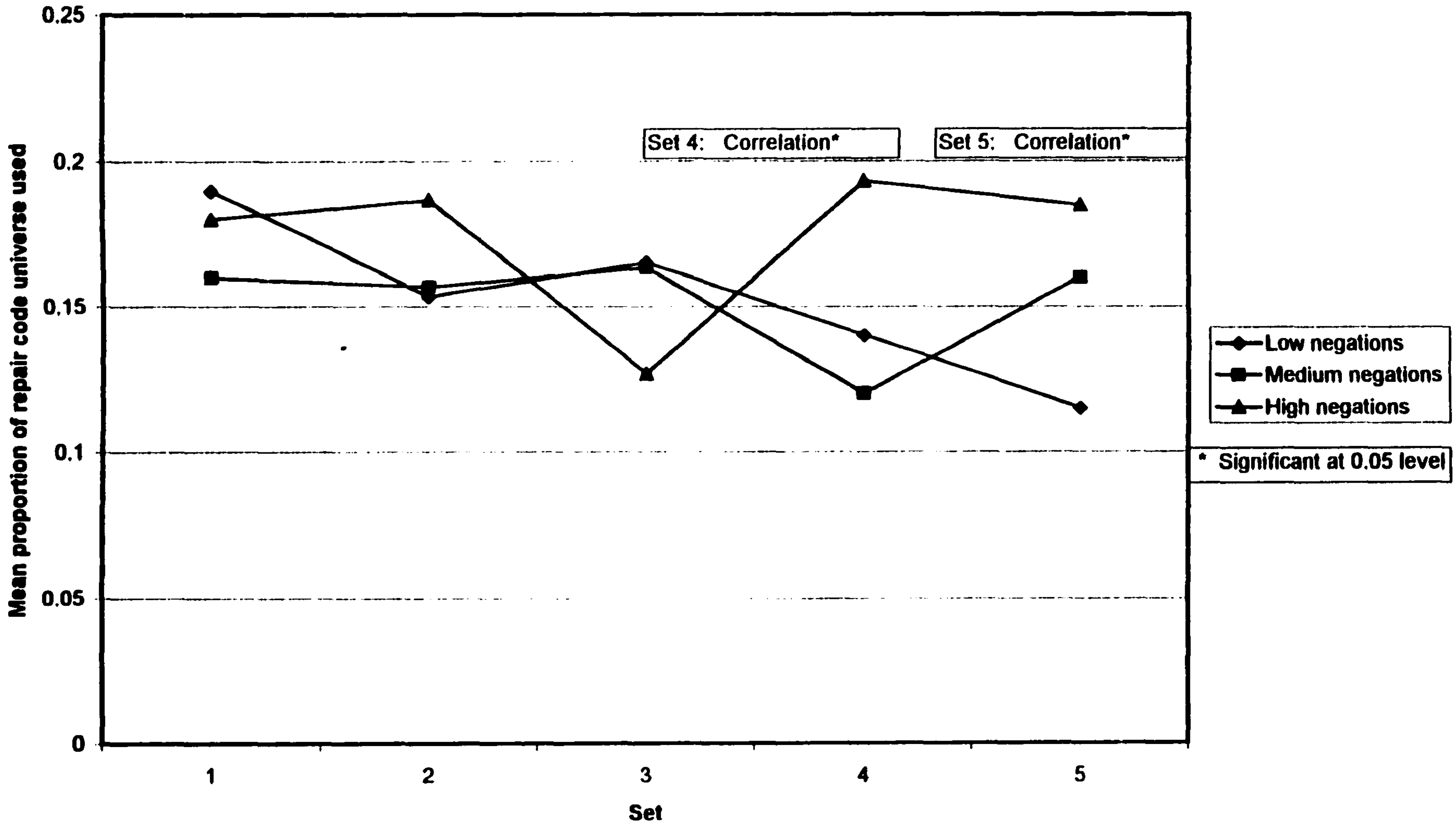


Figure 7.10. Repair code use over time by groups based on contradictions element

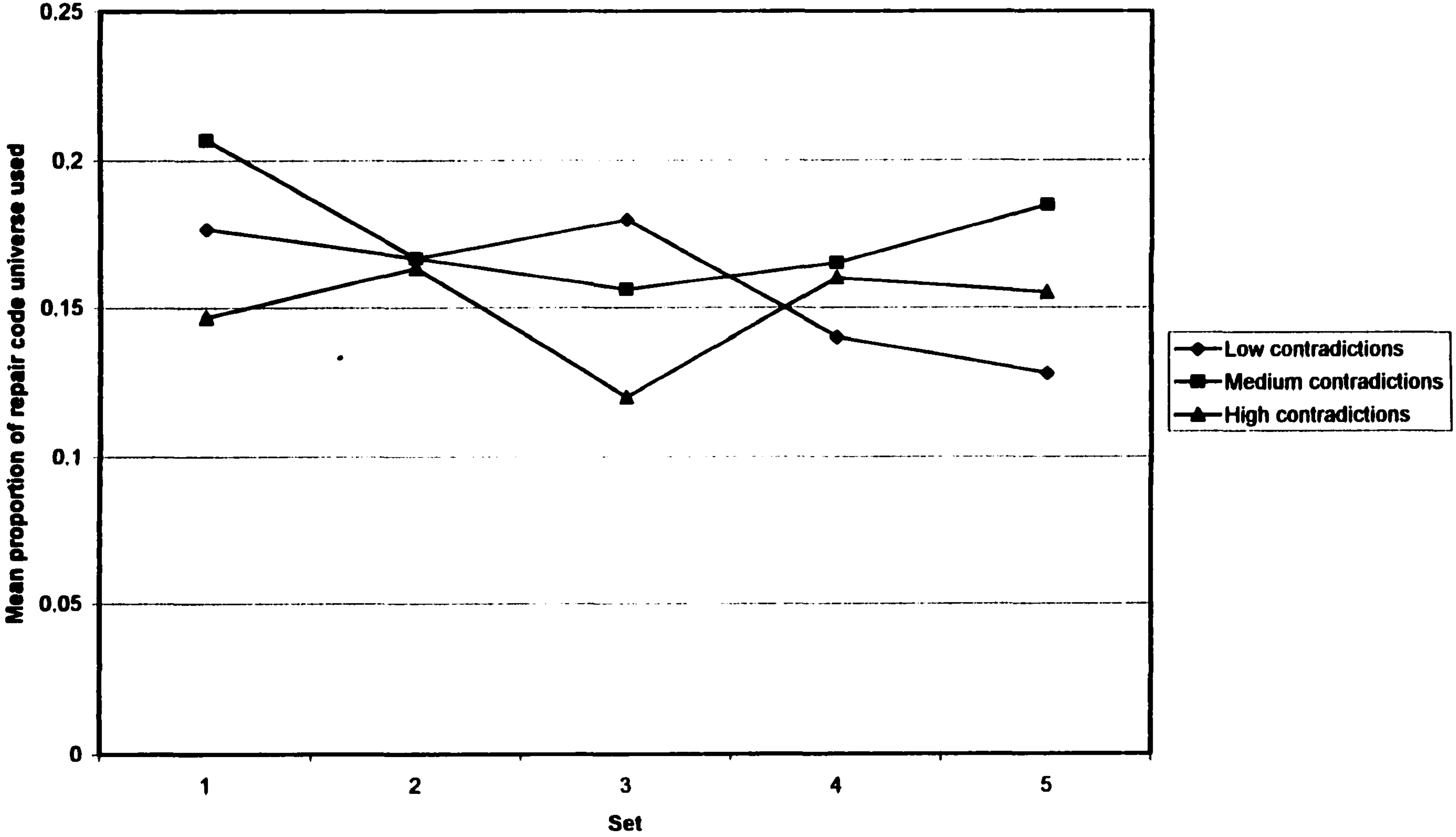


Figure 7.11. Repair code use over time by groups based on reinterpretations element

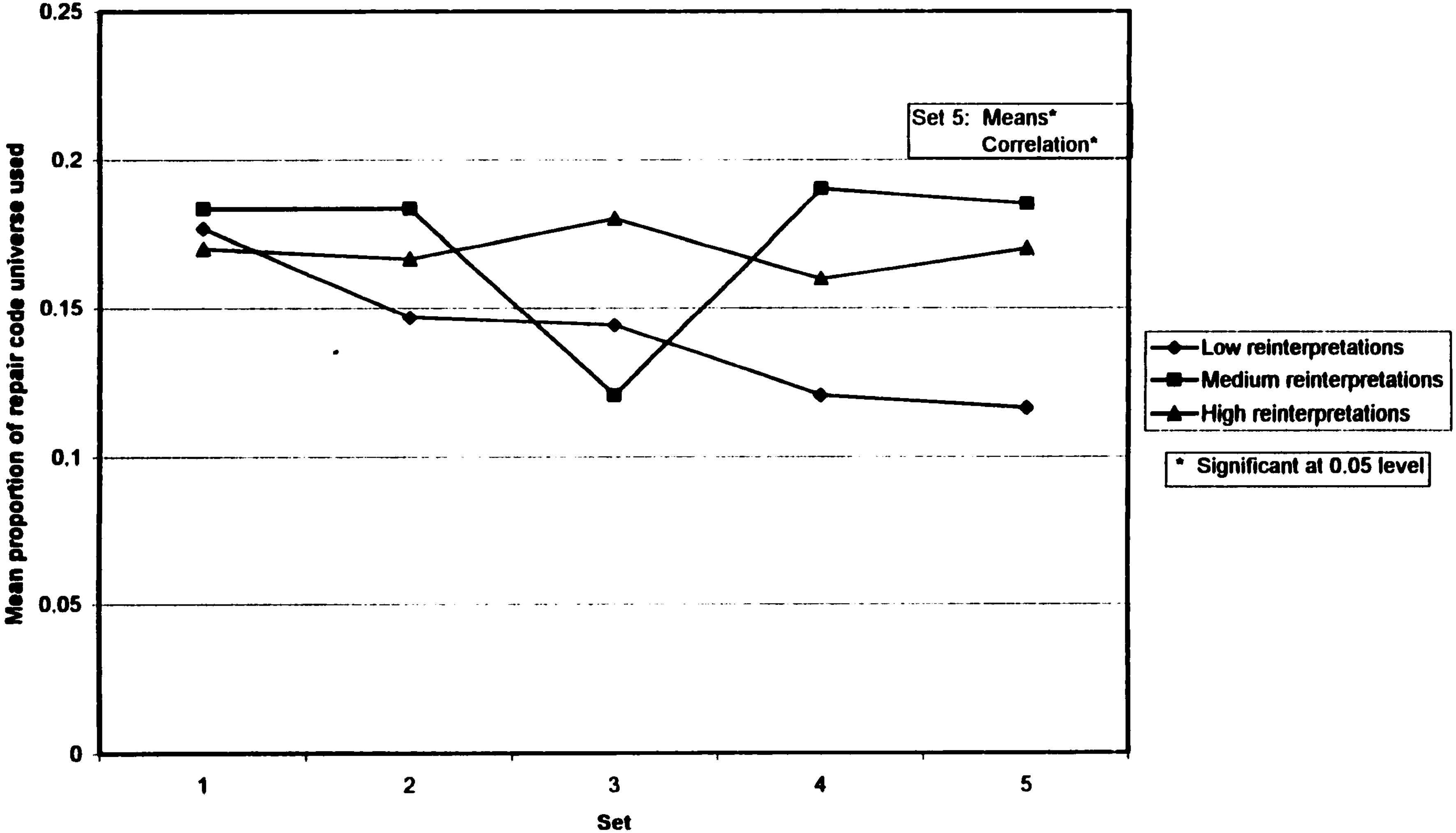


Figure 7.12. Repair code use over time by groups based on new solutions element

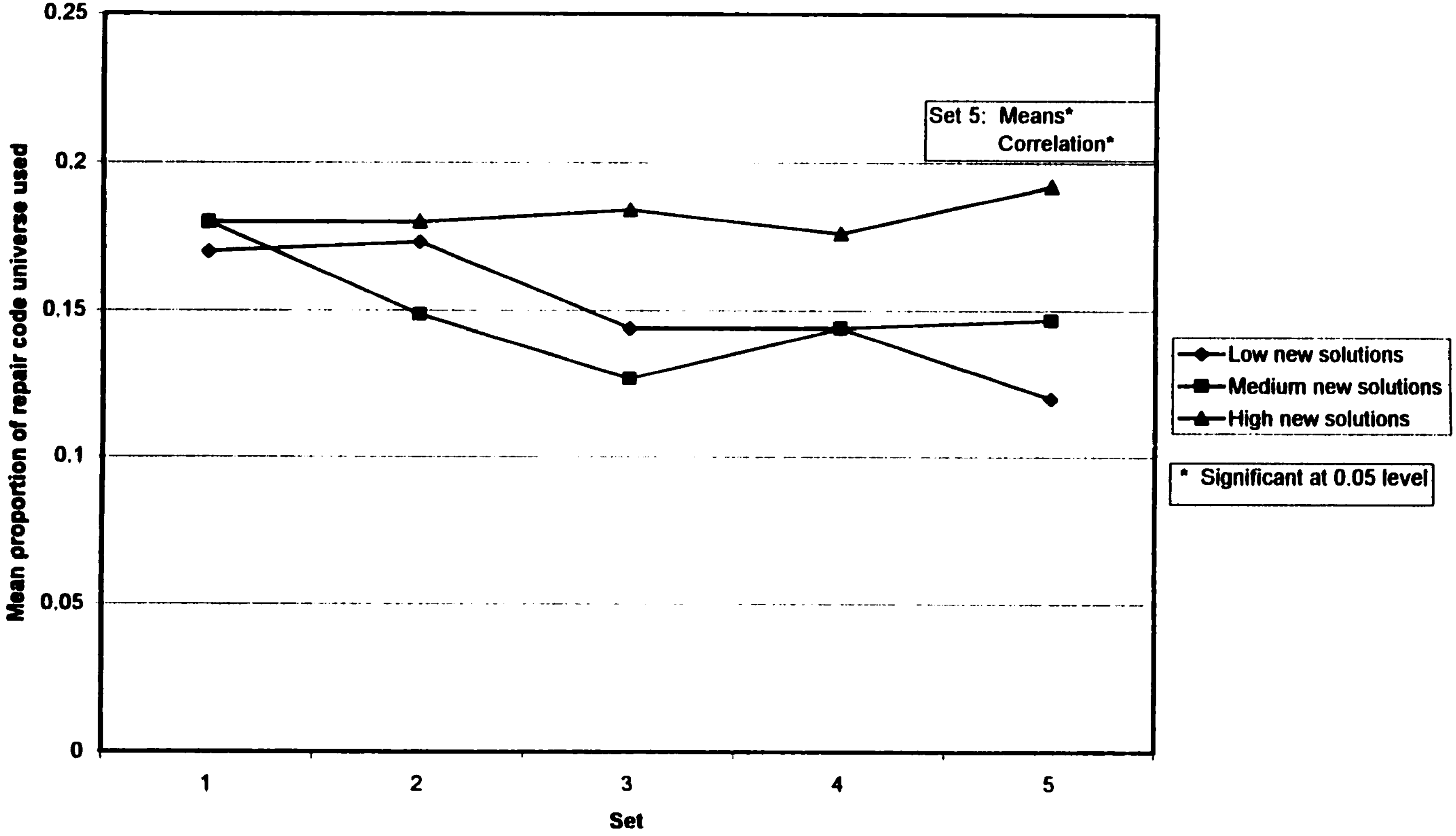


Figure 7.13. Repair code use over time by groups based on metacognition element

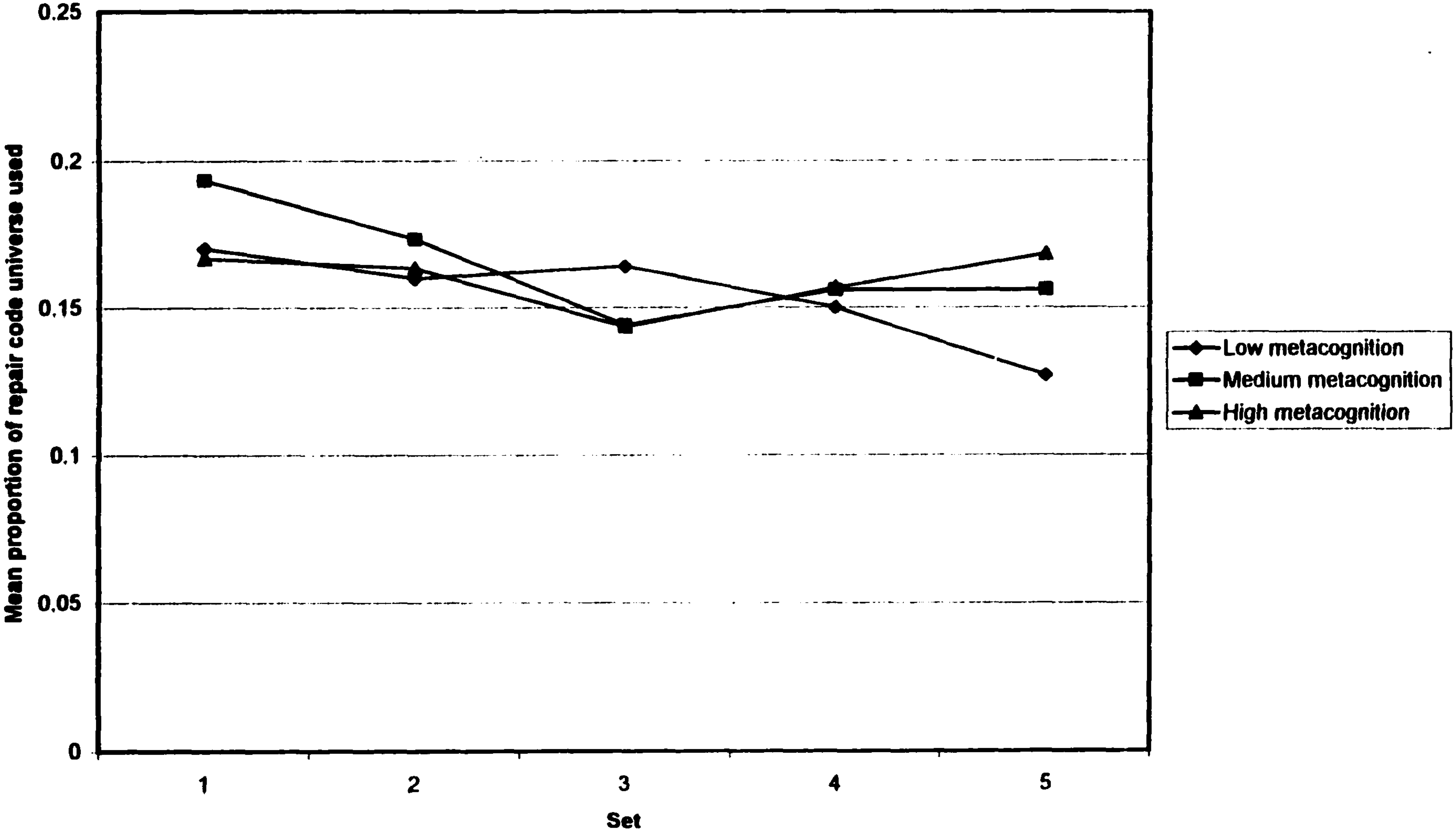


Figure 7.14. Repair code use over time by groups based on critical thinking in Part story

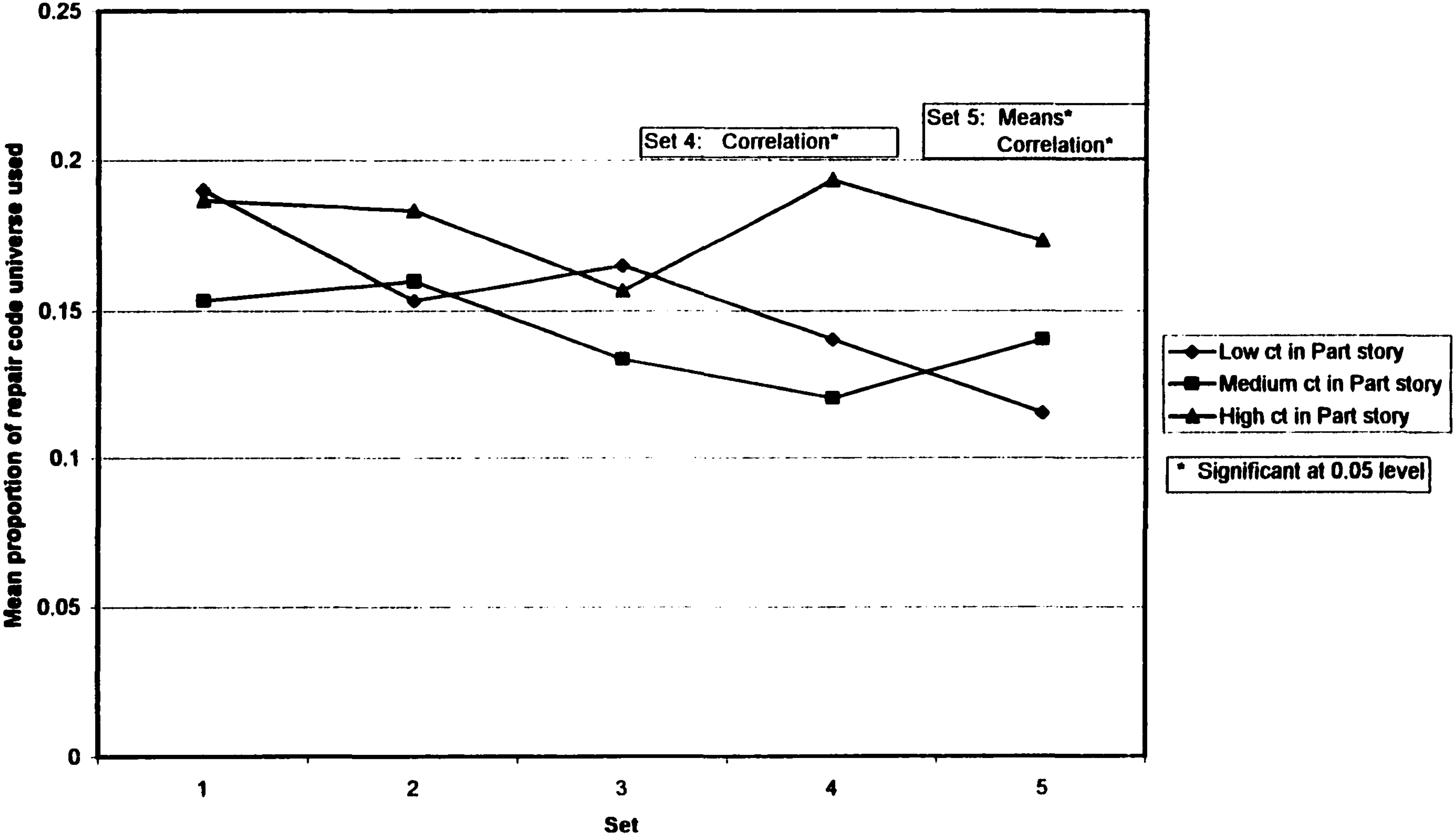


Figure 7.15. Repair code use over time
by groups based on critical thinking in Note story

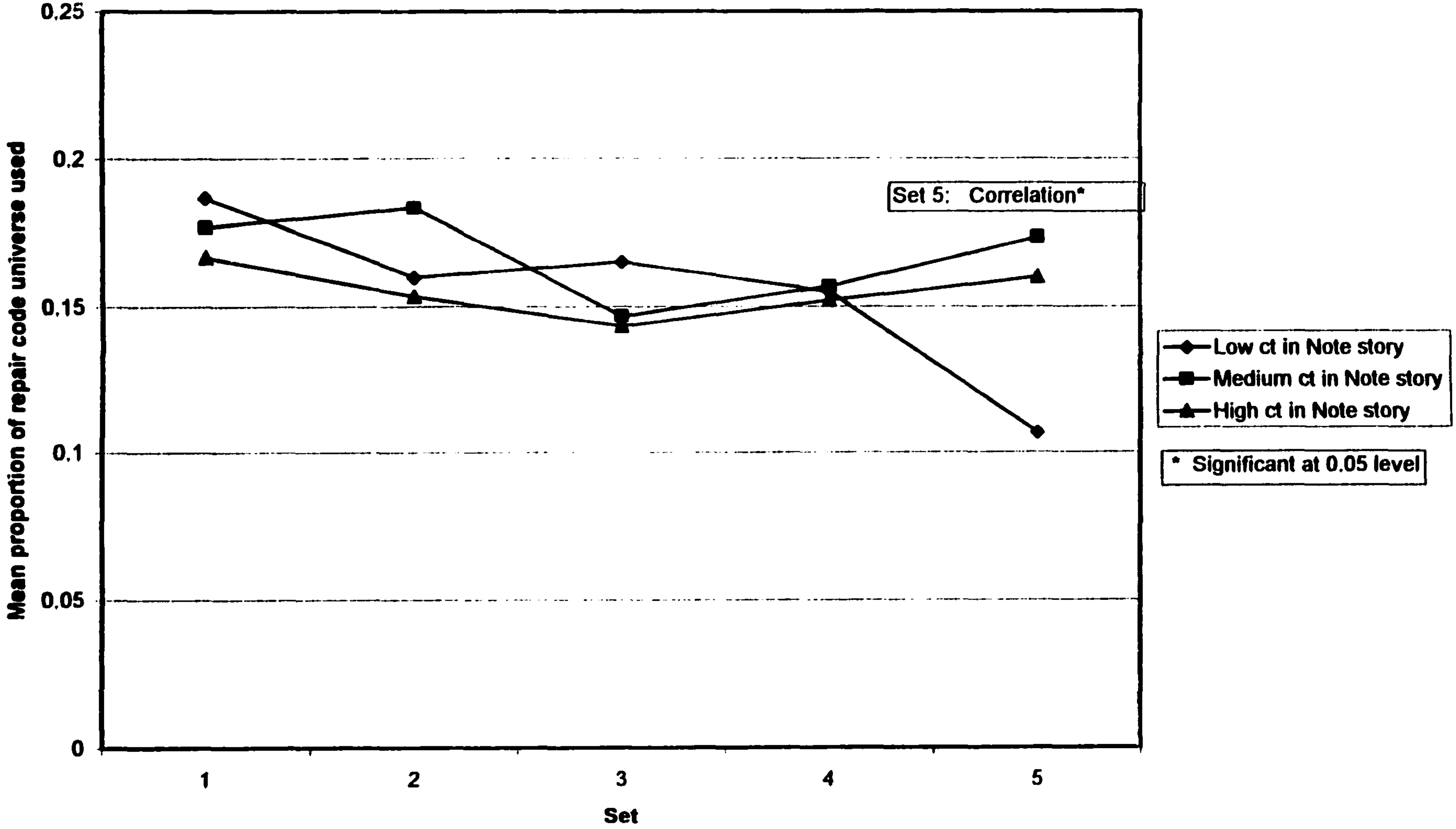


Figure 7.16. Repair code use over time by groups based on critical thinking in Code story

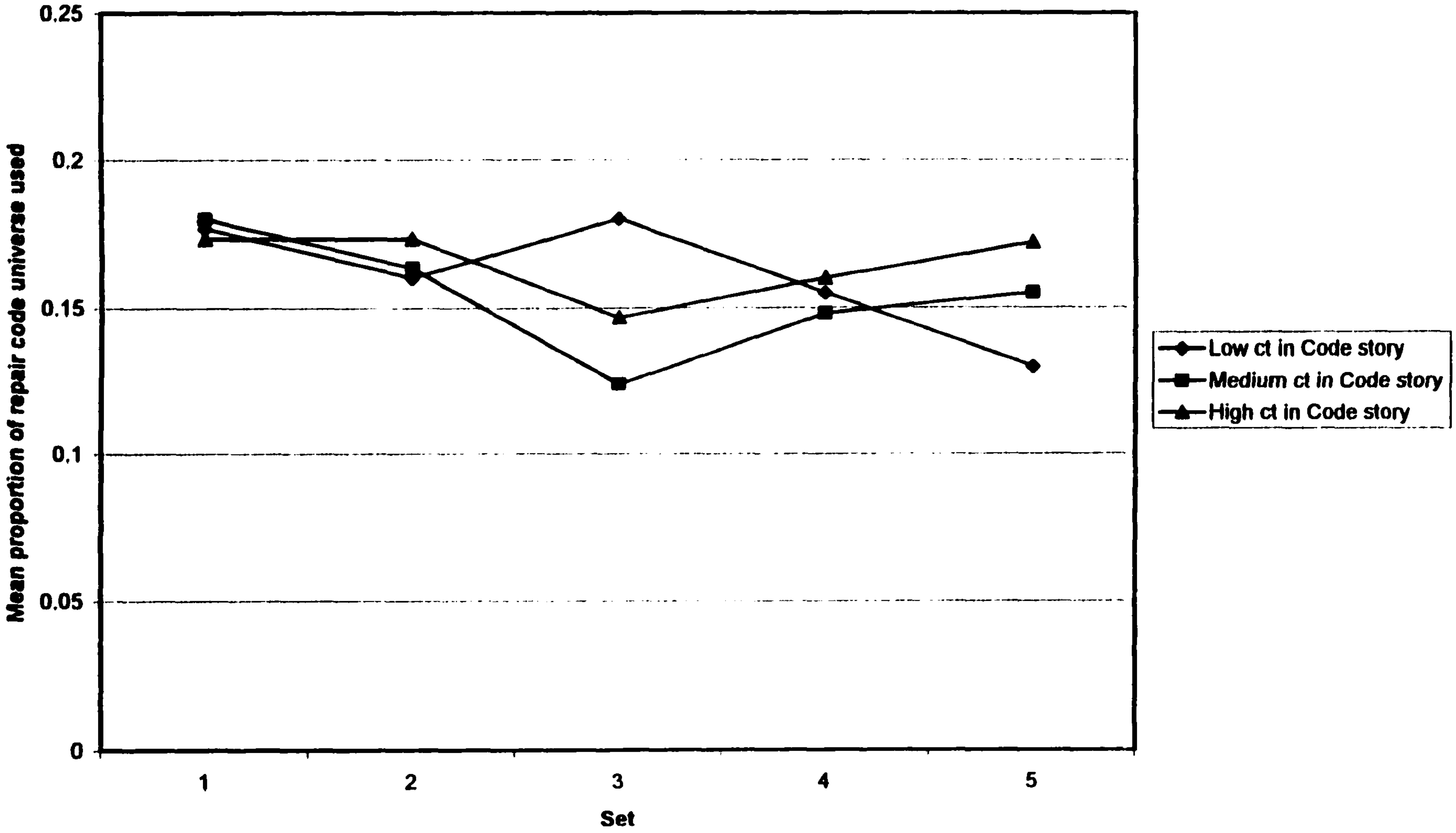
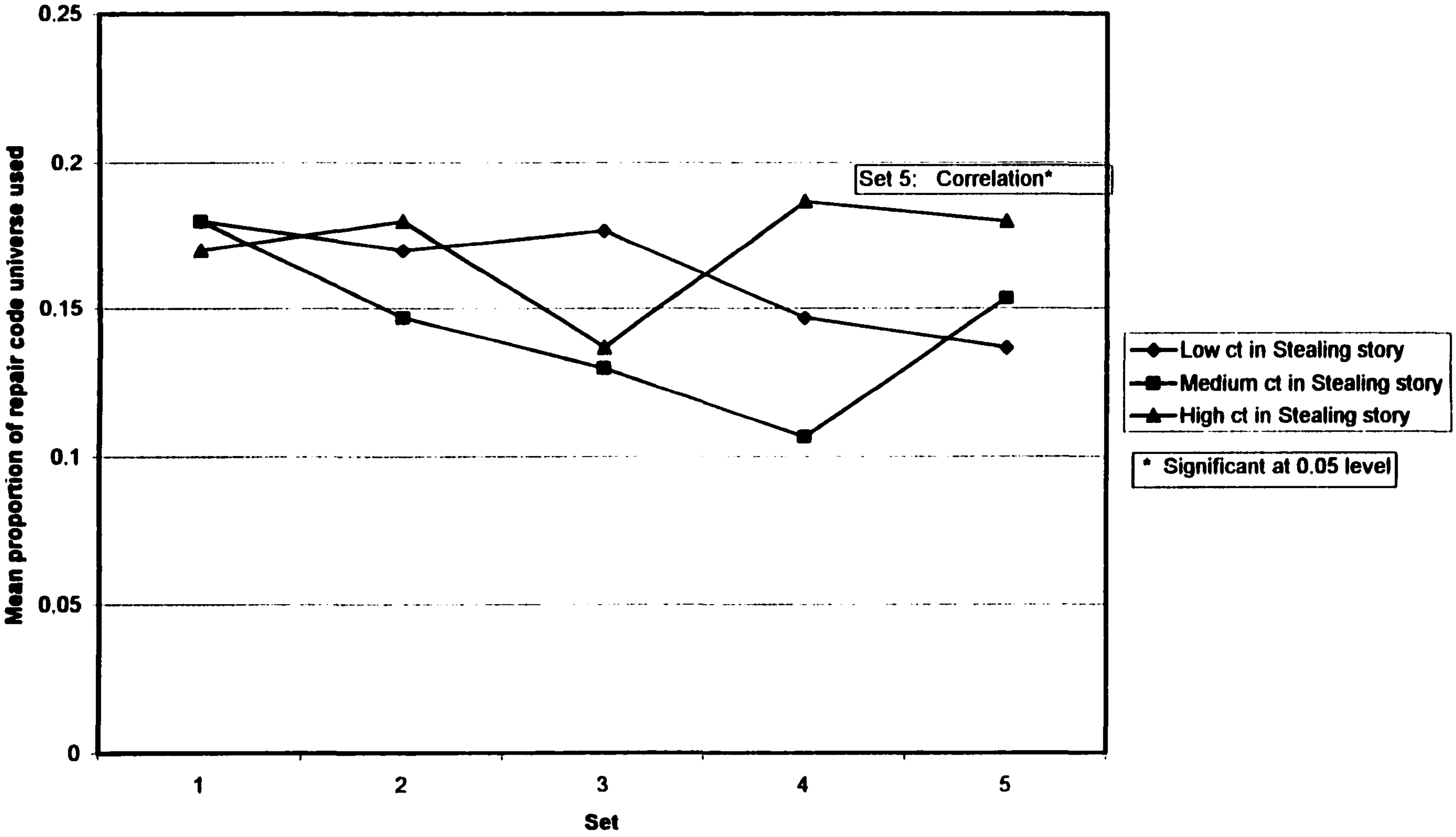


Figure 7.17. Repair code use over time by groups based on critical thinking in Stealing story



Overall rate of critical thinking did significantly predict sustained high levels of repair code use. The primary factor identified in factor analysis of critical thinking elements showed a high significant correlation with high level of repair code use in Set 5 (Pearson r = .667, n=13, p= .013). The repair code use curves of those with low, medium, and high scores on the primary factor are presented in Figure 7.5. The difference among the three groups in Set 5 was in the borderline of statistical significance (low M = .120, medium M = .153, high M = .200; F = 4.115; df 2,10; p = .050).

Figure 7.6 shows similar curves for groups based on the rate of all seven elements combined. The findings are parallel to those for the primary factor. High positive correlations were observed between the combined rate and repair code use in Sets 4 and 5. The correlation for Set 5 (Pearson r = .675, n=13) was statistically significant (p = .011), and the correlation for Set 4 (Pearson r = .458, n=15) approached statistical significance (p = .086). Differences between means of high, medium, and low groups were significant for both Sets 4 (low M = .155, medium M = .108, high M = .193; F = 4.861; df 2,12; p = .028), and Set 5 (low M = .130, medium M = .136, high M = .200; F = 5.196; df 2,10; p = .028).

Separate analyses were performed for each of the seven critical thinking elements to test for association with sustained computer use. Figures 7.7 to 7.13 present repair code use over time as a function of low, medium, and high rates of each critical thinking element. Four of the seven elements had significant associations with repair code use. The rate of Negation correlated highly with repair code use in Set 4 (Pearson r = .598, n=15, p = .019), and in Set 5 (Pearson r = .807, n=13, p = .001). The rate of Reinterpretations was highly correlated with repair code use in Set 5 (Pearson r = .711, n=13, p = .006), and a similar association with Set 5 repair code use was also found for the rate of New solutions (Pearson r = .644, n=13, p = .018).

Although the evaluation-element was excluded in the factor analysis from the primary Factor (see Chapter 6), it alone had a significant association with repair code use. Rate of Evaluations showed a significant positive correlation with repair code use in Set 4 (Pearson r = .554, n=15, p = .032), and in Set 5 (Pearson r = .689, n=13, p = .009). The remaining three elements - Identification of assumption, Contradiction, and Metacognition - did not individually show any significant relationships with repair code use.

Differences were found in the rates of critical thinking across the four Stories (See Chapter 6). The rate of all critical thinking elements combined was obtained for each story, and these story-specific rates were associated with repair code use. The rate in three of the four stories correlated significantly with repair code use in Set 5. The correlation was .730 (n=13, p = .005) with the Part story rate, .561 (n=13, p = .046) with the Note story rate, and .643 (n=13, p = .018) with the Stealing story rate. The Code story, which discusses the use of codes such as the repair code, did not relate significantly to actual repair code use.

Analyses were also performed with component code use and comment use as dependent variables. Compared to repair code use, fewer predictors of these two outcome variables were found among the interview variables. Component code use in Set 2 was associated with the overall level of critical thinking, as measured by the primary critical thinking factor, with the rate of Evaluations, and with the rate of all elements in the Part story. Component code use in Set 3 was also related to the rate of

Evaluations. Component code use in Set 4 was associated with the combined rate of all elements, with the rate of Negations, and with the overall rate in the Part story and the Stealing story. The significant predictors of comment use in Month 2 included the rate of Evaluations and the overall rate in the Part story. Comment use in Month 5 was associated with the rate of all elements combined.

Summary of predictors of computer use

The analyses presented above show strong support for Hypothesis 4, but not for Hypothesis 2. Hypothesis 4, stating "High levels of critical thinking predict constructive computer use patterns", is supported by the consistent association found between rates of critical thinking elements in the interviews and repair code use in the 60 symptoms (Sets 4 and 5) completed after the first 90 symptoms. Although Hypothesis 2, stating "Initially critical attitudes predict constructive computer use patterns", is not specifically supported by the analyses of questionnaire responses and repair code use, some relationships were found between the questionnaire Factors and repair code use. All significant relationships between predictor variables and the primary outcome measure, repair code use, are summarized in Table 7.3.

High levels of repair code use were significantly related to high overall levels of critical thinking, as measured by the primary critical thinking Factor defined through factor analysis, and by a rate of all seven critical thinking elements combined. Among the specific elements, high rates of Negation, Reinterpretation, New solution, and Evaluation were significantly associated with high levels of repair code use. Identification of assumptions, Contradictions, and Metacognitions did not individually show significant relationships to repair code use. Three out of four story-specific rates of critical thinking elements were significantly associated with repair code use. These included the Part story, the Note story, and the Stealing story. The Code story, which is about a mechanic entering a code on the computer system, was the only story not significantly predicting actual repair code use.

Among the questionnaire factors, Factor 2 (Positive regard for one's job) was the strongest predictor of repair code use. It was positively correlated with high level of repair code use in Sets 7 and 8. More negativity towards the new system (Factor 1) predicted low levels of repair code use in Set 7. More "careful optimism towards the new system" (Factor 3) predicted high levels of repair code use in Sets 5 and 6, but not in Sets 7 and 8. No relationship was found between repair code use and Factor 4, which measures "knowledge and confidence" towards the new system and computers in general.

Table 7.3 Summary of significant predictors of repair code use

Predictor		Repair code use over time Set of 30 symptoms: 1	2	3	4	5	6	7	8
Questionnaire Factors	1: Negativity towards new system							(*)	
	2: Positive regard for one's job							*	*
	3: Careful optimism towards new system					*	*		
	4: Knowledge and confidence								
Interview	Interview factor					*			
	All elements				*	*			
	Id. Assumption								
	Evaluation	*			*	*			
	Negation				*	*			
	Contradiction								
	Reinterpretation					*			
	New solution					*			
	Metacognition								
	Part story				*	*			
	Note story					*			
	Code story								
	Stealing story					*			

* Correlation between predictor and outcome variable and/or differences between predictor variable groups (low/medium/high) are significant at least at 0.05-level. Parentheses indicate a negative correlation.

Chapter 8: Discussion and Conclusions

The evidence described in the preceding chapters was gathered to document a dialectic process of adaptation to a new technology among mechanics in the two bus depots. The setting for the adaptation process was described as embedded and intersecting spheres of socio-cultural and technological context where the workers engage in activity systems as they face the new technology. Analyses of data obtained from the computer system showed that the proportion of options the mechanics as a group utilized within the system declined over the first five months. This declining trend indicates that, as a group, the mechanics failed to engage in sustained productive computer use patterns. But great variability was observed across individuals, and many individual workers did sustain adaptive computer use patterns over time.

Responses to interviews and questionnaires obtained early in the implementation of the new technology were interpreted as evidence of a high propensity toward "critical thinking" among the workers. Critical thinking is defined here as "forms of thought, discourse and activity that negate and reinterpret existing ideas, arguments, and activities; identify assumptions and contradictions, and as a result, create new solutions". In addition to questionnaires and interviews, critical thinking was observed, for example, in such "artifacts of critical thinking" as stickers or newspaper clippings posted in the depots. A hypothesis about more critical thinking in discourse about familiar contexts than about a hypothetical moral context was not supported by the interview data.

Following the idea of a dialectic process where conflict leads to adaptation, it was hypothesized that high levels of critical thinking will be associated with adaptive computer use patterns. This hypothesis was supported by the significant associations between frequencies of elements of critical thinking in the interviews and later computer use patterns. As shown in Table 7.3 above, critical thinking in interviews is specifically associated with code use after the first 90 times of using the system. It appears that the critical thinkers were able to sustain high levels of code use, despite of the declining overall level of code use in the group. The association between critical thinking measures during early implementation and later computer use is consistent with the assumption of a causal direction from critical thinking to computer use, although, as a correlation, it cannot prove causality.

Seven specific goals for the study, and four hypotheses, were listed in the Introduction-Chapter. The discussion of the findings is organized into sections on each of the goals and hypotheses.

1. **To describe a process of adaptation to a new technology, and to place the process within layers of cultural, social, and technological context.**

The description of the adaptation process is dispersed across the chapters above. The workers' attitudes and thinking were described through their responses to the questionnaires and interviews. Their actual use of the technology over time was described with data obtained from the managed information system database. Chapter 4, Observations of Activity in Embedded Contexts, addresses the broader descriptive aim of placing the study within different layers of context. It provides information about characteristics of the work organization, the local community, the technological system, and the workers and their activities.

Attempts to organize field notes collected during the study lead to the construction of a map of embedded contexts (Figure 3.1). The context of the study appeared to consist of distinguishable cultural, social and technological spheres that constituted the arenas for the activity systems engaging the workers. The map became a tool for displaying the complexity of embeddedness and intersections among different layers of context. Bronfenbrenner's (1979) ecological psychology is one of the rare attempts to conceptualize layering of context, but a description of embedded micro, meso, exo, and macrosystems seemed inadequate to account for the complexity of intersecting activity systems.

Lave's (1988) discussion of context as arenas and settings that constitute activity can be applied to the new computer system as a context of activity. According to her analysis, settings are repeatedly experienced, personally ordered and edited versions of arenas, which are realizations of dialectical relations among semiotic systems, social structure, and political economy. The new computer system as an arena is an ambivalent technology (Feenberg, 1991), embodying constraints, as well as potential, for users and the organization. Each user experiences the computer system as his own setting of use, and realizes a portion of the potential afforded by the system. It is argued here that what portion of the affordances gets utilized through the user's activity is partly determined through the user's critical engagement with issues regarding the new system and the workplace. The critical engagement involves negations, reinterpretations, identification of assumptions and contradictions, and creation of new solutions.

Theories of activity (Leont'ev, 1974; Engestrom, 1996) view human beings as engaged in activity systems with tools and objects. Activity of the system is always purposeful and goal-directed. In choosing aspects of context to describe for the present study, the goals and purposes of the activity systems involved became a topic of analysis.

Some activity systems outside of the two depots, such as the bus system of the city, or home and family, seemed to play an important role in giving meaning to the mechanics' work in the depots. The goals and purposes that energized the workers' activity systems in the depot could only be understood as part of a larger network of activity systems. Furthermore, these larger systems were not hidden in the workers' everyday conversation, consciousness, and critical thinking.

Some activity theory approaches to human-computer studies have emphasized the role of computer as a tool, and described how computers can serve as *functional organs*. Several such examples are described in a recent volume edited by Nardi (1996). This study adopts a different level of analysis, where a human activity system is trying to adapt to computerization. It asks how people approach the idea of using computers as tools in their work, and how they adapt to optimal use of a particular computer system. The users initial reactions to the computer system are used here to predict later use patterns. This study does not focus primarily on the processes of making the computer a *functional organ*, but asks instead, under what psychological and socio-cultural conditions users become good users who use an optimal range of affordances in the system. In activity theory terms, the critical thinking process is an important *mediator* between the workers as *subjects* and the computer system as *object*.

One objective of this study was to look for indicators of critical thinking in activities and objects outside of thinking and speech expressed in questionnaires and interviews. Chapter 3 includes a description of objects that were characterized as "artifacts of critical thinking", such as collages of pictures and newspaper clippings. Although these artifacts were not extensively analyzed in this study, they provide evidence of the possibility of studying critical thinking as it "crystallizes" into textual and other objects created by people.

2. To describe computer use patterns over several months among a group of workers.

Study of computer technologies in their human context is an emerging field of social science with no existing standard methodologies of measuring technology usage. One challenge in this study was to design meaningful measures of "good" and "constructive" computer use patterns. Development of the measures was conducted in the context of what the computer system was designed to accomplish, which in this case was an accurate database of bus maintenance histories. Three different measures were designed to capture how broadly the workers utilized affordances of the system in their efforts to describe their work as accurately as possible. Computer use data were obtained from files downloaded from the system database over the first five months the system was in operation in the two bus depots.

As a group, the workers did utilize a wide proportion of the options provided by the system. For example, 96% of all possible repair codes, which describe the repair action, were used at least once during the five months. The overall utilization rate of options in the system declined over time, in other words, the range of affordances that was used narrowed with increasing experience with the system. This declining trend is detrimental from the point of view of accumulating an accurate database, because only a wide range of usage guarantees that each repair job is described specifically and accurately. The declining trend did not, however, apply to all individual users. Wide variability was observed across individual workers' computer use patterns. Some mechanics' computer use patterns did not follow the overall declining trend, but stayed stable over time, or in many cases, showed an increase in the range of options utilized.

3. To describe the workers attitudes towards issues related to the new computer system and their work.

<u>Hypothesis 1</u>: **Questionnaire responses will form factors corresponding to components of attitudes and elements of critical thinking.**

As a methodology, self-administered paper-and-pencil questionnaires served a role complementing the field-observations and the interviews, and provided some information about the workers' attitudes not obtained through other methods. In the questionnaires, the workers expressed limited knowledge and confidence regarding the new system and computers in general, but were relatively optimistic about being able to learn the new technology. Attitudes towards the new system were generally quite ambivalent. Most workers expressed positive attitudes towards their work in general, and indicated high levels of critical thinking through their questionnaire responses. Results on the group as a whole illustrate a general tone of attitudes among the workers, but it is important to note that the questionnaires also indicated wide variability across individuals.

Hypothesis 1 predicted clustering of questionnaire responses according to eight categories described in the proposal for this study. Factor analysis of the questionnaire responses resulted in a four-factor solution, which partly follows the originally proposed categories. Therefore, Hypothesis 1 was partially supported. Factor 4 (Knowledge and confidence) corresponds perfectly with an originally proposed category. Factor 2 (Positivity and responsibility for one's job) and Factor 1 (Negativity towards the new system) partly follow the groupings proposed in the original categories. Factor 3 (Careful optimism towards the new system) incorporates items from four of the eight proposed categories. These findings support the originally proposed division between cognitive and affective components of attitudes. Factor 1 represents a cognitive component, while Factors 2, 3, and 4 each convey a different affective tone. The factor structure generally confirms that the questionnaire items conveyed their intended meaning.

4. To use measures of attitudes to predict computer use patterns.

Hypothesis 2: Initially critical attitudes predict adaptive computer use patterns.

Three of the four Factors extracted from the questionnaire responses were related to subsequent computer use patterns. High scores on Factor 2 (Positivity and responsibility for one's job) were associated with constructive computer use. High scores of Factor 1 (Negativity towards new system) were associated with declining patterns of computer use, suggesting that early negative feelings towards the system, as measured by the questionnaire, predict low usage of affordancies in the system. This finding can be interpreted as contradictory to Hypothesis 2 which predicted that critical attitudes will be associated with constructive computer use.

High scores on Factor 3 (Careful optimism towards new system) did predict higher levels of computer use, but this relationship was only temporary. There was an association between Factor 3 and repair code use between the 120th and 180th time of system use (Sets 5 and 6), but the correlation disappeared between the 180th and 240th time of system use (Sets 7 and 8). In other words, computer use differences predicted by careful optimism did not last.

No relationship was found between the workers' knowledge and confidence regarding the new system and computers in general (Factor 4) and their actual computer use patterns. The presence of significant findings for the other three factors, and the lack of findings for Factor 4 suggest that constructive computer use is less a matter of mastering skills related to the technology (Factor 4), and more a matter of feelings and opinions about the new technology (Factors 1and 3) and the workplace as a whole (Factor 2).

Hypothesis 2 was not supported by the data, partly because the workers' attitudes could not be characterized simply as "critical" or "not critical". If negativity towards the new system (Factor 1) is construed as critical, the finding is contradictory to Hypothesis 2. The following items were the major contributors to Factor 1 (factor loadings listed in parentheses):

Overall, I think the Midas system is a good system. (-.819)

I do not trust the Midas system. (.768)

I doubt that the Midas system will ever work. (.674)

Midas is there just to watch the workers. (.669)

I am nervous about the Midas system. (.627)

Other findings of significant computer use predictors, including Factor 3 and critical thinking measures in the interviews, suggest that critical thinking does relate to constructive computer use patterns. Why is it then that Factor 1 predicts lower levels of computer use? There are at least two possible, and not mutually exclusive, explanations. First, Factor 1 predicts repair code use between the 180th and 210th times of using the system (Set 7), while Factor 3 and the interview-based measures predict repair code use around the 90th to 180th times of using the system (Sets 4 to 6). Unfortunately, it was not possible to test in the current data whether the interview-based predictors' effect lasted beyond the 150th time of using the system (Set 5).

The other possible explanation is that the items included in Factor 1 are different from the other measures of critical thinking. It is noteworthy that Factors 1 and 3 predict computer use in the opposite directions. Careful optimism (Factor 3) seems to be completely separate from negativity towards the new system (Factor 1), although Factor 3 includes such items as "I have many questions in my mind about the Midas system" (.693), and "Midas is there just for accounting purposes" (.484). The kind of critical thinking that is associated with constructive computer use outcomes may be best characterized as a more "benign" kind of criticism, as exemplified by Factor 3, and not simply as an overwhelming negativity towards the system, as exemplified by Factor 1.

The interview-based measures' association with the computer use outcomes clearly suggests that critical thinking, including the negation element, does predict level of computer use. What was measured in the interviews as "elements of critical thinking" may be closer to the benign kind of critical thinking (Factor 3) than to the complete negativity (Factor 1). The negation element of critical thinking did predict repair code use, but negation is not the same as negativity. Negation was defined as "A statement denying something", as for example in "We <u>don't</u> have enough parts here", or "When the computers <u>go down</u> they <u>don't</u> have any backup". When denying something was used as a tool of reasoning in an argument it was coded as negation. In contrast, negativity refers to negative feelings and opinions, as those expressed by the items included in Factor 1.

In conclusion, negative feelings and opinions predict low levels of computer use, while a more benign kind of critical thinking, including negations in arguments, predict high levels of computer use.

5. To describe markers of critical thinking in the workers' discourse during interviews, to examine relationships among the markers, and to propose a revised definition of critical thinking based on the results.

A coding of seven elements of critical thinking was developed, partly based on existing definitions and instruments measuring critical thinking, partly based on considerations of the specific context of this study, and partly derived from the interview data. The coding was applied to a segment of the interview where the workers were probed with pre-designed clinical interview probes. In other words, what is coded here is not only spontaneously expressed discourse, but discourse that was specifically probed for consistency, coherence, and stability of arguments. Because this particular segment was coded, the study is capturing something that is closer to the workers' underlying "competence" of critical thinking than their "unprobed performance" of critical thinking.

High levels of critical thinking were found in the coded segment of the interview. There were, on the average, 1.75 elements of critical thinking per utterance (an utterance roughly corresponds to a turn of talk). The following rates per utterance were obtained for the individual elements:

Negations .477

Evaluations .331

Identifications of assumption .282

Metacognition .230

Reinterpretations .205

New solutions .122

Contradictions .105

There was wide variability across individuals around the average rates per utterance presented above. The overall rate of all elements combined ranged from 1.21 to 2.54 in the sample of 18 interviews.

The high rates of Negation and Evaluation are likely to be partly due to their prevalence in speech in general, and especially when responses to dilemmas are elicited. The rate of Identification of assumption, which is a much more complex construction than Negation and Evaluation (Halpern, 1996), was remarkably high. This may be partly due to the nature of the questions asked in the coded interview segment, although it should be noted that frequent examples of Identification of assumption were also seen in the more open-ended segments of the interviews.

The rate of Metacognition in the participants' speech is surprisingly low, considering that such common phrases as "I think" were coded in this category. Although no comparative data are available, the low rate suggests that there is less explicitly marked reflection on processes of thought among the mechanics, compared to, for example, academic discourse. In his discussion on activities of the "proletariat" as "praxis", Merleau-Ponty (1973) contrasts the activities of "theoriticians" and "proletarians": "...praxis is not subjucated to the postulate of theoretical consciousness, to the rivalry of consciousnesses. For a philosophy of praxis, knowledge itself is not the intellectual possession of a signification, of a mental object; and the proletarians are able to carry the meaning of history, even though this meaning is not in the form of an "I think". (p50)

Factor analysis of the rates of the seven elements revealed one strong primary factor which included Reinterpretation, Negation, Contradiction, Identification of assumption, and New solution, and excluded Metacognition and Evaluation. The definition of critical thinking presented in the proposal for this study (also included in Chapter 7) was revised based on the factor analysis findings suggesting that metacognition and evaluation are not associated with the other elements. The following revised definition of critical thinking, therefore, takes into account empirical data obtained in the interviews:

Forms of thought, discourse and activity which:

1) negate, and reinterpret existing ideas, arguments, and activities
2) identify assumptions and contradictions
3) as a result, create new solutions

The five elements of the primary factor identified in the factor analysis are underlined in the revised definition above. Negation was made the first step, not only due to considerations of logic, but also because it was the most frequently identified element. Reinterpretation, which is a new element entirely derived from the data, was combined with negation in the first step because it can be considered to be a relatively simple initial tool in the process of critical thinking. Identification of assumption and contradiction, which were considered relatively complex elements of critical thinking, were combined in step two. If the process is understood temporally organized, the initial negation and reinterpretation are followed by identification of assumption and contradiction. As in the originally proposed definition, new solution is the last step, or the end-result, in the critical thinking process.

A more traditional interpretation of the dialectic process, where negation occurs as an intermediate step, would probably reverse steps 1 and 2 above. In the definition above, however, identification of assumption and contradiction were proposed as an intermediate step that follows negation and reinterpretation. The rationale was to start with more simple elements, i.e., negation and reinterpretation, and then move on to more complex elements, i.e., identification of assumption and contradiction. It is suggested that the simpler elements may build an elementary foundation for the more complex elements.

How does the revised definition relate to the traditional definitions reviewed in Chapter 1? It makes more explicit the dialectic flow implied by most traditional definitions. Terms as such as reflection, justification, and questioning populate those definitions with rare attempts of operationalization. The revised definition includes the domains of discourse and activity typically excluded from the notion of critical thinking. Perhaps, the term thinking conveys a mentalistic idea, and in fact, during the writing of this thesis, "critical engagement with activity system" was sometimes preferred as a more comfortable alternative to "critical thinking". It is also possible to view the term "thinking" more broadly, as exemplified by Scribner's (1983/1997) functionalist approach to thinking as "mind in action".

6. **To examine the relationship between context-specificity and level of critical thinking in interview discourse, by comparing critical thinking elements in discourse across four dilemmas varying in context-specificity.**

<u>Hypothesis 3</u>: Context-specific dilemmas elicit more critical thinking than a hypothetical moral dilemma.

The coded segment of the interviews consisted of discourse about four different stories involving dilemmas to be solved. The content of the stories varied from familiar bus-related and computer-related dilemmas to a hypothetical moral dilemma. The Part story was about a bus mechanic who cannot find a part to repair a bus, the Note story was about a mechanic who wants to type in additional notes on the computer, the Code story is about a mechanic who is making a decision about entering a code on the computer, and the Stealing story is about a man deciding whether to tell the police about his friend's stealing. The content of the stories was designed to vary in context-specificity, or context-familiarity, which made it possible to examine critical thinking in the workers' discourse across types of context. It was specifically hypothesized that more critical thinking elements would be identified in discourse about the familiar stories (Part, Note, Code), than in discourse about the hypothetical story (Stealing).

Hypothesis 3 was not generally supported by the data. A significantly <u>higher</u> average rate of all critical thinking elements combined was found for the hypothetical Stealing story than for the stories with a familiar context. This pattern, however, did not uniformly apply to all seven elements of critical thinking. A noteworthy exception was the Part story, which had very high rates of identification of assumption and contradiction. The high frequency of these two complex elements in the Part story are consistent with Hypothesis 3, because the Part story may have the only truly familiar context among the four stories. In contrast to the Note story and the Code story, the Part story is not about the new computer system, but it is about an issue that is familiar to the workers over a very long period of time. Consistent with Hypothesis 3, the Part story with its historically familiar context, elicited significantly higher levels of complex elements of critical thinking than the other three stories.

As discussed in Chapter 6, a further analysis of different dimensions embedded in the content of the four dilemmas may help explain some of the other differences across dilemmas found in rates of critical thinking elements. It may be that the most important difference between the Stealing story and the other stories is not context specificity, but some other dimension such as the nature of the relationship between the story characters. Therefore, the results do not warrant a conclusion that the workers critical thinking is not associated with context-specificity.

The high rates of all critical thinking elements combined in discourse about the hypothetical moral dilemma about stealing is an important finding, because it contradicts Hypothesis 3. Based on a review of literature, it was hypothesized that blue-collar workers' critical thinking would tend to be context-bound. Why do the present results suggest that context-familiarity is not necessary for a high frequency of critical thinking in blue-collar discourse? The explanation may be in the interview method used in the coded segments. The clinical interview method, which thoroughly probes and challenges the interviewee's responses, was probably capturing some arguments in the mechanics' discourse that would not have been uttered spontaneously in an answer to a simple question. Therefore, what was measured was a "competence" of critical thinking, which may not be as context-bound as a less-probed spontaneous "performance" of critical thinking. The results suggest that, at least when probed, blue-collar workers' critical thinking discourse is not generally associated with context-specificity.

7. To use markers of critical thinking in discourse to predict computer use patterns.

Hypothesis 4: High levels of critical thinking predict adaptive computer use patterns.

Rates of critical thinking elements in the interviews conducted with eighteen workers during early implementation of the system were used to predict these workers' computer use patterns over time. Hypothesis 4 about an association between high levels of critical thinking and constructive computer use patterns was supported by the data. Significant relationships were found between several interview-based critical thinking indicators and repair code use in Set 5, which is the set of 30 symptoms completed after the first 120 symptoms (Sets 1 - 4). The primary factor identified in factor analysis of critical thinking elements, as well as the rate of all seven elements combined, significantly predicted high levels of repair code use. Among the seven elements, Negation, Reinterpretation, New solution, and Evaluation were individually related to repair code use. The relationship between critical thinking and repair code use was significant for three of the four stories, Part story, Note story, and Stealing story, but not for the Code story.

Although the results overall strongly support Hypothesis 4, there were some exceptions to the pattern of association between critical thinking and computer use. In contrast to the other four elements, rates of Identification of assumption, Contradiction, and Metacognition were not individually associated with patterns of repair code use. This result, in addition to the factor analysis results, is another indicator that Metacognition is not part of the same cluster with the other elements. The lack of findings for Identification of assumption and Contradiction, which are complex elements of critical thinking, suggests that the significant relationship between critical thinking and computer use is mostly accounted for by simpler elements (Negation and Reinterpretation), and New solution, which is the creative end-result of other critical thinking elements.

It is surprising, in light of the context-specificity hypothesis, that the rate of critical thinking in the Code story, which is specifically about a mechanic making a decision about entering a code on the computer, is not associated with repair code use, while the other three stories are. This result further supports the conclusion also discussed above regarding Hypothesis 3, that context-specificity may not be an important characteristic of the workers' critical thinking. The story that best matches the context of the outcome variable does not predict the outcome variable.

Comparison of questionnaire and interview factors associated with computer use shows that some "positive" attitudes, as indicated in questionnaires, and some "negative" strategies (Negation and Reinterpretation), as indicated in the interviews, were related to adaptive computer use. For instance, low scores on the "Negativity towards new system" factor and high scores on Negation element were both associated with use of more codes on the computer. As discussed above, negativity as an affective component of attitude is different from negation as a tool of argumentation.

As shown in Table 7.3., the questionnaire and interview variables did not show significant relationships to computer use until after an initial period of using the computers. It is argued here that the questionnaire and interview factors predict sustained adaptive use patterns, and that many workers started out with relatively broad use of the system, but only those engaged with relevant issues, as indicated in questionnaires and interviews, sustained a broad level of use. The time lag between indicators of critical thinking and associated indicators of adaptive computer use is consistent with the assumption that critical thinking and computer use patterns have a causal relationship.

Conclusion

What is the role of theoretical concepts in documenting the mechanics' struggle with the new computer system? Wrapping the phenomenon in theory fits it into an explanatory system where pieces of observation get organized according to the logic of the theoretical frame. Theoretical concepts provide a vocabulary of labeling aspects of the phenomenon on an abstract level. This abstraction, in turn, makes the documented phenomenon a "specimen" for academic analysis, and allows it to enter into academic discourse. Another reason for theorizing the phenomenon is to cast it as a general example of a class of phenomena. For example, the results of this study may reveal something about adaptation to technology in general.

The term adaptation was chosen partly based on Piaget's (1947/1981) theoretical definition, and partly because the word generally refers to a process of change in a new and challenging situation. The word adaptation undeniably has a conformist connotation, and to be specific, it applies best to the group of mechanics described in this study who showed high levels of critical thinking and then used a broad range of affordances in the computer system. Their broad utilization of the system conforms to the ideal use pattern that contributes to a specific and accurate maintenance information database. The result of their adaptation is clearly advantageous from the organization's point of view, but it is likely to be constructive from the mechanics' point of view as well. If everyone uses the system properly it has the potential of becoming a powerful and empowering tool in the mechanics' everyday activities.

The results of this study suggest that many of the mechanics engaged in a thorough critical analysis of the system, and concluded, although not necessarily consciously, that they want to learn it and use it as a tool. Or perhaps their critical engagement with the system simply allowed them to learn more about it, in contrast to workers who quickly discounted the system or accepted it too readily. In either case, the group of workers who expressed critical thinking and became well-adapted users is powerful testimony for the usefulness of this particular computer system. In a sense, this group of workers tested and challenged the system, and through their activity of using it, declared it a good system worth adapting to, not only from the organization's perspective, but also from the workers' perspective.

Although the definition of critical thinking as "Forms of thought, discourse, and activity which negate and reinterpret existing ideas, arguments, and activities; identify assumptions and contradictions; and as a result, create new solutions" encompasses discourse, as well as other forms of activity, naming the phenomenon critical thinking may convey a narrowly mentalistic approach. Perhaps critical engagement would have been a more accurate term to describe the entire range of activity, and to distinguish this study from more traditional approaches to critical thinking. But most of the elements comprising the definition have their origins in the traditional literature on critical thinking, and therefore, the word "thinking" was retained in much of the discussion here.

One reason for moving from thinking to engagement is to explain how critical thinking leads to adaptive computer use. The workers who were engaged in thinking about difficult issues related to the new system during the interviews were also engaged with using the computer system on a deeper level. Engagement captures thinking, discourse, and other activities, including the activity of computer use. In addition, while thinking is associated with individualistic mental activity, engagement conveys activity in social, emotional, and political context.

The adaptation process was described as *dialectical*, because critical engagement seemed to lead to adaptive outcomes. Negations and Reinterpretations, among other elements, were implicated as predictors of adaptation. *Dialectic*, commonly known as the formula of *thesis*, *antithesis* and *synthesis*, can be applied as a philosophical system, method of disputation, or an analytical tool (Lunenfeld, 1999). In 1975, a full issue of *Human Development* was dedicated to the theoretical role and application of *dialectics* in developmental psychology, exemplifying a peak of *dialecticism* in the field (Dixon & Lerner, 1992), but since that time the field has applied the concept of *dialectic* infrequently. Perhaps one day it will become fashionable again in developmental research, because so many developmental phenomena follow a non-linear course (Baltes, et al., 1988). For the purposes of this study, *dialectic* serves as a heuristic description of the overall shape of the observed phenomenon.

Regarding the relationship of humans and technology, the results of this study support the view that technologies are ambivalent (Feenberg, 1991). The new computer system did not serve as a neutral tool, but neither did it automatically impose control on its human users. The users adapted to optimal use patterns to varying degrees. Remarkably, perceived levels of knowledge and skills during early implementation did not seem to predict adaptive use patterns, but in contrast, early feelings and opinions proved to be important predictors. Development of skills is undoubtedly important in the adaptation process, but in this implementation skills served a secondary role. The skills and knowledge required for basic level use of the system were relatively simple and attainable compared to the effort required in the attitudinal domain.

Limitations and future directions

The study described here was placed in a specific context, and a detailed description of the context was provided to illustrate the importance of contextualization. But a study of one context limits generalization of the findings. It is tempting to draw conclusions about a general process of adaptation to technology, but that is simply not warranted from a single study. Furthermore, participants of only one gender and social class were included, prohibiting generalizations to other groups. However, based on the results presented here, similar processes can be hypothesized for studies of other groups, other contexts, and other technologies.

The methods applied in the study necessarily present only a partial and selective representation of the entire phenomenon. Only a small sample of workers was available for the interviews and the questionnaires, and only five months of computer use data were obtained from the system. In addition, the workers responses in the interviews and questionnaires reflected what the workers were willing to tell the researcher who was generally perceived as somewhat of an intruder in the workplace. Questioning the workers about their feelings and opinions toward their workplace occurred within the context of the workplace, making it difficult to convince participants of confidentiality.

This study presents only a limited scope of analyses on the data collected at the two depots. For example, a coding system of fifteen categories was developed for the interviews and later narrowed down to a system of seven categories. Several ideas for other types of coding were listed during the first listening and reading of the interviews. The analyses of the computer use data were restricted to the three measures described above. Examples of possible future analyses include a coding of the comments typed into the system by the mechanics.

Many compromising methodological choices were made in the interest of developing reliable measures of the key constructs. For example, the coding for critical thinking in the interviews broke down critical thinking into small individual elements, often defined by means of linguistically based structures. This approach overlooks the ways in which different elements of critical thinking interact to produce a dynamic flow of thought. The definition of critical thinking presented above refers to an integrated process involving different elements, but the coding tends to isolate the elements from one another.

This study takes a small elementary step towards the task of conceptualizing and operationalizing critical thinking, but more questions were raised than answered. The study shows that it is possible to find different indicators of critical thinking in workers' discourse, but whether these indicators can be combined into an operationalized definition requires further examination. No general test of intelligence was included making it impossible to argue how much general "testable" intelligence correlates with the measures of critical thinking used here and accounts for differences in computer use patterns. The findings regarding context-specificity of critical thinking among the workers also warrant further research.

Practical implications of the findings

The significance of attitudinal predictors of computer use patterns shows that a motivated user is critical for the success of systems such as this maintenance information database. It seems that organizations should pay attention to the users' feelings, opinions, and thoughts, and that acquisition of skills in navigating the system may be of secondary importance. This study further indicates that an important aspect of the users' valuable input can be conceptualized as critical thinking. Despite of its seemingly oppositional nature, critical thinking should be nurtured because may be necessary in the process of developing adaptive technology use. Finally, this study identified a select group of workers who showed high levels of critical thinking and well-adapted computer use. It may be possible to train such individuals to be leaders among groups facing new technologies.

[The layoout of this documents has been slightly changed to make it fit the margin requirements.]

MIDAS QUESTIONNAIRE

Today's date: ____________________

Your depot: ____________________

Your job title: ____________________

Your pass number: ____________________

Number of years with T.A.:____________

Number of years in current job title: ________

Number of years in current depot: ________

Instructions:
In the next page you will see some statements.
Please mark on the short line following each statement a number describing your feeling or opinion about the statement.

Use the following scale for your answers:

1	2	3	4	5
Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

For example: Midas is a computer system. _5_

Do not spend too much time thinking about each answer.
Just answer according to your first instinct.
Your answers are confidential and they will not be revealed to your employers.

You can return the completed questionnaire to Mari Millery or mail it back in the enclosed envelope.

1 = Strongly disagree 2 = Disagree 3 = Not sure 4 = Agree 5 = Strongly agree

I know a lot about computers. ___

I don't care about the Midas system. ___

Overall, I like my job. ___

I do not trust the Midas system. ___

I usually respect authorities. ___

I have many questions in my mind about the Midas system. ___

I care about the "big picture" of what is going on in my depot. ___

Midas is there just to watch the workers. ___

I always question what I hear in the news. ___

I feel curious about the Midas system. ___

The quality of my work always depends on other people's work. ___

The maintainers' input will be heard through Midas. ___

It is difficult for me to learn the Midas system. ___

I am the only person responsible for my work. ___

Midas is there just for accounting purposes. ___

I know my way around in the Midas system. ___

Other people in the depot depend on how I do my work. ___

I doubt that the Midas system will ever work. ___

I sometimes openly question decisions made by my superiors. ___

Overall, I think the Midas system is a good system. ___

I am in control of my work. ___

I am nervous about the Midas system. ___

My superiors are responsible if something goes wrong with a bus. ___

Midas will change the operation of bus maintenance. ___

Any comments? ____

Counterprobe Interview

Interview Protocol

General Outline of Interview:
1. Introduction
2. Story A
3. Story B
4. Story C
5. Story D
6. Self-generated situations
7. Conclusion

The order of the four stories (A-D) will be counterbalanced.

Four stories (A-D): Big Picture Story (Cannibalizing buses)
Accountability Story (Time spent on computer)
Interdependence Story (Use of specific codes)
Moral Dilemma Story (Truth vs. Promise)

1. Introduction

    Explain that this is part of MIDAS attitude study.

    Explain that there will be several stories of people in different situations, and that some follow-up questions will be asked after each story.

    Review consent form.

    Explain audiotaping.

2. Tell story A
    Ask follow-up questions and counterprobes.

3. Tell story B
    Ask follow-up questions and counterprobes.

4. Tell story C
    Ask follow-up questions and counterprobes.

5. Tell story D
    Ask follow-up questions and counterprobes.

6. Self Generated Situations

   Ask if participant can recall any incidents from his own life that are similar to the stories.

   Ask if participant can recall an incident in his own life when he did not know what to do.

   Ask if participant can recall an incident at work when he did not know what to do.

7. Conclusion

   Ask for general feelings about the interview.

   Does participant have any questions about interview or study?

   Thank for participation.

Moral Dilemma Story

Joe's friend Gene works at a store. They don't pay Gene too well, so he thinks it's okay to take some money sometimes from the cash register. Gene tells Joe about his stealing, and Joe promises not to tell anyone ever about it. One day the police come to question Joe about Gene's stealing. Joe is wandering whether he should tell the police about Gene's stealing.
What should Joe do? Why?

> Answer: tell the police
> But what about the fact that Joe promised Gene not to tell? Don't you think he should keep his promise?
>
> But they are close friends. But Gene trusts Joe. But the boss did not pay Gene enough.
>
> Answer: not tell the police
> But what about the fact that he is lying to the police? Don't you think he should tell the police the truth?
>
> But Gene broke the law. But Joe would be breaking the law by not telling. What if everyone broke the law?

Big Picture Story (Cannibalizing buses)

The supervisor tells Lenny that he needs to get a particular bus done immediately. They both know that the necessary part is not available. The supervisor tells Lenny to go and find the part. There is another bus that will be held for several days waiting for a big job, and Lenny knows he could take the part he needs out of that other bus.
What should Lenny do? Why?

Answer: cannibalize
But what about the fact that the other bus will be missing the part and there is no record of that? Don't you think that cannibalizing buses is hurting the operation of the depot in the long run?

But there is a policy of not cannibalizing.

Answer: not cannibalize
But what about the fact that the supervisor needs the bus immediately? Don't you think that the most important thing is to get the buses in service?

But isn't the supervisor telling Lenny to cannibalize?

<u>Accountability Story (Time spent on the computer)</u>

Carl is at the computer entering some notes about the job he just finished. He needs to enter on the computer that he found another problem in the bus. The supervisor tells Carl to close out his workorder and get off the computer immediately because the pinball sheet needs to be closed out at the end of the shift.
What should Carl do? Why?

Answer: get off computer
But what about the fact that Carl did not enter his notes on the computer? Don't you think he should try to cover his back on the computer about the other problem in the bus?

But isn't this a case when he is supposed to enter notes on the computer? What if something goes wrong with that bus?

Answer: continue on the computer
But what about the fact that the supervisor needs him to get off the computer? Don't you think the supervisor is responsible here?

But maintainers are not really required to enter notes.

Interdependence Story (Use of specific codes)

Billy is looking for the right component code on the computer to complete his workorder. He knows there is a specific code for the component he fixed, but he would have to ask someone to help him look for it. He is considering using a very general code.
What should Billy do? Why?

Answer: use general code
But what about the fact that people who look at the code later will not have specific information? Don't you think it is his responsibility to find a specific code?

But the next person working on that bus will not know exactly what was done.

Answer: look for help
But what about the fact that he would have to bother someone to help him? Don't you think that it would be better to just complete the workorder fast?

But he is slowing down himself and another person. But what if people are reluctant to help?

CT Coding Manual, Mari Millery 8/26/99

CODING MANUAL FOR CRITICAL THINKING CODING OF INTERVIEWS

Unit of analysis:

Utterance: The unit of analysis for the coding can be defined as an utterance, or an argument. An utterance usually expresses one idea, thought or topic that the speaker is trying to communicate. Typically, there is one utterance per one turn of talk in the conversation, but it is possible to have longer turns of talk consisting of several utterances, or utterances that stretch over more than one turn of talk. The first rule of thumb should be to use a turn of talk as the utterance boundary, and then look for the possibility of exceptions to that rule. Utterances ranging over more than one turn of talk still express only one distinct idea. An idea that starts in one turn of talk is completed in the next turn. In the case of long turns of talk by one speaker, look for "paragraph breaks" to define utterance boundaries. Interrater reliability for defining utterance-boundaries is established first, separately from other coding categories.

Regulatory utterances: Chafe (1993) defines regulatory functions as utterances that do not convey any "substantive content". These are utterances that serve to regulate the flow of the conversation. They are normally very brief in length, for example, "Yeah", or "I don't know." No substantive content is explicitly brought into regulatory utterances. Regulatory functions are fairly common during conversations such as the present interviews. Simple agreements, disagreements, and clarification questions are also coded as regulatory utterances. Regulatory utterances are coded on the agreement and certainty dimensions (below), but not for critical thinking or content.

Informational Utterances: Utterances that provide factual information, and are not codable on critical thinking dimensions. E.g., "I started as a helper, as a fueler." Informational utterances are coded only for content.

Note on responding to the interviewer:

Some of the coding categories below require an analysis of how the interviewee responds to a preceding utterance by the interviewer (e.g., reinterpretation). Interviewer utterances are defined broadly, and they include, the questionnaire questions and other interview material.

CT Coding Manual, Mari Millery 8/26/99

Use a decision tree (yes/no) for each utterance:

1. Is an assumption identified?
2. Is there an evaluation?
3. Is there a negation?
4. Is there a contradiction?
5. Is there a reinterpretation?
6. Is there a creation of new solution?
7. Is there metacognition?

Function Codes:

1. Identification of assumptions

An assumption is a statement for which no proof or evidence is offered (Halpern, 1996). Assumptions are most often unstated or implied. Code for identification of an assumption if the speaker expresses that he is aware of an assumption made by someone. Look for identification of assumptions in statements that are about someone or something else as the subject (actor). For example, what the managers, the researchers, the interviewer, the trainers, the people who designed the computer system assume about the mechanics, the depots, the bus, etc.

Examples:
"The hands-on training was designed for dummies without college education."
[The people who designed the training assume that those without college education are dummies.]

"If the foreman says, 'Go to that bus and take the part from that,' then you would do it."

"Guys help each other out here."

"Because if something happens on the road, they're gonna come lookin' for me."

1a. Subtype: Questioning of assumptions

The speaker who identifies the assumption often expresses that the assumption is wrong or false, or at least not necessarily true. Sometimes the consequences of a false assumption are pointed out.

Examples:
"Midas can do scheduled maintenance in an ideal world, by not in our depots."
[Midas assumes an ideal world, but that is a wrong assumption, because the depots do not work like the ideal world.]

CT Coding Manual, Mari Millery 8/26/99

"What do you mean by...?" [Interviewer assumes that questions would be understood clearly.]

"These are odd questions."

2. Evaluations

Code for evaluation when the speaker expresses his opinion or feeling about the quality of something or someone. Adjectives are one type of marker for evaluations. When possible, code whether the evaluation is positive or negative. Code for the type of target of the evaluation: self (or a group that speaker belongs to), other (person/people), object, abstract target.

Examples:
"We are so used to thinking that way." Negative about self

"What you are saying makes sense." Positive about other

"The managers are so mean because they are insecure." Negative about other

3. Negation

A statement denying something. Look for markers such as "no", "not", "never", "nothing", etc.
Also, some words that have a "negative meaning", e.g., "It's really useless" "The card is lost" "There is a problem"

Examples:
"This system will never work."

3a. Subtype: Informed Negation

Code for informed negation when reasons are given to support the negation.

Examples:
"It doesn't help to look in Midas what was done, because I want to start fixing every problem from the beginning."

5. Contradiction

One utterance, or adjoining utterances, express ideas that are in contradiction or logically incompatible. The speaker may or may not fully be aware of the contradiction. The ideas in contradiction are often linked by connectives such as "but", or "meanwhile".

Examples:
"Computers coming everywhere, so we have to learn them, but they are taking people's jobs."

"It hurts one way and it doesn't hurt another way."

"It ain't part of our job, but it should be."

6. Re-interpretation
When the speaker responds to the interviewer by re-interpreting, re-casting, clarifying, adding to or re-emphasizing what the interviewer said.

Examples:
Interviewer: "Some of these questions are not exactly about Midas."
Speaker: "Yeah, they are actually about supervisors and stuff."

"It depends..."
"To us, 'Go and find the part,' means to go to the stock room."
"Well, it wouldn't be called 'cannibalized'. Borrowed."
"Is this like an ethic question, or what?"

6. Creation of new solutions
A statement that arrives at a new solution to a problem, or suggests a new way of doing something. A hypothetical scenario of the future is expressed.

Examples:
"We would have more useful codes if the workers could add a code to the system every time there is no good code."
"We can find new ways of communicating to them through the system."
"I really think that they should invest the time in making-- facilitating us in how to put more components on the database."

7. Metacognition
Reflecting on one's own or someone else's thought process.

Examples:
I know, think, guess, [Also: I feel, when it is used to express a thought.]

"I feel like I am in control of what I have to do"

"The supervisor wouldn't know."

"You don't know what to do. That's the bottom line here. You have no idea. Confusion sets in."

Speaker	Utterance	Codes
Researcher:	--It's about Carl. He's at the computer, entering some notes about the job that he just finished and he needs to enter on the computer that he found another problem in the bus. And the supervisor tells Carl to close out the work order and get off the computer immediately, because it's the end of the shift and there-- he needs to close up the pinball sheet and go home. The supervisor needs to go home. What do you think Carl should do?	
P:	Enter the notes anyway.	
Researcher:	Enter the notes anyway? Why?	
P:	If he doesn't, he worked on that bus, he'll get in trouble.	Identification of assumption (they will assume he knew about the problem) Negation (doesn't) Evaluation (trouble)
Researcher:	Yeah?	
P:	If he knows about it, he doesn't say anything, then he'll get in trouble, and the foreman will say he should enter it.	Identification of assumption (see above) Negation (doesn't) Evaluation (trouble) Metacognition (knows)
Researcher:	But the foreman is telling him to get out.	
P:	He'll forget about it. He can get amnesia and you're in trouble then.	Identification of assumption (see above) Negation (will forget) Evaluation (trouble) Metacognition (forget, amnesia)
Researcher:	Yeah?	
P:	Yeah.	
Researcher:	So you would stand up and, not fight, but you know, be firm about entering it.	
P:	Yeah, I think-- I think you'd have to.	Metacognition (think)
Researcher:	You'd have to?	
P:	Yeah. To cover yourself, you have to. Yeah.	Identification of assumption (see above) Reinterpretation (clarification with a reason)
Researcher:	Yeah. But you're not really required to-- put in notes.	
P:	It's-- what. You said there's something wrong with the bus.	Identification of assumption (interviewer assumes something wrong with bus) Negation (something wrong) Evaluation (wrong) Reinterpretation (emphasis in story)
Researcher:	Yes.	
P:	That it shouldn't go.	Negation (shouldn't) Reinterpretation (clarification of story)
Researcher:	Yeah.	
P:	If it's a safety sensitive item. If it's, you know, a light bulb out, I guess he can let it go. But if there's somethin' safety sensitive, you have to say somethin'. He	Identification of assumption (it is assumed that safety sensitive has to be reported) Evaluation (safety-sensitive) Reinterpretation (clarification of procedure)

	has-- He has to write it down, you know, bring it to the foreman's attention.	New solution (bring to attention) Metacognition (know, guess, attention)
Researcher:	You have to do that. You're required to do that?	
P:	Yes.	
Researcher:	Because I don't know that you're required to, I don't know. As far as I know, you just have to complete your symptoms and you don't-- you-- you're not required to add anything.	
P:	If you see any, and you tell somebody you see it, you have to be required to, if it's safety sensitive.	Identification of assumption (see above) Reinterpretation (clarification with reason) Evaluation (safety-sensitive)
Researcher:	If it's safety sensitive, because you said that-- you will get in trouble--	
P:	Yes.	
Researcher:	--later if something happens. Okay--, so if it's not put in the computer, don't you, don't you think the supervisor is responsible for that?	
P:	No, because you-- you didn't add any symptoms down there. He's not responsible for that.	Negation (no, didn't, not) Evaluation (responsible)
Researcher:	Yeah. You think it's your job.	
P:	Yeah.	
Researcher:	It's the maintainer's job.	
P:	Well, if he tell-- if he gives you a direct order to leave it go, then you can leave it go. You know, close out what you were doin'. He usually gives you a direct order and you talk to him, somebody else is there. Then I guess you should leave it go. Should put it--	Identification of assumption (it is assumed that direct orders are followed) Evaluation (direct) Reinterpretation (clarification of procedure) New solution (have a witness) Metacognition (know, guess)
Researcher:	Right. If you have like a witness.	
P:	Yeah.	
Researcher:	But let's say it's a safety item. If you go as far as to like get a shop steward or something.	
P:	If it's dangerous, sure.	Evaluation (dangerous) Reinterpretation (specification)
Researcher:	If it's dangerous? Yes? I'm not saying that that's how your supervisors are.	
P:	No.	Negation (no)

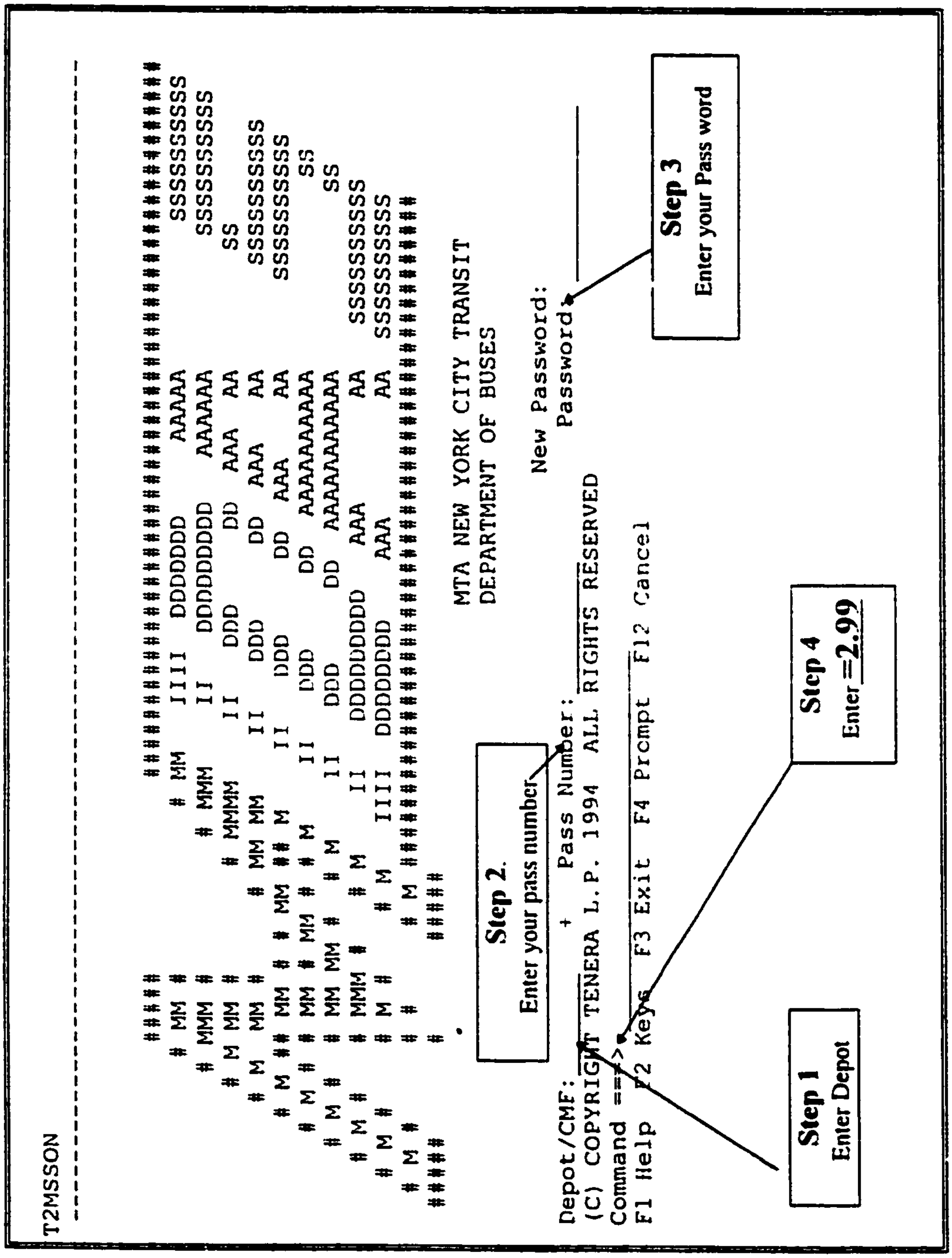
APPENDIX 3A

SCREEN PRINTS

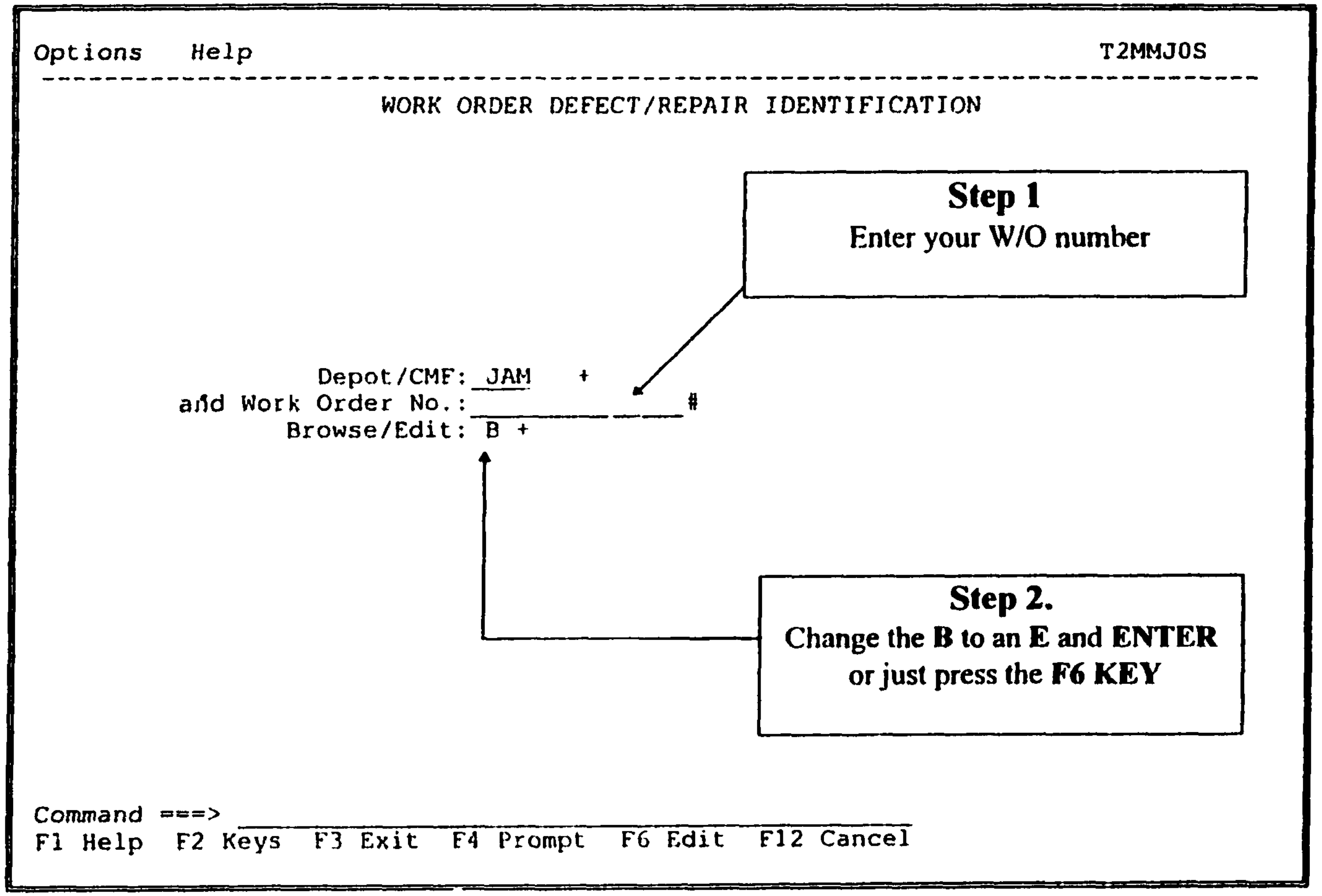
APPENDIX 3A
SCREEN PRINTS

```
                     MTA NYCT DEPT OF BUSES
                      MAINTENANCE WORK ORDER

DEPOT/SHOP     : CUNY             PAGE:        BUS NUMBER:
LINE SUPERVISOR:                               ====================
                                               WORK ORDER:
WORK ORDER STATUS: ACTIVE                      ====================
W/O STATUS DATE  :                             WORK ORDER TYPE  :
                                               MAINTENANCE TYPE:
LIFE TO DATE MILEAGE:                          CAMPAIGN NUMBER  :
SERIAL NUMBER/VIN    :
EQUIPMENT CLASS      : BUS
==============================================================================
TASK DESCRIPTION:

******************************* COMPLETION DATA *******************************

SYMPTOM: ___  ____________________  SEVERITY : _  POSITION : ___  PASS: _____ _
DEFECT : ___  ____________________  SYSTEM   : ___  ____________________
REPAIR : ___  ____________________  COMPONENT: ______  CRITICAL: _
PASS NUMBERS: ______ ______ ______ ______ ______ ______ ______ ______
L/S PASS NO: ______      OK SERVICE: _      SENSITIVE: _      CERTIFIED: _
AUTO COMPLETED BY: _____ _______   COMMENTS                  DATE     MADE BY
____________________________________________________________ ________ ______
____________________________________________________________ ________ ______
____________________________________________________________ ________ ______
```

SCREEN PRINTS



Work Order Identification:



Defect selection screen:

```
File      GoTo      Options   View      Help                    T2MMJ21
------------------------------------------------------------
                 WORK ORDER SYMPTOM SELECTION                          BROWSE
Bus/Location   : 1580   #   Serial No./VIN: 2W7BV812747 #   Depot/CMF: JAM   +
W/O Number     : 0021000   W/O/Maint Type: CO + / PU +      Mileage   :
Total Symptoms:  21                                         Notes     : Y +
A+      Symptom+                     Sev+ Pos+                        Sys+ Comp.#
__ 1. 424 OUT OF ADJUSTMENT                 DOOR REAR                 MGE  06
__ 2. 430 WORN                          RE  POWER STEERING RETURN LINE MY   1004
_S 3. 440 NOT WORKING                       ENGINE EMERGENCY SHUT DOWN ME   240205
__ 4. 412 OIL LEAK                      ALL ENGINE                    ME
__ 5. 433 BULB OUT                          DASH LAMPS                MJ   2441
__ 6. 433 BULB OUT                      RE  MARKER LAMP

Command ===> ______________________________                         More: +
F1 Help   F2 Keys   F3 Exit   F4 Prompt   F7 Bkwd   F8 Fwd   F12 Cancel
```

1. Type the line number on the **Command** line and press the **Enter** key , that will take you to the W/O defect/repair screen.

Work Order Defect/Repair Screen:

```
File      GoTo      Options   View      Help                       T2MMJ23
------------------------------------------------------------------------------
                        WORK ORDER DEFECT/REPAIR DATA                   BROWSE
 Bus/Location   : 1580  #   Serial No./VIN: 2W7BV812747 #     Depot/CMF: JAM   +
 W/O Number     : 0021001                        Mileage   :
 A+ Total Symptoms:   4   Auto Completed By:                 #  Notes    : Y +
   Symptom: 475 + WEAK                     Sev :   + Position: F   +  Pass:       #
   Defect :____ +                          System   : MGA +     STEPS (INTERIOR)
   Repair :____ +                          Component: 1101    #   Critical :   +
   Pass Numbers: _______#
   L/S Pass No: ________#      OK Service:   +    Sensitive:   +    Certified:   +

           Off Serial Number #      On Serial Number #    Position +
       1. ____________________      ___________________
       2. ____________________      ___________________
       3. ____________________      ___________________
Command ===>                                                        More: -
 F1 Help  F2 Keys  F3 Exit  F4 Prompt  F7 Bkwd  F8 Fwd  F12 Cancel
```

Table: Number of times each repair code was used

Repair code	Frequency	Percent
CHANGE OUT (REPL'D)	6216	29.6
COMPLETED	4729	22.6
TO BE CONTINUED	1477	7.0
PASS	919	4.4
INSTALL ONLY	733	3.5
REBUILT/OVERHAULED	704	3.4
PM (PREVENTIVE MAINTENANCE)	680	3.2
SECURED	636	3.0
REWIRED/INSULATED	625	3.0
FAIL	620	3.0
ADJUSTED/ALIGNED	590	2.8
TIGHTENED/CONNECTED	480	2.3
REMOVE ONLY	384	1.8
NO DEFECT FOUND	277	1.3
WASHED/CLEANED	215	1.0
MODIFIED/UPDATED	215	1.0
OK FOR SERVICE	154	.7
REASSEMBLED	136	.6
FABRICATED	126	.6
CHARGED	118	.6
NO STOCK	98	.5
BODYWORK/PATCHED	95	.5
ADDED FLUID	88	.4
STRAIGHTENED	88	.4
CLEARED	72	.3
OOS FOR SHOP	71	.3
RESET	64	.3
WELD/BRAZED	61	.3
LUBED/OILED	57	.3
OOS FOR VENDOR	57	.3
REBRUSHED	26	.1
TRIPPER	24	.1
RELEASED	23	.1
PAINTED	20	.1
MACHINED	15	.1
THREAD/FLARED	13	.1
CALIBRATED	10	>.1
SOLDERED	10	>.1
BLED	9	>.1
ROTATED	8	>.1
TORQUE WHEELS	7	>.1
BYPASS	7	>.1
574 (new code, unknown)	5	>.1
ADDED AIR	3	>.1
FUMIGATED	2	>.1
CYCLED	1	>.1
REPROGRAMMED	1	>.1
SANDING	1	>.1
COMPOUND/TOUCH-UP	0	0
UNDERCOAT	0	0

Examples of comments typed by mechanics

SECURED BUS IN WORK AREA, REMOVED ALL PANELS, TROUBLESHOOT SYSTEM, REPLACED BOOSTER BLOWER BRUSHES, SECURED WIRING, REINSTALLED ALL PANELS REMOVED OK AT THIS TIME
REMOVED TOP OF SEAT, RECONNECTEDAIR LINE, REINSTALLED SAET TOP, BUILT UP AIR, SEAT OPERATING PROPERLY AT THIS TIME.
RAN OU OF FUEL. R/T PRIMED AND STARTED.
REMOVED AND REPLACED DRIVERS SEAT AND REATTACH AIR LINE.
REMOVED BUMBER SKIN AND ALL RELATED HARDWARE.FOUND BUMPER FRAME ASSEM BENT AND BRACKETS TWISTED, REMOVED ALL DAMAGE PARTS TO BE REPLACED OR REPAIRED.T.B.C.
INSTALLED COVER ON GEN OK AT THIS TIME
FOUND RIGHT SIDE DOME LIGHTS NOT WORKING OPENED PANNEL TO BAL IST FOUND WIRES NOT STAYING ON AND PLUGED IN SECURED ALL LOOSE ENDS AND REASSEMBLED OK AT THIS TIME
HAD TO MOVE BUSES FROM SIDE OF BUS TO MOVE TO SHOP R/R LEFT SIDE HEAD LITE OK AT THIS TIME
TORQUED TO SPECS
REPLACED MISSING EMER. GLASS.
R/R FITTIN AND GREASED
FOUND NSTEP LITE HOUSING ROTTED.R/RHOUSING AND REPAIRED WIRE CONNECTION. OK AT THIS TIME. ALSO R/R BULBS ON INTERLOCKS.R/R SIGNAL LITE IN FRONT.OK AT THIS TIME
CHECKED INTO DEFECT, TESTED SENSOR TO BE GOOD,CONTINUED CHECKING LINE FOUND PLUG CONNECTION TO CORRDED. REMOVED AND CLEAN AND ADJUSTED SENSOR.WORKING OK AT THIS TIME

ADJUST MAGNETIC SWITHCHES AND MODIFY DOOR OUTSIDE MAGNETS LOCATE PROBLEM WITH MAGNETIC CIRCUIT AND REPARE WIRING
ADDED 1QT.OF OIL TO PUMP NO LEAKS FOUND SPRAYED WITH PENTRATING OIL BLOW OUT SPRAYED WITH LUBE. STOWING SLOW FOUND BOTH SLIDES STARTING TO RUST FULL OF DIRT
ADJUSTMENTS CHECK SYSTEM AND ROAD TEST #3 DOOR HINGE BEARING ADJUST DOORS AND SET UP AIR VALVE HAD TO FREE UP FROZEN REAR DOOR CAM ON BASEPLATE FREE UP
HAD NO HARDWARE FOR BAR USED LONGER BOLTS WITH SPACERS TO FILL GAP ONLY INSTALLED ONE HOLD DOWN OK AT THIS TIME
N WIRE ON COMPRESSOR AND FOUND LEAK AT SEAL TROUBLE SHOOT AND FOUND COMPRESSORNOTWORKING REPIARED
SECURED LOOSE SEAT CUSHIONS.

Appendix 4C. Correlations among Three Measures of Computer Use

Table 4C.1. Correlations between Repair Code Use and Component Code Use Measures

Component Code Use Measure	Repair Code Use Measure									
Set	1	2	3	4	5	6	7	8	9	10
1	R=.658 * p=.000 N=122	R=.530 * p=.000 N=116	R=.466 * p=.000 N=109	R=.529 * p=.000 N=96	R=.396 * p=.000 N=76	R=.311 * p=.014 N=62	R=.408 * p=.004 N=47	R=.290 p=.108 N=32	R=.624 * p=.002 N=21	R=.466 p=.051 N=18
2	R=.638 * p=.000 N=116	R=.609 * p=.000 N=116	R=.538 * p=.000 N=109	R=.598 * p=.000 N=96	R=.473 * p=.000 N=76	R=.390 * p=.002 N=62	R=.397 * p=.006 N=47	R=.298 p=.098 N=32	R=.629 * p=.002 N=21	R=.523 * p=.026 N=18
3	R=.549 * p=.000 N=109	R=.490 * p=.000 N=109	R=.620 * p=.000 N=109	R=.570 * p=.000 N=96	R=.469 * p=.000 N=76	R=.315 * p=.013 N=62	R=.371 * p=.010 N=47	R=.245 p=.176 N=32	R=.642 * p=.002 N=21	R=.297 p=.231 N=18
4	R=.475 * p=.000 N=96	R=.466 * p=.000 N=96	R=.579 * p=.000 N=96	R=.615 * p=.000 N=96	R=.388 * p=.001 N=76	R=.423 * p=.001 N=62	R=.354 * p=.015 N=47	R=.321 p=.073 N=32	R=.489 * p=.024 N=21	R=.490 * p=.039 N=18
5	R=.519 * p=.000 N=76	R=.334 * p=.003 N=76	R=.374 * p=.001 N=76	R=.428 * p=.000 N=76	R=.600 * p=.000 N=76	R=.509 * p=.000 N=62	R=.272 p=.064 N=47	R=.488 * p=.005 N=32	R=.585 * p=.005 N=21	R=.550 * p=.018 N=18
6	R=.465 * p=.000 N=62	R=.289 * p=.023 N=62	R=.463 * p=.000 N=62	R=.342 * p=.006 N=62	R=.452 * p=.000 N=62	R=.622 * p=.000 N=62	R=.378 * p=.009 N=47	R=.484 * p=.005 N=32	R=.525 * p=.015 N=21	R=.767 * p=.000 N=18
7	R=.574 * p=.000 N=.47	R=.508 * p=.000 N=47	R=.563 * p=.000 N=47	R=.524 * p=.000 N=47	R=.414 * p=.004 N=47	R=.540 * p=.000 N=47	R=.675 * p=.000 N=47	R=.490 * p=.004 N=32	R=.755 * p=.000 N=21	R=.681 * p=.002 N=18
8	R=.449 * p=.010 N=32	R=.434 * p=.013 N=32	R=.497 * p=.004 N=32	R=.510 * p=.003 N=32	R=.452 * p=.009 N=32	R=.501 * p=.003 N=32	R=.600 * p=.000 N=32	R=.784 * p=.000 N=32	R=.785 * p=.000 N=21	R=.600 * p=.009 N=18
9	R=.540 * p=.011 N=21	R=.397 p=.075 N=21	R=.719 * p=.000 N=21	R=.606 * p=.004 N=21	R=.513 * p=.017 N=21	R=.437 * p=.048 N=21	R=.672 * p=.001 N=21	R=.628 * p=.002 N=21	R=.862 * p=.000 N=21	R=.670 * p=.002 N=18
10	R=.527 * p=.025 N=18	R=.451 p=.061 N=18	R=.795 * p=.000 N=18	R=.618 * p=.006 N=18	R=.552 * p=.018 N=18	R=.714 * p=.001 N=18	R=.485 * p=.041 N=18	R=.462 p=.053 N=18	R=.501 * p=.034 N=18	R=.823 * p=.000 N=18

* Correlation significant at 0.05-level.

Table 4C.2. Correlations between Comment Use and Repair Code Use Measures

		Comment Use Measure	
	Set	Month 2	Month 5
Repair Code Use Measure	1	R=.230* P=.011 N=121	R=.374* p=.000 N=117
	2	R=.254* p=.006 N=115	R=.321* p=.001 N=113
	3	R=.233* p=.015 N=108	R=.345* p=.000 N=106
	4	R=.231* p=.024 N=95	R=.398* p=.000 N=93
	5	R=.197 p=.088 N=76	R=.356* p=.002 N=75
	6	R=.124 p=.335 N=62	R=.442* p=.000 N=62
	7	R=.202 p=.173 N=47	R=.445* p=.002 N=47
	8	R=.326 p=.069 N=32	R=.604* p=.000 N=32
	9	R=.457* p=.037 N=21	R=.595* p=.004 N=21
	10	R=.285 p=.251 N=18	R=.748* p=.000 N=18

* Correlation significant at 0.05-level.

Table 4C.3. Correlations between Comment Use and Component Code Use Measures

		Comment Use Measure	
	Set	Month 2	Month 5
Component Code Use Measure	1	R=.375* p=.000 N=121	R=.387* p=.000 N=117
	2	R=.278* p=.003 N=115	R=.319* p=.001 N=113
	3	R=.340* p=.000 N=108	R=.284* p=.003 N=106
	4	R=.257* p=.012 N=95	R=.328* p=.001 N=93
	5	R=.222 p=.054 N=76	R=.272* p=.018 N=75
	6	R=.199 p=.121 N=62	R=.340* p=.007 N=62
	7	R=.208 p=.162 N=47	R=.473* p=.001 N=47
	8	R=.407* p=.021 N=32	R=.676* p=.000 N=32
	9	R=.382 p=.088 N=21	R=.696* p=.000 N=21
	10	R=.300 p=.226 N=18	R=.748* p=.000 N=18

* Correlation significant at 0.05-level.

Table 4D.1 Repair code use: comparison between two depots

Set	Mean of individual percentages of repair code utilization		t	df	Sig. (2-tailed)
	Depot A	Depot B			
1	.165	.171	-.525	120	.601
2	.160	.156	.414	114	.679
3	.153	.150	.258	107	.797
4	.144	.149	-.504	94	.615
5	.142	.149	-.618	74	.538
6	.139	.130	.585	60	.561
7	.135	.131	.219	45	.828
8	.117	.103	.604	30	.550
9	.098	.066	1.471	19	.158
10	.102	.058	1.551	16	.140

Table 4D.2 Component code use: comparison between two depots

Set	Mean number of different component codes used by individuals		t	df	Sig. (2-tailed)
	Depot A	Depot B			
1	19.7	18.9	.549	120	.584
2	18.7	18.8	-.052	114	.958
3	18.2	18.0	.089	107	.929
4	16.4	17.7	-.815	94	.417
5	14.5	16.3	-1.104	74	.273
6	14.1	14.7	-.337	60	.737
7	12.5	14.3	-.890	45	.378
8	11.4	12.2	-.303	30	.764
9	11.2	9.1	.600	19	.555
10	8.6	6.9	.581	16	.570

Table 4D.3 Comment use: comparison between two depots

Month	Average percentage of time comments were used by individuals		t	df	Sig. (2-tailed)
	Depot A	Depot B			
2	52.9	24.8	6.402 *	122	.000
5	29.6	33.7	-.947	117	.346

* Significant at .001-level

Significant correlations among questionnaire items - Page 1 of 3

R (n) * p<.05 ** p<.001	Know computers	Midas difficult to learn	Know way around Midas	Not trust Midas	Midas watching workers	Doubt Midas will work	Midas good system	Nervous about Midas
Know computers		-.457** (39)	.434** (39)	ns	ns	ns	ns	ns
Midas difficult to learn	-457** (39)		-.431** (39)	.326* (38)	ns	ns	ns	.454** (39)
Know way around Midas	.434** (39)	-.431** (39)		ns	ns	ns	ns	ns
Not trust Midas	ns	.326* (38)	ns		ns	.322* (39)	-.416** (38)	.374* (38)
Midas watching workers	ns	ns	ns	ns		.377* (40)	-.537** (39)	ns
Doubt Midas will work	ns	ns	ns	.322* (39)	.377* (40)		-.486** (39)	ns
Midas good system	ns	ns	ns	-.416** (38)	-.537** (39)	-.486** (39)		-.339* (39)
Nervous about Midas	ns	.454** (39)	ns	.374* (38)	ns	ns	-.339* (39)	
Respect authorities	ns	ns	ns	ns	ns	ns	ns	ns
Question news	ns	ns	ns	ns	.323* (39)	ns	ns	ns
Like my job	ns	ns	ns	ns	ns	ns	.382* (39)	ns
Care about big picture	ns	ns	ns	ns	ns	ns	ns	ns
Questions about Midas	ns	ns	ns	ns	ns	ns	ns	ns
Curious about Midas	ns	ns	ns	ns	ns	-.359* (40)	.334* (39)	ns
Input heard in Midas	.381* (40)	ns	ns	ns	ns	ns	ns	ns
Depend on others	ns	ns	ns	ns	ns	ns	ns	.381* (39)
Others depend on me	ns	ns	ns	-.357* (39)	ns	ns	ns	ns
In control of my work	ns	-.350* (39)	ns	ns	ns	ns	.334* (39)	ns
Only me responsible	ns	ns	ns	ns	ns	ns	ns	ns
Superiors responsible	ns	ns	ns	ns	ns	ns	ns	ns
Openly question superiors	ns	ns	ns	ns	ns	.552** (39)	ns	ns
Midas just for accounting	ns	ns	ns	ns	ns	ns	ns	ns
Don't care about Midas	ns	ns	ns	ns	ns	ns	ns	ns
Midas will change operation	ns	.336* (30)	ns	ns	ns	ns	ns	ns

Significant correlations among questionnaire items - Page 2 of 3

R (n) * p<.05 ** p<.001	Respect authorities	Question news	Like my job	Care about big picture	Questions about Midas	Curious about Midas	Input heard in Midas	Depend on others
Know computers	ns	ns	ns	ns	ns	ns	.381* (40)	ns
Midas difficult to learn	ns	ns	ns	ns	ns	ns	ns	ns
Know way around Midas	ns	ns	ns	ns	ns	ns	ns	ns
Not trust Midas	ns	ns	ns	ns	ns	ns	ns	ns
Midas watching workers	ns	.323* (39)	ns	ns	ns	ns	ns	ns
Doubt Midas will work	ns	ns	ns	ns	ns	-.359* (40)	ns	ns
Midas good system	ns	ns	.382* (39)	ns	ns	.334* (39)	ns	ns
Nervous about Midas	ns	ns	ns	ns	ns	ns	ns	.381* (39)
Respect authorities		-.479** (39)	.489** (40)	.381* (40)	ns	ns	ns	ns
Question news	-.479** (39)		ns	ns	ns	ns	ns	ns
Like my job	.489** (40)	ns		.528** (40)	ns	ns	ns	ns
Care about big picture	.381* (40)	ns	.528** (40)		ns	.498** (40)	.407** (40)	ns
Questions about Midas	ns	ns	ns	ns		ns	.439** (40)	.324* (40)
Curious about Midas	ns	ns	ns	.498** (40)	ns		.534** (40)	ns
Input heard in Midas	ns	ns	ns	.407** (40)	.439** (40)	.534** (40)		ns
Depend on others	ns	ns	ns	ns	.324* (40)	ns	ns	
Others depend on me	ns	ns	ns	ns	ns	ns	ns	ns
In control of my work	ns	ns	ns	ns	ns	ns	.369* (40)	ns
Only me responsible	ns	-.335* (39)	ns	.405** (40)	ns	ns	ns	ns
Superiors responsible	ns	ns	ns	-.430** (40)	ns	ns	-.346* (40)	ns
Openly question superiors	ns	ns	ns	ns	ns	ns	ns	ns
Midas just for accounting	ns	ns	-.337* (40)	ns	ns	ns	ns	ns
Don't care about Midas	ns	ns	ns	ns	ns	ns	ns	ns
Midas will change operation	ns	ns	ns	ns	.501** (39)	ns	ns	ns

Significant correlations among questionnaire items - Page 3 of 3

R (n) * p<.05 ** p<.001	Others depend on me	In control of my work	Only me responsible	Superiors responsible	Openly question superiors	Midas just for accounting	Don't care about Midas	Midas will change operation
Know computers	ns	ns	ns	ns	ns	ns	ns	ns
Midas difficult to learn	ns	-.350* (39)	ns	ns	ns	ns	ns	.336* (30)
Know way around Midas	ns	ns	ns	ns	ns	ns	ns	ns
Not trust Midas	-.357* (39)	ns	ns	ns	ns	ns	ns	ns
Midas watching workers	ns	ns	ns	ns	ns	ns	ns	ns
Doubt Midas will work	ns	ns	ns	ns	.552** (39)	ns	ns	ns
Midas good system	ns	.334* (39)	ns	ns	ns	ns	ns	ns
Nervous about Midas	ns	ns	ns	ns	ns	ns	ns	ns
Respect authorities	ns	ns	ns	ns	ns	ns	ns	ns
Question news	ns	ns	-.335* (39)	ns	ns	ns	ns	ns
Like my job	ns	ns	ns	ns	ns	-.337* (40)	ns	ns
Care about big picture	ns	ns	.405** (40)	-.430** (40)	ns	ns	ns	ns
Questions about Midas	ns	ns	ns	ns	ns	ns	ns	.501** (39)
Curious about Midas	ns	ns	ns	ns	ns	ns	ns	ns
Input heard in Midas	ns	.369* (40)	ns	-.346* (40)	ns	ns	ns	ns
Depend on others	ns	ns	ns	ns	ns	ns	ns	ns
Others depend on me		ns	ns	ns	ns	ns	ns	ns
In control of my work	ns		ns	ns	ns	ns	ns	ns
Only me responsible	ns	ns		ns	ns	ns	-.365* (40)	ns
Superiors responsible	ns	ns	ns		ns	ns	ns	ns
Openly question superiors	ns	ns	ns	ns		-.390* (39)	ns	ns
Midas just for accounting	ns	ns	ns	ns	-.390* (39)		ns	ns
Don't care about Midas	ns	ns	-.365* (40)	ns	ns	ns		ns
Midas will change operation	ns	ns	ns	ns	ns	ns	ns	

Table: GLM Repeated Measures Results of Rates of Critical Thinking Elements by Story[1]

	Multivariate test of within-subjects effect (Wilks' Lambda = WL), (df 3,15)	Tests of within-subjects contrasts (df 1,17)					
		Stealing vs. Part	Stealing vs. Note	Stealing vs. Code	Part vs. Note	Part vs. Code	Note vs. Code
All Elements	WL = .624 F= 3.015 p= .063	F= 3.742 p= .070	F= 10.234 p= .005 •	F= 6.926 p= .017 •	F= 5.897 p= .027 •	F= 2.166 p= .159	F= 2.318 p= .146
Identification of Assumption	WL= .388 F= 7.891 p= .002 •	F= 19.519 p= .000 •	F= .021 p= .888	F= .010 p= .923	F= 12.777 p= .002 •	F= 11.286 p= .004 •	F= .002 p= .962
Evaluation	WL= .427 F= 6.713 p= .004 •	F= 6.330 p= .022 •	F= 13.384 p= .002 •	F= 4.238 p= .055	F= 1.314 p= .268	F= .789 p= .387	F= 17.068 p= .001 •
Negation	WL= .573 F= 3.724 p= .035 •	F= 10.170 p= .005 •	F= 10.750 p= .004 •	F= 10.517 p= .005 •	F= 1.733 p= .206	F= .414 p= .529	F= .121 p= .732
Contradiction	WL= .396 F= 7.641 p= .002 •	F= 5.437 p= .032 •	F= 2.872 p= .108	F= 6.194 p= .023 •	F= 16.569 p= .001 •	F= 23.496 p= .000 •	F= .048 p= .828
Reinterpretation	WL= .832 F= 1.010 p= .416	F= .020 p= .890	F= 2.508 p= .132	F= .096 p= .760	F= 2.071 p= .168	F= .348 p= .543	F= .862 p= .366
New Solution	WL= .554 F= 4.024 p= .028 •	F= .214 p= .650	F= 3.956 p= .063	F= .314 p= .582	F= 10.866 p= .004 •	F= .018 p= .896	F= 1.826 p= .194
Metacognition	WL= .235 F= 16.282 p= .000 •	F= 18.359 p= .001 •	F= 25.996 p= .000 •	F= 2.574 p= .127	F= .715 p= .409	F= 7.184 p= .016 •	F= 10.138 p= .005 •

[1] • $p<.05$

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