The Effects of Cooperative and Individualistic Learning Structures on Achievement in a College-level Computer-aided Drafting Course

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Abstract

This study of cooperative learning in post-secondary engineering education investigated achievement of engineering students enrolled in two intact sections of a computer-aided drafting (CAD) course. Quasi-experimental and qualitative methods were employed in comparing student achievement resulting from out-of-class cooperative and individualistic learning structures. The research design was a counterbalanced, repeated measures, nonequivalent control group design. During the first half of the semester, one course section served as the experimental group (cooperative learning) and the other section served as the control group (individualistic learning). During the second half of the semester, the treatment and control conditions were switched to the other section. Data collection involved a pretest, a mid-term exam, a final exam, weekly homework drawing grades, an introductory demographic survey, weekly peer reviews, and interviews.

The data analyses showed that the differences between the treatment and control group means on the mid-term and final exams were not significant. However, the treatment group means on the weekly homework drawings were significantly higher than those for the control group in each half of the semester. The data revealed main effects of race, prior experience, time of achievement test administration, and prerequisite grade. A post-hoc analysis did not show significant differences among the various levels of prerequisite grade. Also, there were first-order interactions for gender-by-time, experience-by-time, method-by-time for the year as engineering major demographic variable, and method-by-academic year. Qualitative data revealed that most participants had positive group experiences, more participants preferred working in cooperative groups during more difficult activities than introductory material, academically stronger participants might have “carried” weaker participants in the cooperative groups, and there were times identified for cooperative group work during which groups did not work cooperatively.

Based upon the findings in this study, one might reasonably conclude that cooperative and individualistic learning structures result in approximately equal student achievement. Thus, when deciding on the use of one learning structure over the other, instructors might focus on which approach seems more appropriate/practical for a particular instructional activity.

Dedication

For Mom and Dad.

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Chapter 1: Introduction

Cooperative learning has served as a major teaching and learning method in primary and secondary education for over 35 years. Its popularity stems not only from research supporting its effectiveness in areas such as student achievement, motivation, and self worth; but also from practical concerns such as financial benefits, limited educational resources, and potential "fun factor" in learning course content. Additionally, school districts typically offer professional development opportunities in cooperative learning to teachers, universities offer similar opportunities to faculty and graduate students, and teacher education majors typically learn about cooperative learning in teaching methods courses and their corresponding textbooks (e.g., Borich, 1996; Freiberg and Driscoll, 1992; Parkay and Stanford, 1992).

Cooperative learning has theoretical roots in social interdependence learning (e.g., Koffka, early 1900s; Lewin, 1930s; Deutsch, 1940s; Johnson and Johnson, 1970s), cognitive-developmental learning (e.g., Piaget, mid 1900s; Vygotsky late 1970s); and behavioral learning (e.g., Skinner, mid 1900s). During the latter decades of the twentieth century, Johnson and Johnson and their colleagues (Johnson, Johnson, Holubec, & Roy, 1984; Johnson, Johnson, & Smith, 1991; Johnson & Johnson, 2006) and Slavin (1983, 1990, 1996) extended these theories into more modern contexts. Their work in cooperative learning has put them in the position of being among the most respected cooperative learning theorists in the world.

There are typically three learning goal structures or environments in a classroom: cooperative, competitive, and individualistic. Johnson and Johnson (2006) comprehensively defined cooperative learning as:

> a relationship in a group of students that requires positive interdependence (a sense of sink or swim together), individual accountability (each of us has to contribute and learn), interpersonal skills (communication, trust, leadership, decision making, and conflict resolution), face-to-face promotive interaction, and processing (reflecting on how well the team is functioning and how to function even better).

Through mutual tasks and rewards, individual student achievement occurs only when the other students in the group also achieve. An example of a cooperative structure using group rewards is: when every student in a group earns at least a certain grade everyone in the group receives bonus points. There is positive interaction and interdependence between or among group members in cooperative learning structures. This is in contrast to competitive learning environments, which focus on individual learning achievement relative to other students achieving not as well or failing. Competitive environments promote negative interaction among students. For example, a teacher may use a "bell curve" grading system in which only a certain number of students may receive grades of either A, B, C, D, or E; students compete for their grades. Individual goal structures do not consider the work of other students. In an individualistic learning environment, there is no interaction among students, and individual student achievement is based solely upon the individual student's abilities.

Johnson, Maruyma, Johnson, Nelson, and Skon (1981) and Slavin (1983) conducted meta-analyses of the research on the three goal structures and reached three major conclusions. First, cooperative learning fosters higher achievement gains than the other two learning structures. Second, cooperative learning structures promote higher levels of self-esteem, satisfaction with school, positive gender and race relations, and general feelings of worth and approval by others. Finally, these results hold true for all grade levels, age groups, and subject matter. However, between 1970 and 1999, a majority (approximately 77%) of the research that investigated student achievement was conducted at the primary and secondary school levels. Research that focused on the achievement of college students and adult learners in cooperative environments constituted less than 24% of the studies between 1970 and 1999 (Johnson, Johnson, & Stanne, 2000).

Authors and practitioners (e.g., Bertoline & Wiebe, 2005; Giesecke, Mitchell, Spencer, Hill, & Dygdon, 1986) in the technical graphics and computer-aided drafting (CAD) fields have stated that engineers and CAD operators need to have high levels of spatial visualization skills in order to be successful. Yet, visualization ability is a prerequisite for other fields as well. Bodner and Guay (1997) at Purdue University based their battery of visualization tests on the visualization skills needed to succeed in chemistry fields. Research has shown that students with high visualization ability achieve higher than students with low visualization ability (Bodner & Guay, 1997; Hsi, Lin, & Bell, 1997). Sarasin (1999) postulated that college students who are visual learners prefer cooperative learning environments (p. 61).

Commonly accepted learning style theories developed by Kolb (1984), McCarthy (1987), and Felder and Silverman (1988) all have components related to visual abilities. Research in learning styles have shown that people with strengths and preferences in visual learning gravitate to college majors and career fields that require visual skills and work in the physical environment, fields such as engineering and architecture (Kolb, 1984). Kolb’s work in adult learning styles led to the development of other learning style theories. For example, McCarthy (1987) based her 4MAT system of learning styles on four dimensions similar to those developed by Kolb, but generalizes her theories mainly to children. Felder and Silverman (1988) adapted theories by Kolb and others into an engineering teaching and learning context at the college level. Subsequently, Soloman and Felder (1997, 2006) developed an on-line form of their learning styles inventory based on the Felder-Silverman theory. Colleges of engineering and other fields throughout the world regularly use the Soloman-Felder learning style inventory (Felder, 2006). Felder has also conducted research in cooperative learning (e.g., Kaufman, Felder, & Fuller, 2000).

Statement of the Problem

The problem of this study was to determine the effectiveness of a particular cooperative learning method on the achievement of college engineering students enrolled in a CAD course. In particular, the researcher wanted to determine if students who learned CAD cooperatively achieved higher than students who learned CAD individually.

Statement of Purpose

The purpose of this study was to offer findings that might help improve teaching and learning in a CAD course and guide the future development of similar CAD courses in various disciplines. Additionally, this research added to the growing body of literature on cooperative learning.

Statement of Need

Cooperative learning research has a rich history and encompasses a variety of fields, from industry to education. Research on cooperation began in the early part of the twentieth century and continues today. Early research focused on group dynamics in college and adult learning settings. Interest in cooperative learning at the college level faded during the mid to late twentieth century, while interest flourished at the primary and secondary education levels. Since the 1970s, most of the research on cooperative learning has occurred in primary and secondary schools (Johnson & Johnson, 2006). However, interest in the application of cooperative learning at the college level has rekindled over the past decade due to demands by industry, recommendations resulting from reports by government agencies, and interest by college faculty for more effective teaching methods (see, for example, Boehm and Gallavan, 2000; Brawner, Felder, Allen, & Brent, 2002; Johnson & Johnson, 1983; Smith, Sheppard, Johnson, & Johnson, 2005; Springer, Stanne, & Donovan, 1999). It is this rekindling of interest in the use of cooperative learning at the college level that formed the need for this study.

In their review of cognitive teaching models, Wilson and Cole (1996) generalized that the development and research of practical teaching models yield important new knowledge about the viability of existing cognitive theories and models. The authors believed that "the development and validation of teaching models is a legitimate research method and has been an important vehicle for advancing knowledge in learning and instruction" (p. 601). Furthermore, "When researchers become interested in the problem of how people learn complex subject matters in realistic learning settings, practical tryout of programs and methods fills a role that no amount of theorizing or isolated-factor research can provide" (p. 602).

Johnson and Johnson (2006) concluded that despite the plethora of research on various aspects of cooperative learning, researchers must not stop studying cooperative learning in education. Similarly, Slavin (1996) stated that even though cooperative learning was the focus of "an extraordinary number" of studies, research must continue in all aspects of cooperative learning in order "…to provide the practical, theoretical, and intellectual underpinnings…" (p. 64). Continuing the research can validate or refute previous research, add to the strengths or weaknesses of theories, add to the cooperative learning knowledge base, and contribute to needed areas of research.

Many aspects of adult life require cooperative engagement between and among people. Many workplaces, from professional football games to construction sites, require cooperative efforts. In *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* (National Academy of Engineering, 2005), the National Academy of Engineering (NAE) stressed the importance of studying humanities areas for future engineering students and called upon colleges of engineering to teach students interpersonal and cooperative skills in order to prepare graduates for the world of work as an engineer. Though technical excellence is the most important attribute of an engineering graduate,

> ….those graduates should also possess team, communication, ethical reasoning, and societal and global contextual analysis skills as well as understand work strategies. Neglecting development in these arenas… is not in the best interest of producing engineers able to communicate with the public, able to engage in a global engineering marketplace, or trained to be lifelong learners. (NAE, p. 52)

The American Association for the Advancement of Science (AAAS) (1989) also recommended that students work with one another frequently. “Scientists and engineers work mostly in groups and less often as isolated investigators. Similarly, students should gain experience sharing responsibility for learning with each other” (p. 148). It is, therefore, important for students to develop the necessary skills and experience required by the workforce by working cooperatively and collaboratively with other students in their courses. This study provided insight into how cooperative and individualistic learning environments affect achievement in an engineering CAD course.

The NAE (2005) believed that curricular approaches that engage students in team exercises and real-world problems that demonstrate the social relevance of engineering retain students successfully. However, the NAE also felt that the engineering community has not rigorously investigated the design of those curricular approaches or their effectiveness on individual student achievement. “Changes in engineering learning experiences involving curricula, pedagogies, and support services should be based on research on learning” (p. 54). Therefore, the NAE recommended:

> The engineering education establishment … should endorse research in engineering education as a valued and rewarded activity for engineering faculty as a means to enhance and personalize the connection to undergraduate students, to understand how they learn, and to appreciate the pedagogical approaches that excite them. (p. 54)

This study added to the body of research in education pedagogy and engineering education, specifically, as an investigation into the effects of a particular curricular approach—cooperative learning.

In addition to the NAE, a variety of professional associations and government agencies (American Association for the Advancement of Science [AAAS], 1989, 1990; the Boyer Commission, 1998; National Research Council [NRC], 1995, 1996, 2002, 2003; National Science Foundation [NSF], 1996) have suggested the need for students in science, technology, engineering, and mathematics (STEM) to gain experiences in cooperative learning. These organizations have reported that “what students learn is greatly influenced by how they learn, and many students learn best through active, collaborative, small-group work inside and outside the classroom” (Springer et al., p. 22).

Among their recommended areas for further research, Bransford, Brown, and Cocking (2000) identified in *How People Learn* a need to “investigate the potential benefits of collaborative learning in the classroom and the design challenges that it imposes” (p. 279)[1]. They further stated that “the research should explore and field-test alternative design strategies” (p. 280). This study explored and field tested an alternative teaching and learning strategy.

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[1] Some authors have made distinctions between collaborative and cooperative learning, others have used the terms synonymously, and others have described cooperative learning as a subset of collaborative learning (Prince, 2004). Bransford, Brown, and Cocking (2000) did not address that matter. However, in their review of the literature to support this recommendation, the authors indicated that “…the community-centered classroom…, in which students learn from each other, can have substantial benefits” (p. 280). One could glean from this particular point that the authors described a *cooperative* learning environment because students would “learn from each other,” implying the use of structured activities in which students work with each other to learn the course content. Regardless, Bransford et al. promoted research on students working together in order to increase learning.

Johnson, Maruyama, Johnson, Nelson, and Skon (1981); Slavin (1983); Johnson and Johnson (1989); Springer, Stanne, and Donovan (1999); and Johnson, Johnson, and Stanne (2000) conducted meta-analyses of cooperative learning research and concluded that students achieve higher in cooperative learning environments than competitive and individualistic environments. Johnson et al. (1981) believed that "the results are so strong that identifying mediating or moderating variables is difficult… Further work is needed to determine the influences on effectiveness of these two goal structures" (p. 57). Some research has shown competitive and individualistic learning structures are better for certain learning activities, but more research is needed in all three goal structures (Johnson & Johnson, 1989). Johnson and Johnson (1998) stated, "It is unclear whether individualistic efforts have any advantage over cooperative efforts. There is considerable more research needed to clarify the conditions under which competitive or individualistic efforts may have more powerful effects than cooperation" (p. 23). This study addressed the need for research in the investigation of individualistic and cooperative efforts.

Johnson et al. (1981) noted that even though results of meta-analyses on cooperative learning research showed the relative efficacy of the major learning goal structures on achievement, they needed (and future researchers need) to identify and examine the mediating or moderating variables that influenced the findings. Slavin (1983) recommended conducting interviews to help explain these mediating variables. He stated, "Perhaps the most important question about the effects of cooperative learning on student achievement is why they occur" (p. 124). In this study, the collection of demographic variables, feedback from weekly peer evaluations, and answers to interview questions helped to examine possible mediating or moderating variables that may have affected the findings.

The NRC (1994) believed that an important limitation of cooperative learning research was that researchers mostly studied children in primary and secondary schools. "Adults may not benefit from cooperative approaches in the same manner as do children, and there is a need to take into account the complexity of most adult learning tasks and to augment the cooperative experience with appropriate aids" (p. 13). The council concluded that "research on cooperative learning with adults is limited, and additional research is needed to validate several tentative conclusions" (p.13). The NRC also believed that more research was needed to understand the mediating or moderating variables of cooperative learning effects and the conditions under which they occur (p. 13).

Researchers (e.g., Johnson, Johnson, & Stanne, 2000) have revealed through their meta-analyses that less than 24% of research focusing on established cooperative learning methods studied college and adult learning classrooms. Slavin (1996) stated there was a need for more research on all cooperative learning outcomes in post-secondary institutions. Springer, Stanne, and Donovan (1999) stated that "few investigations [in cooperative learning] have focused on college students outside the psychology laboratory" (p. 23). This study added to the literature on cooperative learning and college students in real settings.

Brawner, Felder, Allen, and Brent (2002) indicated that engineering faculty have commented frequently "in numerous books, journal articles, conference presentations, and workshops and seminars" (p.393) about the need to move toward more learner-centered instructional methods such as cooperative learning. However, engineering faculty have not provided much research in this area. This study added to the literature on learner-centered classrooms in engineering.

It is under the aforementioned recommendations and statements of need that the researcher formulated the research hypotheses for this study.

Assumptions

The researcher made the following assumptions in pursuit of this study:

1. The research participants were homogenous in composition.

2. Students abided by the tenets of the university's undergraduate honor code with regard to all aspects of their CAD efforts during this study.

3. The instructor taught both sections of the course similarly, graded the drawing assignments consistently between the course sections, and provided unbiased help when students asked questions about assignments.

4. The task structures the students employed and the reward structures the instructor-researcher provided to the students qualified the teaching/learning methodologies as cooperative learning.

5. Success in class was an incentive; students wanted to earn good grades. Achievement scores provided incentives for additional learning.

Limitations

The researcher conducted the study in view of limitations with respect to the treatment location, research design, instrumentation, participants, software, and researcher himself.

Treatment Location

The researcher did not witness students working and studying together during the treatment condition or students working individually during the control condition. However, students in the treatment conditions completed weekly peer evaluations which contained questions about their cooperative efforts.

Research Design

University departmental policy required that any differences in teaching between or among sections of a course be approved by the department's curriculum committee. Accordingly, the researcher used a counterbalanced design in which both course sections received the treatment at different times. During the first half of the semester, students in one section worked in pairs (treatment) and students in the other section worked individually (control). During the second half of the semester, the instructor-researcher reversed the treatment-control conditions. The students who originally worked in pairs worked individually and the students who worked originally by themselves worked in pairs for the remainder of the semester. The curriculum committee found this design more appealing because students would less likely complain about unfair grading due to having opportunities to working individually and in pairs during the semester.

The department's curriculum committee further required that the proportion of each student's grade earned must be weighted equally during the two learning approaches. For example, a student should earn half of his/her grade during the first half of the semester—either the treatment or control period, depending on the course section, and earn the other half of the grade during the second half of the semester—the switched treatment-control period.

Instrumentation

The researcher measured achievement in two ways: 1) pretest/posttest grades; and 2) grades on weekly assignments. A panel of experts validated the test questions; however, the researcher did not measure the reliability of the tests. The researcher developed rubrics for grading the CAD assignments.

Participants

The research participants consisted of engineering students enrolled in two intact sections of a one-credit computer-aided drafting course in an engineering education department at a large four-year university in a Mid-Atlantic state in the U.S.

Software

Participants used AutoCAD software. Class instruction, demonstrations, assignments, and the tutorial book focused specifically on AutoCAD 2007. The majority of the course content covered AutoCAD's two-dimensional (2D) aspects; one lecture covered selected three-dimensional (3D) capabilities.

Researcher

The researcher was the instructor for both sections of the course and conducted the interviews that took place during the study.

Definition of Terms

CAD: Acronym for computer-aided drafting or computer-aided design

CADD: Acronym for computer-aided drafting and design or computer-aided design and drafting

Competitive learning: When a situation is structured competitively, individuals work against each other to achieve a goal that only one or a few can attain. Individuals' goal achievements are negatively correlated; each individual perceives that when one person achieves his or her goal, all others with whom he or she is competitively linked fail to achieve their goals. Thus, individuals seek an outcome that is personally beneficial but detrimental to all others in the situation. (Johnson & Johnson, 1998)

Computer-aided design: A process that uses a computer system to assist in the creation, modification, and display of a design. (Giesecke, Mitchell, Spencer, Hill, & Dygdon, 1986)

Computer-aided drafting: A system of drafting in which the drafter uses computer software to replace the instruments of board drafting. (French & Helsel, 2003)

Cooperation: Working together to accomplish shared goals. Within cooperative activities, individuals seek outcomes that are beneficial to themselves and beneficial to all other group members. (Johnson & Johnson, 1996, p. 1018)

Cooperative learning: A relationship in a group of students that requires positive interdependence (a sense of sink or swim together), individual accountability (each of us has to contribute and learn), interpersonal skills (communication, trust, leadership, decision making, and conflict resolution), face-to-face promotive interaction, and processing (reflecting on how well the team is functioning and how to function even better). (Johnson & Johnson, 2006)

ILS: Soloman-Felder *Index of Learning Styles*

Individualistic learning: When a situation is structured individualistically, there is no correlation among participants' goal attainments. Each individual perceives that he or she can reach his or her goal regardless of whether other individuals attain or do not attain their goals. Thus, individuals seek an outcome that is personally beneficial without concern for the outcomes of others. (Johnson & Johnson, 1998)

Learning style: Differences in the ways people perceive then process new experience and information. (McCarthy, 2006)

ROT: *The Purdue Visualization Test of Rotations*

Visualization: The ability to mentally picture things that do not exist. (Bertoline & Wiebe, 2005, p. 5)

Chapter 2: Review of Literature

Historically, perceptions of post-secondary institutions have included visions of vast numbers of students in large lecture halls attending to every word of a professor standing at the front. Students competed for grades from norm-referenced evaluations of student learning, which typically resulted in "grading on the curve." For one to succeed, another needed to fail or at least not succeed as well. Some faculty realized the negative aspects of competitive learning and gradually implemented individualistic approaches to instruction in which students earned criterion-referenced individual grades. Even so, students worked individually to obtain learning goals separate from those of other students. One's success came from his/her abilities, not from the success or failure of other students. Even fewer faculty realized that there was still something missing.

Cooperative learning approaches offered more opportunities for every student to succeed. Students worked together in small groups to obtain shared learning goals. Individual students achieved their learning goals if, and only if, other group members achieved their goals. Faculty members preset criteria and encouraged groups to ensure that each group member met the criteria. They rewarded groups for their efforts when all group members met certain criteria. Student achievement increased. However, few post-secondary faculty members adopted cooperative learning approaches because of the complexity of cooperative learning methods, lack of student understanding of how to work cooperatively with others, little or no faculty training in effective cooperative learning strategies, and resistance from students to "alternative" teaching and learning methods. Faculty members experienced in cooperative learning procedures overcame these obstacles to implementation when they developed an understanding of the theory, research, and common characteristics of cooperative learning. (Johnson, Johnson, & Smith, 1998)

Johnson, Johnson, and Smith (1991, 1998) posited that colleges concentrate on the "old paradigm" of teaching and learning, focusing on competitive and individualistic learning situations. But, the authors acknowledged that college teaching is changing as more faculty create active learning environments in which students interact, discuss, debate, and cooperate.

Theoretical Roots of Cooperative Learning

The success of cooperative learning methods at various education levels is due to its roots in theory, validation by research, and clear procedures. Regarding its theoretical roots, Johnson, Johnson, and Stanne (2000) postulated that cooperative learning "is based solidly on a variety of theories in anthropology (Mead, 1936), sociology (Coleman, 1961), economics (Von Mises, 1949), political science (Smith, 1759), psychology, and other social sciences." Researchers have focused on the application of psychology theories in cooperative learning (Johnson, Johnson, & Stanne, 2000). In the psychology domain, cooperative learning has theoretical roots in social interdependence learning, cognitive-developmental learning, and behavioral learning.

Social Interdependence Learning Theory

Kurt Koffka, a co-founder of the gestalt school of psychology, began the development of the social interdependence theory with his work in group dynamics during the early 1900s. He proposed that groups were essentially dynamic wholes in which the levels of interdependence among the individuals varied. The nature of the group was based on the interdependence of its group members. (Johnson, Johnson, & Smith, 1998)

Kurt Lewin (1935), Koffka's colleague (Johnson et al., 1998), further theorized that the interdependence among group members created by a common goal formed a tension system within the group that motivates the group toward accomplishing desired common goals. Lewin postulated that the desire for goal accomplishment motivates behavior—intrinsic motivation. Lewin's work in group dynamics coincided with his theories of conducting research in real settings, which he called action research (Lewin, 1946, 1947). Researchers (e.g., Kolb, 1984; Calhoun, 1994) have credited Lewin as the father of action research. Kolb stated, "Although the scope of his work has been vast, ranging from leadership and management style to mathematical contributions to social-science field theory, it is his work on group dynamics and the methodology of action research that have had the most far-reaching practical significance" (p. 8).

Morton Deutsch, one of Lewin's graduate students, was the first to formulate the social interdependence theory in the 1940s (Johnson et al., 1998). Deutsch (1949, 1962) theorized that a group of people may have interrelated intrinsic tension systems and formulated a theory of cooperation and competition. He categorized the types of interdependence as either positive, negative, or nonexistent. Deutsch's initial work during the late 1940s involved studying university classrooms and essentially started the cooperative learning research movement that continues today.

David Johnson, one of Deutsch's graduate students (Johnson et al., 1998), and his brother Roger Johnson, began studying cooperative learning with children during the late 1960s. During the 1970s, Johnson and Johnson refined the theories of interdependence and pioneered cooperative learning research in the primary and secondary school levels. Through their research, Johnson and Johnson further categorized the goal structures of learning environments as either cooperative (positive interdependence), competitive (negative interdependence), or individualistic (zero interdependence). The type of interdependence determines how people interact, which determines outcomes. Positive interdependence results in promotive interaction, during which people help one another learn. Negative interdependence results in oppositional interaction, during which people hinder one another's efforts. Without interdependence, there is no interaction and people work independent of one another (Johnson et al., 1998). Most research in cooperative learning has focused on the goal structures of social interdependence (Johnson & Johnson, 1989; Johnson, Johnson, & Smith, 1991; Johnson, Johnson, & Stanne, 2000)

Cognitive–developmental Learning Theory

The stance of the cognitive-developmental learning theory is that cooperation is necessary for cognitive growth. An individual's cognitive growth results from the coordination of perspectives within a group to reach common goals (Johnson et al., 1998). Jean Piaget found that cooperation generates healthy socio-cognitive conflict within a group and creates cognitive disequilibrium. The disequilibrium increases a person's perspective-taking ability and cognitive development (Johnson et al., 1998). However, Piaget also believed that a person's motives toward cooperation vary with age. According to Sprinthall and Sprinthall (1990), "Piaget tells us that young children are limited in their capacity to cooperate because of *egocentricity*—the inability to take another person's point of view" (p. 535). As people grow cognitively, the ability to cooperate becomes possible.

Lev Vygotsky (1962, 1978) developed a general theory of cognitive development—social development theory, in which he postulated that full cognitive development requires social interaction. He believed that cooperative efforts were necessary for constructing knowledge to learn, understand, and solve problems. Kolb (1984) attributed Vygotsky as the first theorist to connect human development to learning from experience (p. xi). Lave (Lave & Wenger, 1990), in his situated learning theory, also believed that learning requires social interaction and collaboration.

Behavioral Learning Theory

B. F. Skinner's work on group contingencies in the mid 1900s provided a basis for behavioral learning theory. Behavioral learning theory posits that individuals will work hard on tasks that result in rewards, and will not work or "fail to work" (Johnson et al., 1998) on tasks that have no rewards or result in negative reinforcement. Cooperative learning efforts are designed to provide either group or individual incentives for participating in the group's efforts (e.g., Johnson & Johnson, 1991; Slavin, 1983). Deutsch's (1949, 1962) theories on interrelated intrinsic motivation among group members also relate to behavioral learning theory because the interrelated motivations generate extrinsic motivation within an individual.

Research on Cooperative Learning

Research on cooperation, i.e., children working together, in schools started in the early part of the 20^{th} century (Maller, 1929/1972). However, research on cooperative learning strategies in the classroom did not appear until the 1970s (Slavin, 1999). Slavin (1999) stated that cooperative learning was "almost unknown in the mid-1970s" (p.74).

Cooperative learning is one of the major learning goal structures in the classroom. Johnson, Johnson, and Smith (1991) defined a *learning goal* as "a desired future state of demonstrating competence or mastery in the subject area being studied." They defined *goal structures* as "ways in which students will interact with each other and the teacher during the instructional session" (p. 1:15). The authors also used the term *student-student interaction* synonymously with the term *goal structure* (p. 1:14).

A meta-analysis by Johnson, Maruyama, Johnson, Nelson, and Skon (1981) revealed four goal structures pervasive within education: cooperative, cooperation with intergroup competition, competitive, and individualistic. They defined *cooperative* situations as those situations in which the separate individuals can obtain his/her goals if, and only if, the other participants obtain their goals. People in cooperative situations seek mutually beneficial outcomes for all persons involved. *Cooperation with intergroup competition* is a related concept in that the cooperation occurs within a group, and the competition occurs among the various groups within the classroom. (In later publications, Johnson et al. do not discuss this as a separate structure, and rather include it within cooperative goal structures as a whole.) In *competitive* situations, individuals can only obtain their goals if, and only if, the other participants cannot obtain their goals. A person seeks outcomes that are personally beneficial, yet detrimental to the others. *Individualistic* learning situations are those environments in which the outcomes of individual student goals are not dependent upon whether or not other students achieve their goals. Students working individually seek outcomes that are personally beneficial, ignoring the goal achievement efforts of other students. (pp. 47-48.)

Lew, Mesch, Johnson, and Johnson (1986) stated that positive goal and positive reward interdependence are needed to increase achievement and interpersonal skills in children. Even though Lew et al. found that school children need to embrace both of these constructs in order to increase their achievement and interpersonal skills, there are researchers who disagree on which is the mediating factor between cooperation and achievement.

Deutsch (1962) and Johnson and Johnson (1975) believed that positive goal interdependence promoted positive social interaction, which resulted in higher achievement and better interpersonal relationships. Researchers such as Hays (1976) and Slavin (1983) believed that positive reward interdependence was the mediating factor because students will increase their achievement only if there are specific group and collaborative skills contingencies reinforcing them in doing so.

Lew et al. (1986) believed that one can implement positive goal interdependence without positive reward interdependence, but not vice versa. “For group members to be motivated by a group contingency, they must perceive that their goal accomplishments are positively interdependent” (p. 477).

Lew et al. (1986) cited research indicating that “difficulty with peer relationships during childhood and adolescence has been linked to later development problems in such diverse realms such as academic achievement, antisocial behavior, psychological disturbance, and physical health” (p. 477). Consequently, if children do not develop cooperative skills, then as young adults (and older adults) they could lack the necessary socialization skills to succeed in college or the world of work. The idea behind this was that:

> Within competitive and individualistic learning situations, legitimate opportunity to work with peers is infrequent and, therefore, the peer interaction that does occur is often in violation of the rules and is perceived to be disruptive. Within cooperative learning situations, however, students are required to interact constructively with one another and to use collaborative social skills. (p. 478)

Johnson et al. (1998) described the culture and reward systems primarily used in society in general and colleges specifically as oriented toward competitive and individualistic work. Students historically entered college with an understanding of class rank and norm-referenced evaluations and no knowledge of how to work cooperatively with others. Bransford, Brown, and Cocking (2000) outlined the importance of using cooperative groups in order to help transfer knowledge between school and everyday life. Bransford et al. cited research (e.g., Resnick, 1987) that “one major contrast between everyday settings and school environments is that the latter place much more emphasis on individual work than most other environments” (p. 74). The authors then provided examples from research of everyday life scenarios (ship piloting, genetics research, hospital emergencies) where collaboration was necessary to perform defining tasks (p. 74).

Over 750 studies compared the effectiveness of cooperative, competitive, and individualistic learning from 1897 to 2004. Eighty five percent of these studies occurred since 1970, and 41% of the studies investigated participants who were 19 or older (Smith, Sheppard, Johnson, & Johnson, 2005). The research history on the relative impacts of these learning environments formed what Johnson, Johnson, and Smith (1998) considered “the longest-standing research tradition in American social psychology” (p. 30). Several other meta-analyses that investigated the three learning goal structures (e.g., Johnson, Maruyama, Johnson, Nelson, and Skon, 1981; Johnson and Johnson, 1989; Slavin, 1983) have shown the dominance cooperative learning effects have over the other structures in terms of student achievement, self-esteem, gender and ethnic relations, and motivation. As a result of the significant benefits cooperative learning has shown through decades of research, Slavin (1999) characterized cooperative learning as “one of the greatest success stories in the history of educational innovation” (p. 74).

Meta-analyses

Cooperative Learning Domain

Johnson, Maruyma, Johnson, Nelson, and Skon (1981) and Slavin (1983) conducted meta-analyses of cooperative learning research and reached three major conclusions. First, cooperative learning fosters higher achievement gains than competitive and individual learning. Second, cooperative learning structures promote higher levels of self-esteem, satisfaction with school, positive gender and race relations, and general feelings of worth and approval by others. And third, these results hold true for all grade levels, age groups, and subject matter.

Johnson et al. (1981) conducted a meta-analysis of cooperative learning research that dealt with social interdependence and achievement. Their meta-analysis reviewed 122 cooperative learning studies published between 1924 and 1981. Specifically, they reviewed “every study that (a) was available to [them], (b) was conducted on North American samples, (c) contained achievement or performance data, and (d) compared two or more of the four goal structures: cooperation, cooperation with intergroup competition, interpersonal competition, and individualistic effort” (p. 49). One of the main purposes of their meta-analysis was to settle controversies and contradictory conclusions generated by previous independent research in and research reviews about cooperative learning. “The best methodology for such a purpose is meta-analysis, which examines the magnitude of any differences between conditions as well as the probability of finding such differences” (p. 49). The major results of their analysis follow.

Johnson et al. (1981) provided six major results from their meta-analysis procedures. First, they found no real difference (effect size of .00) in student achievement between the two methods of structuring cooperative learning activities, cooperation among individuations and intragroup cooperation (i.e., cooperation with intergroup competition). Second, cooperation promoted higher achievement than competition among students, with an effect size of .78 favoring cooperation. Third, the authors’ data showed some superiority (effect size of .37) of intergroup cooperation over interpersonal competition. Fourth, with another large effect size (.78), cooperation promoted higher achievement than individualistic learning. Fifth, a medium effect size (.50) indicated that intergroup cooperation promoted higher achievement than individualistic learning. Combining the five previous findings revealed a mean effect size of .46 favoring cooperation. Finally, the authors found no significant differences between competitive and individualistic learning achievement. The authors noted that even though their results showed the relative efficacy of the four goal structures on achievement, they needed (and future researchers need) to identify and examine the mediating or moderating variables that influenced the findings.

Johnson et al. (1981) discussed several of the mediating or moderating variables they identified in their meta-analysis. They described the effects of grade level or age of research participants, year of study, size of cooperative groups, setting of the study, course subject areas, type of task, type of response, and quality of journal that published the research. The authors suggested further research in these areas. Slavin (1983) made a similar recommendation.

College Studies

Slavin (1996) stated there was a need for more research on all learning goal structures and their outcomes in college and adult learning settings. Springer, Stanne, and Donovan (1999) reiterated that need when they found that "few investigations [in cooperative learning] have focused on college students outside the psychology laboratory" (p. 23).

Between 1970 and 1999, approximately 77% of cooperative learning research that investigated student achievement was conducted at the primary and secondary school levels. Less than 24% of the research during the same time period focused on achievement of college and adult learners (Johnson, Johnson, & Stanne, 2000).

Johnson, Johnson, and Smith (1998) found over 300 studies conducted between 1924 and 1997 that compared the effects of cooperative, individualistic, and competitive learning systems on individual student achievement in college and adult learning settings. Approximately 55% of the studies investigated the effects of all three learning goals on the achievement of students 18 years or older (p. 31). The results of the Johnson et al. (1998) meta-analysis indicated that these studies showed cooperative learning approaches promoted higher individual achievement than individualistic and competitive approaches, with effect sizes of 0.53 and 0.49 respectively. The authors considered these effect sizes as indicators of "significant, substantial increases in achievement" (p. 31). Cohen (1969) defined *medium effect size* as "one large enough to be visible to the naked eye" (p. 24) and suggested a baseline medium effect size of 0.5 "when no better basis for the ES index is available" (p. 23). Therefore, the Johnson et al. meta-analysis of college and adult learning classrooms showed a medium effect size in achievement gains when cooperative learning methods were used in the classrooms. Though significant, these data are slightly lower than the 1981 meta-analysis effect sizes for cooperative learning achievement gains across all age groups. One may be able to attribute that difference mainly to the proportion of the research on college and adult learning classrooms versus those in primary and secondary classrooms.

The results from the Johnson et al. (1998) analysis were consistent with a similar meta-analysis conducted by Springer, Stanne, and Donovan (1999) on undergraduate students in science, technology, engineering, and mathematics students (STEM).

Case Study

Fiechtner and Davis (1984-1985) surveyed a sample of college students enrolled in "upper-division speech communication and business policy courses at two major southwestern universities" (p. 60). The survey contained questions about the students' classroom group experiences in their college classes up to that time. Students reported their experiences as either a "best experience" or "worst experience." The findings provided some insight on how college students perceived working in groups on class assignments. The data the authors provided covered areas such as group structuring, types of activities, in-class vs. out-of class assignments, and grading methods employed. A summary of these data follows.

From the Fiechtner and Davis (1984-1985) survey, students (78%) indicated more positive group experiences in classes when instructors formed the groups. Along those same lines, the data showed by a nearly 2:1 margin that if students picked their own groups they were likely to list the group as being a "worst group experience." When forming groups, the authors supported the use of heterogeneous groups in cooperative learning tasks. "….[W]e strongly advocate the use of permanent, heterogeneous groups formed by the instructor." (p.62)

Regarding group size, Fiechtner and Davis (1984-1985) stated, "...there were minimal differences between the worst and best group experiences." However, students complained about how larger groups created logistical problems for arranging meeting times outside of class time. Even with these and similar data, the authors concluded, "…four to seven member groups do very well, while smaller groups often lack resources and larger groups have difficulty maintaining cohesiveness" (p. 61). Unfortunately, the authors did not qualify this conclusion with any information about the types of tasks the various groups (and group sizes) performed. One should not read their statement as meaning the best cooperative group sizes include four to seven members. However, the authors did discuss the type and number of graded group activities.

Fiechtner and Davis (1984-1985) found that the "type and number of graded group activities made a significant difference in students' perception [sic] of the learning process" (p.61). The types of learning activities included research projects, class presentations, written reports, and group exams. The authors found that an increase in the number of these types of graded group activities produced different effects.

An increase in the number of research projects did not affect students' perceptions of their group experiences. The number of class presentations, though, did show an effect. Students were more likely to report a "best group experience" when the instructors either did not require a group presentation or only required one presentation. However, students reported "worst experiences" when the instructor required two or more presentations. The data were similar for written reports. At the other end of the spectrum, the data for group exams showed that "an *increas*e in the number of group exams greatly enhanced the probability that students would report a *best* group experience" (p.62).

Even with these variations, students indicated that having too few graded group assignments was detrimental to the cooperative learning process. Fiechtner and Davis admitted that "these findings appear to present a dilemma in deciding how many and what kind of graded group activities to employ" (p. 62). Students needed enough group activities in order to develop cohesive groups, yet too many group activities produced negative results.

Fiechtner and Davis (1984-1985) also found that when more class time was devoted to group work, students spent more time working together outside of class, which increased group cohesiveness and, thus, created more positive group experiences. A majority of the students in their study reported best group experiences when the group work accounted for more than 20% of the course grade, and the margin was even higher when the group work accounted for between 41% and 80% of the course grade. Additionally, three out of five students reported best group experiences when instructors used peer evaluations to determine individual grades and between 21% and 40% of the course grade. The authors cautioned, though, that if peer evaluations accounted for too much of the grade (61%), the impact of peer evaluations would be negative. (p. 65)

Visualization Ability

Textbook authors (e.g., Bertoline and Wiebe, 2005; Giesecke, Mitchell, Spencer, Hill, and Dygdon, 1986) in the technical graphics and computer-aided drafting (CAD) fields have stated that engineers and CAD operators need to have high levels of spatial visualization skills in order to be successful. Researchers (e.g., Kolb, 1984) have linked visualization ability with success in school and the workplace.

Bertoline and Wiebe (2005) believed that the ability to visualize and communicate problem solutions was one of the most important skills for professional engineers (p. 6). The authors stated, “As computer graphics have a greater impact in the field of engineering, engineers will need an ever-growing understanding of and facility in graphics communication” (p.4).

Researchers (e.g., Bodner and Guay, 1997; Hsi, Lin, and Bell, 1997) have concluded that students with high visualization ability achieve higher than students with low visualization ability. Bodner and Guay (1997) found that college students with high spatial abilities achieve higher in chemistry and biochemistry. Their research led to their development of a battery of visualization tests, among which was the Purdue Visualization Test of Rotations (ROT).

Hsi, Linn, and Bell (1997, April) found a significant correlation between spatial visualization skills and course performance in an introductory engineering graphics course. Students who earned high grades in the course also had high spatial ability scores. Students with lower course grades had lower spatial ability scores.

Learning Styles

Learning style theories have been adopted at all levels of education and industry. Theories by Kolb (1983) and McCarthy (1987) are pervasive in primary and secondary education circles, and the theory developed by Felder and Silverman (1988) is apparent in college engineering education.

Kolb (1984) attributed his own theories of experiential learning to research by Dewey, Lewin, Piaget, and Vygotsky. Kolb’s research focused on adults in various career fields and management positions, yet he also collaborated with researchers in primary and secondary education. Kolb theorized from his research that experiential learning shapes individual learning styles. Among the results from his studies, Kolb found that people with strengths and preferences in visual learning gravitate to college majors and career fields that require visual skills and work in the physical environment (pp. 85 - 92). Kolb concluded,

> What these data show is that one's undergraduate education is a major factor in the development of his or her learning style. Whether this is because people are shaped by the fields they enter or because of the selection processes that put people into and out of disciplines is an open question at this point. Most probably, both factors are operating—people choose fields that are consistent with their learning styles and are further shaped to fit the learning norms of their field once they are in it. When there is a mismatch between the field's learning norms and the individual's learning style, people will either change or leave the field. (p. 88)

McCarthy (1987) based the four dimensions of learning of her 4MAT learning styles system on Kolb's (1984) work. McCarthy generalized her theories mainly to children.

Felder and Silverman (1988) adapted theories by Kolb and others into an engineering education context. Subsequently, Soloman and Felder (1997, 2006) developed the Soloman-Felder *Index of Learning Styles* (ILS) for use by engineering faculty and students. Colleges of engineering throughout the world regularly use the ILS (Felder, 2006). Past research (e.g., Felder and Spurlin, 2005; Litzinger, Lee, Wise, and Felder, 2005) with the ILS has found that engineering students tend to be highly visual learners.

Litzinger et al. (2005) used the ILS to study the learning style preferences of students enrolled in colleges of engineering, education, and liberal arts at a large university. The results indicated that, on average, all the students in the study characterized their learning as sequential, sensing, and visual. Engineering students were more extreme along these preferences, however. These extreme preferences by engineering students were consistent in similar studies (e.g., see Felder & Spurlin, 2005).

In the same study, Litzinger et al. (2005) found that female engineering students were significantly more sequential, more sensing, and less visual than male engineering students. However, the researchers cautioned that the significant difference may not be substantial enough to be of practical importance. They also noted that their study was the first to show significant gender differences in learning style preference as measured by the ILS and recommended further study in the area.

Chapter 3: Research Methodology

Research Design

The instructor-researcher used quasi-experimental and qualitative methods for this study. The research design was a counterbalanced, repeated measures, nonequivalent control group design. Data collection involved quantitative data from assessments and qualitative data from surveys and interviews. The population studied consisted of two intact sections (classes) of a university-level CAD course in an engineering education department. The researcher was also the instructor for both course sections.

Since the researcher could not randomly assign the research participants (students) to the course sections, the possibility existed that the two groups were not equivalent in pre-existing ability level (knowledge of the CAD software used in the course) and in other ways. Therefore, the ramifications of a nonequivalent control group design were important considerations throughout the research. The researcher decided to use the nonequivalent control group design for this study because of his desire to study intact classes, time limitations for selecting research participants for another design, and the lengthy process and university procedures needed to create separate course sections and to assign students randomly to either a semester-long treatment or control section.

Cook and Campbell (1979) and Trochim (2006) considered the nonequivalent control group design the most popular quasi-experimental design in social science research. Cook and Campbell recommended it for “situations where nothing better is available” (p. 104). This particular design required random assignment of the treatment to either of the course sections in order to increase the strength of the design.

The possibility that the two groups were nonequivalent necessitated that both groups complete a pretest (Campbell & Stanley, 1963; Cook & Campbell, 1979; Pehazur & Schmelkin, 1991). In this study, pretest scores served as a baseline measurement of participants’ knowledge of the subject matter. Two other instruments, a test of visualization ability and a learning style inventory, were used as attempts to adjust for potential differences along those constructs between the two groups. For this study, the pretest also served as a component of repeated measures.

The repeated measures within the study came in two forms, tests and assignments. All of the participants completed three tests, a pretest and two posttests. The three tests were different from each other. However, half of the pretest consisted of material representative of the first posttest (hereafter, posttest 1) content and the other half of the pretest represented material on the second posttest (hereafter, posttest 2).

Performance on drawing assignments was also part of the data collection. During the first half of the semester, students in both treatment and control groups completed two drawings per week for the first three weeks and one drawing per week for the next two weeks. During the second half of the semester, students completed one drawing over the course of two weeks; one drawing that took one week to complete; and a two week long project. The research treatment, though, involved students completing the assignment in pairs.

Both sections of the course received the treatment at different times, hence the use of the term *counterbalanced* in the research design. The nature of the counterbalanced design involved randomly assigning the treatment to one of the course sections for the first half of the semester and using the other section as a control group. Immediately after the first exam (posttest 1), the treatment and control conditions switched course sections. For the remainder of the semester, the original treatment group served as the control group and the original control group served as the treatment group.

Campbell and Stanley (1963) and Isaac and Michael (1995) described counterbalanced designs in terms of multiple treatments and multiple groups receiving the treatments. However, Trochim's (2006) *switching replications design* was an exact match to the design used in this study. Researchers have used other terms for this design. For example, McCall (1923) used the term *rotation experiments*, Kempthorne (1952) employed the phrase *switch-over design*, and Cochran and Cox (1957) and Cox (1958) liked the term *cross-over designs*. *Latin-square designs* commonly appeared in selected older texts (e.g., Campbell and Stanley, 1963; Winer, 1971) and newer texts (e.g., Cardinal and Aitken, 2006; Cohen and Lea, 2004) about research design and analysis. However, the term *counterbalanced* was the most frequently used modern term for this particular design.

Internal and External Validity of the Research Design

This research design had characteristics of both a nonequivalent control group design and a counterbalanced design. The nonequivalent control group design aspect had inherent strengths. Isaac and Michael (1995) stated that the internal validity of the nonequivalent control group design was "fairly satisfactory if groups have similar means and standard deviations on [the] pretest" (p. 76). Campbell and Stanley (1963) stated that if the treatment and control groups were similar based on proper recruitment, and the similarity was confirmed by pretest scores, then one can regard the nonequivalent control group design "….as controlling the main effects of history, maturation, testing, and instrumentation…" (p. 48). Isaac and Michael extended this viewpoint in that the use of a control group "insures against making effects of history, pretesting, maturation, and instrumentation, for the main-effects of *X*" (p. 76).

Trochim (2006) cautioned that the nonequivalent control group design was "especially susceptible to the internal validity threat of selection." Huck, Cormier, and Bounds (1974) stated that "selection is always a problem for this design" (p. 304). Isaac and Michael (1995) similarly stated that the main threats to internal validity within a nonequivalent control group design could come from selection-maturation, selection-history, or selection-testing interactions. Since the researcher could not initially randomize the research participants to the course sections, the potential existed for "some critical difference" between the groups to "contaminate the posttest data" (p. 77). The pretest and other instruments adjusted for some of these critical differences.

Some of the possible threats to internal validity in a nonequivalent control group design were not an issue due to other characteristics of the research methodology. For example, the *selection-history* extraneous variable was not a concern in this study. The researcher selected intact groups from an existing course. There were only two sections of the course. The university limited the two sections to only selected engineering majors, and these students needed to meet or exceed a grade in a prerequisite course. As a result of the enrollment restrictions, the researcher assumed the research participants were homogenous in composition. Pehazur and Schmelkin (1991) believed it "plausible to assume that history was controlled when intact groups are selected from the same setting" (p. 282). Even with possible threats to internal validity, the research design for this study was not strictly a pure nonequivalent control group design.

Characteristics of the counterbalanced design aspect of this study controlled some of the weaknesses of the nonequivalent control group design. Trochim (2006) stated that the counterbalanced design is "very strong with respect to internal validity." He also stated that since the design allows for multiple independent implementations of the treatment, "it may enhance external validity or generalizability." Isaac and Michael (1995) stated that a counterbalanced design controls for the "critical differences" that could exist due to the nonrandom assignment of participants. The authors stated,

> The Counterbalanced Design rotates out these subjects' differences by exposing all variations of *X* to all groups, at the same time controlling for order-of-presentation effects. If one group happens to be more intelligent than the others, each *X* will profit from this superiority. (p. 78)

Similarly, Campbell and Stanley (1963) believed that by exposing all research participants (or settings) to all treatments "experimental control is achieved or precision enhanced" (p. 50). Correspondingly, they indicated that a counterbalanced design controls for most sources of internal validity—history, maturation, testing, instrumentation, regression to the mean, selection, and mortality (p.40). Even with the strengths of the counterbalanced design, the researcher needed to consider all potential threats to internal and external validity of the research design.

Campbell and Stanley (1963) and Isaac and Michael (1995) cautioned that possible interactions of factors influenced by the nonrandom nature of the participant selection could affect the research findings. For example, a selection-maturation interaction could occur if group performance declined drastically during a treatment. Due to the nature of this study, the researcher could not predict interactions among extraneous variables and interactions between the treatment and extraneous variables. The researcher assessed possible interactions after conducting the study and analyzing the data.

Isaac and Michael (1995) warned that the "primary weakness" of the counterbalanced design was the possibility of carry-over effects, an external validity factor (p. 78). Similar social interaction effects were possible. During the research, the instructor-researcher needed to consider effects related to diffusion or imitation of treatment, compensatory rivalry, resentful demoralization, and compensatory equalization of treatment.

Students in the two sections more than likely knew one another. Therefore, they could have known about one another's learning situation (treatment or control) during that half of the semester, could have helped one another when they were not supposed to help one another, etc. This diffusion or imitation of treatment was a possible factor for the researcher to consider during data analysis.

Another possible issue was compensatory rivalry. This could have occurred when people in the control group worked harder to do a better job in order to compete with the treatment group. As a result, the researcher also needed to consider this during the analysis of the treatment outcomes.

Resentful demoralization, the opposite of compensatory rivalry, was another potential concern. Since the control group knew about the treatment given to the other group, the control group may have gotten discouraged or angry about not receiving the treatment at the same time. They may have given up or performed much more poorly. As a result, treatment effects could have been greatly exaggerated. The researcher was especially concerned about resentful demoralization during the second half of the semester when the course content became more complex.

Compensatory equalization of treatment was not an issue because instruction during class time for both treatment and control groups was the same. The instructor-researcher taught both course sections the same way, covered the same content during class, and graded consistently between the two sections. However, the nature of the treatment was not based solely on what happened during class. The main aspects of the treatment occurred outside of class.

The counterbalanced design had inherent strengths with respect to internal validity as discussed previously. The researcher could not assess threats to internal validity nor could he assess possible threats to external validity until the data analysis phase of the research. Trochim (2006) provided an overarching warning for any educational research in which students serve as research participants: "….[W]e will never be able to entirely eliminate the possibility that human interactions are making it more difficult for us to assess cause-effect relationships." Even with possible threats to internal and external validity due to the characteristics of the research design and the nature of human interactions, Trochim believed that the counterbalanced design was "probably one of the most ethically feasible quasi-experiments" because all research participants received the treatment.

Gleaning from Campbell and Stanley (1963), Cook and Campbell (1979), Pedhazur and Schmelkin (1991), and Trochim (2002), the instructor-researcher developed the following notational model of the research design discussed above:

$$\begin{array}{ccccc} O_1 & X & O_2 & & O_3 \\ \hline O_1 & & O_2 & X & O_3 \end{array}$$

Figure 1. Notation of research design.

In Figure 1, *X* represents the treatment, *O* represents an observation, and the number subscripts represent the sequential order of observations. Each row represents a course section. The dashed line signifies the nonrandom composition of the two groups. O_1 is the pretest, O_2 is posttest 1, and O_3 is posttest 2. The *O*s line up vertically because the observations occur at the same time. Similarly, when one group receives the treatment (*X*), the other group does not receive a treatment. The research progresses from left to right in the model.

Population

The population in this study consisted of all students enrolled in the two sections of a one-credit CAD course in an engineering education department during the Fall 2006 semester at a large university in the Mid-Atlantic region of the U.S. (N=122). Students majored in either Industrial and Systems Engineering (ISE) or Biological Systems Engineering (BSE). Both the ISE and BSE departments planned for their students to take this course during the first semester of their second year as a major in their respective departments. However, the academic levels of the participants in this study included sophomore, junior, and senior. Their years as engineering majors included second-year, third-year, and fourth-year. Other demographic data collected, such as gender, race, prior experience with the software used, GPA, and prerequisite grade, appear in the next chapter.

Research Hypotheses

The purpose of this research was to determine if students who learned CAD cooperatively achieved higher than students who learned CAD individually. Based on the literature, visualization ability and learning style were appropriate variables to consider as factors affecting CAD achievement.

The following research hypotheses guided this study:

Hypothesis 1: Both the cooperative and individualistic learning methods result in approximately equal participant achievement.

Hypothesis 2: Participants in the various levels of each selected demographic variable (major, academic year, number of years as an engineering major, gender, race, prior experience with the CAD software, prerequisite grade, and grade point average) achieve approximately equally.

Hypothesis 3: All research participants achieve approximately equally well on each administration of the repeated measures.

Hypothesis 4: The research participants in each learning method group have an approximately identical achievement pattern over the repeated measures.

Hypothesis 5: The achievement pattern is approximately identical for the number of participants of each level of a selected demographic variable across the repeated measures.

Hypothesis 6: The difference in achievement (averaged across repeated measures) of participants from each level of a selected demographic variable is approximately the same magnitude within each of the two learning methods.

Hypothesis 7: The achievement on one of the repeated measures for any subgroup of participants is approximately equally influenced by the unique combination of the selected demographic variable, the learning method, and the specific time of the repeated measure.

Independent Variables

Learning Method

Learning method was the primary independent variable in this study. The learning methods used in this study were cooperative learning and individualistic learning. Cooperative learning served as the treatment condition. Because students typically worked individually during this course in the past, cooperative learning served as an "alternative" method for this study. Individualistic learning served as the control condition. Education-related literature typically considered individualistic learning as a "traditional" teaching method.

The constructs identified in this study's working definition of cooperative learning provided by Johnson and Johnson (2006) included positive interdependence, individual accountability, interpersonal skills, face-to-face promotive interaction, and group processing. These constructs served as guides for structuring the treatment conditions and are described below in the context of this study.

First, positive interdependence was exhibited by the use of group homework grades. Second, individual accountability was manifested by the use of weighted individual grades (in addition to the group grades) based on the level of group member participation. Also, participants completed the tests individually as a measure of individual achievement resulting from the group experience. Individual accountability was also demonstrated by the individual roles of the group members—each group member had a specific role to fulfill during the group experience. Third, the aforementioned role-playing also helped participants with their interpersonal skills. The necessary interpersonal skills for successful cooperative efforts were discussed in class several times during each treatment, and the same information was provided in lesson slides that students could reference at any time (see Appendix K). Fourth, participants exhibited face-to-face promotive interaction when they worked together in person. The role-playing the participants performed fostered the promotive interaction, which was also related to positive interdependence because of the group homework grades. Finally, group processing was manifested by the use of weekly peer rating forms. There were questions on the form that asked participants to specifically describe how they worked together, how much time they spent together working and studying, what they thought they did well together, and what they thought they needed to improve the next time that they worked together. Additionally, written feedback from the instructor on the weekly drawing assignments was also used for group processing.

Though learning method served as the independent variable, the researcher considered several factors that could explain student achievement in CAD. Described below, these factors did not play roles in the research design; i.e., the researcher did not use them as controls for assigning participants to treatments or control groups. However, the researcher considered the factors—visualization ability, learning style, and selected demographic variables—as covariates in the data analysis procedures.

Visualization Abilities—*The Purdue Visualization of Rotations Test*

The researcher investigated visualization ability as a possible explanatory factor. Bodner and Guay's (1997) *The Purdue Visualization of Rotations Test* (ROT) was used to measure the research participants' spatial abilities. The research participants completed the free, printed version of the ROT for this study (see Appendix A).

Through several studies of college students, Bodner and Guay calculated an average Kuder-Richardson 20 (KR-20) reliability coefficient of 0.79 and an average split-half reliability coefficient of 0.82. Several similar studies conducted by graduate students at Purdue (e.g., Carter, 1984; LaRussa, 1985; McMillen, 1983; Pribyl, 1984) found similar means and standard deviations as Bodner and Guay found.

Guay and McDaniel (1978) and Guay, McDaniel, and Angelo (1978) studied the ROT's construct validity. Guay and McDaniel compared the ROT with four other visualization instruments. They found that the two most highly correlated (r = .061, p < .001) instruments were the ROT and the Shepard-Metzler Rotations (S-M) test adapted by Vandenberg (1975) for group testing. The ROT was least correlated (r = .025, p < .01) with the Revised Minnesota Paper Form Board (MPFB) test. Guay, McDaniel, and Angelo found that test takers were least likely to perform confounding analytical processing tasks on the ROT and S-M tests, than on the MPFB. Analytical processing involves test takers breaking down entities into individual parts and then processing the relationships among the parts into one-to-one relationships. The ROT requires holistic or gestalt processing, which involves forming and transforming mental images as organized wholes. Researchers have widely accepted that gestalt processing is the key component of spatial ability (Bodner & Guay, 1997; Michael, Guilford, Fruchter, & Zimmerman, 1957; Smith, 1964; Spearman & Jones, 1950).

Learning Styles—Soloman-Felder *Index of Learning Styles*

The researcher also studied learning style as a possible explanatory factor. The Soloman-Felder *Index of Learning Styles* (ILS) (Felder, 2006) was used to categorize research participants' learning style preferences. The researcher asked the research participants to complete the free, web-based version of the ILS for this study (see Appendix B).

Livesay, Dee, Nauman, and Hites (2002); Seery, Gaughran, and Waldmann (2003); and Zywno (2003) found 0.70, 0.80, and 0.59 test-retest reliability scores for the ILS's four learning style dimensions (averaged together), respectively. Litzinger, Lee, Wise, and Felder (2005); Livesay et al. (2002); Spurlin (2002); van Zwanenberg, Wilkinson, and Anderson (2000); and Zywno (2003) found 0.67, 0.61, 0.66, 0.53, and 0.62 internal consistency reliabilities for the ILS's four learning style dimensions (averaged together), respectively.

Felder and Spurlin (2005) reported the results from 16 studies that investigated the learning style preferences (as measured by the ILS) of students at 10 universities. The authors of those published studies found distinct, consistent, predictable differences between engineering student's learning styles and those in other college majors (p. 110). The results of those studies supported the ILS's construct validity.

Answers to Interview Questions

The researcher conducted interviews with three pairs of students from each treatment group. These pairs represented three achievement levels ("A" group grades, "B" group grades, and "C" or lower group grades) after they worked together for two weeks. Each interviewee participated in one separate, individual interview during his/her respective treatment. At the end of each treatment, the researcher interviewed each of the pairs. Individual and group answers to the interview questions helped to explain individual and group successes or failures in achievement. The researcher developed the questions based on prior experience in the course, the nature of the assignments, the structure of the cooperative learning, and feedback from selected university faculty members. Recommendations by Ely, Anzul, Friedman, Garner, and Steinmetz (1991) and Silverman (1993) served as guidelines for the researcher in the development and structure of the interviews and interview questions. The researcher refined the interview questions prior to conducting this study after conducting pilot interviews the previous semester. (See Appendix C for the interview protocol.)

Demographic Data

The researcher developed a survey similar to the one used by Kaufman, Felder, and Fuller (2000) to explore demographic variables as explanatory factors in this study. Recommendations by Suskie (1996) guided the development of the survey instrument. Discussions about race and ethnicity in the U.S. Census Bureau (2006) website outlined the race categories used on the survey instrument. The other demographic data consisted of major, gender, age, academic level, years as engineering major, grade point average (GPA), and prior experience with the software covered in the course. After selected professors from the researcher's dissertation committee provided feedback about the types and wording of survey questions, the researcher modified the instrument into its final form during the spring of 2006. Research participants completed the survey on the first day of class of the fall semester. (See Appendix D for the survey.)

Dependent Variable and Instrumentation

Achievement was the dependent variable in this study. Measures of achievement included posttests and weekly assignment grades. A pretest implemented at the beginning of the semester served as a baseline measurement of the research participants' course content knowledge in the data analysis. The pretest content was representative of the content in the subsequent posttests. Half of the pretest content represented posttest 1 and the other half represented posttest 2.

Posttest 1 was the mid-term exam, which tested students on material from the first half of the semester. This was basically an assessment of participants' achievement gains during the first treatment-control phase of the counterbalanced design.

The final exam served as posttest 2 and tested students on material from the second half of the semester. It served as an assessment of participants' achievement gains during the second treatment-control phase of the counterbalanced design.

The researcher followed a content validity procedure for the pretest and both posttests similar to that described by Rubio, Berg-Weger, Tebb, Lee, and Rauch (2003). Three faculty members at two universities who had extensive experience teaching and using the CAD software used in this course agreed to participate in the validation process. In a Microsoft Word file, each member of the validation team scored each test question based on the degree to which it represented the course content domain and the clarity of the question wording. The reviewers had the option to provide comments or suggestions after each question. A separate file (Adobe PDF format) that contained excerpts from the course syllabus describing the goals, objectives, and weekly lecture topics for the course was provided as a reference. All three reviews were returned within four weeks. (See Appendix E for the instructions and samples from the question pool and ratings form.)

After receiving all three evaluations, the researcher analyzed the data from the forms. First, the researcher created a Microsoft Excel spreadsheet for the question ratings and added the scores to the spreadsheet. Related to the scoring method Rubio et al. (2003) used, two types of scores indicated the quality of the questions. First, the inter-rater agreement (IRA) for each question and the pool of questions indicated the reliability of the ratings by the experts. There were IRAs for both the representative and clarity ratings. IRAs for the individual questions helped isolate questions with problems. The IRA for the entire question pool indicated the overall quality of all the questions. The researcher assessed the entire pool together and the mid-term and final exam portions separately. Second, a content validity index (CVI) for each question and the entire question pool indicated how representative the questions were of the course content domain. Again, CVIs for the individual questions isolated good and bad questions; CVIs for the entire question pool and each half indicated how representative the questions were of the course content domain. Rubio et al. suggested using averages of 80% or higher as an indication of whether or not the questions were representative and clear. The researcher sought clarity from the experts on questions with low ratings or on comments they provided.

The researcher conducted one iteration of the content validity process and used the resulting set of questions as the question pool for developing the pretest and two posttests (mid-term and final exams). The question pool contained 119 questions. The first 58 questions represented content from the first half of the course semester. The remaining 61 questions represented content from the second half of the semester. Within both halves of the question pool was a core set of questions with either alternate forms or questions about related topics. The additional questions helped make the pool from which to draw the pretest questions. The researcher randomly selected 15 questions from the core set of questions in each half of the question pool. These 30 questions formed the pretest. The alternate forms of these questions and one of the questions from each of the remaining pairs or sets of questions formed the mid-term and final exams, posttest 1 and posttest 2 respectively. (See Appendix F for the final versions of each test.)

Similar questions to the ones validated for this study appeared on exams in previous semesters. The high reliability of those exam scores across multiple classes over two semesters led the researcher to believe that the questions consistently measured what they were measuring. Though there was no formal validation for those exam questions, the researcher generated those questions based on input from colleagues. Regarding the current research, measuring the reliability of the pretest and posttests was beyond the scope of this study.

Other measures of individual and group achievement included grades on homework drawings and a project. The first treatment and control groups completed eight homework drawings over a five week period. The first three assignments consisted of two drawings. The last two assignments required single drawings with more elements relative to each drawing during the first three weeks; the time commitment to complete a single drawing during the latter weeks was about the same as for completing two simpler drawings earlier in the semester.

The assignments during the last half of the semester included two homework drawings and a project drawing. The first homework drawing required a two week commitment. The second assignment included a drawing and a Microsoft Excel spreadsheet, and was due in one week. The project took two weeks to complete and also required a drawing and Microsoft Excel spreadsheet.

For the purpose of tracking achievement in the CAD assignments, the researcher needed to develop a grading system that removed potential bias in the instructor's grading. One assessment method the researcher considered was the use of a grading rubric. Typical rubrics, however, contain a certain element of relative subjectivity. In order to minimize subjectivity, the researcher developed unique rubrics for each CAD assignment. Each rubric identified each element of the CAD drawing (and other supplemental portions of an assignment, when necessary) and counted the characteristics of each element. Examples of element characteristics include size, location, layer, and linetype. The researcher used a special CAD software plug-in that allowed comparisons between two drawings at a time as an aid in determining the accuracy of a drawing.

For the purposes of this study, it was important not to penalize a single mistake twice. For example, it would be unfair to penalize a student for an incorrect angle of the hypotenuse of a right triangle when s/he incorrectly drew the height of the vertical leg of the triangle. Therefore, the researcher developed the rubrics so that potentially multiple mistakes would be penalized only once.

Even with this more objective grading method, some characteristics of a drawing had more point-value than others. This weighting was based on feedback from faculty members who either taught this course in the past or currently teach similar courses within the same department. Selected drawing characteristics that received more weight include plot scale, viewport scale, scale indicated in the title block, and plot quality. Additionally, students needed to submit both a plot of the drawing and the digital CAD file. The absence of either the plot or the CAD file resulted in half credit for the assignment. Based on all of these factors, the students received a percent score/grade on the material they submitted rather than a breakdown of every single element that the instructor-researcher used to assess the drawing. The graded assignments did contain typical comments and markings one would normally see on a drawing assignment.

Assessing the characteristics of each element within a drawing was important in order to eliminate potential instructor bias from determining student achievement in the CAD assignments. The unique rubrics for each assignment objectified the grading process for the CAD drawings, which then became consistent with the other objective instruments the instructor-researcher used in this study. (See Appendix G for all of the grading rubrics.)

The treatment groups received an additional grading element in their assignments. This additional element served as one of the factors leading to positive interdependence between the group members. Each student in a cooperative pair completed a weekly survey about his/her partner's contribution to the homework assignment completed that week. The researcher developed a peer rating system based on a design by Kaufman, Felder, and Fuller (2000) and a similar method used by Walker (2006). Each week, the researcher calculated and applied a group weighting factor to the group grade on the assignment to determine an individual's grade. Group grades appeared on the drawing, but individual grades appeared on-line. Both the group and individual grades were part of the data analysis. (See Appendix H for the peer rating form.)

Research Setting

Each course section (class) met once a week for 50 minutes. One class met every Tuesday afternoon and served as the initial control section the first half of the semester and as the treatment section the second half of the semester. This situation was reversed for the other class, which met Thursday afternoons. The treatment—students working in pairs—occurred outside of class.

The instructor-researcher chose the group size based on his knowledge of the technical subject matter, the complexity level of the assignments, the university recommended student time commitment to the course based on credit level, and the amount of time he believed was reasonable for a single student to complete each of the assignments. Also, based on responses from the piloted interview protocol from the previous semester, students indicated that dyads were the appropriate group size for these assignments. With all of the aforementioned information, the instructor-researcher decided that cooperative pairs would be the most effective groups to study—Groups larger than two would more than likely result in someone in the group not participating.

Lectures took place in a classroom with tiered seating and a capacity of 64 students; each class was limited to 64 students. The seating arrangement consisted of two columns of seats permanently affixed to the floor. Each row of seats shared a common table. Each student brought a laptop computer with the required software to class each week.

The instructor area at the front of the classroom consisted of a table with base cabinets and electrical outlets, a chalkboard extending the length of the classroom, a motorized projection screen, and a mobile overhead projector on a cart. A digital projection system hung from the ceiling in the middle of the classroom; the location of the connections for the digital projection system was by the instructor's station below the projection screen. The instructor-researcher presented lecture material and software demonstrations via a laptop computer and the digital projection system.

Students completed the surveys, exams, and Purdue ROT during class. They completed the Soloman-Felder ILS, homework assignments, and end-of-semester project outside of class. During the weekly lectures, students had opportunities to perform in-class practice of concepts related to the homework drawings.

Statement of Procedure

The researcher developed and pilot tested a demographic data collection instrument and an interview guide during the spring 2006 semester.

The researcher completed the test question pool for the three tests (pretest, posttest 1, and posttest 2) in early July 2006. Three content experts participated in the content validity study of the test questions, ending in early August 2006. Following a procedure used by Rubio et al.

(2003), the researcher analyzed the responses provided by the validation team and made necessary adjustments to the test questions. Prior to the start of the fall semester, the researcher developed on-line versions of the three tests. A paper version of the tests served as a contingency for computer or networking problems during class.

Just prior to the first day of class, the application for exemption from the university's Institutional Review Board (IRB) was approved. Between the time of initial application and the approval date, the researcher applied for an amendment to the initial application because of the addition of a question on the introductory survey for the students. The amendment was accepted and the study continued to qualify for exempt status. (See Appendix I for the IRB approval letters.)

On the first day of class, students completed the introductory survey. Students who did not attend the first day of class had the option of completing the survey either in the instructor's office or on-line before noon the day before the next class meeting. The researcher then attempted to pair students heterogeneously based on: previous experience with the software used in this course, prerequisite course grade (As, Bs, or Cs), major, gender, race, academic level, and years as engineering major. While assessing characteristics of heterogeneity, the researcher considered extracurricular interests and time available for group work, essentially characteristics of group homogeneity. Time available for group work was a crucial consideration in hopes to control for potential scheduling problems between group members.

After obtaining the final course enrollment the first week of classes, a research assistant generated a unique research identification number (RID) for each student and e-mailed the RID to each student individually prior to the second class meeting. Students used their RIDs on selected documents and instruments so the researcher could not tie individual students with scores on the ROT, ILS, and survey responses during the data analysis. The researcher provided the research assistant with a regularly updated gradebook during the semester in order to maintain a database of the raw research data. At the end of the semester, the research assistant provided the researcher with the database containing only RIDs identifying each participant. (See Appendix J for the research assistant protocol.)

The research participants completed the on-line pretest during the first half of the second class meeting. After the students completed the pretest, the instructor briefly discussed with the class the first homework assignment and characteristics of effective cooperative groups (see Appendix K). The instructor then assigned students their partners. At the end of class, the instructor asked the students to complete the on-line ILS using only their RIDs and bring a printout of the results to the next class.

At the start of the third class meeting, members of the treatment group completed the peer evaluations for the homework assignment they just completed. The control group skipped this step. The students then completed the ROT. They supplied their RIDs on the answer sheet rather than names (as with the ILS). The instructor spent 5 minutes discussing the format of the instrument and sample problem with the class. The students completed the 44 questions within the 10-minute time limit. After collecting the question booklets and answer sheets, the instructor covered material related to the next assignment, reviewed effective cooperative group skills (see

Appendix K), and encouraged students to study together during the following weeks up to the mid-term exam.

The treatment group completed a peer evaluation form at the start of class on each subsequent homework due date during the treatment condition. When the two course sections switched treatment and control conditions, the new treatment group followed the same weekly procedure.

During the third week of both treatment-control phases, the researcher conducted interviews with six students from three cooperative pairs. The research assistant selected interviewees using a stratified random sampling technique. The strata were group grade averages of A, B, and C or lower for the previous homework drawings completed during the treatment. The research assistant contacted potential interviewees via e-mail, described the interview process, and indicated the tangible incentive they would receive for their participation. Each student in the pair needed to participate. Additionally, the research assistant told the potential interviewees that they would receive a larger incentive if they participated in both the first and second interviews. The researcher conducted the second interviews after the posttest following the treatment with each of the selected cooperative pairs. If the selected students decided not to participate either in the initial or follow-up interviews, the research assistant contacted other potential interviewees.

The research task schedule for the semester appears in Appendix L.

Data Analysis

The researcher used SPSS for each of the quantitative analyses.

The literature supported visualization ability and learning style preference for use as covariates in measuring treatment effects (learning method) on the dependent variable (achievement). The first step in the data analysis required separate comparisons of the covariate scores between the two course sections using independent-samples *t*-tests. After comparing the group means on the covariates, the researcher calculated the correlation between each covariate and each posttest. (Huck, Cormier, & Bounds, 1974; Pehazur & Schmelkin, 1991)

Based on the data collected between the covariates and posttests, the researcher decided to separate the data analyses into two experiments, rather than one semester-long experiment. The researcher first calculated descriptive statistics for all the independent and dependent variables. The next step included conducting independent-samples *t*-tests in each experiment to compare achievement scores between the two course sections.

In order to gain further insight about factors affecting achievement, the last step involved using repeated measures ANOVAs with two between subjects variables and one within subjects variable. The researcher determined the effects of each demographic variable as a between subjects variable in the repeated measures ANOVAs.

After analyzing all quantitative data, the researcher analyzed the interview responses, the weekly peer reviews from the interviewees, and the various grades for the interviewees to provide further insights.

Chapter 4: Research Results

The problem of this study was to determine the effectiveness of a particular cooperative learning method on the achievement of college engineering students enrolled in a CAD course in an engineering education department. The study consisted of two experiments. The demographic data collected and the pretest that was taken at the beginning of the semester were used in both experiments. The first experiment was the first half of the semester, during which one section of the course served as the treatment group and the other section served as the control group. Repeated measures analyses involved the pretest, the mid-term exam (posttest 1), and demographic data. The second experiment followed the same procedures, but the treatment and control conditions were switched to the other section. The same pretest, the final exam (posttest 2), and the same demographic data were used in the repeated measures analyses for the second experiment. All data herein were analyzed with alpha set at the .05 level.

The data analyses for the first experiment (first half of the semester) showed that the difference in means on posttest 1 for the cooperative learning treatment group (n = 61, M = 84.036, SD = 8.137) and the individualistic learning control group (n = 61, M = 84.821, SD = 7.696) was not significantly different. However, regarding achievement on the weekly homework assignments, the mean scores for the cooperative learning group (n = 61, M = 88.458, SD = 8.654) were significantly higher than the mean scores for the individualistic learning group (n = 61, M = 82.334, SD = 14.508).

The data analyses for the second experiment (second half of the semester) showed similar results to those from the first experiment. The difference in means on posttest 2 for the cooperative learning treatment group (n = 61, M = 74.787, SD = 9.840) and the individualistic learning control group (n = 59, M = 73.534, SD = 10.720) was not significantly different. However, as with the first experiment, the means of the achievement scores on the weekly homework assignments for the cooperative learning group (n = 61, M = 83.281, SD = 13.618) were significantly higher than the mean achievement scores for the individualistic learning group (n = 59, M = 74.634, SD = 22.961).

The aforementioned results are qualified by the data that appear in the following sections.

Demographic Data for Participants

The population in this study consisted of 122 students enrolled in two sections of a college CAD course. Demographic data were collected on the first day of class via a paper survey (see Appendix D). The data collected included major, academic year, number of years as an engineering major, gender, race, prior experience with the CAD software used in the course (AutoCAD), prerequisite grade, and grade point average (GPA).

Most of the participants were ISE majors (n = 104, 85.2%), with several BSE majors in each class (n = 18, 14.8%). The academic levels of the participants in this study included sophomore (n = 61, 50.0%), junior (n = 46, 37.7%), and senior (n = 15, 12.3%). Their years as engineering majors included second-year (n = 80, approximately 67.2%), third-year (n = 33, approximately 27.7%), and fourth-year (n = 6, approximately 5.0%); three students did not respond to this item. The gender composition of the population was 63.9% male (n = 78) and 36.1% female (n = 44).

Most participants reported their race as White (73.5% of respondents), and the rest of the participants (26.5% of respondents) reported belonging to another race. Several participants (n = 9) chose not to indicate their race. Table M1 shows the racial/ethnicity and gender breakdown of the participants.

Regarding participants' prior experience with the software, just over 64% of respondents (n = 77) reported having no experience, almost 17% of respondents (n = 20) reported little exposure such as a unit of instruction in high school, slightly over 9.0% of respondents (n = 11) indicated that they had formal coursework in high school or college, and 10% of respondents (n = 12) reported regular use of the software beyond formal coursework. Two participants did not provide information regarding their prior experience with the software.

The average grade earned in the prerequisite technical design course was a high B; however, 24 participants declined to provide that information. Of the participants who responded to this survey question, 14.3% (n = 14) indicated that they earned an A, 54.1% (n = 53) reported earning a B, and 31.6% (n = 31) stated that they earned a C.

Participants reported a wide variety of GPAs, ranging from 1.74 to 4.00 (on a 4.00 scale). However, the mean, median, and mode GPAs were 3.07, 3.10, and 3.20, respectively. Less than 75% (n = 91) of the participants volunteered to indicate their GPAs. Of the respondents who indicated their GPAs, approximately 29.7% (n = 27) had GPAs between 3.50 and 4.00, approximately 31.9% (n = 29) had GPAs between 3.00 and 3.49, approximately 19.8% (n = 18) had GPAs between 2.50 and 2.99, approximately 17.6% (n = 16) had GPAs between 2.00 and 2.49, and one student reported a GPA less than 2.00. See Table M2 for all of the demographic data collected.

Covariate Analyses

Visualization

The literature suggested that visualization ability was necessary for engineering students and could be used as a predictor for success in CAD. An independent samples t-test revealed that the first control and treatment groups, with means of 15.770 (n = 61, SD = 3.035) and 14.748 (n = 61, SD = 3.610), respectively, were not significantly different from each other in terms of visualization ability (t = 1.710, df = 120, p = .090). However, visualization ability as measured by the Purdue ROT was not used as a covariate because correlations analyses revealed low-positive correlations with the various tests (see Table M3) and were lower than Cohen's (1969) recommended medium effect size to be useful. Also, Figures 2 through 4 show graphs of low-positive relationships between visualization scores and the various tests.

The researcher also conducted correlation analyses between visualization ability and overall homework grades (drawing assignments). There was a weak, non-significant correlation between visualization ability and the homework drawings for the first half of the semester; but, there was a significant, moderate correlation at the .01 level between visualization ability and the homework drawings for the second half of the semester (see Table M4). Figures 5 and 6 show graphs of the relationships between visualization scores and overall homework grades for each half of the semester.

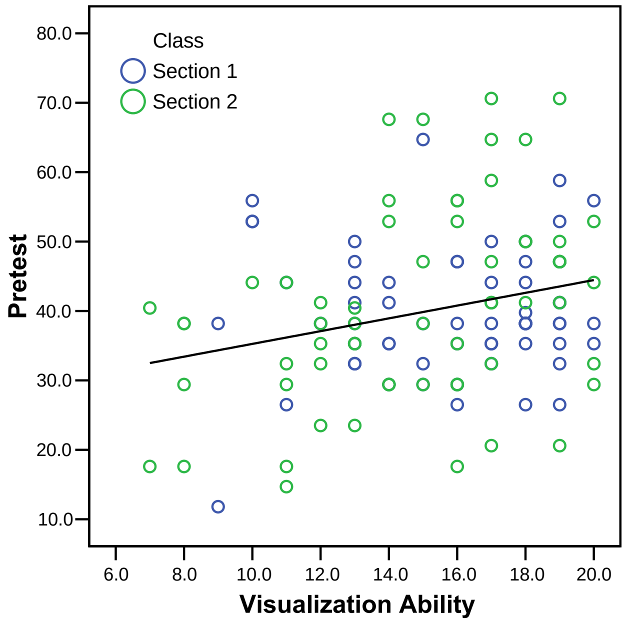

Figure 2. Scatterplot of correlation between visualization and pretest scores.

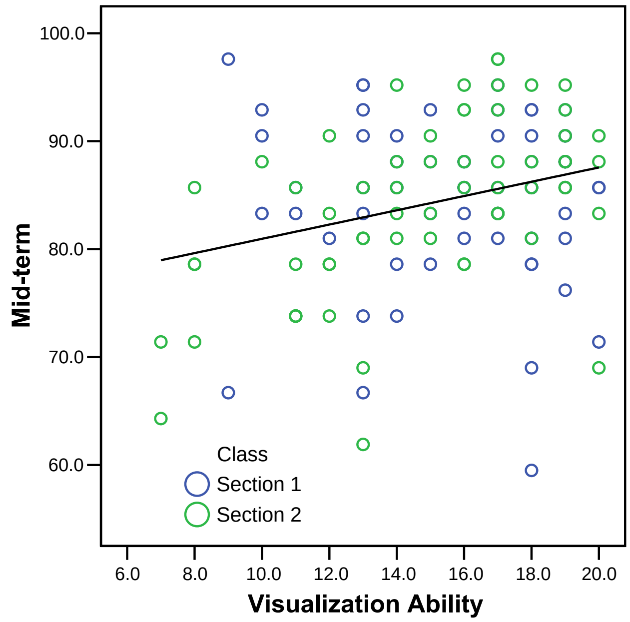

Figure 3. Scatterplot of correlation between visualization and mid-term exam (posttest 1) scores.

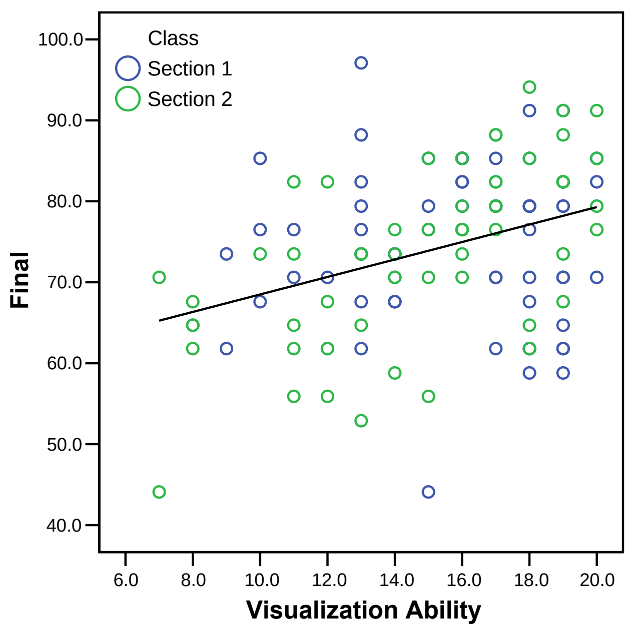

Figure 4. Scatterplot of correlation between visualization and final exam (posttest 2) scores.

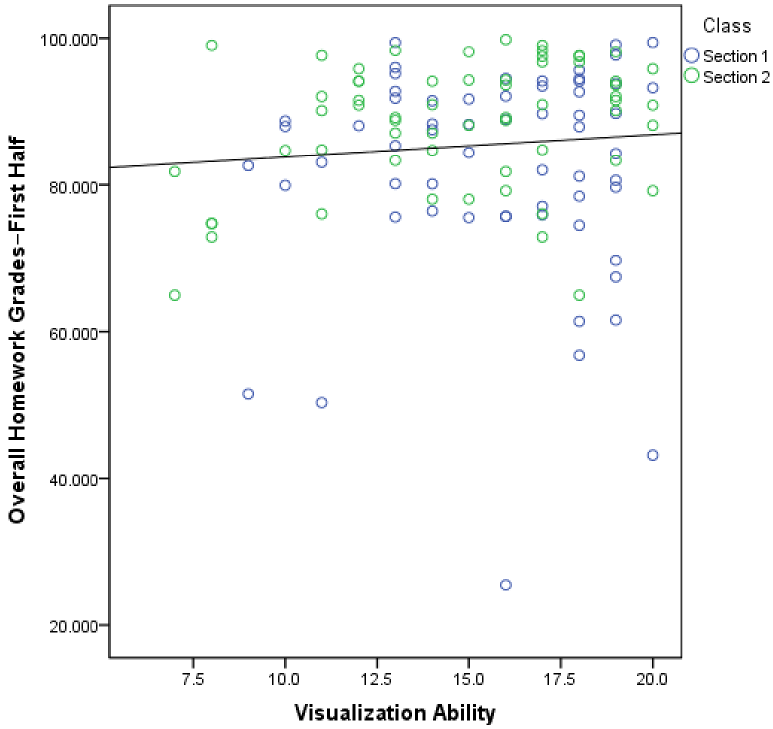

Figure 5. Scatterplot of correlation between visualization and homework grades (first half of semester).

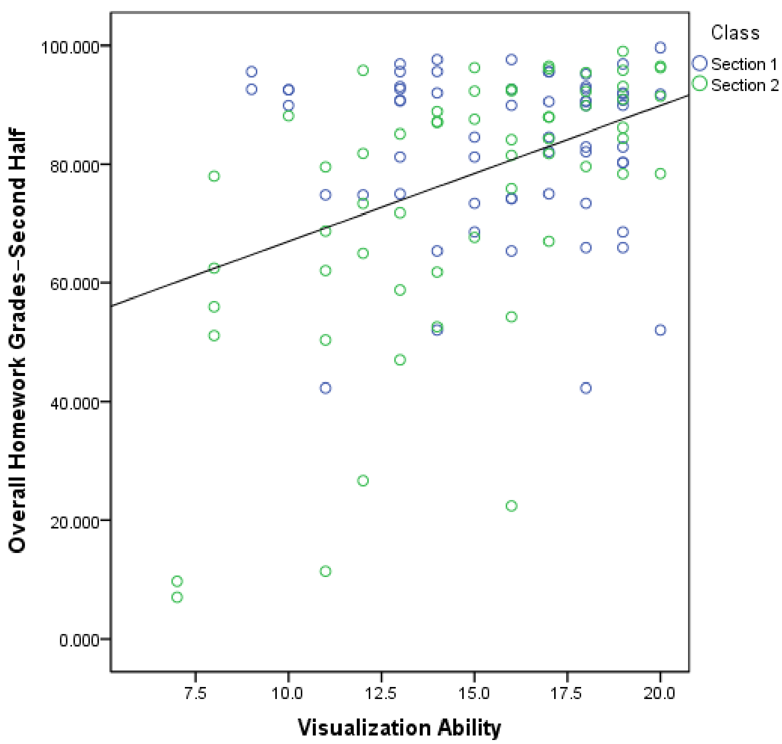

Figure 6. Scatterplot of correlation between visualization and homework grades (second half of semester).

Learning Styles

The scoring method for the Solomon-Felder ILS did not produce an overall score that one could use as a covariate in a repeated-measures analysis. The overall class scores on the ILS appear in Table M5. Next, independent samples *t*-tests on each dimension between the two course sections indicated whether or not the sections had equivalent learning style preferences (see Table M6). Overall, the two course sections were equivalent on the various learning style dimensions, with the exception of the reflective (REF) dimension.

Achievement Analyses

Pretest

An independent samples *t*-test on the pretest revealed that the first control and treatment groups, with means of 39.755 (n = 61, SD = 9.130) and 40.426 (n = 61, SD = 14.145), respectively, were equivalent in terms of prior knowledge (as measured by the pretest) of the CAD content covered in this course and came from the same population (t = -.311, df = 120, p = .756). The pretest served as the first test in the repeated measures analyses in the two experiments.

First Experiment

Posttest

The maximum score for the posttest was 100. The mean posttest score for the first cooperative learning treatment group was slightly lower than the mean posttest score for the first individualistic learning treatment group (see Table M7). An independent-samples *t*-test revealed that this difference was not significant (t = .548, df = 120, p = .585).

Weekly Homework

During the first half of the semester, students were responsible for completing eight drawings over a five week period. For the first through third weeks, students submitted two drawings per week. The means of the homework assignments for the first half of the semester (i.e., the first experiment) indicated that the treatment group (cooperative learning) earned higher grades than the control group (individualistic learning). (See Table M7.) When comparing group versus individual performances, an independent samples *t*-test revealed that there was a significant difference in overall performance between treatment and control groups during the first half of the semester when all homework grades were included (t = -2.832, df = 120, p = .005).

Demographic Variables

The effects of selected demographic variables on achievement for the treatment and control groups were analyzed using repeated measures analyses (see Tables M8 – M15). The pretest and the posttest 1 (mid-term exam) served as the repeated measures in the analyses. For the first experiment, the data revealed main effects of race, $F(2, 107) = 10.523$, MSE = 104.320, $p < .001$, $\eta^2 = .16$ (see Table M8); prior experience, $F(3, 112) = 10.124$, MSE = 102.410, $p < .001$, $\eta^2 = .21$ (see Table M13); and time of achievement test administration for each of the demographic variables (see Tables M7 – M14). There were first-order interactions for gender-by-time, $F(1, 118) = 10.961$, MSE = 67.010, $p = .001$, $\eta^2 = .09$ (see Table M8); and experience-by-time, $F(3, 112) = 10.742$, MSE = 55.655, $p < .001$, $\eta^2 = .22$ (see Table M13).

Due to how little some races were represented in the research sample, the researcher grouped the race categories into White, Asian, and All Other Races. At least three categories were necessary to conduct post-hoc analyses in SPSS. Post-hoc analyses were necessary to identify which race(s) influenced the significant main effect of race.

Since race was a main effect and it had three levels, the researcher conducted a post-hoc analysis using Tukey's HSD (honestly significant difference) test. The data indicated that the differences in means were significant between White (*M* = 64.279, *SD* = 9.057) and both Asian (*M* = 56.597, *SD* = 8.923) and All Other Races (*M* = 56.022, *SD* = 10.538), but not between Asian and All Other Races.

The researcher conducted a post-hoc analysis using Tukey's HSD test on experience, which had four levels. The data indicated that the differences in means were significant between No Experience (*M* = 59.819, *SD* = 8.914) and both Formal Coursework (*M* = 69.100, *SD* = 8.236) and Regular Use (*M* = 70.675, *SD* = 7.893), and between Little Exposure (*M* = 63.395, *SD* = 9.427) and Regular Use.

Second Experiment

Two students dropped the course after the first half of the semester. Their data for the first half of the semester remained useful. However, their partial data for the second half of the semester were dropped for the second experiment.

Posttest

As with the test in the first experiment, the maximum score for the posttest in the second experiment was 100. The mean posttest score for the second cooperative learning treatment group (*n* = 61) was slightly higher than the mean posttest score for the second individualistic learning control group (*n* = 59). (See Table M16.) An independent-samples *t*-test revealed that this difference was not significant ($t = .667$, $df = 118$, $p = .506$).

Weekly Homework

During the second half of the semester, students were responsible for completing three assignments over a five week period. The first and third assignments were two-week assignments. The means of the homework assignments for the second half of the semester (i.e., the second experiment) showed that the treatment group (cooperative learning) performed better than the control group (individualistic learning). (See Table M16.) When comparing groups versus individual performances, an independent samples *t*-test revealed that there was a significant difference in overall performance between treatment and control groups during the second half of the semester when all homework grades were included ($t = 2.519$, $df = 118$, $p = .013$).

Demographic Variables

As with the first experiment, the effects of selected demographic variables on achievement were analyzed using repeated measures analyses (see Tables 17 – 24). The pretest and posttest 2 (final exam) served as the repeated measures in the analyses. For the second experiment, the data revealed main effects of race, $F(2, 105) = 10.394$, $MSE = 130.593$, $p < .001$, $\eta^2 = .17$ (see Table M18); prior experience, $F(3, 110) = 12.441$, $MSE = 126.725$, $p < .001$, $\eta^2 = .25$ (see Table M22); prerequisite grade, $F(2, 90) = 3.215$, $MSE = 161.192$, $p = .045$, $\eta^2 = .07$ (see Table M23); and time of achievement test administration for each demographic variable (see Tables M16 – M23).

There were first-order interactions for method-by-time for the year as engineering major demographic variable, $F(1, 111) = 4.011$, $MSE = 78.552$, $p = .048$, $\eta^2 = .04$ (see Table M21); gender-by-time, $F(1, 116) = 6.189$, $MSE = 77.336$, $p = .014$, $\eta^2 = .05$ (see Table M17); experience-by-time, $F(3, 110) = 3.438$, $MSE = 72.776$, $p = .019$, $\eta^2 = .09$ (see Table M22); GPA-by-time, $F(4, 80) = 2.654$, $MSE = 76.292$, $p = .039$, $\eta^2 = .12$ (see Table M24) and method-by-academic year, $F(2, 114) = 3.166$, $MSE = 159.191$, $p = .046$, $\eta^2 = .05$ (see Table M20).

Tukey's HSD revealed similar significant mean differences in the main effect of race as in the first experiment. The data for the second experiment indicated that the differences in means were significant between White ($M = 59.265$, $SD = 9.948$) and both Asian ($M = 49.819$, $SD = 12.092$) and All Other Races ($M = 50.420$, $SD = 10.566$), but not between Asian and All Other Races.

A post-hoc analysis using Tukey's HSD test on experience in the second experiment indicated that the differences in means were significant between No Experience ($M = 54.102$, $SD = 10.002$) and both Formal Coursework ($M = 66.986$, $SD = 10.392$) and Regular Use ($M = 65.079$, $SD = 9.088$), and between Little Exposure ($M = 58.975$, $SD = 10.076$) and Formal Coursework.

The repeated measures ANOVA showed a main effect of prerequisite grade during the second experiment. However, a Tukey's HSD post-hoc analysis did not show any significant mean differences among the various levels of the prerequisite grade demographic variable.

Research Hypotheses

Hypothesis 1

Both the cooperative and individualistic learning methods result in approximately equal participant achievement.

The data analyses revealed no main effect of learning method. The cooperative and individualistic learning methods employed in this study resulted in no significant differences in participant achievement as measured by the posttests in both experiments.

Hypothesis 2

Participants in the various levels of each selected demographic variable achieve approximately equally.

Gender

The data analyses revealed no significant differences between male and female participants' achievement in both experiments.

Race

The data revealed a main effect of race in both experiments. Race was initially divided into seven categories. Due to low numbers in most of the identified races, three categories were used: White, Asian, and All Other Races. Post-hoc analyses indicated significant differences between White and the two other categories, but not between Asian and All Other Races. (See Figures 7 and 8.)

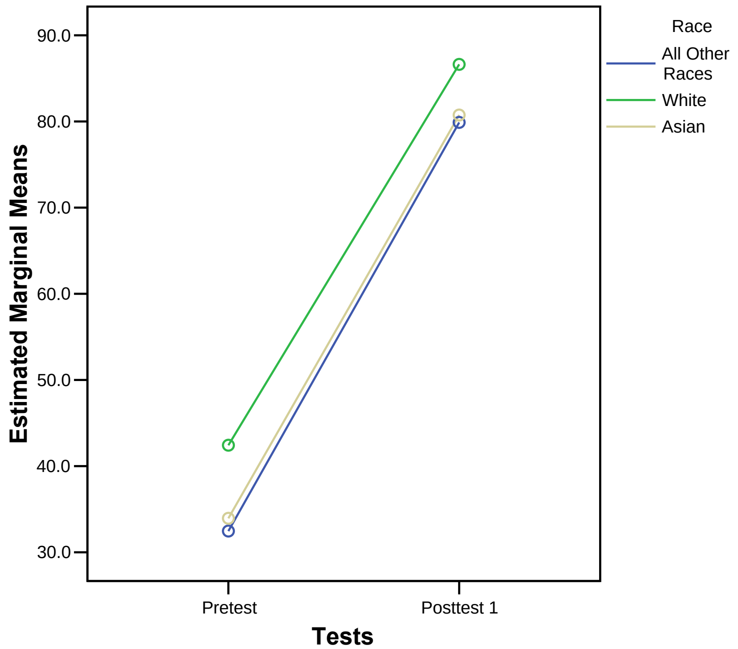

Figure 7. Test score means for Experiment 1 based on race.

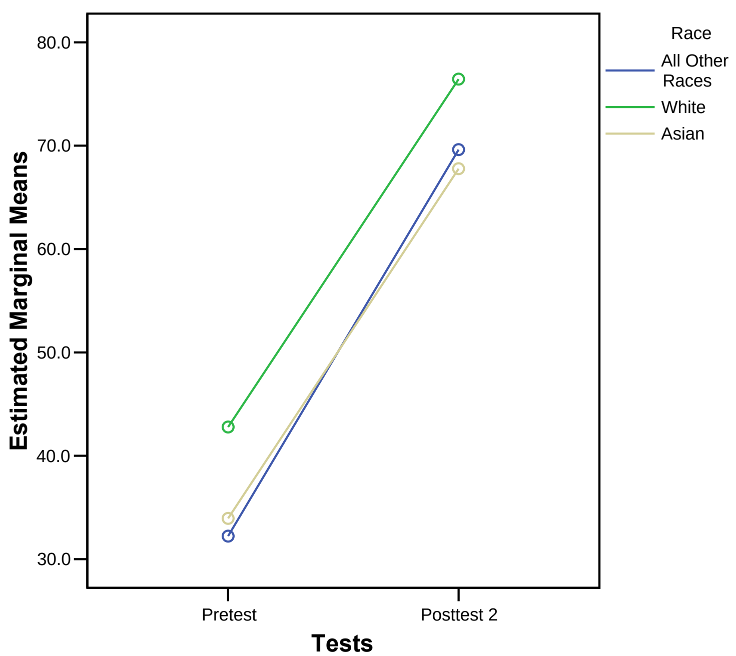

Figure 8. Test score means for Experiment 2 based on race.

Major
The data analyses revealed no significant differences between ISE and BSE participants' achievement in both experiments.

Academic Year
The data analyses revealed no significant differences in achievement based on participants' academic year (sophomore, junior, or senior) in both experiments.

Year As Engineering Major
The data analyses revealed no significant differences in achievement based on participants' year as an engineering major (second-year, third-year, or fourth-year or higher) in both experiments.

Prior Experience
The data analyses revealed a main effect of prior experience in both experiments. Regarding the pretest, participants who took formal courses in CAD and those who used the software regularly outperformed those who had no prior experience or had little exposure. However, the achievement levels of these four groups on posttest 1 (mid-term exam) were much closer together. During posttest 2 (final exam), the relative performance levels of the groups were similar to the pretest results, but not as pronounced. (See Figures 9 and 10.)

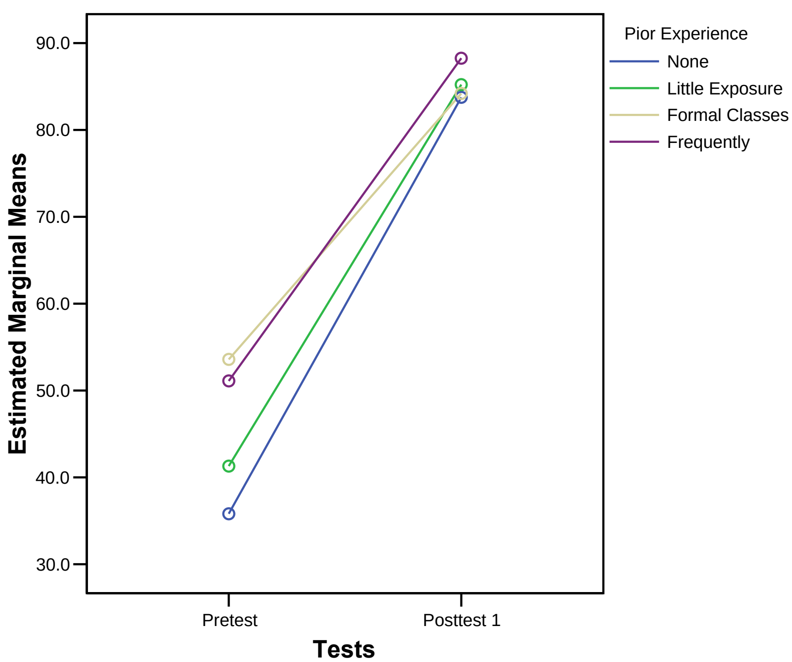

Figure 9. Experiment 1 mean test scores based on prior experience level.

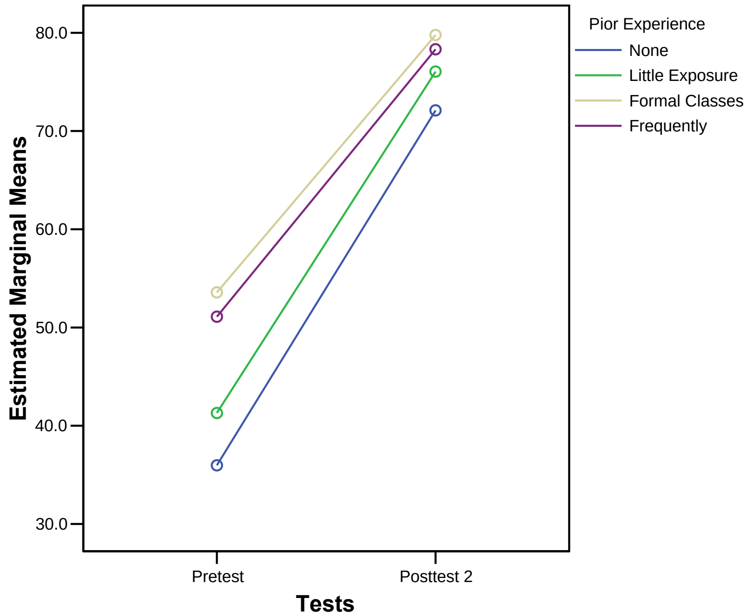

Figure 10. Experiment 2 mean test scores based on prior experience level.

Prerequisite Grade

Prior to taking the CAD course that was under study, students were required to earn at least a C grade in the prerequisite technical design course. In this technical design course, students studied a variety of technical sketching methods (e.g., orthographic sketches, pictorials) and a 3D CAD program. The researcher considered students' performances in that course as a factor affecting their performances in this CAD course.

Initial repeated measures analyses did not indicate a main effect of prerequisite grade in Experiment 1, but there was a main effect (p = .045) in Experiment 2. However, post-hoc analyses revealed no significant differences among students who earned A, B, and C grades in Experiment 2. (See Figures 11 and 12.)

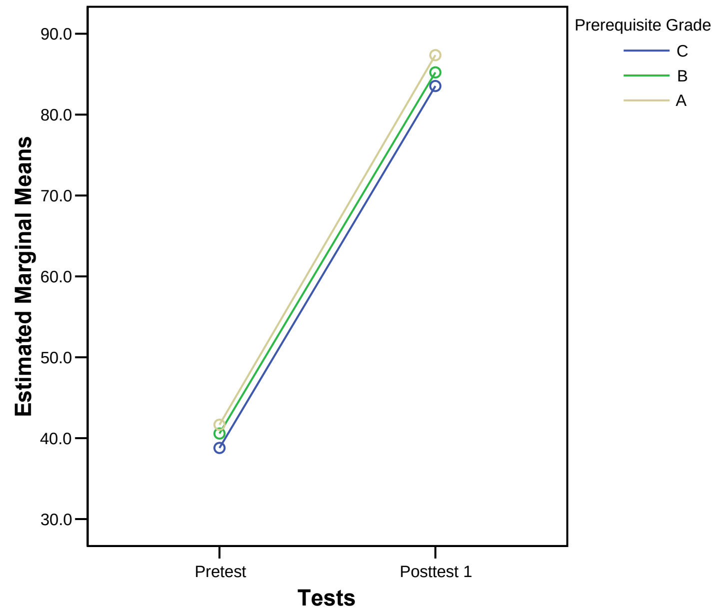

Figure 11. Mean test scores for Experiment 1 based on prerequisite grade.

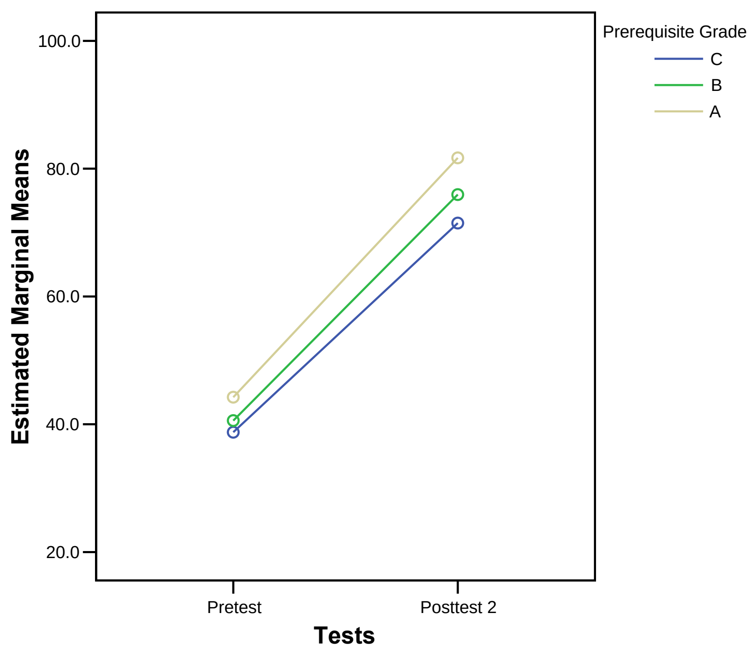

Figure 12. Mean test scores for Experiment 2 based on prerequisite grade.

GPA (Grade Point Average)

Due to the variety of GPAs reported, the researched grouped the GPAs into five strata: 4.00 – 3.50, 3.49 – 3.00, 2.99 – 2.50, 2.49 – 2.00, and < 2.00. The data analyses revealed no significant differences in achievement based on participants' GPA in both experiments.

Hypothesis 3

All research participants achieve approximately equally well on each administration of the repeated measures.

The data analyses revealed a main effect of time of achievement test administration. There were significant differences in participant achievement as measured by the tests (pretest and posttest) in both experiments.

Hypothesis 4

The research participants in each learning method group have an approximately identical achievement pattern over the repeated measures.

Overall, the data analyses did not reveal a first-order interaction of method-by-time. However, only the repeated measures ANOVA with the year as engineering major demographic variable as a between-subjects variable showed a method-by-time interaction (p = .048) during the second experiment (see Figure 13).

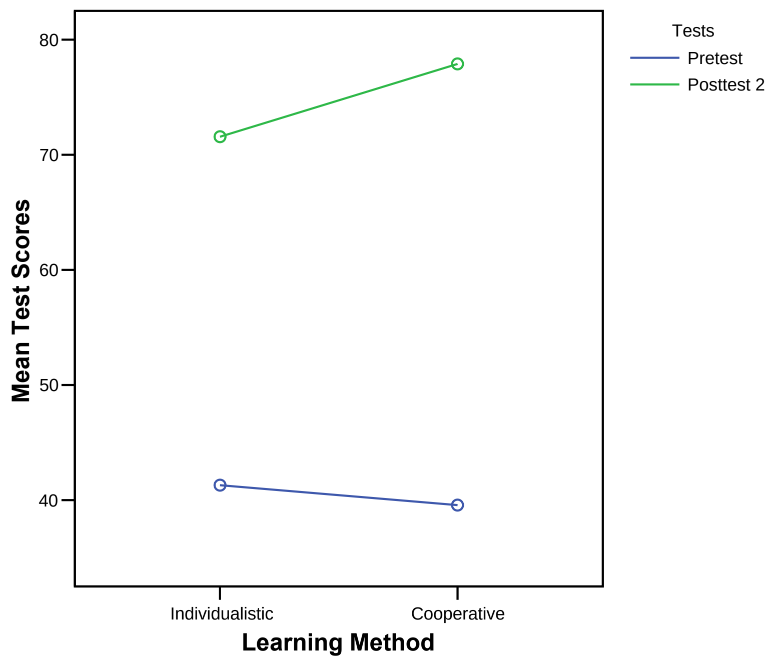

Figure 13. Experiment 2 had a method-by-time interaction when Year As Engineering Major was the second between subjects variable.

Post-hoc analyses showed that second-year (n = 79, M = 57.531), third-year (n = 32, M = 55.931), and fourth-year (n = 6, M = 59.986) were not significantly different.

Hypothesis 5

The achievement pattern is approximately identical for the number of participants of each level of a selected demographic variable across the repeated measures.

Gender

The repeated measures analyses revealed first-order gender-by-time interactions in both experiments. Male participants performed better than female participants on the pretest; however, female participants performed better than males on both posttests (see Figures 14 and 15).

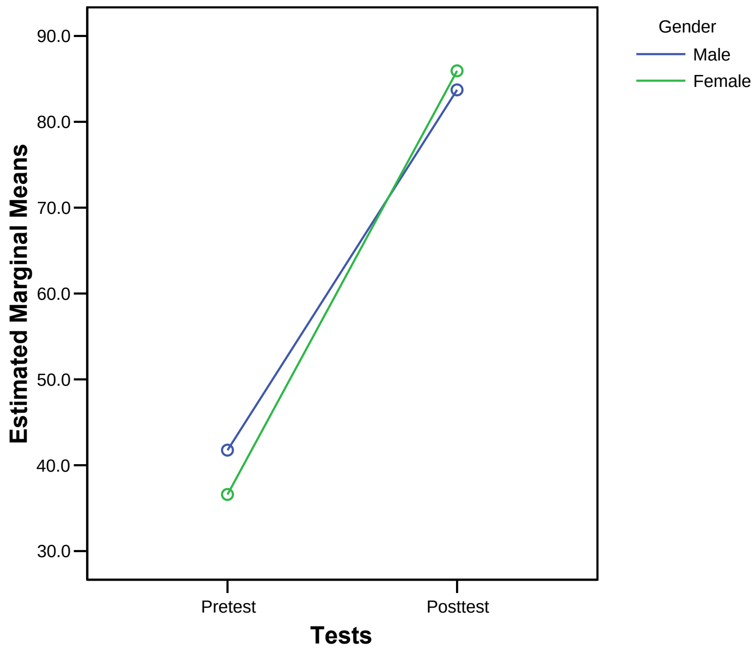

Figure 14. Experiment 1 mean test scores based on gender.

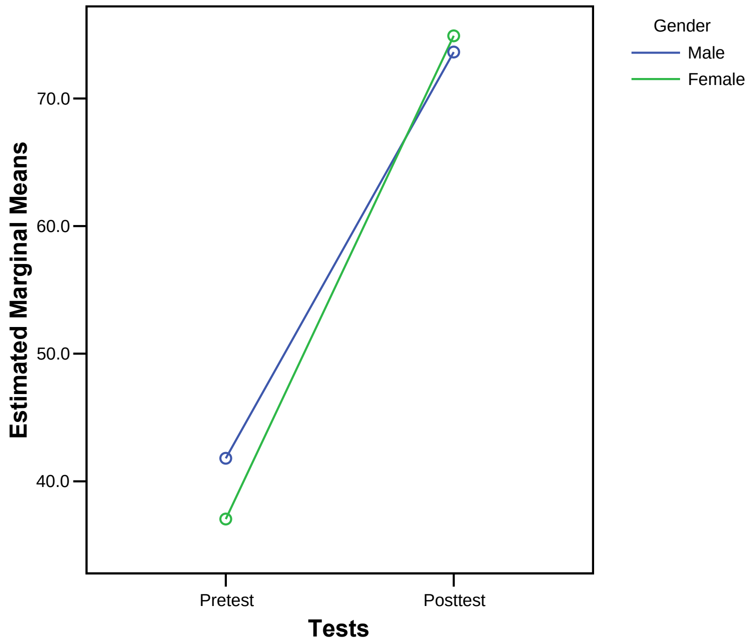

Figure 15. Experiment 2 mean test scores based on gender.

Race

The data analyses did not reveal a race-by-time interaction in either experiment. The achievement patterns for participants in each of the racial groups in this study were approximately identical.

Major

The data analyses did not reveal a major-by-time interaction in either experiment. The achievement patterns for participants in each major were approximately identical.

Academic Year

The data analyses did not reveal an academic year-by-time interaction in either experiment. The achievement patterns for participants in each academic year strata in this study were approximately identical.

Year As Engineering Major

The data analyses did not reveal an engineering major-by-time interaction in either experiment. The achievement patterns for participants in the identified years as an engineering major were approximately identical.

Prior Experience

The repeated measures ANOVAs revealed a first-order prior experience-by-time interaction in both experiments. This interaction might be explained by the larger differences on pretest mean scores compared to the smaller differences on both posttests (see Figures 9 and 10).

Prerequisite Grade

The data analyses did not reveal a prerequisite grade-by-time interaction in either experiment. The achievement patterns for participants in each of the prerequisite grade strata in this study were approximately identical.

GPA

Repeated measures ANOVAs did not indicate a first-order interaction of GPA-by-time for the first experiment, but there was a significant interaction in the second experiment. After conducting another repeated measures ANOVA excluding a single outlier case with a GPA lower than 2.00, the researcher no longer found a significant GPA-by-time interaction. With the outlier case excluded, the achievement patterns for participants in each of the GPA strata were approximately identical.

Hypothesis 6

The difference in achievement (averaged across repeated measures) of participants from each level of a selected demographic variable is approximately the same magnitude within each of the two learning methods.

Gender

The data analyses did not reveal a learning method-by-gender first-order interaction in either experiment. Any differences between male and female participants’ achievement were not dependent upon learning method (cooperative or individualistic).

Race

The data analyses did not reveal a learning method-by-race first-order interaction in either experiment. Any differences in achievement among the three racial strata used in this study were not dependent upon learning method.

Major

The data analyses did not reveal a learning method-by-major first-order interaction in either experiment. Any differences in achievement among participants in the two majors in this study were not dependent upon learning method.

Academic Year

The data analyses did not reveal a learning method-by-academic year interaction in the first experiment, but there was a significant interaction in the second experiment. The degree to which sophomores, juniors, and seniors differed during the second half of the semester was dependent upon the learning method. In the first experiment, the learning method-by-academic year data still have substantive importance. (See Figures 16 and 17.)

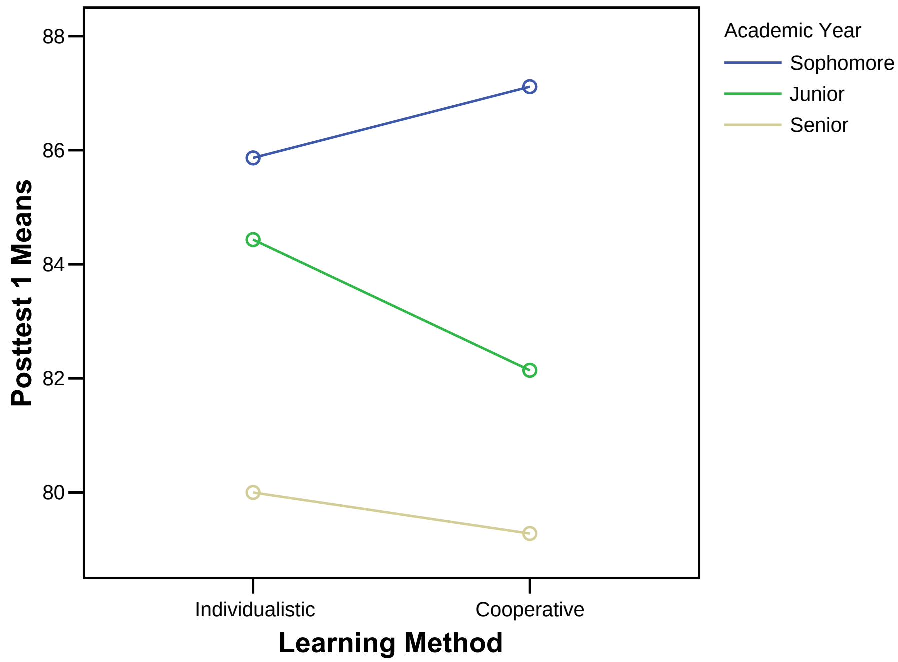

Figure 16. A method-by-academic year interaction in Experiment 1 was not statistically significant.

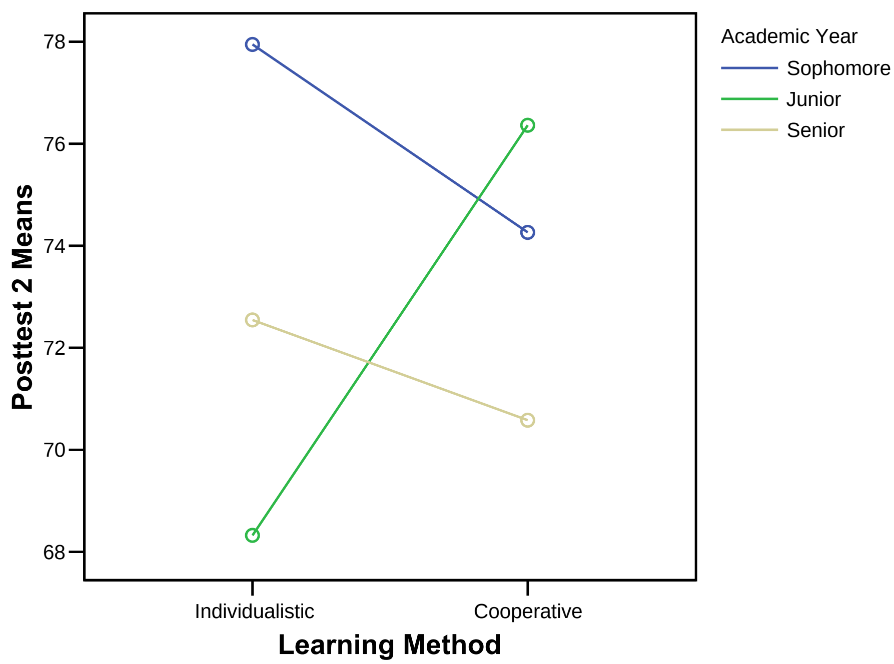

Figure 17. A statistically significant method-by-academic year interaction occurred in Experiment 2.

Year As Engineering Major

The data analyses did not reveal a learning method-by-year as engineering major first-order interaction in either experiment. Any differences in achievement among participants in different years as an engineering major were not dependent upon learning method.

Prior Experience

The data analyses did not reveal a learning method-by-prior experience first-order interaction in either experiment. Any differences in achievement among the four prior experience strata used in this study were not dependent upon learning method.

Prerequisite Grade

The data analyses did not reveal a learning method-by-prerequisite grade first-order interaction in either experiment. Any differences in achievement among the five prerequisite grade strata used in this study were not dependent upon learning method.

GPA

The data analyses did not reveal a learning method-by-GPA first-order interaction in either experiment. Any differences in achievement among the five GPA strata used in this study were not dependent upon learning method.

Hypothesis 7

The achievement on one of the repeated measures for any subgroup of participants is approximately equally influenced by the unique combination of the selected demographic variable, the learning method, and the specific time of the repeated measure.

The various repeated measures ANOVAs did not reveal any significant second-order interactions (method-by-demographic-by-time) in either experiment. Therefore, any trend in test performance across the two tests in each experiment was approximately equal for each subgroup of students.

Chapter 5: Discussion, Conclusions, and Recommendations for Further Research

The problem of this study was to determine the effectiveness of a particular cooperative learning method on the achievement of college engineering students enrolled in a CAD course. The purpose of this study was to offer findings that might help improve teaching and learning in a CAD course and guide the future development of similar CAD courses in various disciplines.

A counterbalanced research design was employed with two intact course sections. Cooperative learning served as the treatment, and individualistic learning served as the control. During the first half of the semester (Experiment 1), one course section was the treatment group and the other course section was the control group. After the mid-term exam, which served as posttest 1, the treatment and control conditions switched course sections. The final exam served as posttest 2 for the second half of the semester (Experiment 2). Students in the treatment sections worked in pairs and completed weekly peer reviews that were intended to help provide insight about their cooperative efforts. Also, the instructor-researcher conducted interviews with selected cooperative pairs that represented achievement/grade strata after working together two weeks into the treatments. The interviews also helped provide insight into how the cooperative pairs worked together.

Since the study had characteristics of a nonequivalent control group design, steps to help control for possible differences between the two course sections were necessary. Students completed a pretest on the second day of class. The pretest data revealed that the two course sections were not significantly different in their prior knowledge of the CAD content covered in this course. To help explain possible variability in achievement during the course, the literature supported the use of visualization ability as a covariate in the data analysis. For that reason, students completed *The Purdue Visualization of Rotations Test* (ROT) during the third class. Analyses between the ROT and each of the posttests revealed low-positive correlations; therefore, visualization ability was not used as a covariate because the correlations were lower than Cohen’s (1969) recommended medium effect size to be useful.

The literature also supported the construct of learning styles as a factor in achievement. Students completed the on-line Soloman-Felder *Index of Learning Styles* (ILS) within the first three weeks of class. The scoring method of the ILS did not produce an overall score that could be used as a covariate in the data analysis. For that reason, learning style was not used as a covariate.

Students also completed an introductory survey on the first day of class. Demographic data from the introductory survey were used to help the instructor-researcher form the cooperative groups.

The use of a course taught by the researcher, the problem and purpose of the study, the research design, and the independent and dependent variables under study led to the formulation of seven research hypotheses. The hypotheses were related to the possible main effects of the independent and dependent variables, possible first-order interactions between combinations of the variables, and a possible second-order interaction among the three variables. The statistical procedures used to analyze data relating to the seven hypotheses included repeated-measures ANOVAs with two between subjects variables (learning method and demographic variable) and one within subjects variable (time of achievement test administration), Tukey's HSD for post-hoc analyses, and independent-samples *t*-tests.

Discussion of Research Hypotheses

Hypothesis 1

Both the cooperative and individualistic learning methods result in approximately equal participant achievement.

This hypothesis was supported by the data in terms of achievement as measured by the posttests. Though meta-analyses by Johnson, Maruyma, Johnson, Nelson, and Skon (1981), Slavin (1983), Johnson, Johnson, and Smith (1998), Springer, Stanne, and Donovan (1999), and Smith, Sheppard, Johnson, & Johnson (2005) showed results favoring cooperative learning, the various positive effect sizes were all less than 1.00, which meant that not all studies had results supporting cooperative learning or indicating significant differences between cooperative learning and other learning goal structures. But, posttests were not the only means for assessing achievement in this study: The weekly homework grades were also analyzed to gauge achievement.

Overall homework grades showed different results than those from the posttests. Students in the cooperative learning groups in both experiments earned significantly higher homework grades than those students learning individualistically. Qualitative data from the weekly peer reviews and interviews were helpful in understanding the discrepancy between homework and posttest scores.

One reason for the discrepancy between homework and posttest scores was that there was evidence in the cooperative groups of higher achieving partners "carrying" weaker performing partners ("slackers"). When the partners took the posttests individually, the achievement levels of students in the treatment conditions "leveled out" and became comparable to those of students in the control conditions. Another possible reason was that group processing, overall, might have been more beneficial towards achieving higher on the weekly homework assignments than on the posttests for the cooperative groups. Most groups spent little time together each week, meeting only once or twice a week. The group processing for the purpose of completing the weekly assignments was beneficial for that relatively brief amount of time each week, but those weekly benefits did not combine over time for an overall benefit towards the posttests. The little amount of time and infrequency of group processing resulted in posttest scores that were comparable to those of students who worked and studied alone.

The weekly peer reviews revealed information about how students worked together during the cooperative treatments. Overall, most of the groups worked well together during the treatments. These groups followed the recommended procedures for working cooperatively and indicated positive experiences. Some groups showed improvement over time while working together and others remained consistent. During the second treatment, which had the more advanced material, there were groups that showed a decline in performance, but they maintained the recommended procedures for working in groups.

In some cases during both treatments, there were groups that did not observe the recommended procedures for working together or the spirit of cooperative learning as discussed in class.

Negative characteristics included times when one of the partners did not participate in working on an assignment, groups that had one of the partners serve in the “drafter” role for several weeks while the other partner served in the “manager” role most of the time, and times when the partners worked separately and met briefly to compare drawings and decide which one to submit.

Slackers

Johnson and Johnson (1998) and others used the term “slackers” to refer to group members who contribute little or nothing to group efforts. Mesch (1991) also referred to those individuals as “hitchhikers”—a person who is just “along for the ride.” Slackers are further characterized by benefiting from the end result(s) of the group effort brought by the other members, and then performing poorly on some sort of individual assessment. In Experiment 1, there was evidence that indicated the possible presence of slackers in the cooperative groups. Twelve groups had members who earned high homework grades and low exam grades during the first experiment and then earned low homework and exam grades during the second experiment when they worked by themselves. Four other groups consisted of students who earned lower grades during the second experiment on the homework assignments and/or the exam after earning high grades during the first experiment on both the homework assignments and the exam. Students in this latter situation might have experienced resentful demoralization in the second experiment rather than performing as a slacker in the first experiment due to their good posttest 1 scores.

Grade trends for two groups from the first experiment showed that they might have continued to work together or possibly experienced imitation of treatment and/or compensatory rivalry. The item in this grade trend for these two groups was continued high achievement on the homework grades in the second experiment and then the low posttest 2 scores. However, overall, the individualistic learning control group in the second experiment earned significantly lower grades than the cooperative learning group.

In Experiment 2, there was also evidence of possible slackers. Just as with the first experiment, there were 12 groups that had members with high scores on the homework assignments and low scores on posttest 2. Three of these groups consisted of a partner who earned low grades during the first half of the semester. There were more individuals who earned lower grades during the individualistic learning phase in the first experiment, but there was no trend in the data that would lead one to believe that these students performed as slackers during the cooperative learning phase in the second experiment.

Resentful demoralization might have occurred within the control group in the second experiment because students indicated that they would have preferred to work with partners on the more difficult material during the second half of the semester. Students in the second experimental group indicated that they preferred working with a partner on the more difficult material rather than working with a partner during the first half of the semester. Resentful demoralization could have made a slacker more pronounced.

Time Together

Another factor to consider was the amount of time the cooperative groups spent together. Though the homework grades for the cooperative groups were significantly higher than those earned by students in the control conditions, the amount of time the groups spent together varied greatly. In the first experiment, there were groups that spent as little as 30 minutes together on a few of the assignments. In the second experiment, some groups met for several hours on more than one of the assignments. The average amount of time most groups spent together in both experiments was about two hours.

Since the course under study was worth one credit, the instructor recommended to everyone—students in both treatment and control conditions—to spend about two to three hours per week outside of class working on assignments and studying, and to spread out that time over several days. (This recommendation was based on information that the university provided in the undergraduate catalog.) Most groups indicated that they did not study together, while some indicated between 30 minutes and one hour. But, when partners did study together, the group study sessions occurred just once a week. Learning occurs over time, and the lack of group studying might have contributed to the findings that there were no significant differences between the cooperative learning and individualistic learning conditions in both experiments: The group experiences, which, in most cases, occurred only once a week, were either so weak or too spread out from week to week that any gains were not strong enough to overcome the strengths of individual studying in the control groups.

Information from Interviewees

Appendices N, O, and P provide the interview responses, weekly peer reviews from the interviewees, and corresponding grades for the interviewees. Appendix Q provides summaries of the information in Appendices N, O, and P in order of groups interviewed in each experiment.

Statements from the selected groups interviewed revealed various degrees of cooperation, but there were also characteristics of their group work that did not represent cooperative learning. Their weekly peer reviews showed similar information. The more successful of the groups interviewed, with high homework grades and individual exam grades, worked together either at the same time on separate computers or used one computer with each partner contributing to the assignment. The less successful groups had either a partner who did more of the work or partners who worked separately most of the time.

Another possible factor was how often the groups met to work and study together. One of the interviewees indicated that when they met they wanted to complete the assignment at that time because they did not want to meet again later in the week. He suggested that when they had difficulty with an assignment they had to take the time to solve the problem right then, which was more problematic than when they worked on their own assignment individually earlier in the semester because they could spread out the work over several days. Another interviewee indicated that her group rushed through the assignments due to extracurricular commitments.

The aforementioned successes and failures were representative of the groups that were not interviewed. However, in both experiments there were groups that exhibited good cooperative learning structures; groups that attempted the recommended structure, but did not switch roles every week; and groups that followed the recommended structure only some of the time. During the course of the semester, the instructor addressed the weekly peer reviews every week at the beginning and end of each class in the treatment groups in order to continue to promote cooperative learning. Issues related to the amount of time the partners spent together, each partner contributing to every assignment, and switching between the recommended roles each week were typical subjects raised every week. When the weekly peer reviews revealed situations in which one partner did most of the work (which would result in individual grade weighting) for any reason, the instructor contacted the students individually to verify their statements and to provide suggestions for working together. Additionally, the instructor reinforced the benefits of cooperative learning each week with the treatment groups during class in order to encourage them to follow the recommended cooperative group structure. To eliminate bias towards a particular learning method, though, the instructor equally supported individual learning with the control groups.

Hypothesis 2

Participants in the various levels of each selected demographic variable (major, academic year, number of years as an engineering major, gender, race, prior experience with the CAD software, prerequisite grade, and grade point average) achieve approximately equally.

This hypothesis was supported with respect to gender, major, academic year, year as engineering major, GPA, and prerequisite grade. The main effect of prerequisite grade in Experiment 2 was found not significant in a post-hoc analysis. As shown in Figures 11 and 12, students with higher prerequisite grades achieved higher on each of the tests. It is reasonable to believe that the prerequisite grade main effect could be the result of these students comprehending the more difficult subject matter better than students who had lower prerequisite grades. However, the differences were not significant according to the post-hoc analysis.

There was a significant difference in achievement found in the race demographic variable. Students in the “White” category achieved significantly higher than students in the two other race categories, “Asian” and “All Other Races.” Upon inspection of the number of students in each race category, one could reasonably attribute the differences to the large number of people in the White category compared to the small number of people in the other categories.

Prior experience was shown to be a significant factor in both experiments. Overall, it appears that students who had prior experience with the software had an advantage over other students when learning new material, especially the more advanced material. Though several of the differences were significant, the knowledge gap among the levels of prior experience reduced over time between the pretest and the posttests.

Hypothesis 3

All research participants achieve approximately equally well on each administration of the repeated measures.

The results of the data analyses indicated a main effect of time of achievement test administration. Both classes showed significant improvement between the pretest at the beginning of the semester and the mid-term exam (posttest 1) and between the pretest and the final exam (posttest 2). One could deduce from this result that learning occurred, which is a relief to know for any instructor. However, since both treatment and control groups showed significant improvement in both experiments from the pretest to their respective posttests, one cannot attribute learning gains to solely the teaching/learning methods employed (see results and discussion for Hypothesis 4). Learning occurred over time as a result of student understanding of the course content as it was introduced. Even considering students who indicated relatively high prior knowledge of the software from regular use and/or courses taken in high school, all students showed significant achievement gains from the pretest to the posttests.

Hypothesis 4

The research participants in each learning method group have an approximately identical achievement pattern over the repeated measures.

Overall, this hypothesis was supported by the data, but the year as engineering major demographic variable showed a method-by-time interaction (p = .048) during the second experiment. The probability level of .048 is very close to the alpha level set for the study, and the effect size of .04 addresses a very small percentage of the variability. For Hypothesis 6, though, the probability level of .051 was not considered a significant interaction between learning method and year as engineering major.

For Experiment 2, when grouping students only by how many years they had been engineering majors, students in the individualistic learning condition scored slightly higher on the pretest than the students in the cooperative learning treatment group, but students in the cooperative learning treatment group scored higher on posttest 2 than students in the individualistic learning condition. The data for Hypothesis 2 already established that students in the various levels of this variable achieved approximately equally, but it seems as though their performances during the second half of the semester "leveled the playing field" when compared to their performances during the first half of the semester. Though an interaction occurred when comparing pretest and posttest 2 scores according to year as engineering major, the differences between the groups were not significant.

Hypothesis 5

The achievement pattern is approximately identical for the number of participants of each level of a selected demographic variable across the repeated measures.

This hypothesis held true when considering only race, major, academic year, year as engineering major, prerequisite grade, or GPA. For Hypothesis 2, post-hoc analyses showed that perquisite grades were not significant factors on the posttests, even though students with higher prerequisite grades earned higher pretest and posttest scores. For Hypothesis 5, there was no significant interaction between prerequisite grade and time of achievement test administration because students with higher prerequisite grades earned higher pretest and posttest scores. Also for Hypothesis 5, there was a GPA-by-time interaction in the second experiment, but further analysis revealed that the removal of a single outlier resulted no interaction between GPA and time.

For Hypothesis 2, the data revealed no significant difference in achievement between male and female participants. For Hypothesis 3, there was a significant increase in achievement between the pretest and both posttests across all groups. For Hypothesis 5, however, the repeated measures analyses revealed gender-by-time interactions in both experiments. Though there was no significant difference between male and female participants' achievement, female participants earned higher scores on both posttests. Though learning style was not used as a covariate in the data analyses, learning style preference might have affected achievement scores.

The prior experience-by-time interaction in both experiments might be explained by the larger differences on pretest mean scores compared to the smaller differences on both posttests (see

Figures 9 and 10). Clearly, students with little or no prior experience with the software reduced the knowledge gap between the time of the pretest and the time of both posttests. This corresponds to the data supporting Hypothesis 2 and Hypothesis 3, both of which showed that students performed approximately equally well on the posttests.

Hypothesis 6

The difference in achievement (averaged across repeated measures) of participants from each level of a selected demographic variable is approximately the same magnitude within each of the two learning methods.

This hypothesis was supported by the data collected for each demographic variable except for academic year. Sophomores excelled in both learning methods during the first experiment, with slight preference for cooperative learning. Juniors were the next highest achievers in the first experiment, showing higher preference for individualistic learning. Seniors had the lowest scores, with a slight preference for individualistic learning. Even with these observations, the differences in magnitude within each learning method for each academic year level were not significant.

During the second experiment, there was a change in relative performance among the academic year levels. The one aspect that did not change was that sophomores were the highest achieving group in the individualistic learning condition; however, sophomores in the cooperative learning condition did not achieve as well as their individualistic learning counterparts. Juniors showed the greatest difference: They had the lowest scores in the individualistic learning condition, yet they had the highest scores in the cooperative learning condition. Seniors had the second highest scores in the individualistic learning condition and the lowest scores in the cooperative learning condition, with a preference for individualistic learning.

Hypothesis 7

The achievement on one of the repeated measures for any subgroup of participants is approximately equally influenced by the unique combination of the selected demographic variable, the learning method, and the specific time of the repeated measure.

This hypothesis was supported by the data. The unique combination of the independent and dependent variables together for each subgroup of participants did not produce significantly different levels of achievement among participants. Though the data analyses revealed selected main effects and interactions, the main effects and interactions were no longer present when all of the variables were considered at the same time.

Other Considerations

Since the course content differed in each experiment (first half vs. second half of the semester) and built upon previous material covered in the course, it is unclear if the student achievement levels were due to the learning methodology or the difficulty level of the content as the semester progressed. As discussed earlier, the higher treatment group homework grades were significantly different from the control group grades in both experiments, but the homework grade trends were similar for the treatment and control groups in both experiments. The treatment groups benefitted in some way from working together on the homework assignments, but that cooperation did not translate to the exam/posttest grades, which were shown not significantly different between treatment and control groups in both experiments.

Regarding learning methodology, there were no carry-over practice or fatigue effects in this study's counterbalanced design because the content changed when the treatment was switched. Practice or fatigue effects could occur in a counterbalanced design if the treatment and control content were the same both (or more) times. The content was different during each experiment in this study. However, a practice effect could have occurred in this study if students in Experiment 2 continued working together during the second half of the semester and students in Experiment 1 continued working individually during their treatment phase. There were a few cases in which data showed the possibility of a few students continuing to work together in the control phase of Experiment 2, but there was no proof of that occurring because all work was conducted outside of class time. Regarding the repeated measures (pretest, posttest 1, posttest 2), there were no practice or fatigue effect in this study's counterbalanced design because the tests were at least seven weeks apart.

Another factor may have been the level of difficulty of the assignments. The assignments were developmental, progressing from easy to hard from the start of the semester to the end of the semester. Similarly, this instructional design drew out a sort of progression in learning models.

First, the semester started with instruction on the basic commands for and methods of using the software. Students needed to learn the basics in order to move on to the next level of activities. The first few class lectures and assignments focused on students learning basic commands and procedures. Feedback on initial assignments indicated the degree to which student knowledge of the commands and related tasks were successful. One could consider this low-level processing. This initial teaching-learning model fits the behaviorist learning model. Students needed to know what commands and procedures were necessary to start using the software. After initial exposure to the software, students were ready to move on to more challenging assignments.

Second, after learning basic commands and procedures, students moved on to more complex situations which required effective use of prior commands and procedures. Mastery of the prior material could only be achieved if students developed the cognitive structures needed to remember the material. Regular studying and effective completion of assignments were necessary to develop those structures and were stressed by the instructor. The content required students to move on to tasks that required successful procedural execution of prior material. However, cognitive processing—i.e., knowing how—occurred throughout the semester, during simple and complex tasks. After developing basic knowledge about effective use of commands (behavioral development) and exercising procedural skills in using the commands in a variety of situations (cognitive development), students moved on to more of a problem-solving environment.

Lastly, one could consider the latter part of the semester as a constructivist learning environment. Even though students needed to learn new content to nearly the end of the semester, students could develop and produce the drawing assignments using any number of commands and procedures to which they were exposed throughout the semester and with which they were most comfortable. This was emphasized in class by exposing students to a variety of methods of completing selected tasks; e.g., command entry methods such as dynamic input versus command prompt, and procedural commands such as offsetting lines versus the multiline command for producing walls on floor plans. Students needed to produce the last few drawings using their prior experience in the course.

One could suggest that the aforementioned developmental nature was equal across all groups because all groups experienced it, and, therefore, would not be a factor. But, as indicated earlier, there were students in both treatment and control groups who either submitted incomplete assignments, receiving at most half-credit for the particular assignments, or did not submit a particular assignment. This was more prevalent in the control groups. The significant differences between the treatment and control groups on the homework assignments might not have occurred if everyone submitted complete assignments. However, all grades were considered in the analyses because the zero- and half-credit grades attest to the students' commitment to learning and their corresponding achievement as a result of working either with a partner or individually, which might have affected their performances on the exams/posttests.

Discussion of Limitations

The first limitation of the study listed in Chapter 1 was the treatment location. Since the researcher did not witness students working and studying during the treatment and control conditions, one might question the generalizability of the results to a larger population or even the validity of the results. Also, the self-reporting (interview responses and weekly peer reviews) by students in the treatment conditions was the primary method of trying to explain the achievement data that were the results of the learning conditions taking place where the treatment locations occurred. However, this is a limitation that is observed by most college-level courses. One could presume that most college courses follow a traditional lecture-discussion format. It would be difficult to consistently implement and study in-class cooperative learning efforts and introduce new content and discussion topics on a regular basis in such a course. But, the use of cooperative base groups and the jig-saw method could be used as a teaching-learning method for students to learn about new topics on their own during class meetings. Cooperative learning, though, is still considered an alternative learning method at the college level. So, though one could consider the treatment location used in this study as a limitation, most college students conduct their work and studying related to their courses outside of class time. This study involved cooperative and individualistic learning taking place under typical conditions.

The instruments used to measure achievement were/are limitations to consider. The pretest and posttests were validated by a panel of experts, but the tests were not officially tested for reliability. As noted earlier, the instructor-researcher used much of the content from the tests in previous semesters and obtained consistent results. Similarly, the grading rubrics for the various assignments were developed by the instructor-researcher and attempted to eliminate potential bias in grading between the two learning conditions. The grading rubrics were not tested for validity or reliability, yet faculty who taught the course in the past or related courses provided feedback in the development of the rubrics. Based on feedback from expert faculty, the instructor-researcher believed that the tests and homework grading rubrics were valid instruments.

Another one of the limitations listed earlier was related to the participants in the study. For most, if not all, studies, the characteristics of the study participants qualify the generalizability of the results to the larger population. Rather than the participants themselves as a limitation (since there are undergraduate engineering programs in large universities throughout the county and the world), the nature of a one-credit course was more of a limitation. It was unknown to the researcher how many other one-credit CAD courses for engineering majors were in the population. How students work(ed) in a one-credit course versus courses with a larger credit value was/is important to consider. As mentioned earlier, perhaps student commitment to a three-credit course would have yielded different results.

Conclusions

Implications for Professional Practice

Based on statements from interviewees, information in weekly peer reviews, and informal conversations with students, cooperative learning might not be appropriate for relatively simple activities or introductory material in a CAD course. More students seemed to think it would be better to have cooperative groups during more difficult activities than those who appreciated learning introductory material with a partner. Obtaining feedback from students about how class activities are working out is important. In some cases, though, instructors should be cautious when considering student feedback. For example, the motive for the use of cooperative groups for advanced assignments at the end of the semester could be related to planned “slacking” or the desire for a lighter load of work due to the typically hectic nature of end of semester projects and activities in most classes. Additionally, students are not experts in subject matter or learning theories. However, this pessimistic view of student motivation/opinion should not dissuade an instructor from considering student feedback. After all, as was one of the assumptions made in pursuit of this study, success in a class was an incentive because students wanted to earn good grades; earning good grades provided incentives for additional learning.

Since achievement scores on the posttests were not significantly different between the treatment and control groups, one could reasonably conclude that students could use either learning method—cooperative or individualistic—for any of the assignments and still attain an approximately equal achievement if they had used the other learning method. Even though overall homework grades from the treatment conditions were significantly higher than those from the control groups, any gains in learning according to those higher scores were not realized on the posttests. Therefore, the instructor could safely utilize either learning method for the homework assignments. The consideration, then, becomes which learning method would be more practical for a particular activity. Of course, potentially higher student achievement should be the guiding factor.

Similarly, one could reasonably conclude that a combined approach, using both cooperative and individualistic learning methods, might be the best approach for a CAD course such as the one studied. Based on participant responses from interviews and weekly peer reviews, more students indicated a preference for working with a partner during the more complex subject matter in Experiment 2 than those who preferred working with a partner on introductory material in Experiment 1. Also, the achievement analyses on posttest 2 revealed that the means for the treatment group were higher than the means for the control group, though the difference was not significant. Based on this information, utilizing cooperative and individualistic learning structures at various times throughout the semester, when practical, might serve students best.

The literature (e.g., Johnson, Maruyma, Johnson, Nelson, & Skon, 1981; Slavin, 1983) found gains not only in achievement as a result of cooperative learning, but also in other areas such as motivation, self-worth, satisfaction with school, positive gender and race relations, and general feelings of worth and approval by others. In this study, the weekly peer reviews and interviews revealed gains in similar areas, though studying gains in those areas was not the intent of this study. In the weekly peer reviews and interviews, students indicated positive group experiences, increased confidence with the subject matter, and the development of new friendships with other people in their major. Furthermore, many of the successful groups were heterogeneous in composition in terms of gender and race. One could deduce, therefore, that there were positive gender and race relations.

The literature (e.g., Fiechtner & Davis, 1984-1985) also found positive group experiences when group work accounted for a large percentage of the course grade, and when instructors used peer evaluations to determine individual grades and a relatively medium portion of the overall course grade. For the course under study, group work accounted for 50% of the course grade, which fell within the suggested range in the literature.

What we know from the literature and the results of this study, I believe that cooperative learning has a place in a CAD course such as the one under study. Cooperative learning might not be as effective in simple/basic CAD content activities as with complex/advanced CAD content, as evidenced by achievement scores on the posttests/exams. That does not mean, however, that cooperative learning activities should be limited to learning advanced content. Cooperative learning activities should be used at multiple times throughout the semester. Early use could lead to better understanding of content that forms the foundation of the content domain and promote positive peer relations that could be useful throughout the semester. Later use, such as during final projects, could lead to better understanding of complex content and promote peer interactions representative of real-world settings. Ultimately, the instructor is most familiar with the course content and structure of the learning activities and can decide which learning goal structure (cooperative, individualistic, or competitive) is best suited for a particular activity. Even so, more research is needed on CAD cooperative learning structures in a variety of applications and settings.

Cooperative learning should not be the only teaching-learning method in any class, though Johnson, Johnson, Holubec, and Roy (1984) believed that it should be the dominant goal structure (p.86). Even though research in cooperative learning for decades has shown the benefits of this teaching-learning method, educators know their curricula and through experience know what methods work for particular activities. Johnson et al. (1984) stated, “An essential instructional skill that all teachers need is knowing how and when to structure students’ learning goals competitively, individualistically, and cooperatively. Each goal structure has its place; an effective teacher will use all three appropriately” (p. 1). The counterbalanced research design used in this study was an appropriate structure for the course. Each student had opportunities to work individually and cooperatively with a partner. It was difficult to assess whether or not various social threats to internal validity (e.g., diffusion or imitation of treatment, resentful demoralization) or carry-over effects that affected external validity actually took place, but there were data that supported the possibility existed with a few cases. Trochim (2006) provided an overarching warning for any educational research in which students serve as research participants: "….[W]e will never be able to entirely eliminate the possibility that human interactions are making it more difficult for us to assess cause-effect relationships."

Recommendations for Further Research

Researchers should study cooperative learning in college-level courses with varying credit levels. The effects of cooperative learning might be more detectable and noticeable in courses that meet more often and require a longer time commitment outside of class from students (such as a three-credit course) than in courses that do not meet often and require a smaller outside commitment (such as a one-credit course). Students might be more willing and able to follow cooperative learning strategies when their schedules permit/require them to meet often and the final course grade has a higher value/impact on their GPAs. Furthermore, more group processing, including studying, might take place when groups meet more often.

Longitudinal studies should be conducted on the effects of cooperative learning over time. Do the effects of the cooperative experience carry over into subsequent courses, especially in courses that are part of a sequence of courses covering the same content domain? For example, were the students in this study able to apply their CAD knowledge into subsequent courses for which this course was a prerequisite (in particular, the facility design courses in their respective majors) and do they attribute that ability to their cooperative learning experience in this course? They either learned a lot from working with a partner with respect to the introductory material the first half of the semester, which provided the foundation for everything else later on, or gained more from working with a partner during the facility design phase of the semester, which had more application to their later facility design courses.

Similarly, one should conduct the same study multiple times and study the effects of CAD cooperative learning over multiple semesters. Would the results from this study be similar if one conducted the study several times in subsequent semesters? Drawing conclusions about CAD cooperative learning based on results from multiple iterations of a study would be more powerful than a single iteration of a study.

Another area to study includes the effects of cooperative learning in subject matter with selected degrees of difficulty or levels of task complexity. Is cooperative learning more effective when learning simple tasks that form the foundation for advanced subject matter, or would it be more effective for studying complex subjects? In this study, there were students who supported both scenarios: Some students believed that it was or would have been better to utilize cooperative learning strategies during the introductory material, and other students believed that cooperative learning was or would have been better to use during the more advanced topics later in the semester. Overall, more students indicated that they preferred working with a partner on the more difficult assignments. But, there were students who commented that they appreciated working with a partner on the introductory material because they thought it was helpful to learn something new with someone who also did not have prior experience.

Similar to the previous recommendation, one should further study the use of multiple learning structures throughout a CAD course. The literature supports the use of the all three learning structures (cooperative, individualistic, and competitive) in classes, and it would be up to the instructor to determine when to use each learning structure. In this study, the effects of cooperative and individualistic learning structures were investigated. Both learning structures seemed appropriate at various times. When is it best to use cooperative, individualistic, and competitive learning structures in a CAD course?

Further studies should be conducted on different cooperative learning strategies for a CAD course like the one in this study. Will different cooperative learning strategies work better in a particular CAD course?

Researchers should study how personal and group study habits affect outcomes of various learning structures. In particular, researchers should determine how the amount of time spent on group processing in cooperative learning and the frequency of that processing affects learning outcomes.

More research needs to be conducted in real settings such as the one in this study. Learning takes place over time in a variety of settings and under a variety of conditions. Studying the effects of cooperative learning structures outside of the classroom has relevance for most, if not all, college classroom settings. Though students' self-reporting of their cooperative efforts outside of class could bring into question the validity of a study about the effectiveness of cooperative learning, further research is needed on these out-of-class efforts.

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Appendix A

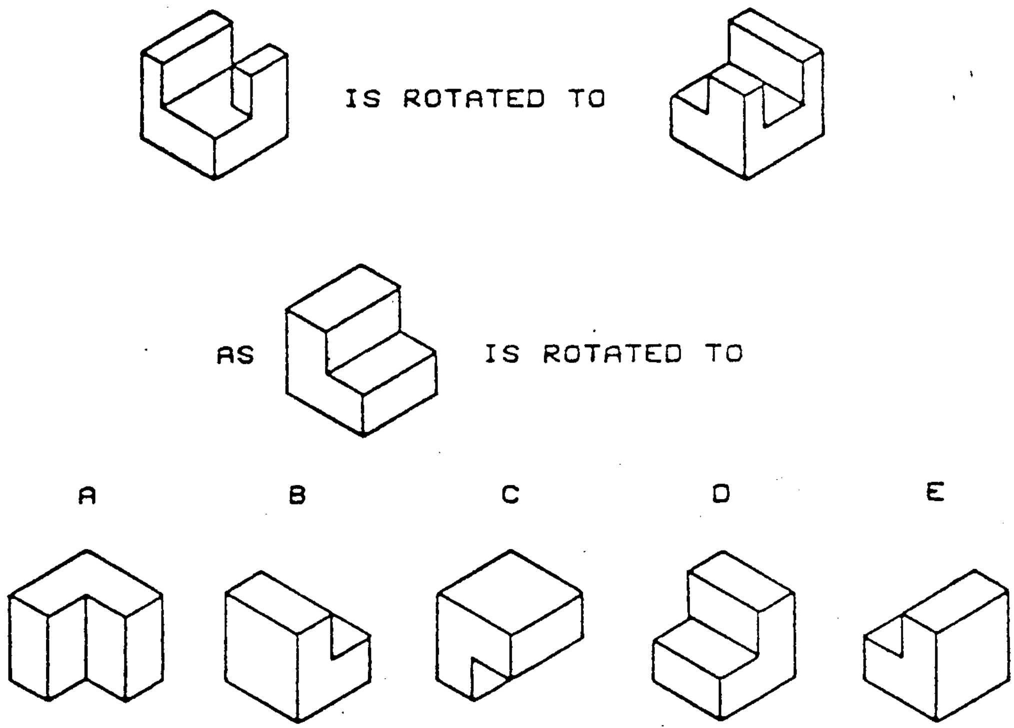
The Purdue Visualization of Rotations Test

The following 12 pages comprise Bodner and Guay's (1997, October 3) *The Purdue Visualization of Rotations Test*, provided free of charge on-line at http://chemeducator.org/bibs/0002004/00020138.htm. The resources available include a research article, the test, and an answer key.

Do NOT make any marks on this exam.
Mark your answers on the separate answer sheet

DIRECTIONS

This test consists of 20 questions designed to see how well you can visualize the rotation of three-dimensional objects. An example of the type of question included in this test is shown below.



For each question, you should:

I. Study how the object in the top line of the question is rotated.

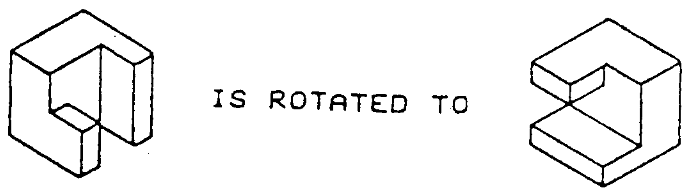
II. Picture in your mind what the object shown in the middle line of the question looks like when rotated in exactly the same manner.

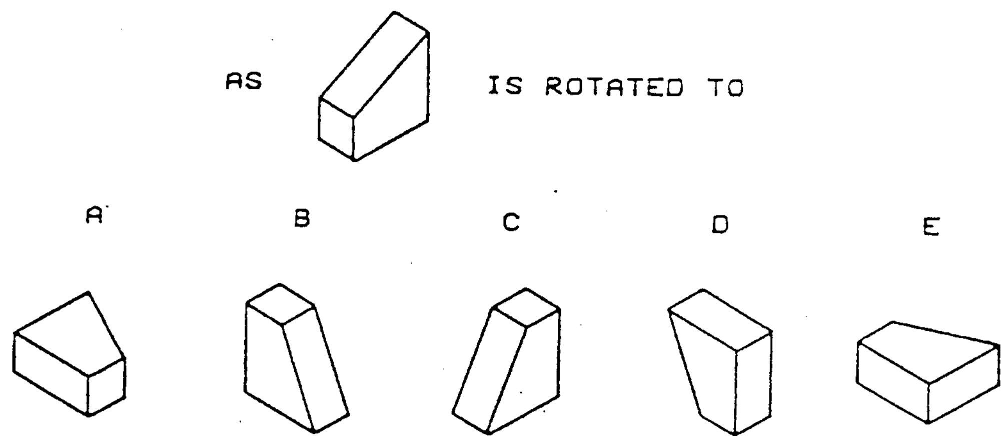
III. Select from among the five drawings (A, B, C, D, or E) given in tbe bottom line of the question the one that looks like the object rotated in the correct position.

What is the correct answer to the example shown above?

Answers A. B. C. and E are wrong. Only drawing D looks like the object after it hsa been rotated. Remember that each question has only one correct answer.

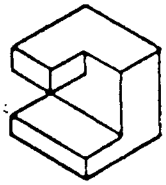
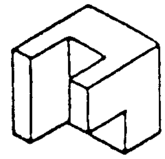
Now look at the example shown below and try to select the drawing that looks like the object in the correct position when the given rotation is applied

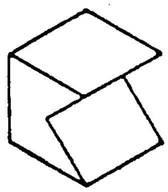


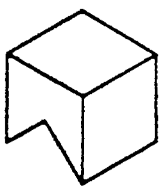
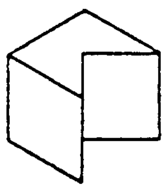
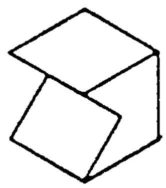
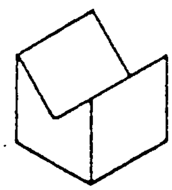
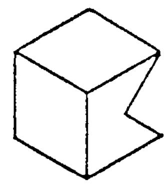


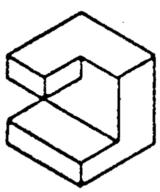
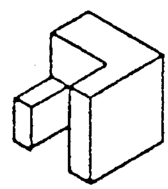
Note that the rotation in this example is more complex. The correct answer for this example is B.

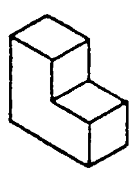
Do NOT make any marks in this booklet.
Mark your answers on the separate answer sheet.
You will be told when to begin

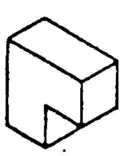
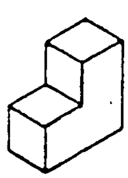
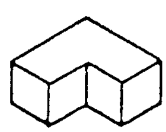
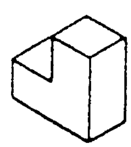
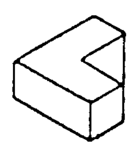
1  IS ROTATED TO 

AS  IS ROTATED TO

A 
B 
C 
D 
E 

2  IS ROTATED TO 

AS  IS ROTATED TO

A 
B 
C 
D 
E 

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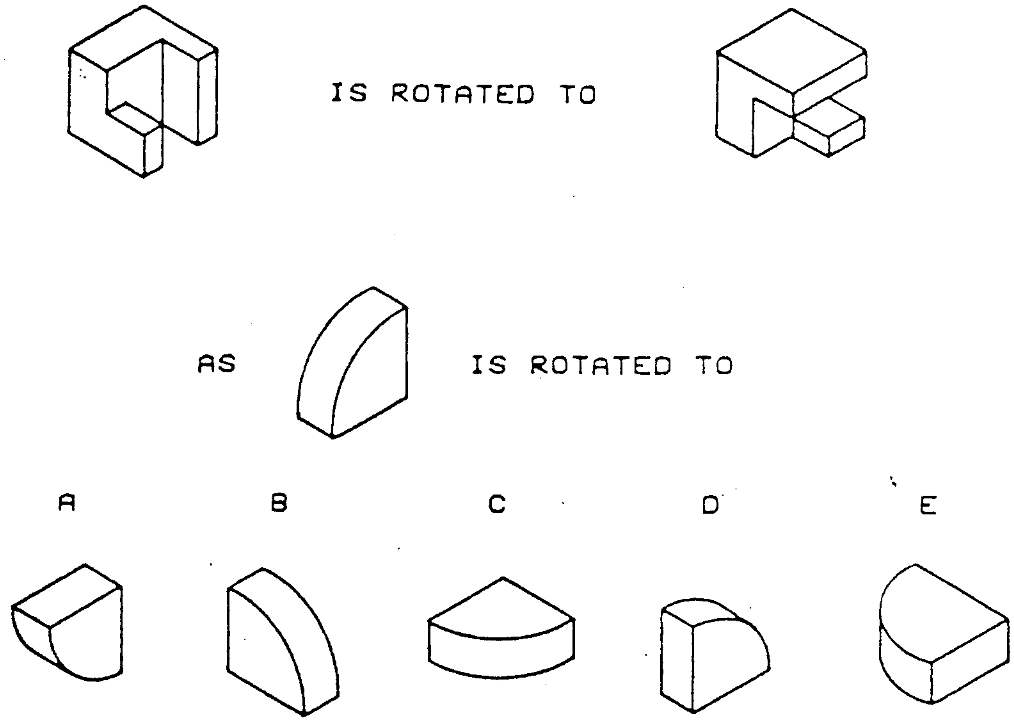
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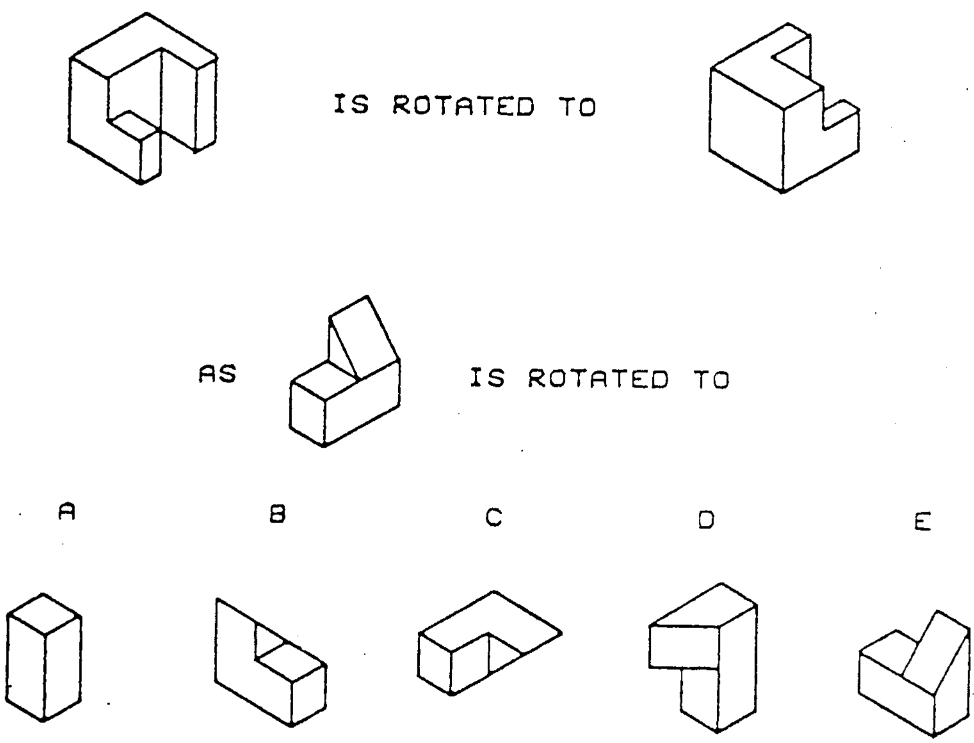
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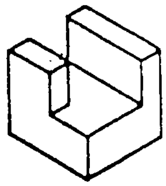
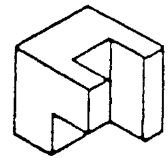
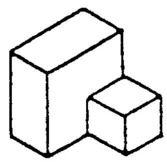
5  IS ROTATED TO 

AS  IS ROTATED TO

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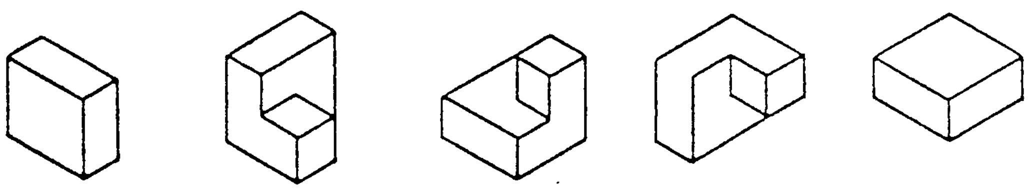
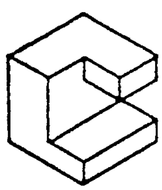
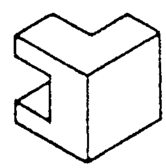
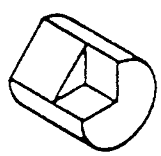


6  IS ROTATED TO 

AS  IS ROTATED TO

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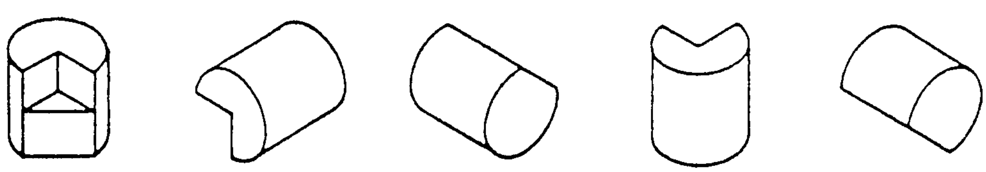
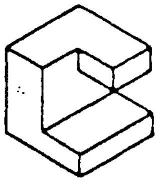
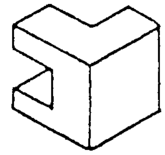
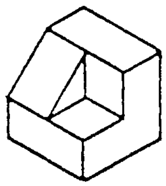


7  IS ROTATED TO 

AS  IS ROTATED TO

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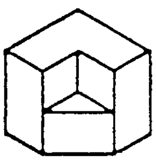
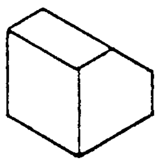
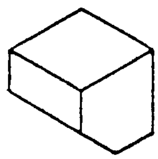
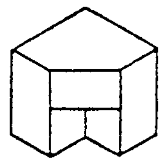
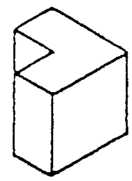
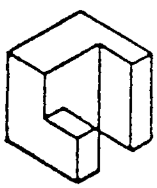
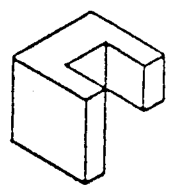
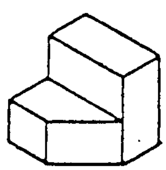
				

8  IS ROTATED TO 

AS  IS ROTATED TO

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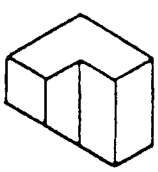	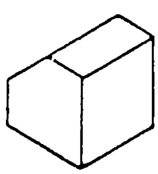	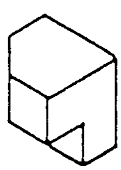	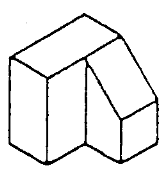	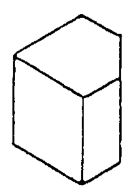

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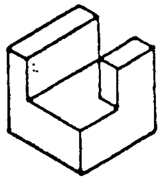

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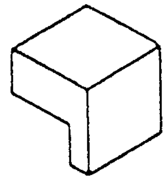

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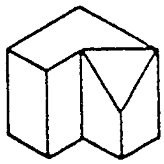

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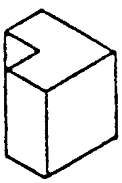

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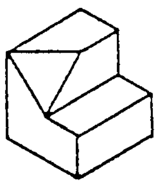

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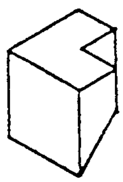

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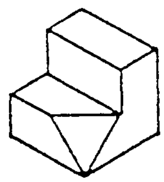

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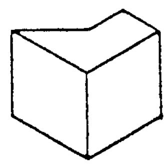

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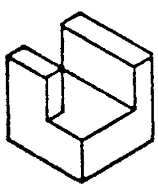

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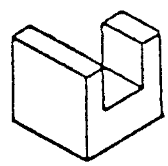

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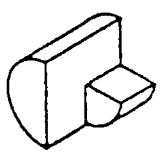

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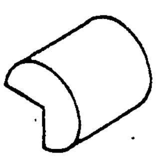

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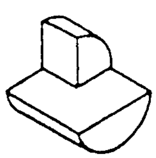

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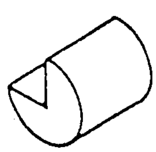

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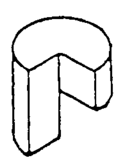

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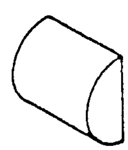

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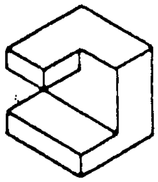

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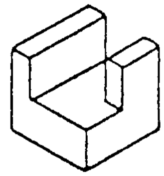

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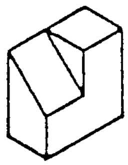

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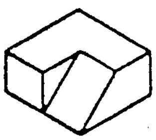

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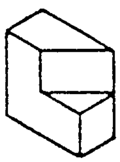

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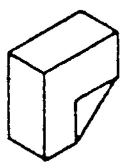

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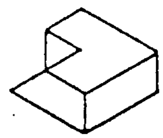

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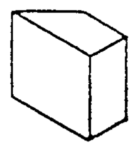

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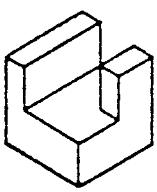

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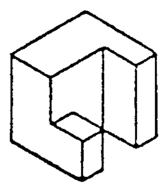

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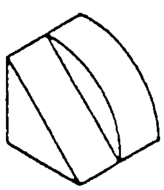

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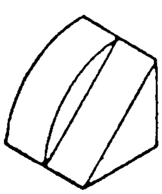

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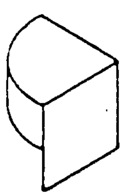

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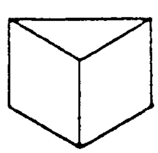

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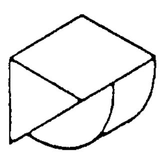

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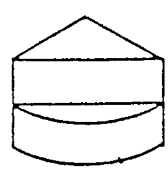
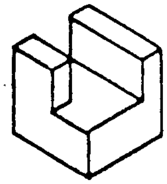
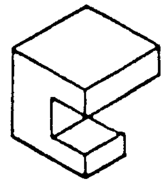
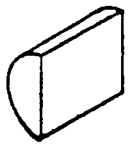
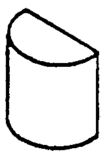
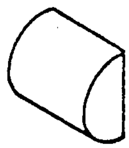
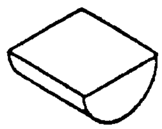


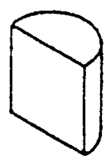
13  IS ROTATED TO 

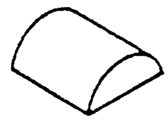
AS  IS ROTATED TO

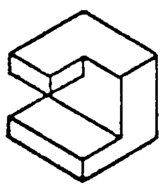
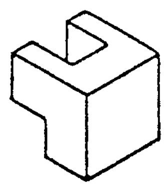
A 

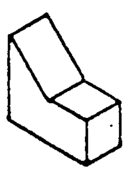
B 

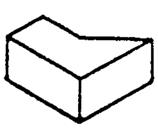
C 

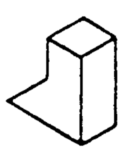
D 

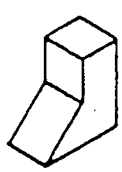
E 

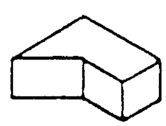
14  IS ROTATED TO 

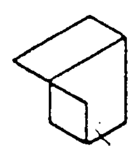
AS  IS ROTATED TO

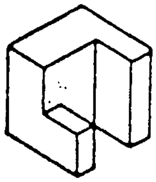
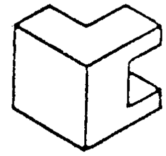
A 

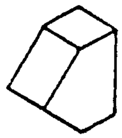
B 

C 

D 

E 

15  IS ROTATED TO 

AS  IS ROTATED TO

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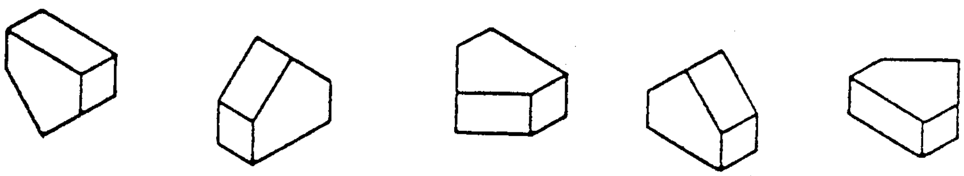
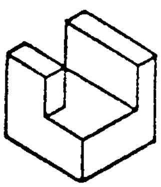
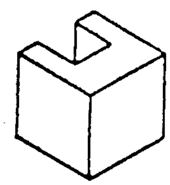
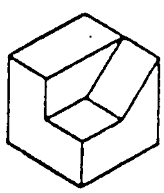


16  IS ROTATED TO 

AS  IS ROTATED TO

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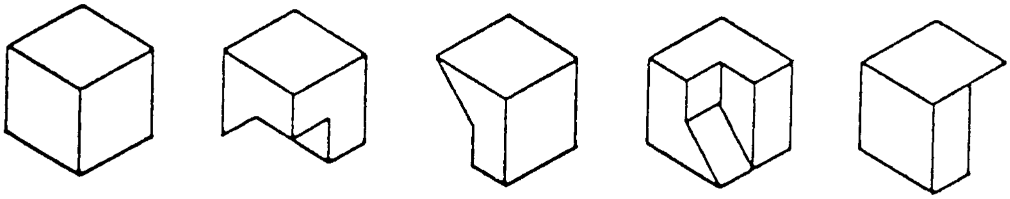
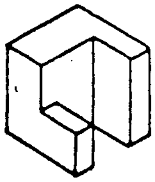
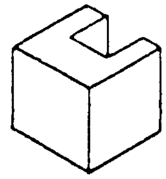
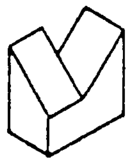
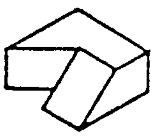
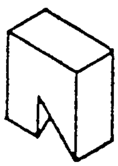
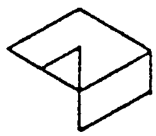


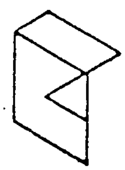
17  IS ROTATED TO 

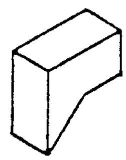
AS  IS ROTATED TO

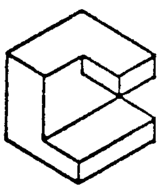
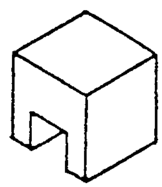
A 

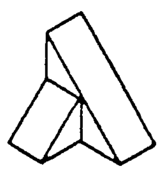
B 

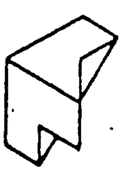
C 

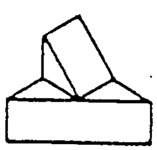
D 

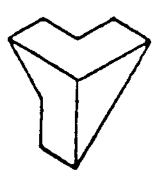
E 

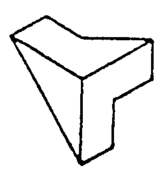
18  IS ROTATED TO 

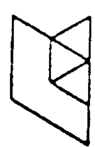
AS  IS ROTATED TO

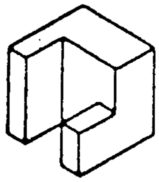
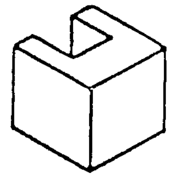
A 

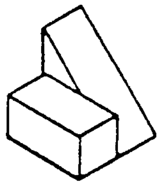
B 

C 

D 

E 

19  IS ROTATED TO 

AS  IS ROTATED TO

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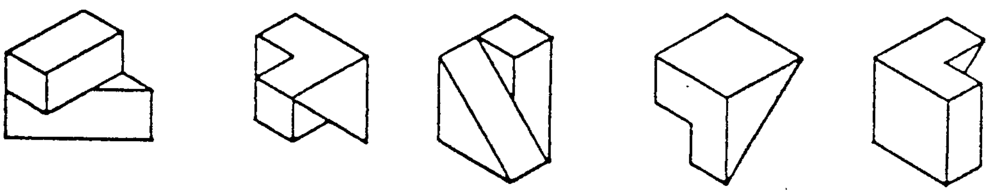
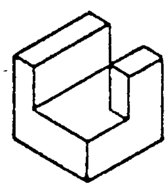
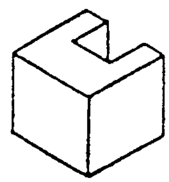
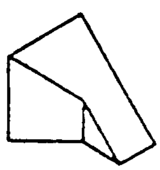


20  IS ROTATED TO 

AS  IS ROTATED TO

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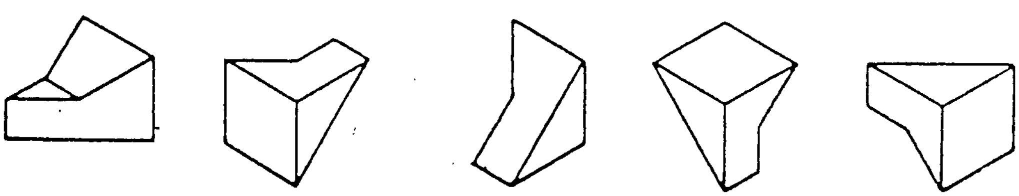

Appendix B

Soloman-Felder *Index of Learning Styles*

The following pages consist of the license for using the Soloman-Felder (1997) *Index of Learning Styles Questionnaire*, the questionnaire, and a sample output. The questionnaire is available free of charge on-line at http://www.engr.ncsu.edu/learningstyles/ilsweb.html.

Index of Learning Styles

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Return to the list of frequently asked questions about the Index of Learning Styles.

NC STATE UNIVERSITY

Index of Learning Styles Questionnaire

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Directions

Please provide us with your full name. Your name will be printed on the information that is returned to you.

Full Name ____________________

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1. I understand something better after I
   - ○ **(a)** try it out.
   - ○ **(b)** think it through.

2. I would rather be considered
   - ○ **(a)** realistic.
   - ○ **(b)** innovative.

3. When I think about what I did yesterday, I am most likely to get
   - ○ **(a)** a picture.
   - ○ **(b)** words.

4. I tend to

○ **(a)** understand details of a subject but may be fuzzy about its overall structure.
○ **(b)** understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to
○ **(a)** talk about it.
○ **(b)** think about it.

6. If I were a teacher, I would rather teach a course
○ **(a)** that deals with facts and real life situations.
○ **(b)** that deals with ideas and theories.

7. I prefer to get new information in
○ **(a)** pictures, diagrams, graphs, or maps.
○ **(b)** written directions or verbal information.

8. Once I understand
○ **(a)** all the parts, I understand the whole thing.
○ **(b)** the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
○ **(a)** jump in and contribute ideas.
○ **(b)** sit back and listen.

10. I find it easier
○ **(a)** to learn facts.
○ **(b)** to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
○ **(a)** look over the pictures and charts carefully.
○ **(b)** focus on the written text.

12. When I solve math problems
○ **(a)** I usually work my way to the solutions one step at a time.
○ **(b)** I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
○ **(a)** I have usually gotten to know many of the students.
○ **(b)** I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
○ **(a)** something that teaches me new facts or tells me how to do something.
○ **(b)** something that gives me new ideas to think about.

15. I like teachers

- ◯ **(a)** who put a lot of diagrams on the board.
- ◯ **(b)** who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
    - ◯ **(a)** I think of the incidents and try to put them together to figure out the themes.
    - ◯ **(b)** I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
    - ◯ **(a)** start working on the solution immediately.
    - ◯ **(b)** try to fully understand the problem first.

18. I prefer the idea of
    - ◯ **(a)** certainty.
    - ◯ **(b)** theory.

19. I remember best
    - ◯ **(a)** what I see.
    - ◯ **(b)** what I hear.

20. It is more important to me that an instructor
    - ◯ **(a)** lay out the material in clear sequential steps.
    - ◯ **(b)** give me an overall picture and relate the material to other subjects.

21. I prefer to study
    - ◯ **(a)** in a study group.
    - ◯ **(b)** alone.

22. I am more likely to be considered
    - ◯ **(a)** careful about the details of my work.
    - ◯ **(b)** creative about how to do my work.

23. When I get directions to a new place, I prefer
    - ◯ **(a)** a map.
    - ◯ **(b)** written instructions.

24. I learn
    - ◯ **(a)** at a fairly regular pace. If I study hard, I'll "get it."
    - ◯ **(b)** in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
    - ◯ **(a)** try things out.
    - ◯ **(b)** think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
   - **(a)** clearly say what they mean.
   - **(b)** say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
   - **(a)** the picture.
   - **(b)** what the instructor said about it.

28. When considering a body of information, I am more likely to
   - **(a)** focus on details and miss the big picture.
   - **(b)** try to understand the big picture before getting into the details.

29. I more easily remember
   - **(a)** something I have done.
   - **(b)** something I have thought a lot about.

30. When I have to perform a task, I prefer to
   - **(a)** master one way of doing it.
   - **(b)** come up with new ways of doing it.

31. When someone is showing me data, I prefer
   - **(a)** charts or graphs.
   - **(b)** text summarizing the results.

32. When writing a paper, I am more likely to
   - **(a)** work on (think about or write) the beginning of the paper and progress forward.
   - **(b)** work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
   - **(a)** have "group brainstorming" where everyone contributes ideas.
   - **(b)** brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
   - **(a)** sensible.
   - **(b)** imaginative.

35. When I meet people at a party, I am more likely to remember
   - **(a)** what they looked like.
   - **(b)** what they said about themselves.

36. When I am learning a new subject, I prefer to
   - **(a)** stay focused on that subject, learning as much about it as I can.
   - **(b)** try to make connections between that subject and related subjects.

37. I am more likely to be considered
    - **(a)** outgoing.
    - **(b)** reserved.

38. I prefer courses that emphasize
    - **(a)** concrete material (facts, data).
    - **(b)** abstract material (concepts, theories).

39. For entertainment, I would rather
    - **(a)** watch television.
    - **(b)** read a book.

40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
    - **(a)** somewhat helpful to me.
    - **(b)** very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
    - **(a)** appeals to me.
    - **(b)** does not appeal to me.

42. When I am doing long calculations,
    - **(a)** I tend to repeat all my steps and check my work carefully.
    - **(b)** I find checking my work tiresome and have to force myself to do it.

43. I tend to picture places I have been
    - **(a)** easily and fairly accurately.
    - **(b)** with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
    - **(a)** think of the steps in the solution process.
    - **(b)** think of possible consequences or applications of the solution in a wide range of areas.

When you have completed filling out the above form please click on the Submit button below. Your results will be returned to you. If you are not satisified with your answers above please click on Reset to clear the form.

Submit Reset

Dr. Richard Felder, felder@ncsu.edu

NC STATE UNIVERSITY

Learning Styles Results

```
Results for: Test

ACT            X                                                  REF
     11   9    7    5    3    1    1    3    5    7    9    11
                              <--  -->

SEN                      X                                        INT
     11   9    7    5    3    1    1    3    5    7    9    11
                              <--  -->

VIS                      X                                        VRB
     11   9    7    5    3    1    1    3    5    7    9    11
                              <--  -->

SEQ                                X                              GLO
     11   9    7    5    3    1    1    3    5    7    9    11
                              <--  -->
```

- If your score on a scale is 1-3, you are fairly well balanced on the two dimensions of that scale.
- If your score on a scale is 5-7, you have a moderate preference for one dimension of the scale and will learn more easily in a teaching environment which favors that dimension.
- If your score on a scale is 9-11, you have a very strong preference for one dimension of the scale. You may have real difficulty learning in an environment which does not support that preference.

We suggest you print this page, so that when you look at the explanations of the different scales you will have a record of your individual preferences.

For explanations of the scales and the implications of your preferences, click on Learning Style Descriptions.

For more information about learning styles or to take the test again, click on Learning Style Page.

Appendix C

Interview Protocol

This appendix consists of items used in the interview protocol followed in this study. The first item (below) is the list of statements read by the interviewer (the instructor-researcher) to the interviewees before each interview began.

The following four pages consist of the interview questions. Before the interviews started, the interviewees completed first section with the demographic information themselves.

Interviewer Statements

1. "The purpose of this interview is for our department to gain some insight about how students participate in and feel about working in groups on CAD assignments outside of class."

2. "You may decline to answer any question that you do not feel comfortable answering."

3. "The answers you do or do not provide will not affect your grade in this course in any way."

4. "You may withdraw from this interview at anytime. Withdrawing from this interview will not affect your grade either."

- (Check for understanding or needed clarification.)

Interview Questions

Date: ________________ Time: ______________

Section I

1. **Research ID Number (RID)**: ________________________________
2. **ENGE 2344 Section** (*please circle*): 13T (CRN: 92398) or 13R (CRN: 92399)
3. **Major** (*please circle*): ISE or BSE or other:____________
4. **Academic Year** (*please circle*): sophomore, junior, senior
5. **Year As Engineering Major** (*please circle*): 2nd-year, 3rd-year, 4th-year or higher
6. **GPA**: ____________
7. **Gender** (*please circle*): Male or Female
8. **Race** (*please circle letter*):*

   a. Multiracial (If so, please circle this letter and other appropriate letters.)

   b. White, but not Hispanic or Latino

   c. Hispanic or Latino (Includes: Mexican, Puerto Rican, Cuban, or other Hispanic or Latino)

   d. Black or African American

   e. Middle Eastern

   f. American Indian or Alaska Native

   g. Asian (Includes: Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, or other Asians)

   h. Native Hawaiian and other Pacific Islander (Includes: Native Hawaiian, Guamanian or Chamorro, Samoan, or other Pacific Islander)

*Note: These categories come from the U.S. Census Bureau.

Did you have experience with AutoCAD before taking this class?

- Yes, No
    - If yes, to what extent?

Did your partner have prior AutoCAD experience?

- Yes, No
    - If yes, to what extent?

Do you generally like learning something on your own or with other people?

1. On own, with others, mixed

2. Why?

<u>Section II</u>

How do you feel you learn things best:

a. going to a lecture?
b. getting hands-on experience?
c. reading about it on your own?
d. other ways?

Section III

How did it work out when working with a partner on the CAD assignments?

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?

2. study?

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- Was the amount of time allotted to you to complete each assignment:
  - Just right?
  - Need more time?
  - Too much time?

- How would you feel about the time allotted if you had to work by yourself?

How did you feel about working with a partner on the CAD assignments?

*Optional question for second treatment group:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner

- By yourself

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

*End of treatment question:
How would you have felt about working with a partner for the entire semester?

What is your level of confidence in knowledge of the software?

*Optional question for second treatment group:

- Do you think you learned more about the software by working with a partner or by yourself?

Do you have any additional comments about your group experience so far?

Appendix D

Introductory Survey

Your instructor will keep your answers on this survey in strict confidentiality and will not divulge any personally identifiable information to anyone. This questionnaire is for research and class purposes for setting up groups. Your answers will not affect your grade in this course in any way. *You may skip any question you feel intrudes upon your privacy*. This survey will be destroyed at the end of this semester.

9. **Name [Required]** (*please print*): ________________________________

10. **ENGE 2344 Section [Required]** (*please circle*): 13T (CRN: 92398) or 13R (CRN: 92399)

11. **Major [Required]** (*please circle*): ISE or BSE or other:____________

12. **Academic Year** (*please circle*): sophomore, junior, senior

13. **Year As Engineering Major** (*please circle*): 2nd-year, 3rd-year, 4th-year or higher

14. **GPA**: ____________

15. **Gender** (*please circle*): Male or Female

16. **Race** (*please circle letter*):*

    a. Multiracial (If so, please circle this letter and other appropriate letters.)
    b. White, but not Hispanic or Latino
    c. Hispanic or Latino (Includes: Mexican, Puerto Rican, Cuban, or other Hispanic or Latino)
    d. Black or African American
    e. Middle Eastern
    f. American Indian or Alaska Native
    g. Asian (Includes: Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, or other Asians)
    h. Native Hawaiian and other Pacific Islander (Includes: Native Hawaiian, Guamanian or Chamorro, Samoan, or other Pacific Islander)

    *Note: These categories come from the U.S. Census Bureau.

17. **Grade earned in EF 1016, ENGE 1114, or similar technical design course that satisfied the prerequisite for this course**: __________

18. **What kind of activities do you enjoy outside of classes or school?**

19. **During what days and times during the week would you be available to work with a classmate on a project for this class?**

20. **Describe your previous AutoCAD experience in terms of the number and types of courses you have taken and how long ago you took them.**

Appendix E

Test Validation Protocol

The test validation procedure included several steps. First, the researcher e-mailed current and former CAD professors who might serve as experts in the test validation protocol. After receiving confirmations from three professors that they would help, the researcher e-mailed two documents to the test validation team: 1) excerpts from the course syllabus appropriate for determining whether or not the test questions represented the course content, and 2) the test questions pool with accompanying instructions for rating each question. After receiving feedback from the test validation team, the researcher scored the ratings for the test items and then created the final test pool. Next, the researcher randomly selected half of the questions—either the main or alternate question—from the first half of the question pool, which represented content for the mid-term exam (posttest 1), and half of the questions from the second half of the question pool, which represented content for the final exam (posttest 2). The randomly selected questions formed the pretest. The remainder of the questions that were not chosen for the pretest formed the mid-term and final exams.

The first item below is the content of the e-mail sent to the test validation team. The next two pages contain the excerpts from the course syllabus. Finally, the test validation instructions and sample questions are provided. The final versions of the tests appear in Appendix F.

E-mail to Test Validation Team

Professors,
Thank you very much for your willingness to participate in the validation process for the AutoCAD exams used in part of my dissertation research. I estimated that your time commitment should take no longer than three hours because there are 119 test questions in the pool and space available to rate and provide comments for each question.

I have attached two Microsoft Word 2002 files. The test questions with accompanying feedback space are in the file titled, “Swab-AutoCAD_Exam_Question_Pool.doc.” The other file, entitled “Swab-Selected_Syllabus_Sections.doc,” contains information about the course I teach that may help you rate and assess the relevancy of the test questions.

Thank you for your time and assistance. You may contact me via e-mail if you have any questions.

Thanks.

- Jeff

Selected Syllabus Sections from AutoCAD Course (1 credit)

Catalog Course Description:

Introduction to computer-aided drafting concepts, primarily in two dimensions. Creation of two-dimensional system views utilizing lines, polygons, polylines, construction lines; creating drawing views principally applied to facilities design and layout. Prerequisite: ENGE 1016/1114 (C- or better).

Course Goals:

The purposes of this course are for students to:

- develop two-dimensional CAD drawings using AutoCAD 2007,
- apply practical drafting techniques to CAD,
- use typical CAD terminology, and
- develop an intuitive familiarity with AutoCAD 2007's 2D capabilities in order to efficiently develop designs for subsequent engineering courses.

Course Objectives:

After completing this course, students will be able to:

- effectively use common AutoCAD drawing commands,
- create and modify two-dimensional CAD entities,
- generate orthographic views of CAD entities,
- create and insert blocks with attributes,
- create and extract entity attributes,
- produce drawings demonstrating architectural practices,
- develop plans related to facility design and plant layout, and
- plot scaled drawings.

Required Materials:

1. Hardware and Software:
    - Laptop computer with appropriate performance capabilities and wireless Internet connectivity
    - **AutoCAD 2007**, available in the Inventor 11 bundle at Software Distribution
    - **Microsoft Excel**, for use during the last few weeks of the semester
    - **Web browser** (Microsoft Internet Explorer preferred)
    - Printer that generates good printouts
2. Textbook:

    Shih, R. H. (2006). *AutoCAD 2007 Tutorial – First Level: 2D Fundamentals*. Mission, KS: SDC Publications.
3. Resources for taking notes
4. #2 pencil for sketching and certain assessments

Tentative Schedule:

Week	Date	Topic	Assignment
1	8/22/2006	Course Intro., Syllabus, Software & Hardware Requirements, Computer Management	Load AutoCAD 2007, Read *Introduction*
2	8/29/2006	AutoCAD Intro., MOVE & Text commands, File Types; Plotter Manager; Grading; Blackboard use	DWGs: Chapter 1 Tutorial, Chapter 1 Ex. 2
3	9/5/2006	Drawing Habits & Procedures, Drafting Settings, Templates; DYN, Grips, OSNAPs, TRIM	DWGs: Chapter 2 Tutorial, Chapter 2 Ex. 1
4	9/12/2006	Drawing Procedures; OFFSET, HATCH, OSNAPs; Layers	DWGs: Chapter 3 Tutorial, Chapter 3 Ex. 3
5	9/19/2006	Metric Units, OTRACK, Model & Paper Space, Title Blocks & Sheet Layouts, Plot vs. Viewport Scales	DWG: Chapter 5 Tutorial with additional elements
6	9/26/2006	Construction Lines, LWT, MIRROR, ARRAYs	Read Chapter 6, DWG: modified Chapter 7 Tutorial
7	10/3/2006	Review for Mid Term Exam	Study for Exam
8	10/10/2006	**Mid Term Exam**	DWG: Begin Chapter 4 Tutorial
9	10/17/2006	MLINE, Floor Plans & Symbols, Architectural Scales; Customizing AutoCAD	DWG: Complete Chapter 4 Tutorial
10	10/24/2006	DIM Settings; Blocks & Attributes; MS Excel	DWG: CAD Room & Excel Spreadsheet
11	10/31/2006	Project Intro., Large DWGs, Layer Management, Multiple Viewports; Attributes	Begin Project
12	11/7/2006	DesignCenter; 3D Features; Attributes; Plot Style Table, Plotting	Complete Project
13	11/14/2006	Review for Exam	Study for Exam
14		THANKSGIVING BREAK	
15	11/28/2006	**Final Exam**	Pick up project during exam week

Validation Form for Jeff Swab's AutoCAD Exam Questions

<u>Instructions</u>
Please evaluate the test questions within this document in terms of how representative the items are of the content domain appropriate for a one-credit college course in AutoCAD 2007. The students who take the course are engineering majors in Industrial and Systems Engineering and Biological Systems Engineering. The course serves as a prerequisite for facility design courses in both majors. As you evaluate each test question consider to what extent the question measures knowledge of AutoCAD. Another important characteristic of each question is its clarity. Please evaluate the clarity of each question. Lastly, please evaluate the overall comprehensiveness of the test questions for each half of the semester by indicating which questions should be added or deleted. For your reference, I have attached portions of the course syllabus in a separate document.

Answers for all the questions have been highlighted in green. Most questions appear on separate pages within this document and have either two forms or a set of similar questions that cover the same content area. These questions appear one after the other and are numbered sequentially. The purpose of the alternate questions is to draw from the question pairs or sets pretest questions representative of the content covered in the actual midterm and final exams. A few questions have multiple alternates and a few questions have only one form. The questions with only one form are questions that either have an alternate form the other half of the semester or make reference to specific assignments unique to this course.

Below each question or sets of alternatives, please rate the representativeness and clarity of the question(s) on a scale of 1 to 4, with 4 being the most representative, by highlighting your numbered rating in the table. (See below for the rating scales and a sample table.) You may provide any necessary feedback/comments for that question in the lower part of the table.

Scale for Representativeness:

1 = Item is not representative
2 = Item needs major revisions to be representative
3 = Item needs minor revisions to be representative
4 = Item is representative

Scale for Clarity:

1 = Item is not clear
2 = Item needs major revisions to be clear
3 = Item needs minor revisions to be clear
4 = Item is representative

Sample table:

Representativeness:				Clarity:			
1	2	3	4	1	2	3	4
Comments:				Comments:			

FIRST HALF OF SEMESTER

(pages 2 – 54)

Multiple Choice Questions

1) To repeat the last command in AutoCAD, one can:

   a) press the [Spacebar].
   b) press the [Enter] or [Return] key.
   c) retype the command.
   d) all of the above.

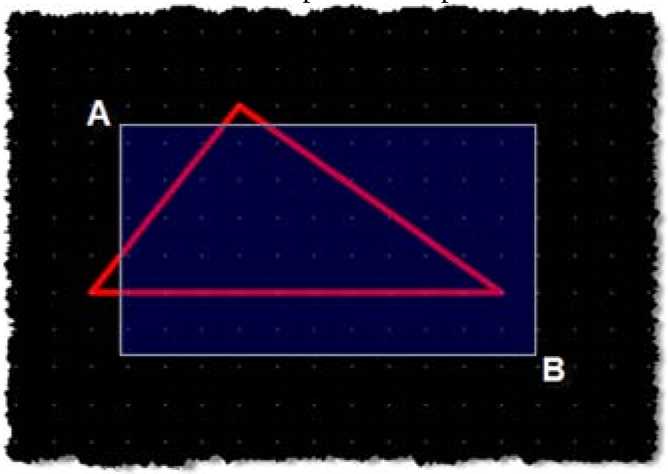
Representativeness:				Clarity:			
1	2	3	4	1	2	3	4
Comments:				Comments:			

Alternate for Question 1:

2) After completing a command and a blank command prompt appears, what happens when you press the [Spacebar] on your keyboard?
   a) Nothing
   b) A space appears first in the command prompt
   c) An error message pops up
   d) It repeats the previous command

Representativeness:				Clarity:			
1	2	3	4	1	2	3	4
Comments:				Comments:			

5) In the figure below, how many lines of the red triangle will become selected if you drag a selection window from point A to point B?

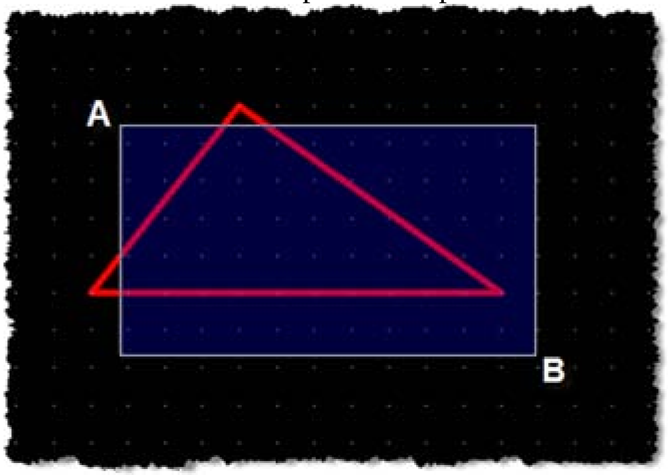


e) 0
f) 1
g) 2
h) 3

Representativeness:				Clarity:			
1	2	3	4	1	2	3	4
Comments:				Comments:			

<u>Alternate for Question 5</u>:

6) In the figure below, how many lines of the red triangle will become selected if you drag a selection window from point B to point A?



a. 0
b. 1
c. 2
d. 3

Representativeness:				Clarity:			
1	2	3	4	1	2	3	4
Comments:				Comments:			

Appendix F

Tests—Pretest, Posttest 1 (Mid-term Exam), and Posttest 2 (Final Exam)

The pretest, posttest 1, and posttest 2 were delivered on-line through the university's learning management system, Blackboard. The questions in each test were randomized—an option in Blackboard—for each student in order to help prevent cheating on the tests. The tests provided in this appendix contain the questions that appeared on each test, but the order of the questions as they appear here is not representative of the order that they appeared to each student.

For simplification purposes in this appendix, the researcher made the following modifications:

- added question type section headings to the tests;
- separated the "first half of semester" questions and the "second half of semester" questions in the pretest;
- reduced the size of selected graphics in order to make better use of space; and
- did not duplicate the Blackboard interface in terms of input method; e.g., use of radio buttons for multiple choice questions.

PRETEST QUESTIONS

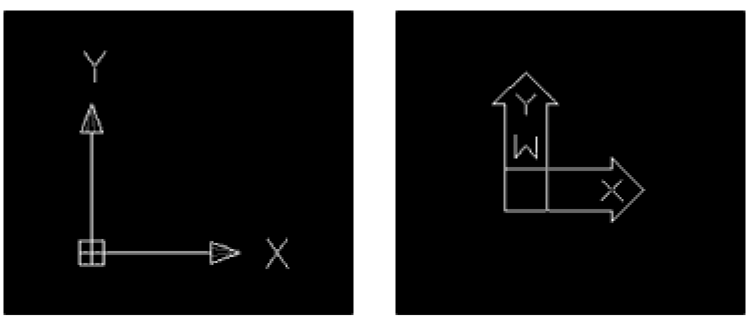
Instructions:

- You are **not** allowed to use any notes, your textbook, or AutoCAD when taking this pretest.
- **No outside resources** may be used. **Turn off** cell phones, PDAs, and instant messaging software.
- The **Honor System** is in effect. Any attempt at cheating will be handled by the Honor Court. If you witness or suspect cheating, you are obligated to report any information to your instructor.
- For **Fill-in-the-Blank** questions:
  - **Write the answers exactly as you would in AutoCAD.**
  - ***Spelling and punctuation count.***
  - ***Write commands and button names in all capital letters.***
  - **Incorrect spelling, extra spaces, and extra characters will result in wrong answers.**

FIRST HALF OF SEMESTER

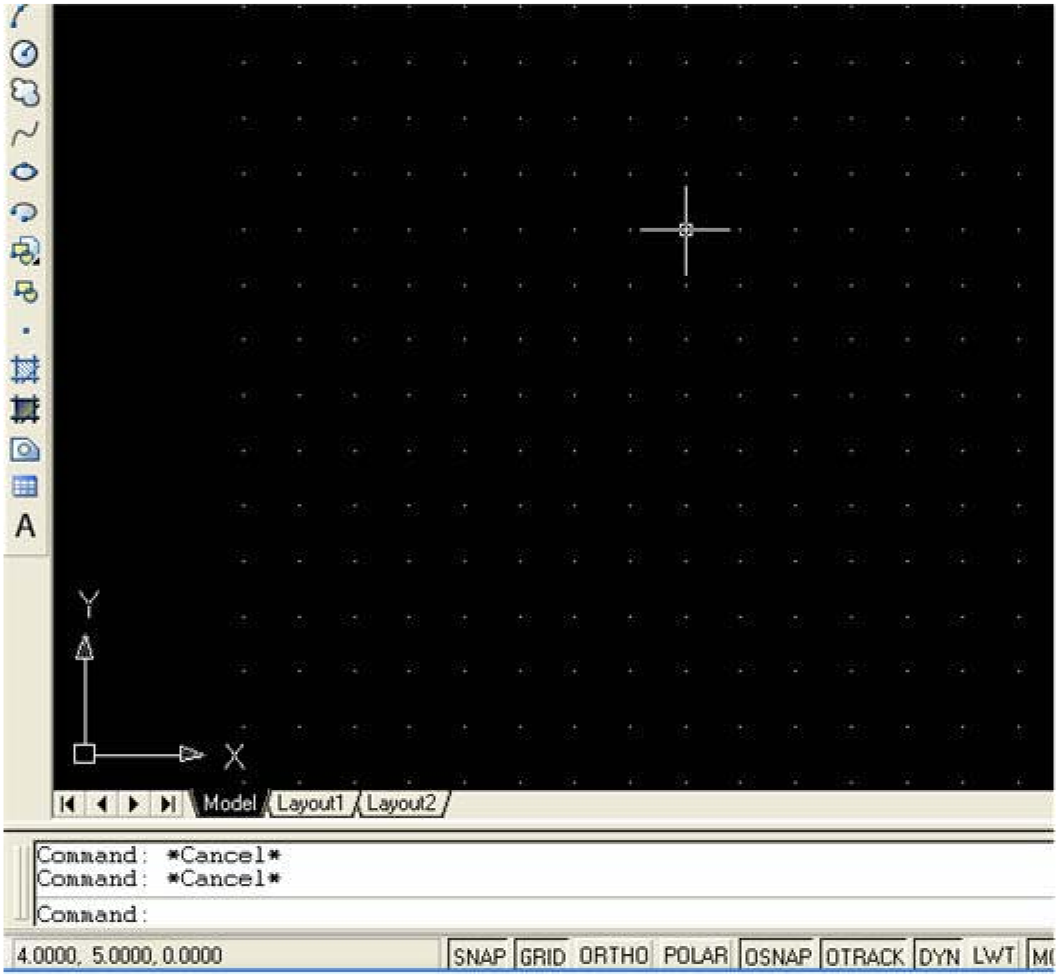
Multiple Choice Questions:

1) In the figure below, compare the symbol on the right with the symbol on the left. The symbol on the **right** indicates:



a) a 3D UCS icon.
b) a 2D UCS icon.
c) someone rotated the Y axis.
d) the user is in a three-dimensional view.

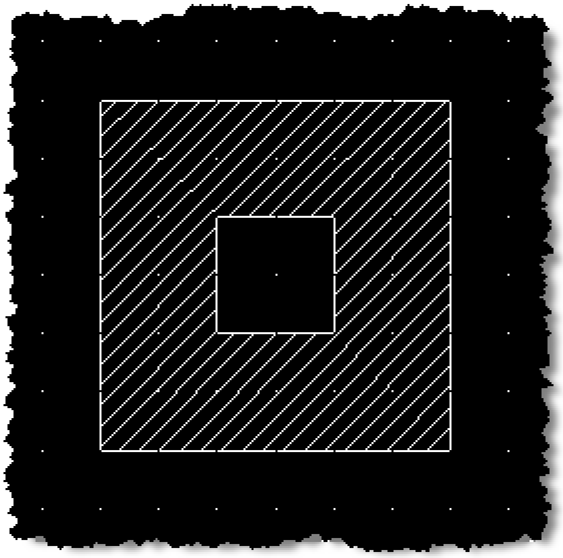
2) In the figure below, what is the current X,Y coordinate location of the graphics cursor?



a) 8,10
b) 16,20
c) 4,5
d) There is not enough information to answer this question.

3) A scale of 2:1 in a title block for a drawing means that:
a) the object drawn appears half the size of the actual object.
b) the plot scale should be 2":1'-0".
c) the object drawn appears twice the size of the actual object.
d) the manufacturer needs to produce two objects.

4) The angled lines in the figure below *most probably* illustrate the use of what command?



a) HATCH
b) PATTERN
c) DUPLICATE
d) BLOCK

True/False Questions

5) AutoCAD users need to be familiar with geometry principles and technical drawing standards in order to create appropriate CAD drawings.
a) True
b) False

6) An object drawn within the boundaries of an active viewport in a layout tab will appear in the model tab.
a) True
b) False

Fill-in-the-blank Questions

7) The __________ command controls the total length and height (or area) of the grid display. **Note: This statement requires a one word answer.**

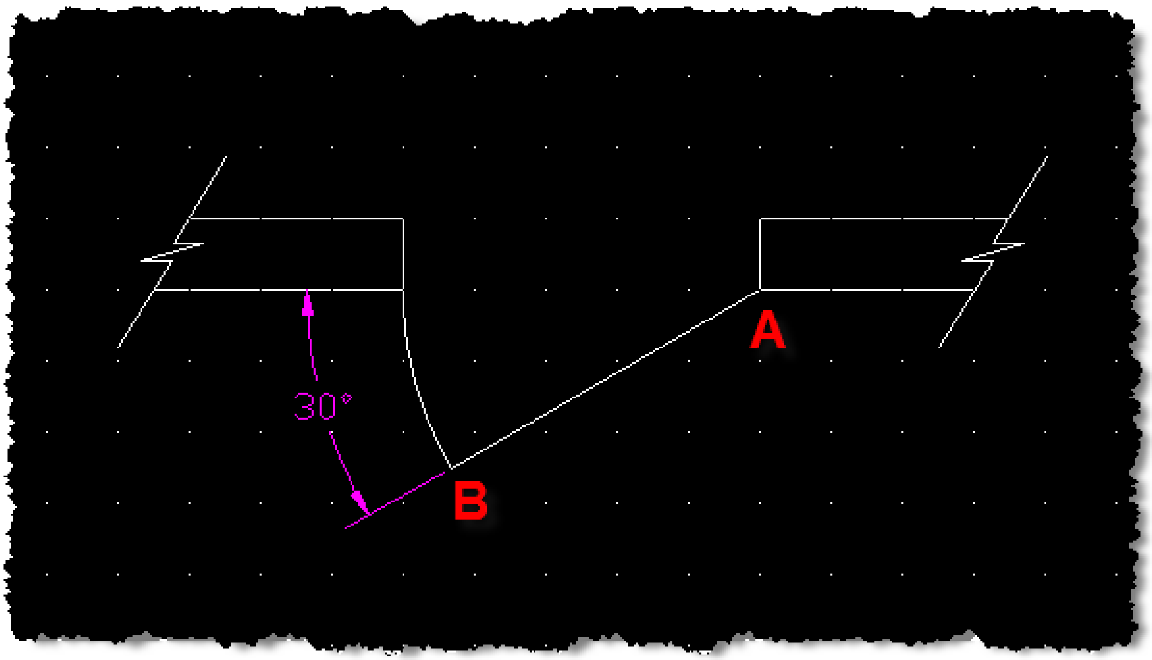
8) The __________ dialog box allows the user to change the color and layer, for example, of a drawing entity in one dialog box in AutoCAD.

9) What is the absolute X,Y coordinate of the second point of the line after the following series of commands? **Note: Do not add extra spaces before, between, or after characters. Do not use numbers with decimal points.**

Command: LINE
Specify first point: 4,13
Specify next point or [Undo]: @-1,-3

Answer: __________

10) In the figure below, points A and B are the ends of the angled line. Given that the angled line is 30 units long and 30 degrees to the horizontal, you might enter __________ to locate point B if you started the line at point A and used the relative polar coordinate entry method. **Note: Assume that the DYN button is in the off position. Do not add extra spaces before, between, or after characters. Do not use numbers with decimal points.**



11) With the __________ command/option turned on, you are restricted to drawing only horizontal or vertical lines.

12) The size of a __________-size sheet of paper is 11 x 17 inches. **Note: Your answer must be one letter of the alphabet.**

Matching Questions

13) Below the figure, match the command on the left with the corresponding letter of the symbol identified in the figure. **Note: A letter may be used only once.**

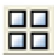
a) 

b) 

c) 

d) 

e) 

f) 

g) 

1) OFFSET = ______
2) EXTEND = ______
3) COPY = ______
4) CHAMFER = ______

SECOND HALF OF SEMESTER

Multiple Choice Questions

14) The ATTDIA command:
   a) creates an attribute dimension.
   b) creates a diameter symbol in an attribute.
   c) toggles the attribute entry dialog box on or off.
   d) opens the Attribute Definition Input Array.

15) Entering EATTEXT at the command prompt:
   a) deletes all text within a drawing.
   b) begins the attribute extraction process.
   c) enables all text.
   d) executes attribute programming.

16) If you decide to change your drawing sheet layout from C-size to D-size, you need to access the __________ while in the layout tab in order to change the sheet size that appears in the layout.
   a) Plotter Manager
   b) Page Setup Manager
   c) plot dialog box
   d) print preview

17) From the figure below, identify the letter pointing to the layer control icon that turns a layer ON or OFF.

a) A
b) B
c) C
d) D

True/False Questions

18) You can use drawing commands within viewports in a layout tab in AutoCAD 2007.
a) True
b) False

19) The ATTEXT command allows you to turn off all attributes in a drawing.
a) True
b) False

20) If you create a block on layer "0" you may insert the block on any other layer and it will take on the linetype and color of that new layer.
a) True
b) False

21) After mirroring a block with attributes you need to mirror the attribute text again separately in order to make the text correct-reading.
a) True
b) False

22) You do not need to make any changes to AutoCAD's default dimension scale when you want to dimension the contents of a scaled layout viewport.
a) True
b) False

23) DesignCenter is an AutoCAD tool that allows users to follow a step-by-step "wizard" for creating designs.
   a) True
   b) False

24) To draw single line segments one after the other you should use the MLINE command.
   a) True
   b) False

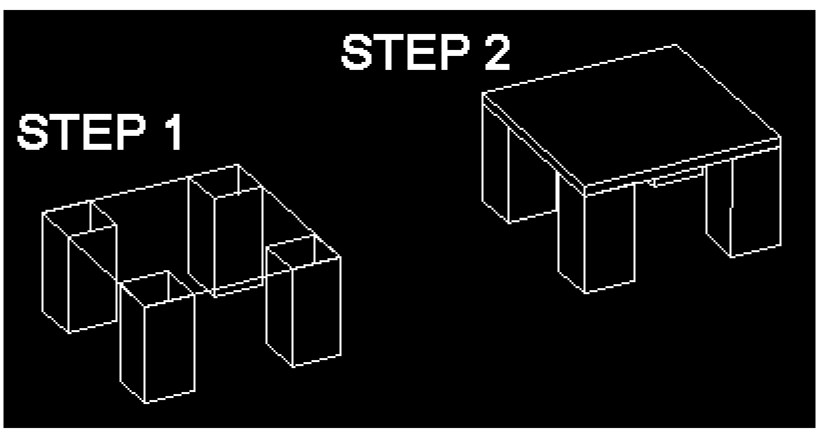
25) If you want to reassign an object to another layer in AutoCAD 2007, you would use the MOVE command.
   a) True
   b) False

Fill-in-the-blank Questions

26) You want to create a drawing of a facility in which you draw every one foot length of the actual facility as one half inch. What architectural scale do you indicate in the title block? **Note: Your answer must consist of architectural units with proper and complete notation. Missing numbers or characters will result in wrong answers. Do not add spaces before, between, or after any of the characters.**

   Answer: __________

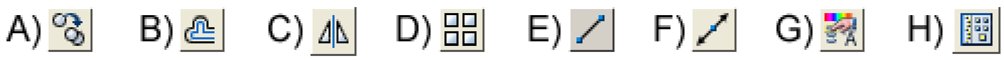
27) The figure below shows two small tables in three-dimensional views after evoking the HIDE command. What command *most likely* was used to modify the table top on the left and make the table top on the right? **Note: The answer is a single word command.**



   Answer: __________

Matching Questions

28) Below the figure, match the command with the letter of its corresponding button icon.



a) ARRAY = ___________
b) Construction Line (XLINE) = ___________
c) DesignCenter = ___________
d) MIRROR = ___________

POSTTEST 1 QUESTIONS

Instructions:

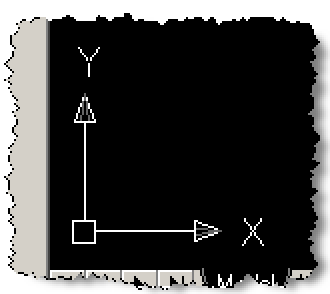
- You are **not** allowed to use any notes, your textbook, or AutoCAD when taking this pretest.
- **No outside resources** may be used. **Turn off** cell phones, PDAs, and instant messaging software.
- The **Honor System** is in effect. Any attempt at cheating will be handled by the Honor Court. If you witness or suspect cheating, you are obligated to report any information to your instructor.
- For **Fill-in-the-Blank** questions:
  - **Write the answers exactly as you would in AutoCAD.**
  - ***Spelling and punctuation count.***
  - ***Write commands and button names in all capital letters.***
  - **Incorrect spelling, extra spaces, and extra characters will result in wrong answers.**

Multiple Choice Questions

1) To repeat the last command in AutoCAD, one can:

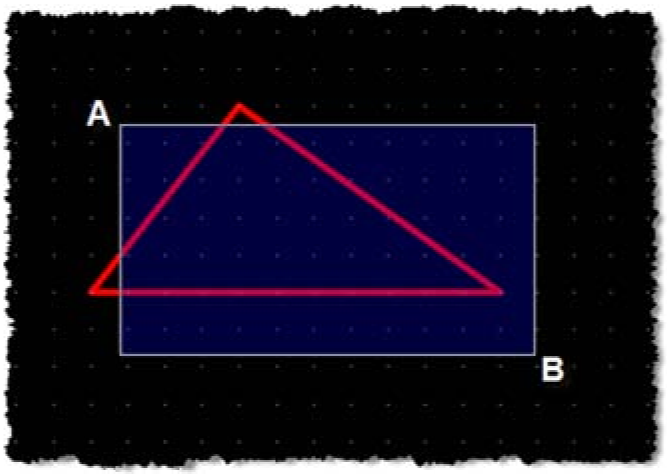
   a) press the [Spacebar].
   b) press the [Enter] or [Return] key.
   c) retype the command.
   d) all of the above.

2) The figure below shows what symbol?



   a) direction arrows
   b) UCS icon
   c) origin arrows
   d) none of the above

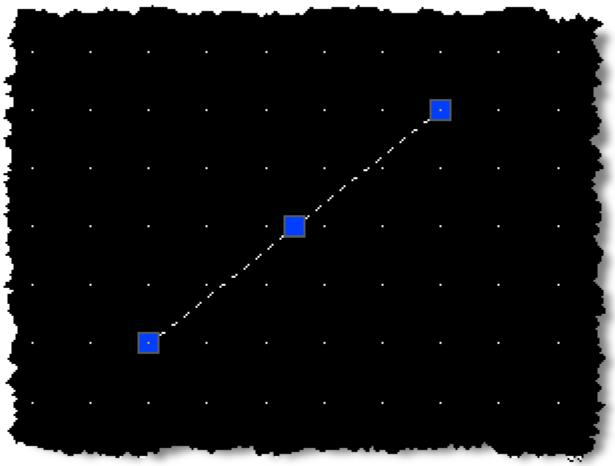
3) In the figure below, how many lines of the red triangle will become selected if you drag a selection window from point B to point A?



a) 0
b) 1
c) 2
d) 3

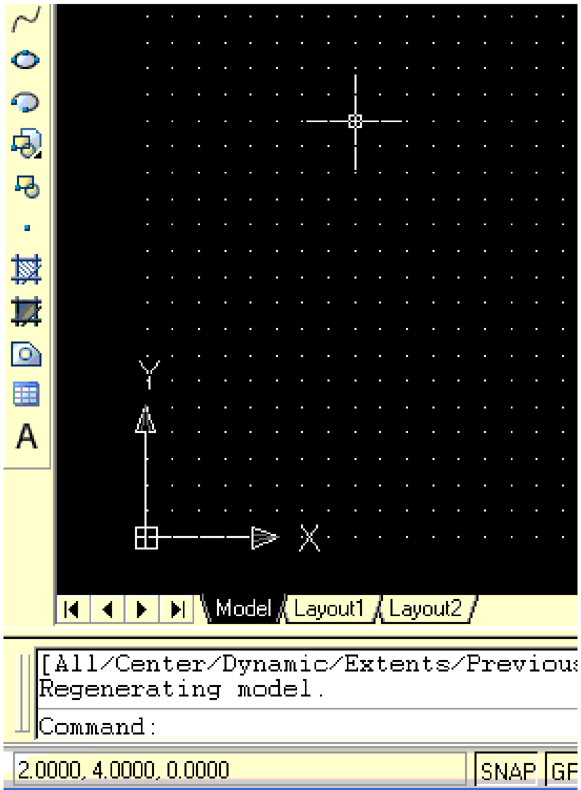
4) Without the use of viewports, if you want to plot a drawing of an object half of the object's actual size your plot scale would be:
a) 2:1
b) 1:2
c) 1:1
d) 1:0.5

5) In the figure below, the blue squares on the line:



a) represent object snap icons.
b) indicate the user can rotate the line on one of the three points.
c) indicate block insertion points.
d) represent grips.

6) What is the current X,Y coordinate location of the graphics cursor in the figure below?



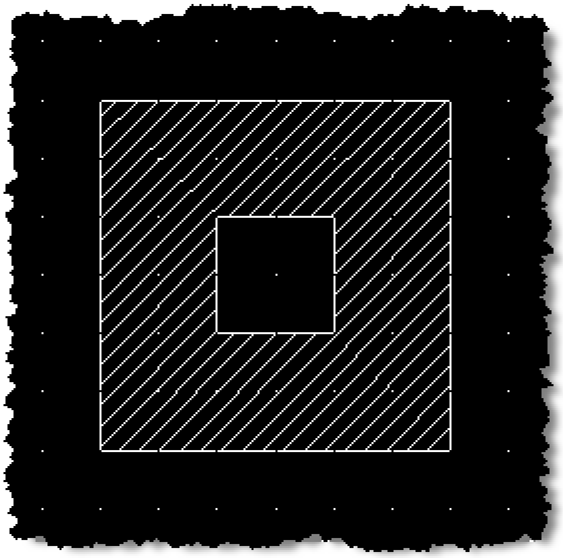
a) There is not enough information to answer this question.
b) 8,16
c) 4,8
d) 2,4

7) The DYN button (*see figure below*) toggles:

a) dynamic dimensioning.
b) dynamic drawing.
c) dynamic input.
d) do-it-yourself drawing.

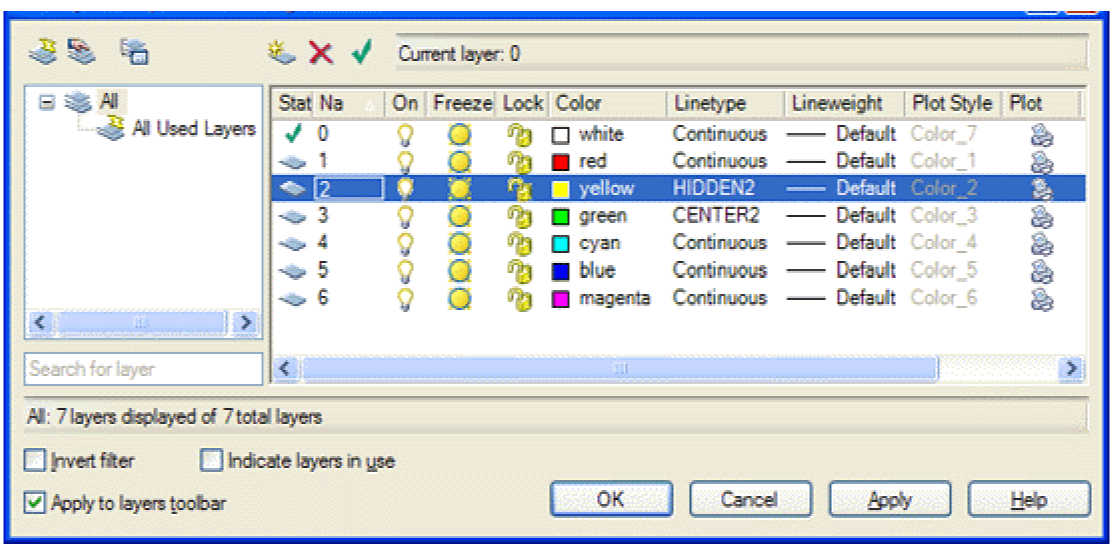
8) The FIELD command allows one to:
a) create text that automatically updates itself, such as the date the drawing was saved last.
b) draw a rectangular text box.
c) draw a green rectangle.
d) copy an object multiple times to create a pattern.

9) The *most straight-forward* way to draw the angled lines in the figure below is to use the:



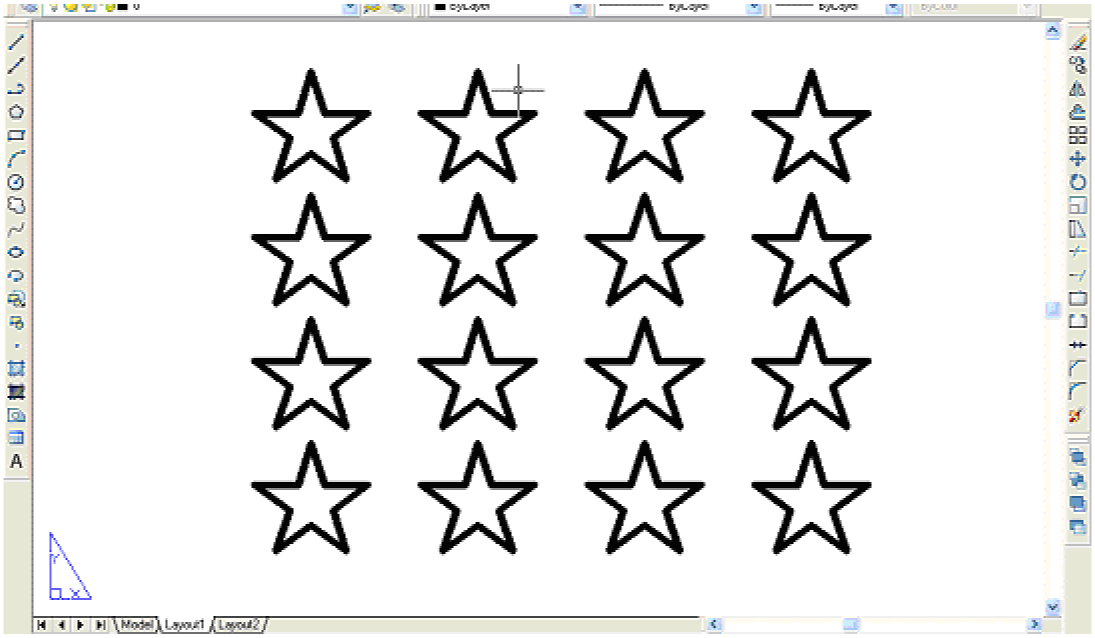
a) HATCH command.
b) LINE and COPY commands.
c) OFFSET command.
d) PATTERN command.

10) In the figure below, what is the linetype of the current layer?



a) There is not enough information to answer this question.
b) CENTER2
c) HIDDEN2
d) Continuous

11) How might someone create the pattern of stars in the figure below?:



a) Create a polar array.
b) Create a horizontal array.
c) Create a vertical array.
d) Create a rectangular array.

True/False Questions

12) AutoCAD's capabilities can replace the designer's experience with geometry and graphic conventions for a specific field.
a) True
b) False

13) The Layer Properties Manager allows you to change the X,Y,Z coordinates of a drawing entity.
a) True
b) False

14) An object drawn outside the boundaries of a viewport in a layout tab will appear in the model tab.
a) True
b) False

Fill-in-the-blank Questions

15) The __________ command opens a dialog box and allows one to adjust the precision and type of measurement in a drawing. **Note: The statement requires a one word answer.**

16) The __________ command allows the user to specify the lower left and upper right coordinates of the grid display. **Note: This statement requires a one word answer.**

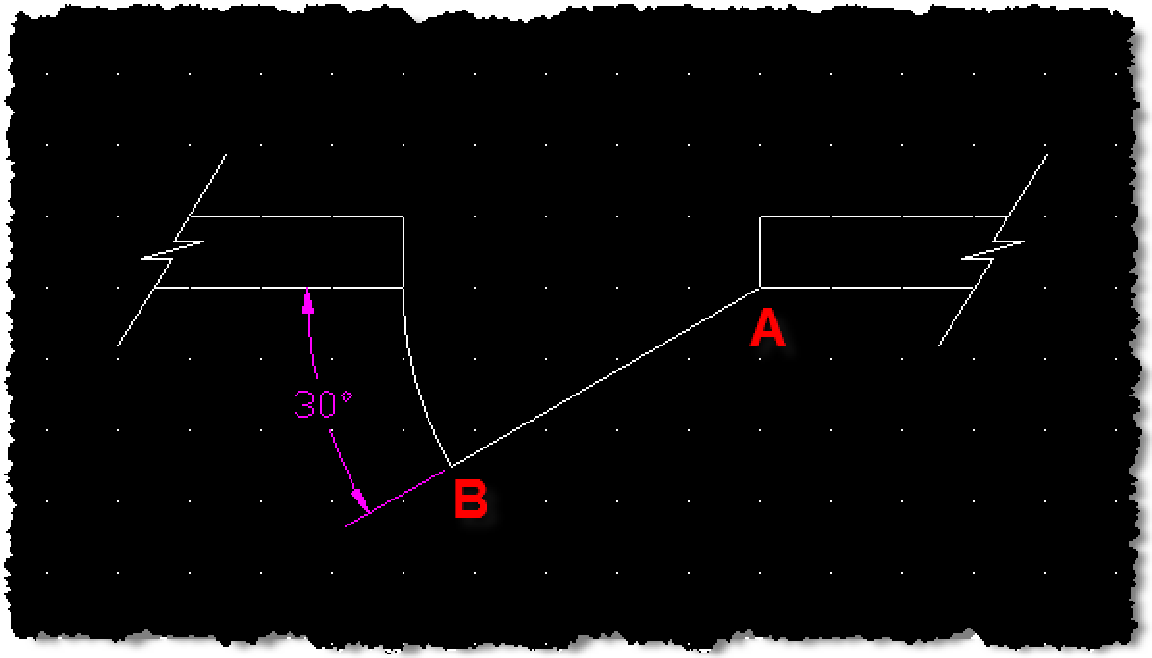
17) You can see and change a variety of characteristics—layer, color, X locations, length, scale, etc.—of a drawing entity within one dialog box by selecting the __________ button.

18) What is the absolute X,Y coordinate of the circle's 270 degree quadrant point after the following sequence? **Note: Do not add extra spaces before, between, or after characters. Do not use numbers with decimal points.**

    Command: CIRCLE Specify center point for circle or [3P/2P/Ttr (tan tan radius)]: 4,4
    Specify radius of circle or [Diameter]: 3

    Answer: __________

19) In the figure below, points A and B are the ends of the angled line. Given that the angled line is 30 units long and 30 degrees to the horizontal, you might enter __________ to locate point B if you started the line at point A and used the relative polar coordinate entry method. **Note: Assume that the DYN button is in the off position. Do not add extra spaces before, between, or after characters. Do not use numbers with decimal points.**



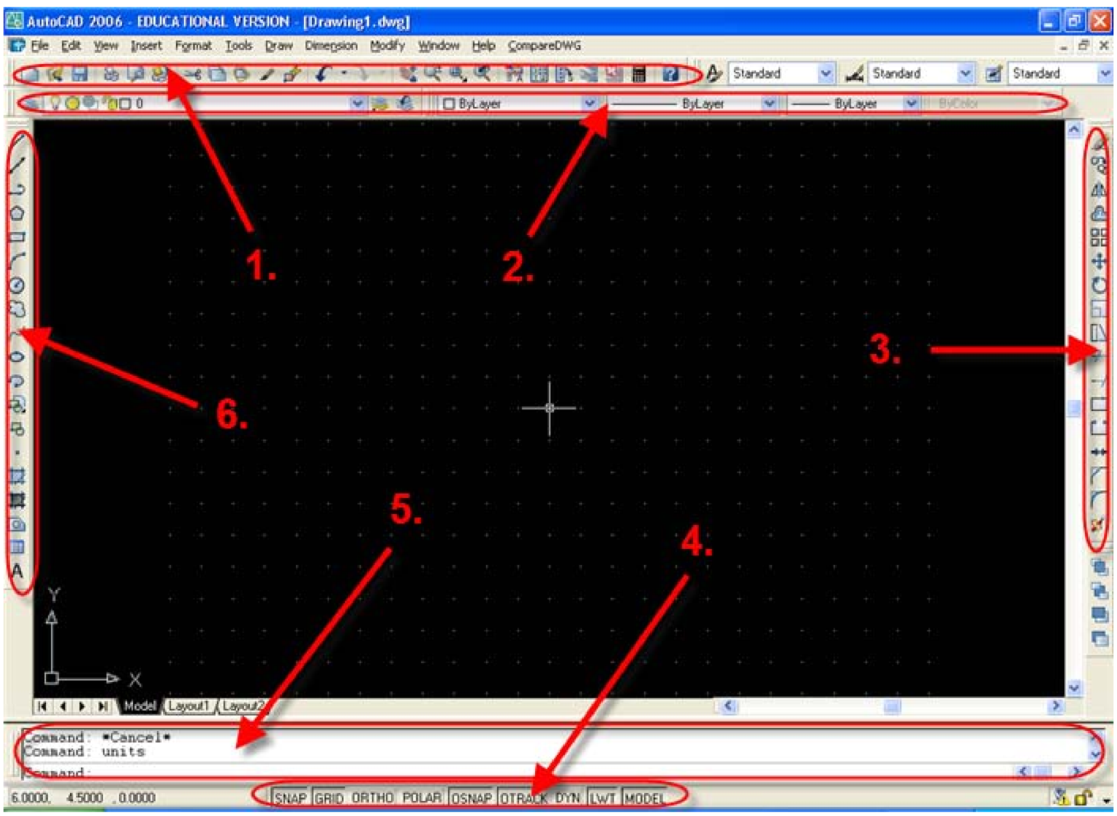
20) Backup files of AutoCAD drawing files have the __________ file extension. **Note: Your answer must be comprised of the three letters in capitals.**

21) The __________ command restricts users to draw lines only horizontally and vertically.

22) Turning on the __________ allows the graphics cursor to jump directly onto grid points.

23) The size of an __________-size sheet of paper is 8.5 x 11 inches. **Note: Your answer must be one letter of the alphabet.**

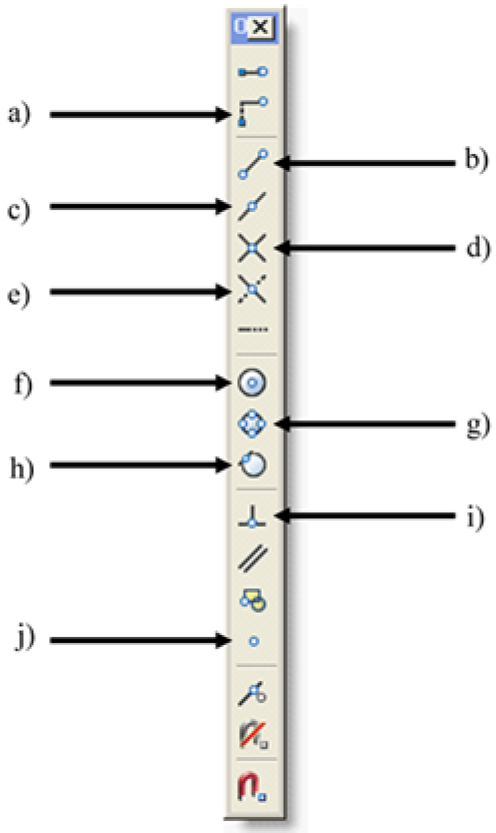
24) The figure below shows the AutoCAD screen. Certain elements have been highlighted and have item numbers pointing to them. Below the figure, match the item number on the left with the letter from the list on the right that corresponds to the element identified.



1) __________
2) __________
3) __________
4) __________
5) __________
6) __________

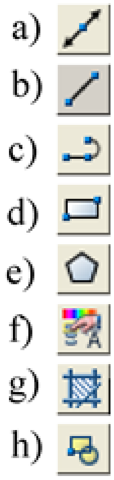
a) standard toolbar
b) draw toolbar
c) command prompt
d) modify toolbar
e) draw order toolbar
f) layers and object properties toolbars
g) option buttons
h) styles toolbar

25) Below the figure, match the object snap names with the letter pointing to the corresponding button in the figure. **Note: A letter may be used only once.**



1) Tangent = ______
2) Center = ______
3) Perpendicular = ______
4) Snap from = ______
5) Midpoint = ______
6) Node = ______

26) Below the figure, match the scenario on the left with the letter next to the symbol of the command you need in the figure. **Note: A letter may be used only once.**



1) Add a pattern that represents a certain material = ______
2) Change the scale of a viewport = ______
3) Automatically draw an octagon = ______
4) Draw the outline of an irregularly shaped object as a continuous line = ______

27) Below the figure, match the command on the left with the corresponding letter of the symbol identified in the figure. **Note: A letter may be used only once.**

1) COPY = ______
2) OFFSET = ______
3) TRIM = ______
4) FILLET = ______

POSTTEST 2 QUESTIONS

Instructions:

- You are **not** allowed to use any notes, your textbook, or AutoCAD when taking this pretest.
- **No outside resources** may be used. **Turn off** cell phones, PDAs, and instant messaging software.
- The **Honor System** is in effect. Any attempt at cheating will be handled by the Honor Court. If you witness or suspect cheating, you are obligated to report any information to your instructor.
- For **Fill-in-the-Blank** questions:
    - **Write the answers exactly as you would in AutoCAD.**
    - ***Spelling and punctuation count.***
    - ***Write commands and button names in all capital letters.***
    - **Incorrect spelling, extra spaces, and extra characters will result in wrong answers.**

Multiple Choice Questions

1) Which of the following is not a standard viewport scale in AutoCAD?
    a) 2:1
    b) 3/16”=1’-0”
    c) .75
    d) All of the above

2) In order to turn on the attribute entry dialog box (which is off by default) in AutoCAD 2007, you need to change the value of the ___________ setting.
    a) ATTDIM
    b) ATTDEF
    c) ATTDIA
    d) ATTEXT

3) The ATTEDIT command allows you to:
    a) create attribute text.
    b) check the spelling within your attributes.
    c) change the value of an attribute.
    d) edit tags.

4) At the command prompt, one can type the ___________ command to begin the attribute extraction process.
    a) EATTEXT
    b) ATTDEF
    c) EXTRACT
    d) BATTMAN

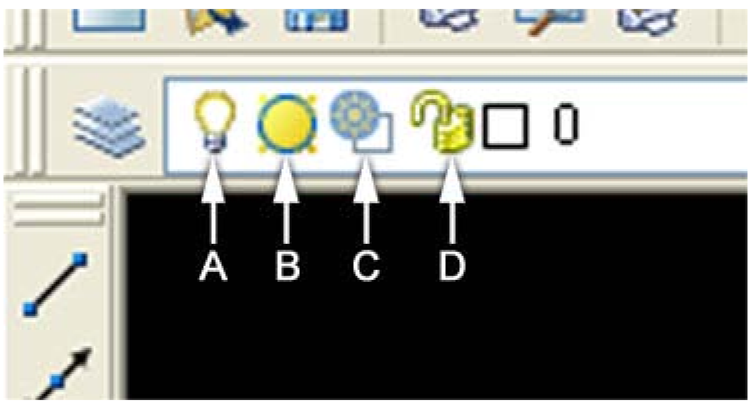
5) You have a drawing containing blocks with several text lines of attributes. One of the attributes must not appear on the drawing, but it should remain in the attribute database. One way to make that change is to:
    a) let the BATTMAN solve it.
    b) type “0” for the attribute value.
    c) explode the block and delete the attribute.
    d) change the attribute’s mode to invisible.

6) Near the end of the attribute extraction process, one has the option of exporting the attributes in a plain text file in .csv format. The file extension .csv stands for:
    a) comma separated version.
    b) comma sequential volume.
    c) column standard version.
    d) column superimposed variation.

7) The default Imperial sheet size dimensions in an AutoCAD 2007 layout tab is:
    a) 17x22.
    b) 8.5x11.
    c) 11x17.
    d) 22x34.

8) Accessing the __________ while in an AutoCAD layout tab allows users to change the sheet size that appears in the layout.
    a) Plotter Manager
    b) Page Setup Manager
    c) plot dialog box
    d) print preview

9) From the figure below, identify the letter pointing to the layer control icon that would allow you to make a drawing entity not appear in one viewport but still appear in another viewport.



    a) A
    b) B
    c) C
    d) D

10) The dimensions of a C-size sheet of paper are:
    a) 22”x34”
    b) 17”x22”
    c) 11”x17”
    d) 8.5”x11”

True/False Questions

11) One of the limitations of using viewports in a layout tab in AutoCAD 2007 is that you cannot modify models that appear in the viewports while in the layout tab.
    a) True
    b) False

12) If the title block in a drawing indicates that the drawing is at a scale of 1:2, you should set the plot scale to 1:2 when you plot the drawing.
    a) True
    b) False

13) The ATTDISP command allows you to turn off all attributes in a drawing.
    a) True
    b) False

14) The value of an attribute and an attribute tag are the same thing.
    a) True
    b) False

15) A block that you create on layer “0” will not change properties if you insert it on another layer.
    a) True
    b) False

16) If one wanted to MIRROR a block with attributes, one would need to retype the attribute text in order to make the text correct-reading.
    a) True
    b) False

17) One should leave viewport boundaries turned on when plotting a drawing from a layout tab in this class.
    a) True
    b) False

18) Dimensioning the contents of a scaled layout viewport requires changing the default dimension scale in AutoCAD 2007.
    a) True
    b) False

19) DesignCenter is a service provided by Autodesk to AutoCAD users in which users can make requests for drawing blocks via e-mail.
    a) True
    b) False

20) The justification options for the MLINE command are top, bottom, and middle.
    a) True
    b) False

21) The purpose of the MLINE command is to draw single line segments one after the other.
    a) True
    b) False

22) Pressing the secondary click button on a mouse or laptop allows users to bring up additional options and menus in AutoCAD.
    a) True
    b) False

23) To reassign an object to another layer in AutoCAD 2007, you must BLOCK the object then INSERT it onto the desired layer.
    a) True
    b) False

Fill-in-the-blank Questions

24) What architectural scale do you indicate in the title block if you drew every one foot length of the actual facility as one eighth inch? **Note: Your answer must consist of architectural units with proper and complete notation. Missing numbers or characters will result in wrong answers. Do not add spaces before, between, or after any of the characters.**

    Answer: __________

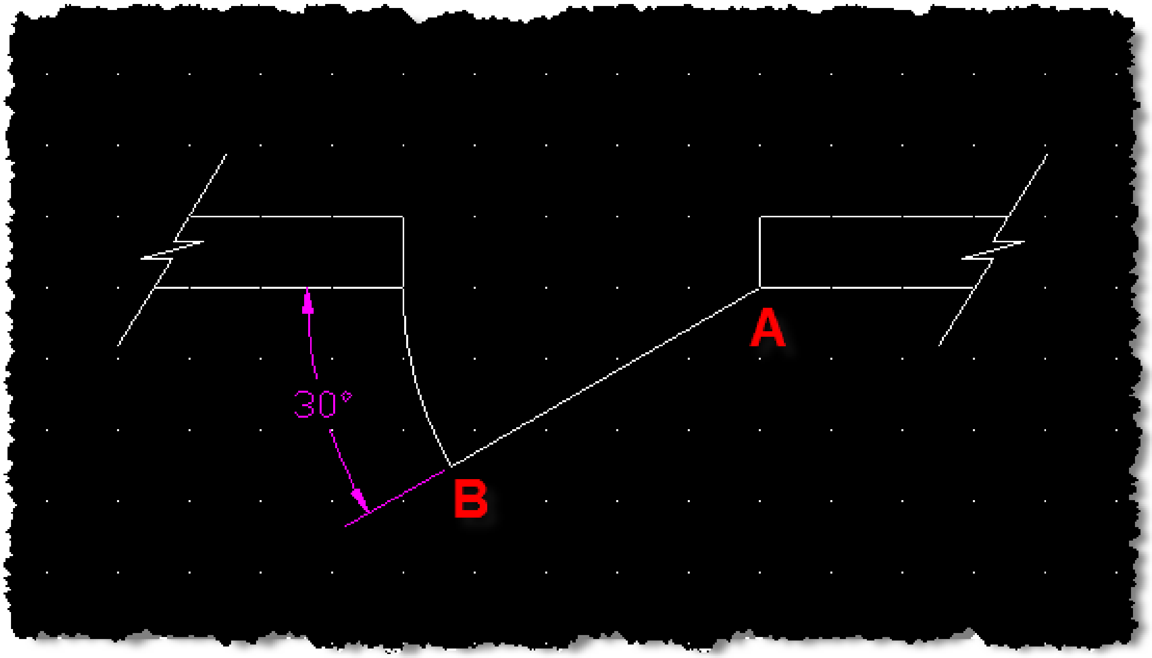
25) Besides any variation of the COPY command, name one command we have covered in this class that allows you to copy objects in AutoCAD 2007. **Note: Your answer must be a single word command and the command cannot be part of a sequence of commands.**

    Answer: __________

26) What command do you need to type at the command prompt when you want to create a block attribute?

    Answer: __________

27) In the figure below, points A and B are the ends of the angled line. Given that the angled line is two feet ten inches long and 30 degrees to the horizontal, you would enter __________ to locate point B if you started the line at point A and used the relative polar coordinate entry method with architectural units. **Note: Your answer must consist of architectural units with proper and complete notation in feet and inches. Assume that the DYN button is in the off position. Do not add spaces before, between, or after characters.**



28) The __________ property of a line allows you to show wall height in a three-dimensional view.

29) To raise an object drawn with polylines in an isometric view of a floor plan, you should adjust that object's __________ property.

30) Drawing a countertop with a polyline and then using the __________ command on the polyline makes the countertop a solid object so you cannot see anything underneath it after evoking the HIDE command in a three-dimensional view. **Note: The answer is a single word command.**

31) Below the figure, match the command with the letter of its corresponding button icon.

a) ARRAY = __________
b) Construction Line (XLINE) = __________
c) DesignCenter = __________
d) MIRROR = ________

Appendix G

Grading Rubrics for Weekly Assignments

The grading sheets in this appendix have been altered from the originals due to spacing limitations on the page (i.e., the inclusion of a page header)—text size and spacing between sections have been reduced. Not all of the pages needed these alterations, but all of them were changed to maintain consistency.

The chapter titles listed below refer to content from the course text/tutorial book.

Experiment 1 (first half of semester):

Semester Week Given	Semester Week Due	Assignment Title
Week 2	Week 3	1. Chapter 1–Tutorial 2. Chapter 1–Exercise 2
Week 3	Week 4	3. Chapter 2–Tutroial 4. Chapter 2–Exercise 1
Week 4	Week 5	5. Chapter 3–Tutroial 6. Chapter 3–Exercise 3
Week 5	Week 6	7. Chapter 5–Tutorial Modified
Week 6	Week 7	8. Chapter 7–Tutorial Modified

Experiment 2 (second half of semester):

Semester Week Given	Semester Week Due	Assignment Title
Week 8	Week 10	1. Chapter 4–Tutorial Modified
Week 10	Week 11	2. CAD Room
Week 11	Week 13	3. Project

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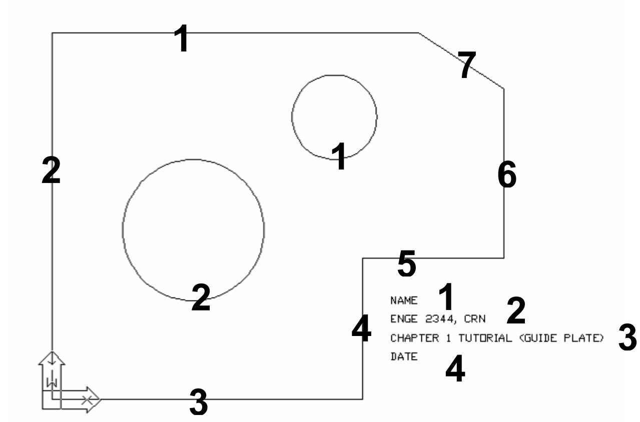
Chapter 1 Tutorial Grade Sheet

Name: ___________________________________ CRN: _____________



Element	Length	Angle	DIA or R	Location	Other
Line 1					
Line 2					
Line 3					
Line 4					
Line 5					
Line 6					
Line 7					
Circle 1					
Circle 2					
Text – Name					
Text – Date					
Text – Course & CRN					
Text – Title					
				Subtotal	
				Incorrect Scale (-15%)	
				Each Additional Error (-10%)	
				Other Deductions: missing files or plots (-50%), incorrect file names	
				TOTAL	/22

Comments:

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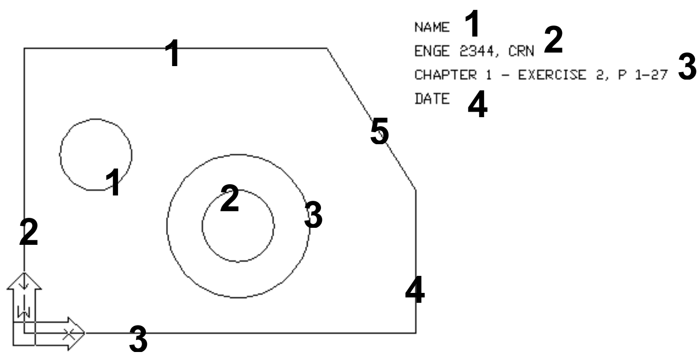
Chapter 1 Exercise 2 Grade Sheet

Name: ___________________________________ CRN: _____________



Element	Length	Angle	DIA or R	Location	Other
Line 1					
Line 2					
Line 3					
Line 4					
Line 5					
Circle 1					
Circle 2					
Circle 3					
Text – Name					
Text – Date					
Text – Course & CRN					
Text – Title					
Subtotal					
Incorrect Scale (-15%)					
Each Additional Error (-10%)					
Other Deductions: missing files or plots (-50%), incorrect file names					
TOTAL					/20

Comments:

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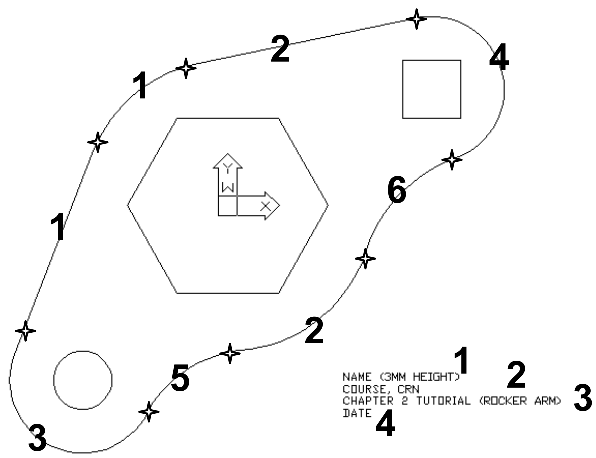
Chapter 2 Tutorial Grade Sheet

Name: ___________________________________ CRN: _____________



Element	Size	Location	Other
Units (2)			
Arc 1			
Arc 2			
Arc 3			
Arc 4			
Arc 5			
Arc 6			
Line 1			
Line 2			
Points of Tangency (8)			
Hexagon			
Square			
Circle			
Text – Name			
Text – Date			
Text – Course & CRN			
Text – Title			
Subtotal			
Incorrect Scale (-15%)			
Each Additional Error (-10%)			
Other Deductions: missing files or plots (-50%), incorrect file names, etc.			
TOTAL			/30

Comments:

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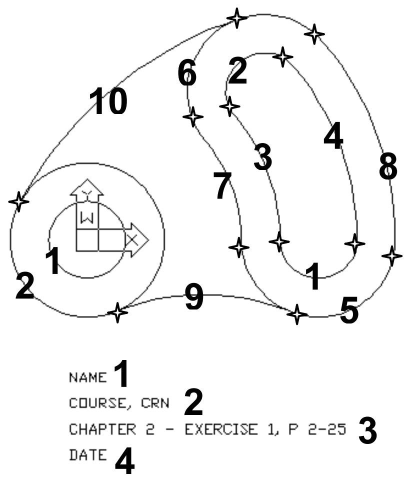
Chapter 2 Exercise 1 Grade Sheet

Name: ___________________________________ CRN: _____________



Element	Size	Location	Other
Units (3)			
Circle 1			
Circle 2			
Arc 1			
Arc 2			
Arc 3			
Arc 4			
Arc 5			
Arc 6			
Arc 7			
Arc 8			
Arc 9			
Arc 10			
Points of Tangency (12)			
Text – Name			
Text – Date			
Text – Course & CRN			
Text – Title			
		Subtotal	
		Incorrect Scale (-15%)	
		Each Additional Error (-10%)	
		Other Deductions: missing files or plots (-50%), incorrect file names, etc.	
		TOTAL	/41

Comments:

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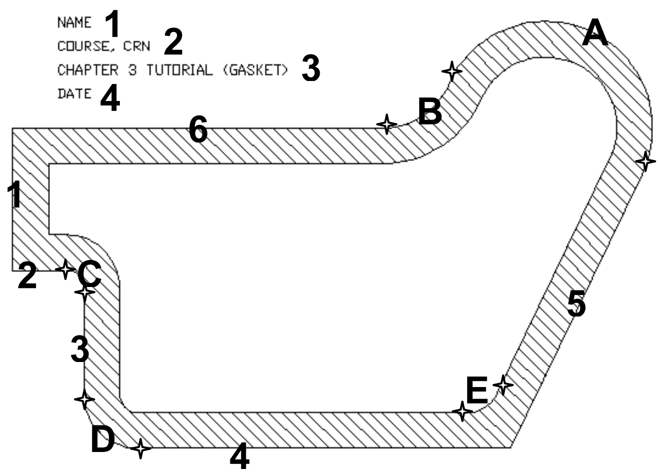
Chapter 3 Tutorial Grade Sheet

Name: ___________________________________ CRN: _____________



Element	Size	Location	Other
Line 1			
Line 2			
Line 3			
Line 4			
Line 5			
Line 6			
Arc A			
Arc B			
Arc C			
Arc D			
Arc E			
Outer Polyline (2 pts.)			
Inner Offset (6 pts.)			
Points of Tangency (9)			
Hatch—pattern (2), angle (1)			
Text – Name			
Text – Date			
Text – Course & CRN			
Text – Title			

Subtotal	
Incorrect Scale (-15%)	
Each Additional Error (-10%)	
Other Deductions: missing files or plots (-50%), incorrect file names, etc.	
TOTAL	/38

Comments:

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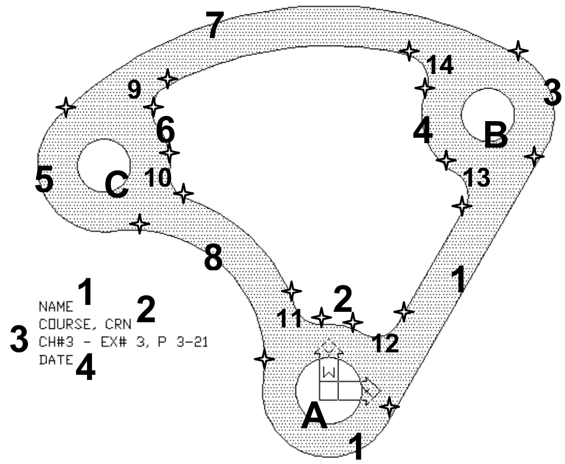
Chapter 3 Exercise 3 Grade Sheet

Name: ___________________________________ CRN: _____________



Element	Size	Location	Other
Circle A			
Circle B			
Circle C			
Arcs 1 & 2			
Arcs 3 & 4			
Arcs 5 & 6			
Arc 7			
Arc 8			
Arc 9			
Arc 10			
Arc 11			
Arc 12			
Arc 13			
Arc 14			
Line 1			
Outer Polyline (2 pts.)			
Inner Offset (4 pts.)			
Points of Tangency (18)			
Hatch (4 pts.)			
Text – Name			
Text – Date			
Text – Course & CRN			
Text – Title			
		Subtotal	
		Incorrect Scale (-15%)	
		Each Additional Error (-10%)	
		Other Deductions: missing files or plots (-50%), incorrect file names, etc.	
		TOTAL	/53

Comments:

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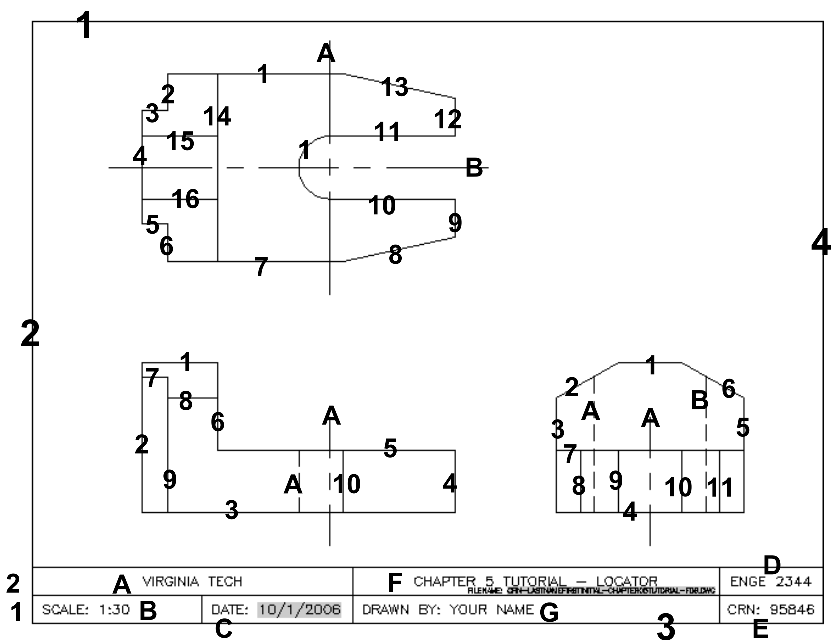
Chapter 5 Homework Grade Sheet

Name: ______________________________ CRN: ___________



Top View	**Accuracy (Size & Location)**	**Front View**	**Accuracy (Size & Location)**	**Side View**	**Accuracy (Size & Location)**
Line 1		Line 1		Line 1	
Line 2		Line 2		Line 2	
Line 3		Line 3		Line 3	
Line 4		Line 4		Line 4	
Line 5		Line 5		Line 5	
Line 6		Line 6		Line 6	
Line 7		Line 7		Line 7	
Line 8		Line 8		Line 8	
Line 9		Line 9		Line 9	
Line 10		Line 10		Line 10	
Line 11		Hidden Line		Line 11	
Line 12		Centerline		Hidden Line A	
Line 13				Hidden Line B	
Line 14				Centerline	
Line 15					
Line 16					
Arc 1					
Centerline A					
Centerline B					
T-Block, DWG Border Lines, & Text					
Border Lines (4)					

Row 1 Ht. (2)					
Row 2 Ht. (2)					
Cell A (2)		Cell A Text (2)			
Cell B (2)		Cell B Text (2)			
Cell C (2)		Cell C Text (2)		Date FIELD (2)	
Cell D (2)		Cell D Text (2)			
Cell E (2)		Cell E Text (2)			
		Cell F Text (2)		Filename FIELD (2)	
		Cell G Text (2)			

Layers	**Existence**	**Linetype**	**Additional Elements**	**Accuracy**
Center			Viewport Turned OFF on Plot (3)	
Construction			LTSCALE (2)	
Hidden				
Object				
T-block & Bord.				
Text				
Viewport				

Subtotal	/100
Incorrect Viewport Scale (-10%)	
Incorrect Plot Scale (-10%)	
Entire Drawing Drawn in Model Tab or Layout Tab (-20%)	
Other Deductions: missing files or plots, incorrect file names, etc.	
TOTAL	/100

Comments:

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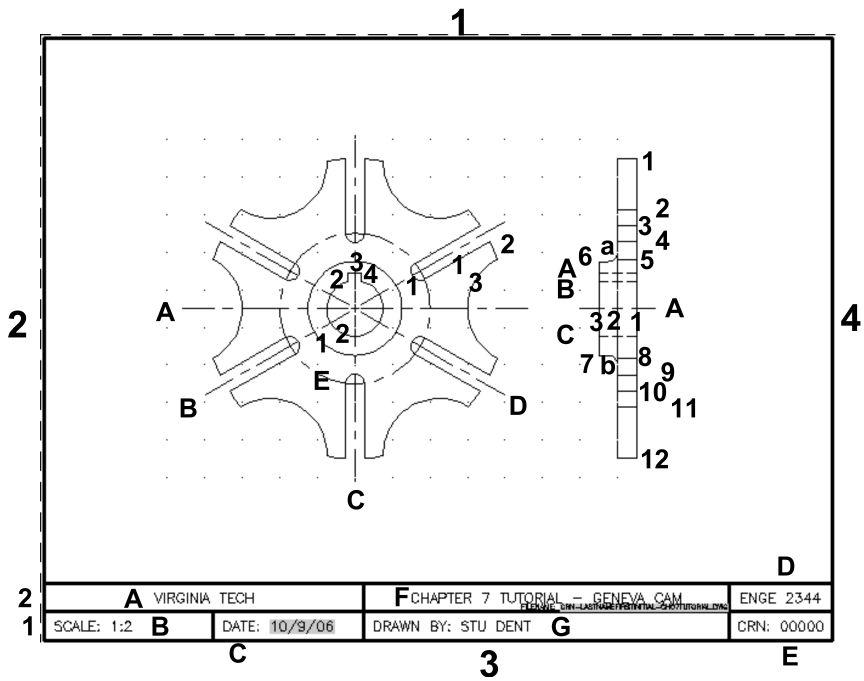
Chapter 7 Homework Grade Sheet

Name: ______________________________ CRN: ____________



Front View	Accuracy (Size & Location)	Side View	Accuracy (Size & Location)
Source: Arc 1		Vertical Line 1	
Source: Arc 2		Vertical Line 2	
Source: Arc 3		Vertical Line 3	
Source: Line 1		Horizontal Line 1	
		Horizontal Line 2	
Source: MIRROR (4)		Horizontal Line 3	
Source: ARRAY (4)		Horizontal Line 4	
		Horizontal Line 5	
Circle 1		Horizontal Line 6	
Circle 2		Horizontal Line 7	
Line 2		Horizontal Line 8	
Line 3		Horizontal Line 9	
Line 4		Horizontal Line 10	
Centerline A		Horizontal Line 11	
Centerline B		Horizontal Line 12	
Centerline C		Hidden Line A	
Centerline D		Hidden Line B	
Centerline E (circle)		Hidden Line C	
		Centerline A	
		Fillet a	
		Fillet b	

T-Block, DWG Border Lines, & Text			
Border Lines (4)			
Row 1 Ht. (2)			
Row 2 Ht. (2)			
Cell A (2)		Cell A Text (2)	
Cell B (2)		Cell B Text (2)	
Cell C (2)		Cell C Text (2)	
Cell D (2)		Cell D Text (2)	
Cell E (2)		Cell E Text (2)	
		Cell F Text (2)	
		Cell G Text (2)	
Layers	**Existence**	**Linetype**	**Lineweight**
Center			
Construction			
Hidden			
Object			
T-block & Border			
Text			
Viewport			
Additional Elements		**Accuracy**	
Viewport Turned OFF on Plot (4)			
Lineweights on Plot (5)			
		Subtotal	/100
		Incorrect Viewport Scale (-10%)	
		Incorrect Plot Scale (-10%)	
		Entire Drawing Drawn in Model Tab or Layout Tab (-20%)	
		Other Deductions: missing files or plots, incorrect file names, etc.	
		TOTAL	/100

Comments:

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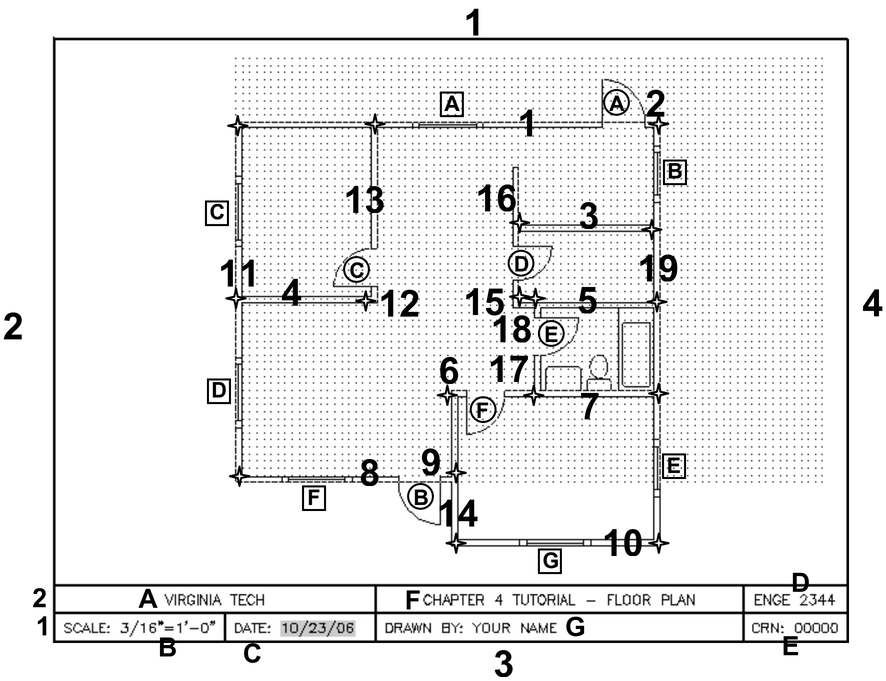
Chapter 4 Homework Grade Sheet

Name: ___________________________________ CRN: _____________



Walls	Length	Width	Location	End Cap
Wall 1				
Wall 2				
Wall 3				
Wall 4				
Wall 5				
Wall 6				
Wall 7				
Wall 8				
Wall 9				
Wall 10				
Wall 11				
Wall 12				
Wall 13				
Wall 14				
Wall 15				
Wall 16				(2)
Wall 17				
Wall 18				
Wall 19				
Open Wall Intersections (17)				

Doors	Line Length	Arc Radius	Threshold Line	Location on Wall
Door A				
Door B				

Door C				
Door D				
Door E				
Door F				

Windows	Length	Width	Trim	Pane	Aligned to Wall	Location
Window A						
Window B						
Window C						
Window D						
Window E						
Window F						
Window G						

Bathroom Fixtures	Length	Width	Rounded Corners	Location
Tub			(4)	
Sink			(2)	
Toilet			(2)	

Mirrored Fixtures	Existence	Location
Sink & Toilet	(4)	(4)

T-Block, DWG Border Lines, & Text			
Border Lines (4)			
Row 1 Ht. (2)			
Row 2 Ht. (2)			
Cell A (2)		Cell A Text (2)	
Cell B (2)		Cell B Text (2)	
Cell C (2)		Cell C Text (2)	
Cell D (2)		Cell D Text (2)	
Cell E (2)		Cell E Text (2)	
		Cell F Text (2)	
		Cell G Text (2)	

Layers	Existence	Linetype
Walls		
Doors		
Windows		
Bathroom		
T-block & Border		
Text		
Viewport		

Additional Elements	Accuracy
Viewport Turned OFF on Plot (11)	

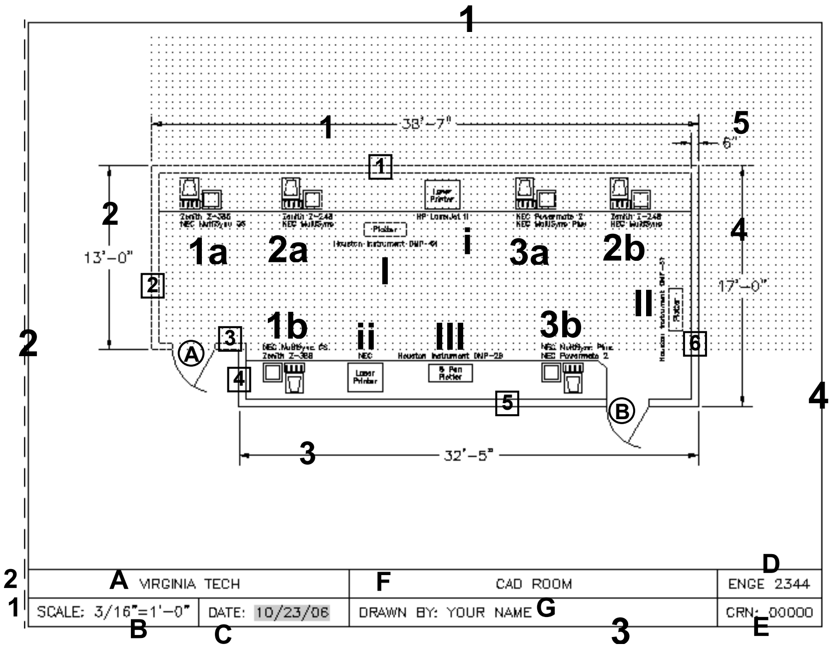
Subtotal	/223
Floor Plan Not Moved to Origin (-5%)	
Incorrect Viewport Scale (-10%)	
Incorrect Plot Scale (-10%)	
Entire Drawing Drawn in Model Tab or Layout Tab (-20%)	
Other Deductions: missing files or plots, incorrect file names, etc.	
TOTAL	/223

Comments:

Virginia Tech
ENGE 2344
Department of Engineering Education

CAD Room Homework Grade Sheet

Name: ___________________________________ CRN: _____________



Blocks	Block (2 pts.)	Attribute 1 (2)	Attribute 2 (2)	Attribute 3 (2)	Location (1)
Computer					
Monitor					
Keyboard					
Digitizer					
Workstation 1a					
Workstation 1b					
Workstation 2a					
Workstation 2b					
Workstation 3a					
Workstation 3b					
Plotter I **Label (1)**			(optional)		
Plotter II **Label (1)**			(optional)		
Plotter III **Label (1)**			(optional)		
Printer i **Label (1)**					
Printer ii **Label (1)**					

Walls	Length (1)	Width (1)	End Cap
Wall 1			
Wall 2			
Wall 3			**(2)**
Wall 4			
Wall 5			**(2)**
Wall 6			
Open Wall Intersections **(6)**			

Doors	Line Length (1)	Arc Radius (1)		Location on Wall (1)
Door A				
Door B				

Countertops	**Length (1)**	**Width (1)**	**Chamfer**
Top			
Bottom			**(2)**
T-Block, DWG Border Lines, & Text			
Border Lines **(4)**			
Row 1 Ht. **(2)**			
Row 2 Ht. **(2)**			
Cell A **(2)**		Cell A Text **(2)**	
Cell B **(2)**		Cell B Text **(2)**	
Cell C **(2)**		Cell C Text **(2)**	
Cell D **(2)**		Cell D Text **(2)**	
Cell E **(2)**		Cell E Text **(2)**	
		Cell F Text **(2)**	
		Cell G Text **(2)**	
Dimensions	**In Layout Tab (2)**	**Placement (1)**	**Accuracy (1)**
DIM 1			
DIM 2			
DIM 3			
DIM 4			
DIM 5			
DIM Formats	**Setting (1)**		
Units			
Extension Lines			
Arrow Size			
Text Size			
Scale DIMs to Layout			
Layers	**Use (1)**	**Linetype (1)**	
0 (Blocks only)			
Countertop			
DIMs			
Doors			
Walls			
T-block & Border			
Text			
Viewport			

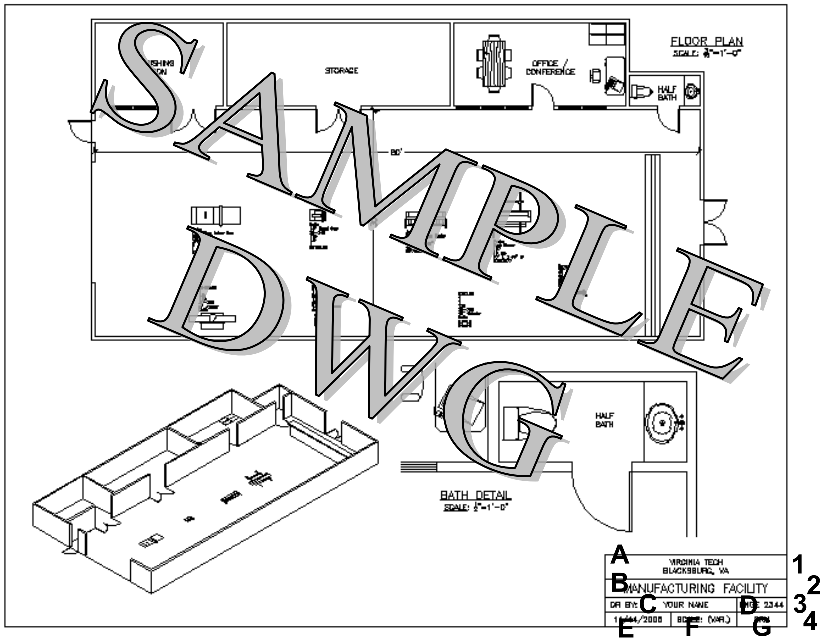
Attributes Printout (85 Total)	
Physical Printout (75)	
Order of Columns and Rows (3)	
Formatting: Printed “Fit to Page” & “Landscape” Orientation (6)	
Formatting: Cell Border Lines (3)	
Formatting: Bold Column Headings/Tags (3)	
Subtotal	/284
Incorrect Viewport Scale **(-10%)**	
Viewport Was Not Turned OFF on Plot **(-5%)**	
Incorrect Plot Scale **(-10%)**	
Entire Drawing Drawn in Model Tab or Layout Tab **(-20%)**	
Attributes Printout Did Not Match Attribute Extraction **(-10%)**	
Other Deductions: missing files or plots, incorrect file names, etc.	
TOTAL	/284

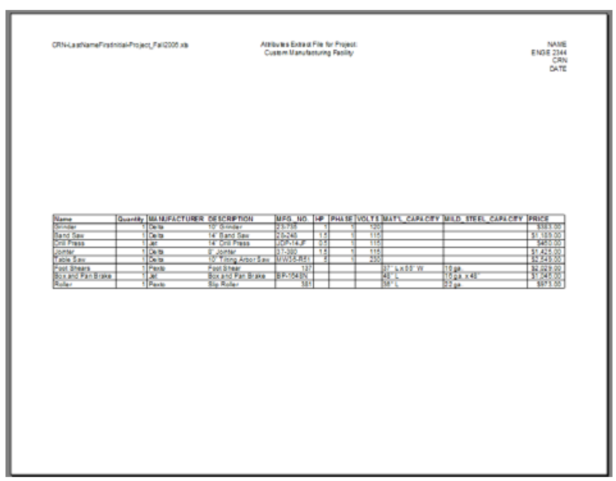
Comments:

Virginia Tech
ENGE 2344
Department of Engineering Education

Project Grade Sheet

Name: ____ CRN: _____________





Blocks	Block	Att. 1	Att. 2	Att. 3	Att. 4	Att. 5	Att. 6	Att. 7	Spacing	Layer
Table Saw										
Jointer										
Band Saw										
Drill Press										
Grinder										
Box and Pan Brake										
Foot Shear										
Slip Roller										
										Subtotal: ______/15%

Walls	**6" Width**	**7' Tall**	**Layer**	
All walls				
				Subtotal: ______/12%

Facility Spaces	**Existence/Accuracy**	**Doors**	**Windows**	**Furniture/Fixtures**
Production Area		(3)		
2400 sq. ft.				
Greeting Counter:				
4' Wall Elevation				
Countertop Elevation				
Extruded Countertop				
Office			(multiple)	(4)
Adj. to Prod. Area				
Enclosed				
Restroom				(2)
Minimum size				
Storage Room				
Holds 14' Stock				
Finishing Room				
				Subtotal: ______/15%

T-Block, DWG Border Lines, & Text				
C-size Sheet Layout (10%)				
DWG Border Lines:	**Accuracy**	**Layer**		
19.375" (2)				
15.5" (2)				
Form 5 Title Block:				
Row 1 Ht.				
Row 2 Ht.				
Row 3 Ht.				
Row 4 Ht.			**Accuracy**	**Cell Text Layer**
Cell A		Cell A Text		
Cell B		Cell B Text		
Cell C		Cell C Text		
Cell D		Cell D Text		
Cell E		Cell E Text		
Cell F		Cell F Text		
Cell G		Cell G Text		
				Subtotal: ______/15%

Dimensions	**Attempted**	**Layer**	
DIMs of Prod. Area			
			Subtotal: ______/3%

Viewports	**Existence**	**Layer**	**Standard Scale**	
Floor Plan				
Zoom-in				

3D View			
Height of walls shown			
Shows countertop elevation			
			Subtotal: ______/7%

Labels	Size	Layer	
Office			
Restroom			
Storage Room			
Finishing Room			**Every Label Element Present and Accurate**
Floor Plan Viewport			
			Subtotal: ______/6%

Layers	Use	Color	
Machines/equipment			
Walls, doors, windows, plumbing fixtures (these may be separate layers)			
Furniture			
Attribute text			
Border and title block lines			
Text			
Dimensions			
Viewports			
			Subtotal: ______/7%

Attributes Printout	
All Columns Present (5)	
Order of Columns (4)	
Formatting: Printed “Fit to Page” (4)	
Formatting: Cell Border Lines (1)	
Formatting: Bold Column Headings/Tags (1)	
Title, Name, Course, CRN, Date (5)	
	Subtotal: ______/20%

Subtotal	/100%
Viewports Were Not Turned OFF on Plot **(-5% DWG)**	
A-size Plot was not set to “Fit to Page” **(-10% DWG)**	
Entire Drawing Drawn in Model Tab or Layout Tab **(-20% DWG)**	
Attributes Printout Did Not Match Attribute Extraction **(-10% TOTAL)**	
Other Deductions: missing files or plots, incorrect file names, etc.	
TOTAL	/100%

Comments:

Appendix H

Peer Rating of Team Members

Your Name: ______________________________________ Date: __________________

1. Please check the appropriate box for the rating that describes the degree to which your partner fulfilled his/her responsibilities in completing the assignment this week. The possible ratings are as follows:

   - ☐ **Normal** participation level
   - ☐ **Below normal** participation level
   - ☐ **Above normal** participation level
   - ☐ **No participation**

   These ratings should reflect your partner's level of participation and effort and sense of responsibility, not his or her academic ability.

   Name of partner

   ____

   Your signature: ____

2. Indicate the amount of time you spent working together on this assignment in terms of hours and minutes. (Example: 2 hours, 30 minutes or 2:30)

3. Indicate the amount of time you and your partner spent studying together this past week for this class in terms of hours and minutes.

4. Briefly describe how you and your partner worked together on this assignment, in general terms of the tasks each of you performed to generate the final drawing you submitted.

5. Briefly describe your group's computer use while completing this assignment. For example, did each of you use your own computer or did you share a computer?

6. Describe something you did well together when working on this assignment.

7. Describe something about your working together that you need to improve.

Adapted from R.M. Felder (1997) and Walker (2006)

Appendix I

IRB Letters of Exempt Status

The following two pages in this appendix are the letters of exempt status from the university's Institutional Review Board (IRB). The first letter is the original IRB letter providing exempt status for the entire study. After the researcher's dissertation prospectus exam, the researcher added a question to the weekly peer reviews. This addition required filing an amendment to the original application. The second letter indicates the IRB's approval of the amendment and the continued exempt status of the study.

VirginiaTech

Office of Research Compliance
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4358 Fax: 540/231-0959
E-mail: ctgreen@vt.edu
www.irb.vt.edu
FWA00000572(expires 7/20/07)
IRB # is IRB00000667.

DATE: August 21, 2006

MEMORANDUM

TO: Mark E. Sanders
Jeff Swab

FROM: Carmen Green

SUBJECT: **IRB Exempt Approval:** "Cooperative Learning in Computer-aided Drafting" , IRB # 06-452

I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status. Approval is granted effective as of August 21, 2006.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.

2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File

VirginiaTech

Office of Research Compliance
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4358 Fax: 540/231-0959
E-mail: ctgreen@vt.edu
www.irb.vt.edu

FWA00000572(expires 7/20/07)
IRB # is IRB00000667.

DATE: September 5, 2006

MEMORANDUM

TO: Mark E. Sanders
Jeff Swab

FROM: Carmen Green

SUBJECT: **IRB Amendment 1 Approval:** "Cooperative Learning in Computer-aided Drafting" , IRB # 06-452

This memo is regarding the above referenced protocol which was previously granted approval by the IRB on August 21, 2006. You subsequently requested permission to amend your IRB application. Approval has been granted for requested protocol amendment, effective as of September 5, 2006.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File

Appendix J

Research Assistant Protocol

1. Monday, August 28, 2006: Generate research identification (RID) numbers for students in both sections of the course.

    a. The department chair will generate RID numbers for the students and provide the department administrative assistant (research assistant) with the student list and corresponding RIDs.

    b. The researcher will not have access to that list.

    c. The department administrative assistant will secure this list by password-protecting computer document and/or locking printed document in cabinet.

2. Monday, August 28, 2006: The department administrative assistant will send an e-mail to each student (N=128) indicating his/her RID number.

    - All students need their RIDs during weeks 2 (August 29 and 31) and 3 (September 5 and 7) for completing the learning styles inventory at home and the in-class visualization test. (I can delay assigning the learning styles inventory until week 3 if necessary.)

3. The research assistant will maintain a record of student names, RID numbers, grades, and scores on assessments. The researcher will provide the research assistant with an updated electronic gradebook (Excel file) regularly during the semester in order to maintain a database of the research data.

    - Students will complete the learning styles inventory (ILS) and visualization test (ROT) using only their RIDs. After they complete the instruments, the researcher will provide the research assistant with the scores. Only the research assistant can tie RIDs and student names.

4. At the start of week 4, the research assistant will select 3 pairs of students as potential interviewees from the treatment group using a stratified random sampling technique based on current group grades (one pair each from A grades, B grades, and C or below grades).

    a. The research assistant will contact potential interviewees via e-mail, following a script provided by the researcher. The script will contain information about the interview purpose, participant confidentiality, the incentives for participating, and how their decisions whether or not to participate will not affect their grades. The research assistant may need to contact other pairs of students in order to obtain a total of three pairs of interviewees from that treatment group.

b. Once the interviewees have agreed to participate, the research assistant will need to 1) write their RIDs on the gift cards they will receive as the incentive for participating, and 2) provide the financial administrative assistant with their names and addresses as required by the university controller's office.

5. The research assistant will repeat the process described in step 4 for the second treatment group starting week 11.

6. The researcher will provide the research assistant with all updated grades (final exams, final project, final course grades, etc.) at the end of the semester.

    a. The research assistant will delete all student names in the final version of the database, change the group numbers for each cooperative pair of students, and then randomize the rows of data.

    b. The research assistant will then provide the researcher with the updated database containing student RID numbers, assignment grades, exam grades, course grades, visualization test scores, and learning style inventory scores.

    c. The research assistant will then destroy her electronic and paper copies of the databases and RID coding.

Appendix K

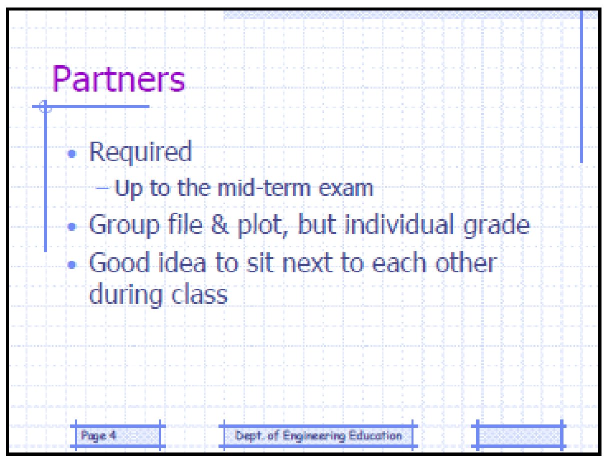
Cooperative Learning Slides from Lessons

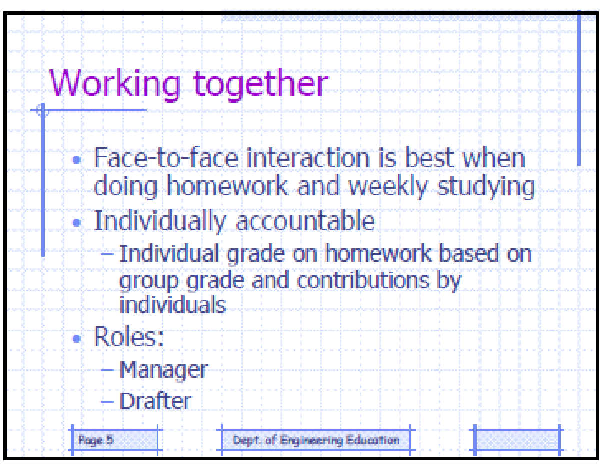
The following images are screen captures of selected slides from class lessons that covered various aspects of cooperative group efforts during the two treatment phases. During the first two weeks of each treatment phase, the instructor covered the details of the cooperative group efforts. In subsequent weeks, class discussions included positive and negative characteristics of the cooperative group efforts during the previous weeks as indicated in the weekly peer reviews. Class slides were available to students for reference. Note that the slide order below proceeds left to right from the top row to the last row.

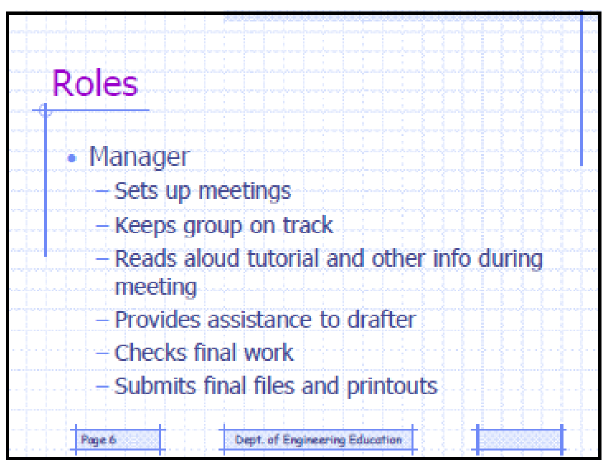
The second treatment phase started during week 8, which was the same week as the mid-term exam (posttest 1). General instructions for the upcoming assignment, cooperative group work, and information about the cooperative learning slides was provided at the start of class before the start of the exam. The instructor followed the same format as the first treatment phase in subsequent weeks.

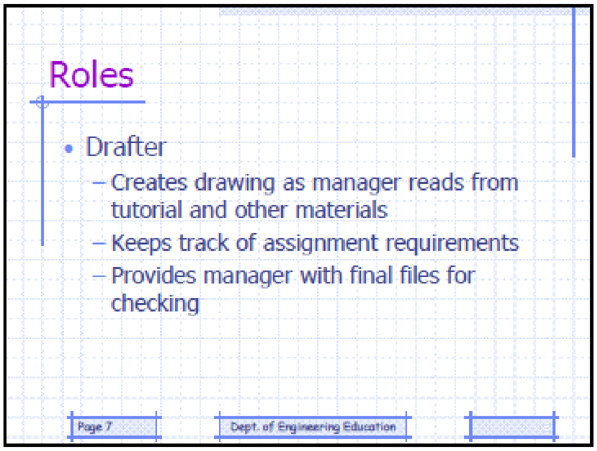
Experiment 1

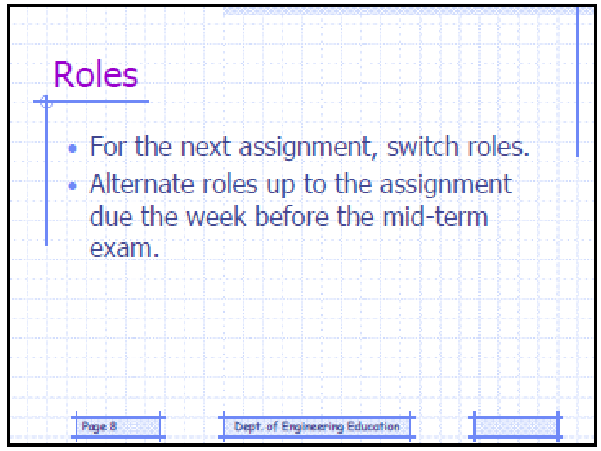
Week 2

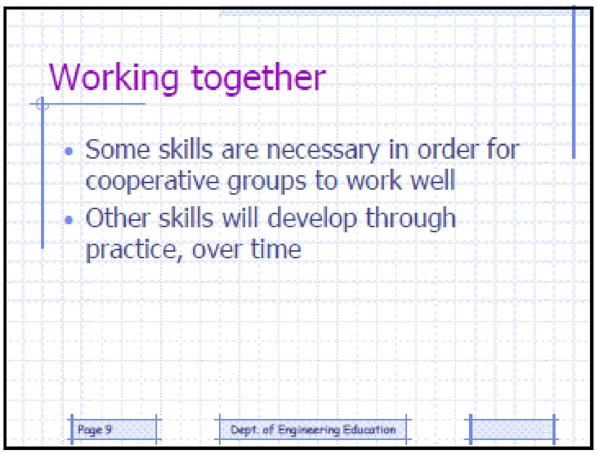


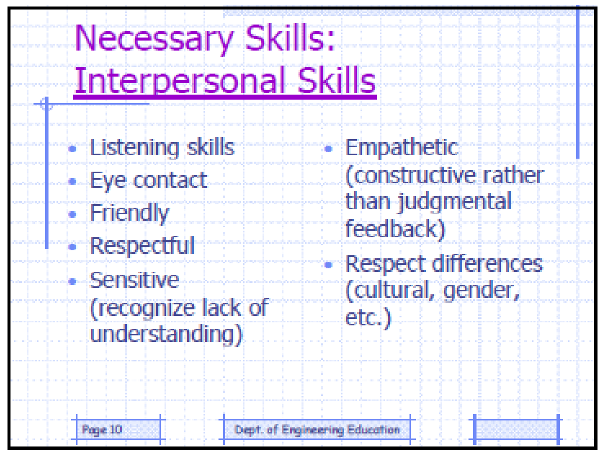


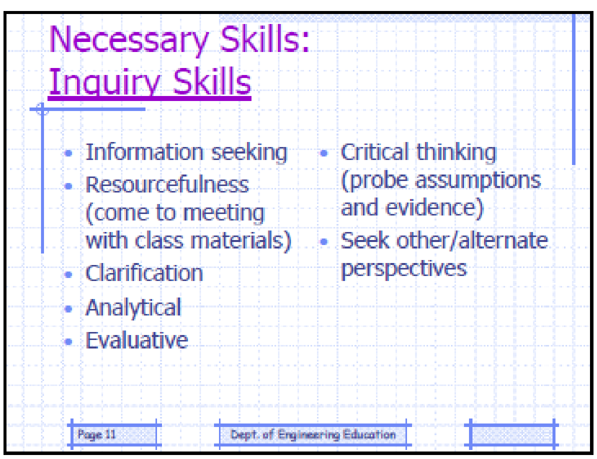


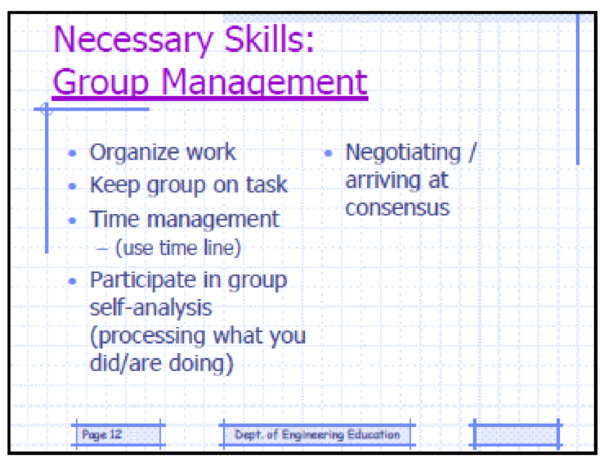

Roles
• Drafter
– Creates drawing as manager reads from tutorial and other materials
– Keeps track of assignment requirements
– Provides manager with final files for checking
Page 7
Dept. of Engineering Education


Roles
• For the next assignment, switch roles.
• Alternate roles up to the assignment due the week before the mid-term exam.
Page 8
Dept. of Engineering Education


Working together
• Some skills are necessary in order for cooperative groups to work well
• Other skills will develop through practice, over time
Page 9
Dept. of Engineering Education


Necessary Skills: Interpersonal Skills
• Listening skills
• Eye contact
• Friendly
• Respectful
• Sensitive (recognize lack of understanding)
• Empathetic (constructive rather than judgmental feedback)
• Respect differences (cultural, gender, etc.)
Page 10
Dept. of Engineering Education


Necessary Skills: Inquiry Skills
• Information seeking
• Resourcefulness (come to meeting with class materials)
• Clarification
• Analytical
• Evaluative
• Critical thinking (probe assumptions and evidence)
• Seek other/alternate perspectives
Page 11
Dept. of Engineering Education


Necessary Skills: Group Management
• Organize work
• Keep group on task
• Time management
– (use time line)
• Participate in group self-analysis (processing what you did/are doing)
• Negotiating / arriving at consensus
Page 12
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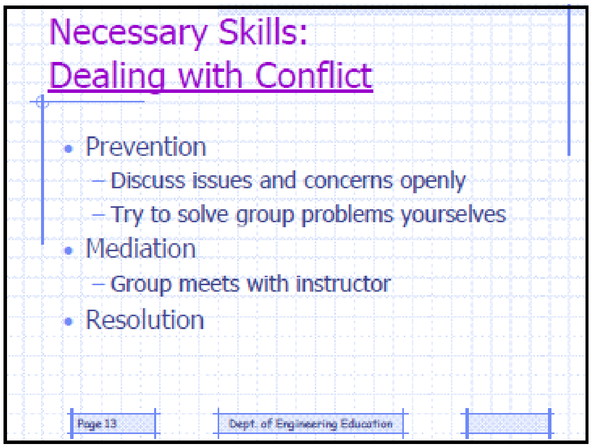
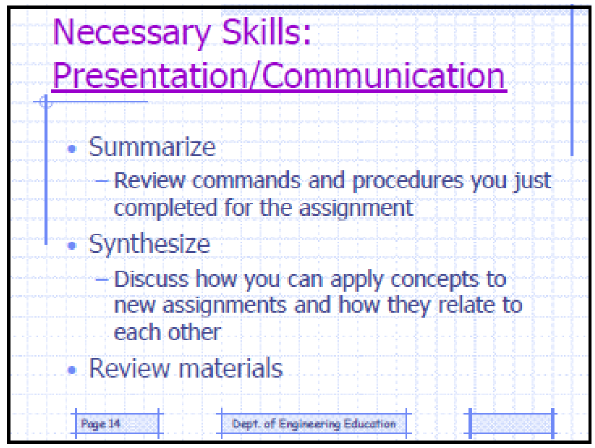
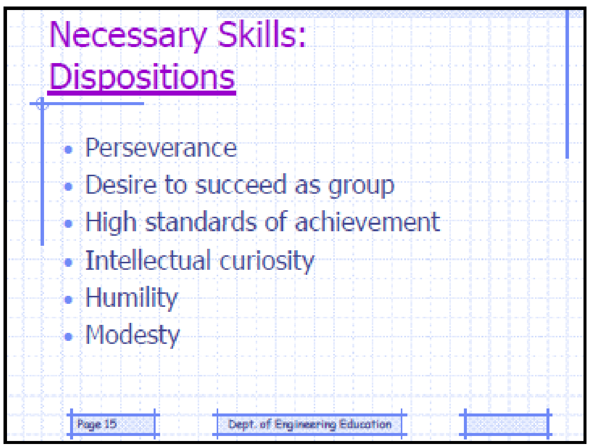
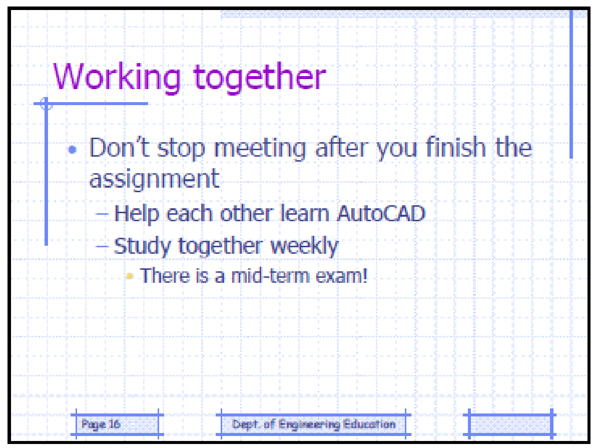
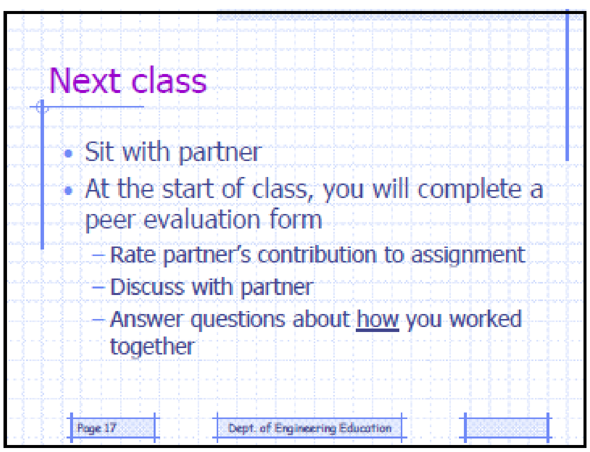
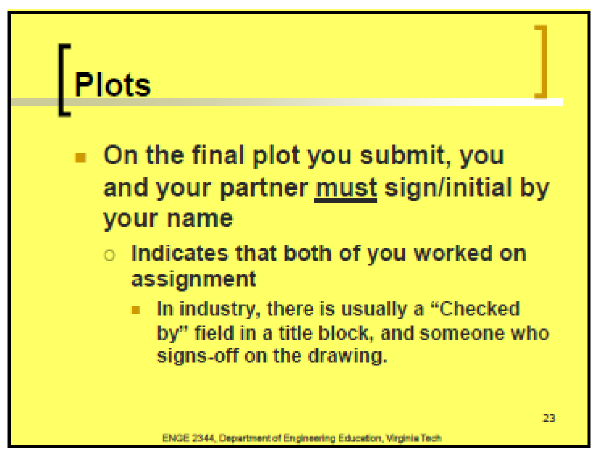

Necessary Skills:
Dealing with Conflict
Prevention
Discuss issues and concerns openly
Try to solve group problems yourselves
Mediation
Group meets with instructor
Resolution
Page 13
Dept. of Engineering Education

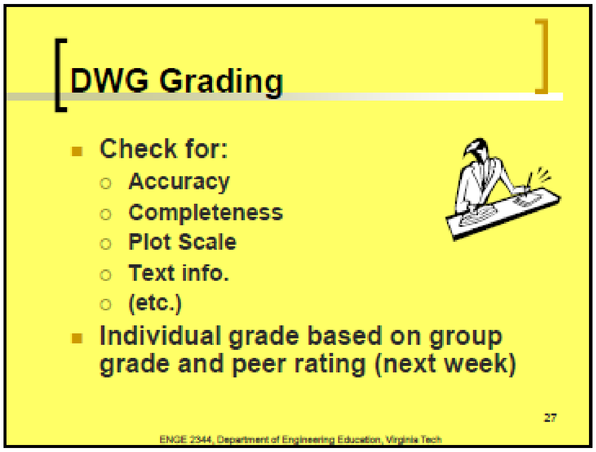

Necessary Skills:
Presentation/Communication
Summarize
Review commands and procedures you just completed for the assignment
Synthesize
Discuss how you can apply concepts to new assignments and how they relate to each other
Review materials
Page 14
Dept. of Engineering Education


Necessary Skills:
Dispositions
Perseverance
Desire to succeed as group
High standards of achievement
Intellectual curiosity
Humility
Modesty
Page 15
Dept. of Engineering Education

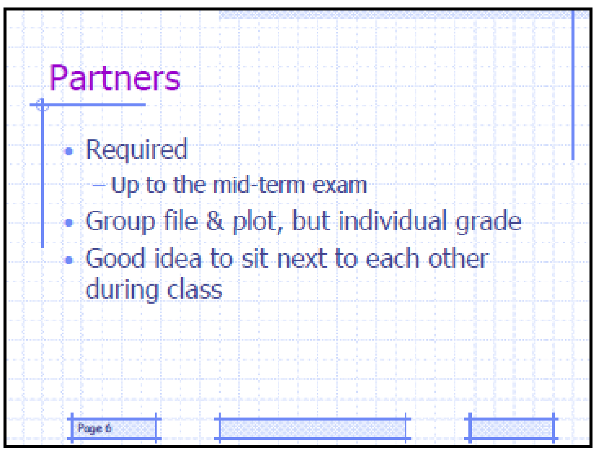

Working together
Don't stop meeting after you finish the assignment
Help each other learn AutoCAD
Study together weekly
There is a mid-term exam!
Page 16
Dept. of Engineering Education

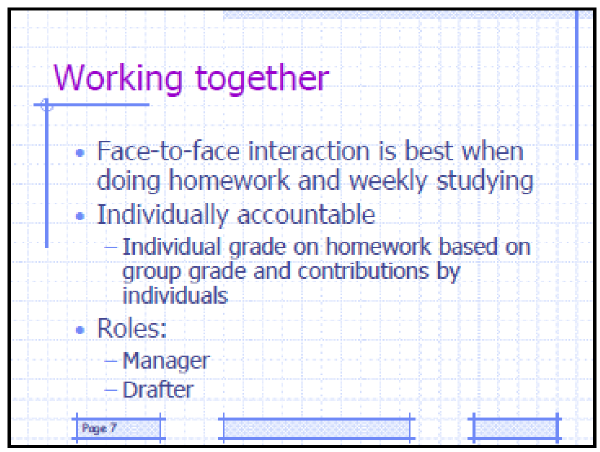

Next class
Sit with partner
At the start of class, you will complete a peer evaluation form
Rate partner's contribution to assignment
Discuss with partner
Answer questions about how you worked together
Page 17
Dept. of Engineering Education

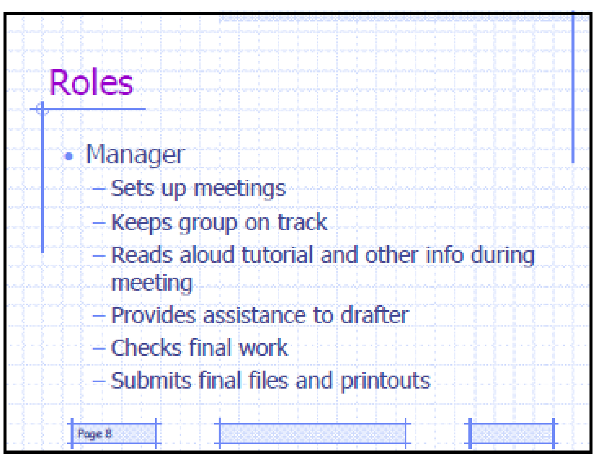

Plots
On the final plot you submit, you and your partner must sign/initial by your name
Indicates that both of you worked on assignment
In industry, there is usually a "Checked by" field in a title block, and someone who signs-off on the drawing.
23
ENGE 2344, Department of Engineering Education, Virginia Tech

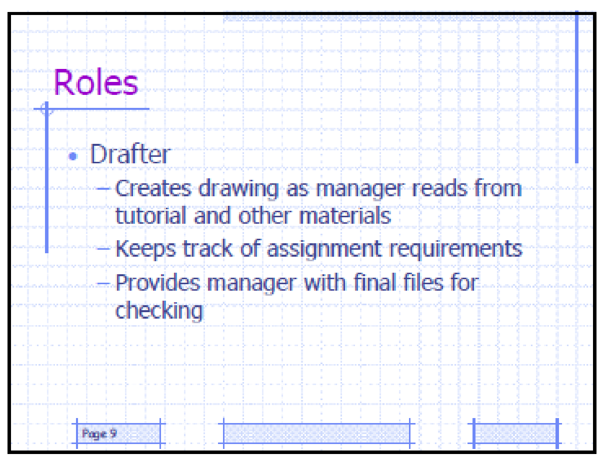

DWG Grading
Check for:
Accuracy
Completeness
Plot Scale
Text info.
(etc.)
Individual grade based on group grade and peer rating (next week)
27
ENGE 2344, Department of Engineering Education, Virginia Tech

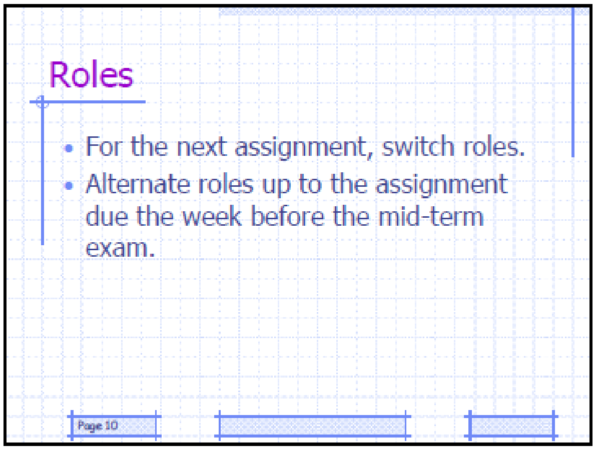
Week 3

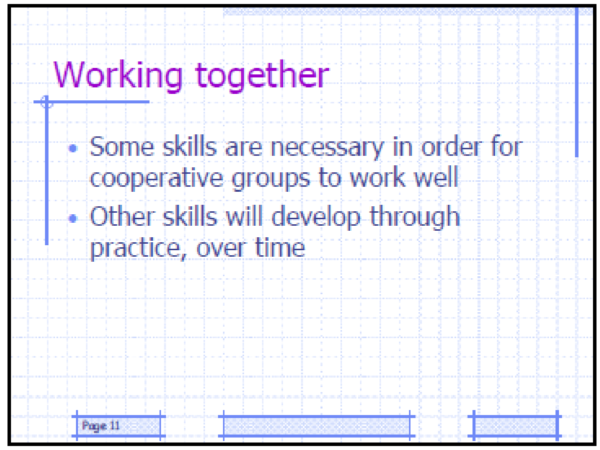

Partners
Required
– Up to the mid-term exam
Group file & plot, but individual grade
Good idea to sit next to each other during class
Page 6

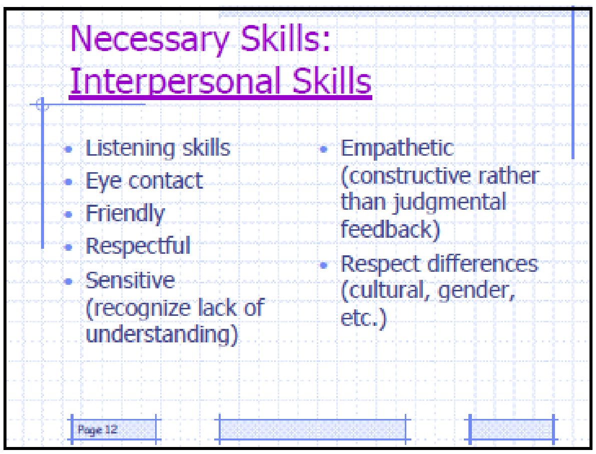

Working together
Face-to-face interaction is best when doing homework and weekly studying
Individually accountable
– Individual grade on homework based on group grade and contributions by individuals
Roles:
– Manager
– Drafter
Page 7

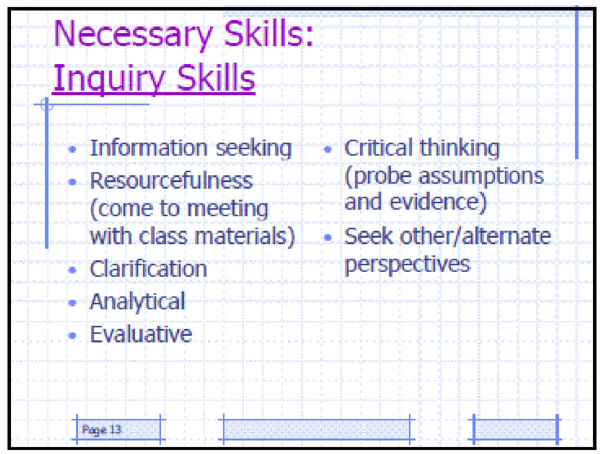

Roles
Manager
– Sets up meetings
– Keeps group on track
– Reads aloud tutorial and other info during meeting
– Provides assistance to drafter
– Checks final work
– Submits final files and printouts
Page 8


Roles
Drafter
– Creates drawing as manager reads from tutorial and other materials
– Keeps track of assignment requirements
– Provides manager with final files for checking
Page 9


Roles
For the next assignment, switch roles.
Alternate roles up to the assignment due the week before the mid-term exam.
Page 10


Working together
Some skills are necessary in order for cooperative groups to work well
Other skills will develop through practice, over time
Page 11


Necessary Skills:
Interpersonal Skills
Listening skills
Eye contact
Friendly
Respectful
Sensitive (recognize lack of understanding)
Empathetic (constructive rather than judgmental feedback)
Respect differences (cultural, gender, etc.)
Page 12


Necessary Skills:
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Information seeking
Resourcefulness (come to meeting with class materials)
Clarification
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Critical thinking (probe assumptions and evidence)
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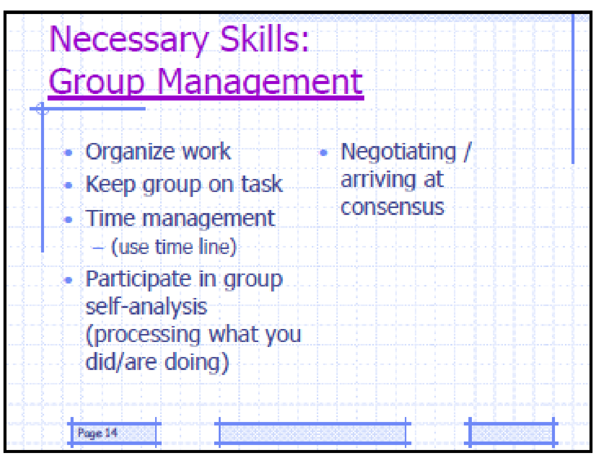
Page 13


Necessary Skills:
Group Management
Organize work
Keep group on task
Time management
– (use time line)
Participate in group self-analysis (processing what you did/are doing)
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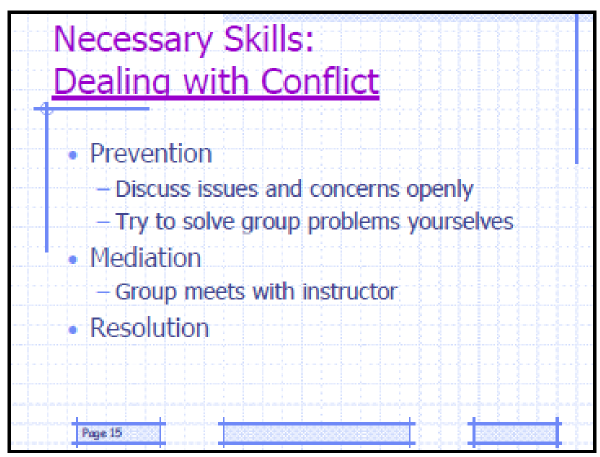
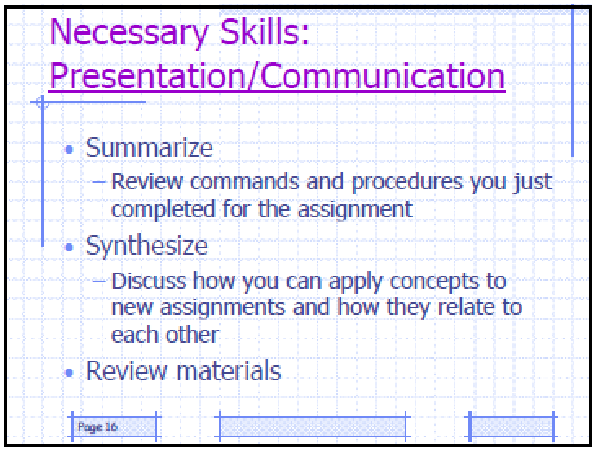
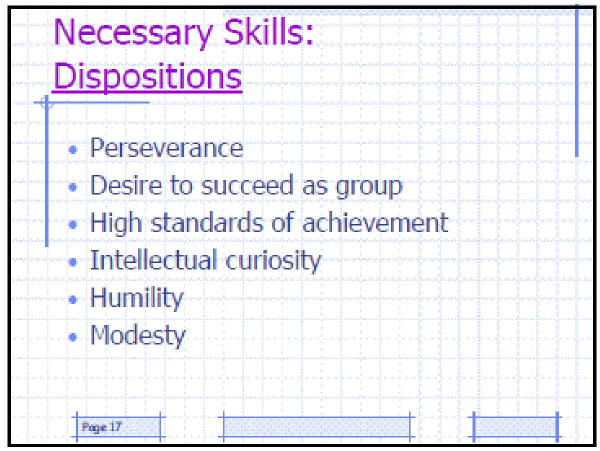
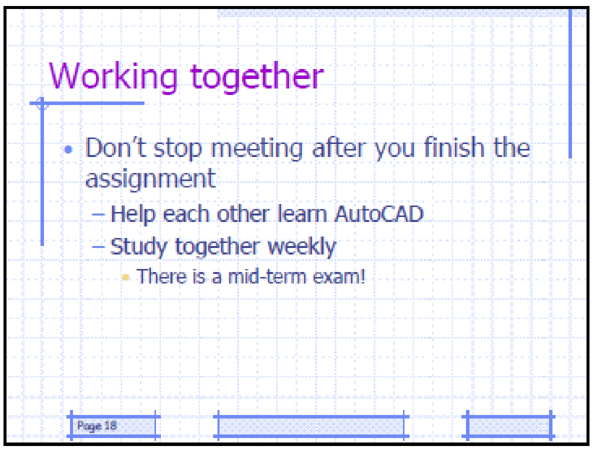
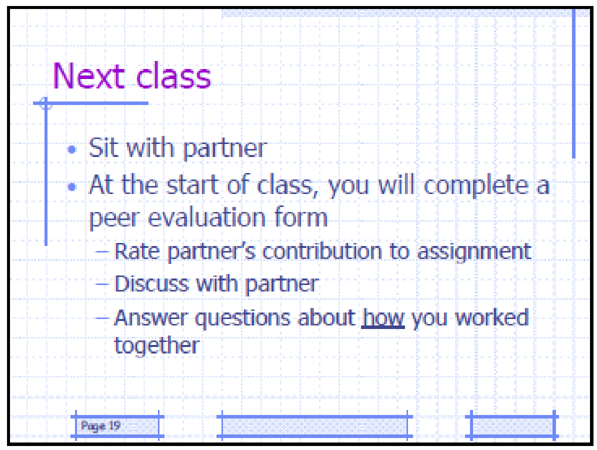
Page 14


Necessary Skills:
Dealing with Conflict
Prevention
– Discuss issues and concerns openly
– Try to solve group problems yourselves
Mediation
– Group meets with instructor
Resolution
Page 15

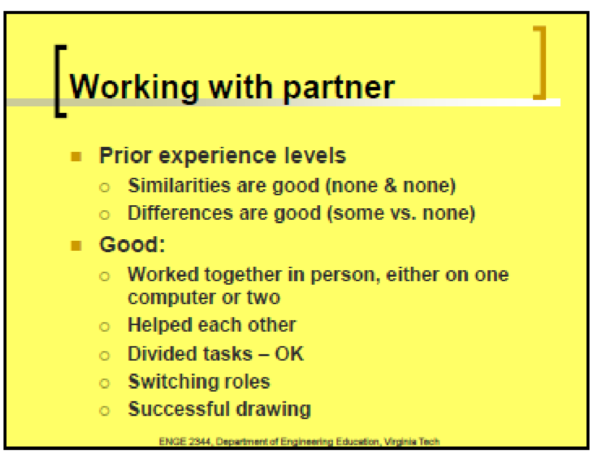

Necessary Skills: Presentation/Communication
Summarize
– Review commands and procedures you just completed for the assignment
Synthesize
– Discuss how you can apply concepts to new assignments and how they relate to each other
Review materials
Page 16


Necessary Skills: Dispositions
Perseverance
Desire to succeed as group
High standards of achievement
Intellectual curiosity
Humility
Modesty
Page 17


Working together
Don't stop meeting after you finish the assignment
– Help each other learn AutoCAD
– Study together weekly
There is a mid-term exam!
Page 18


Next class
Sit with partner
At the start of class, you will complete a peer evaluation form
– Rate partner's contribution to assignment
– Discuss with partner
– Answer questions about how you worked together
Page 19

Week 4


Working with partner
Prior experience levels
Similarities are good (none & none)
Differences are good (some vs. none)
Good:
Worked together in person, either on one computer or two
Helped each other
Divided tasks – OK
Switching roles
Successful drawing
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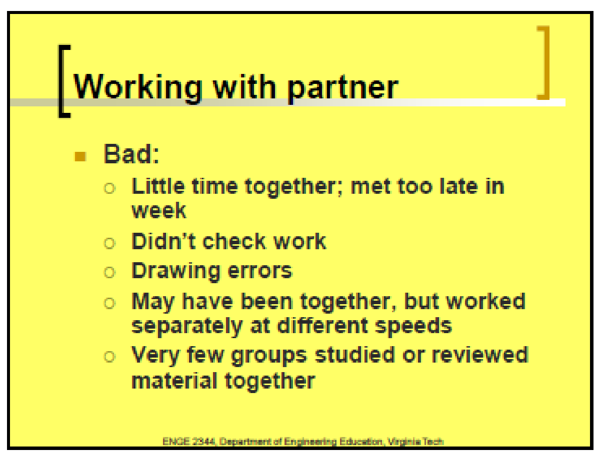
Working with partner
Bad:
Little time together; met too late in week
Didn't check work
Drawing errors
May have been together, but worked separately at different speeds
Very few groups studied or reviewed material together
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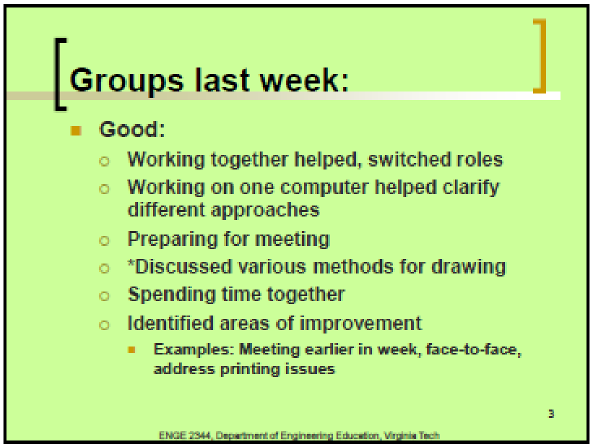
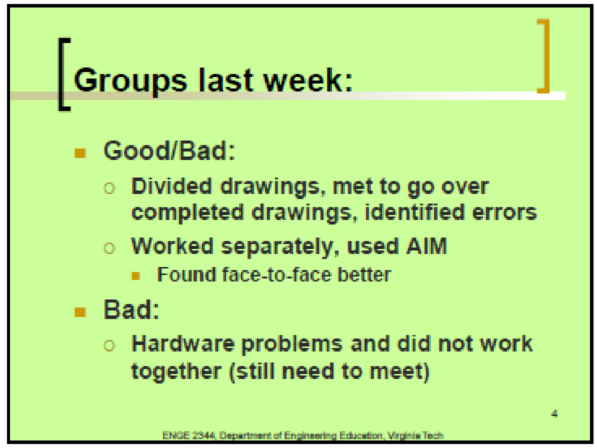
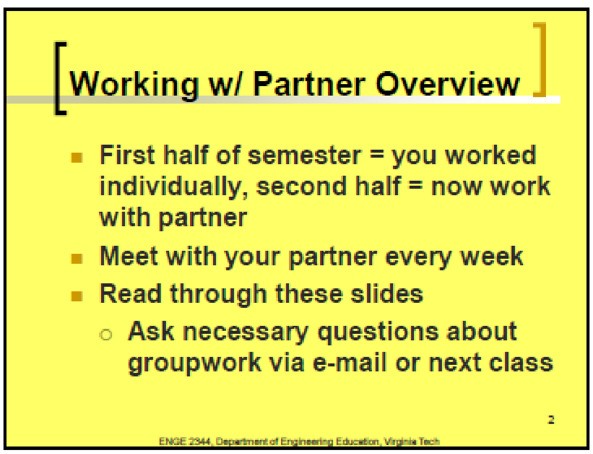
Week 5

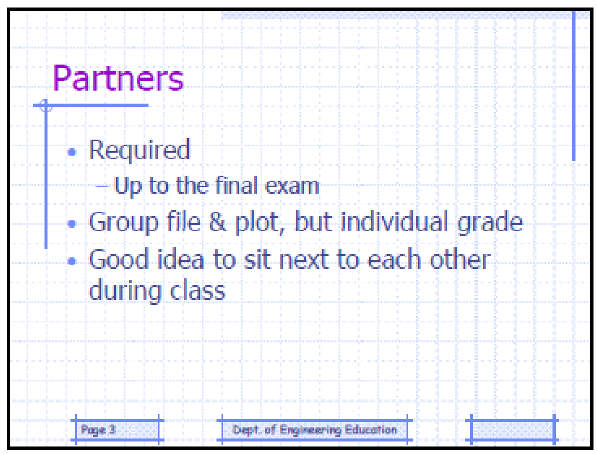


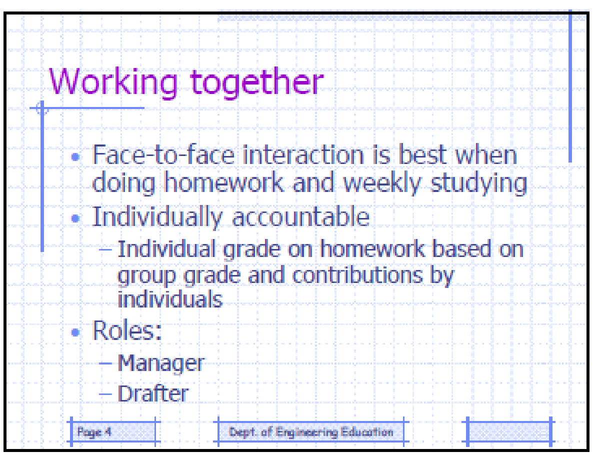


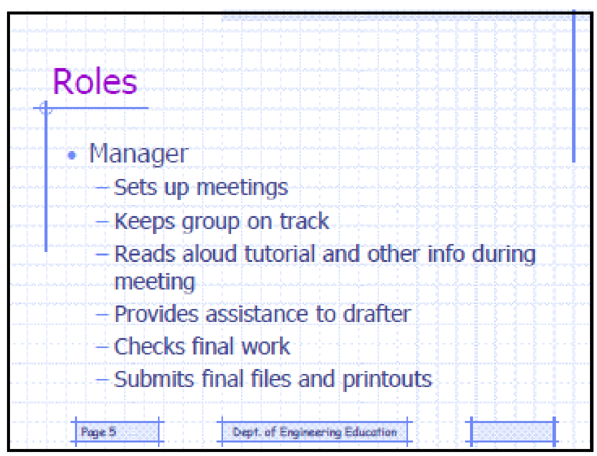
Experiment 2

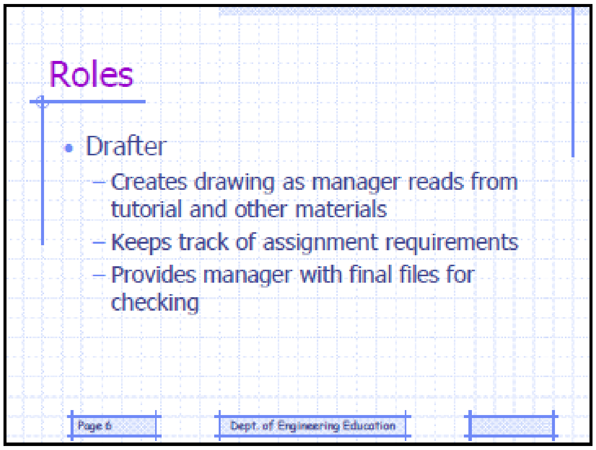
Week 8

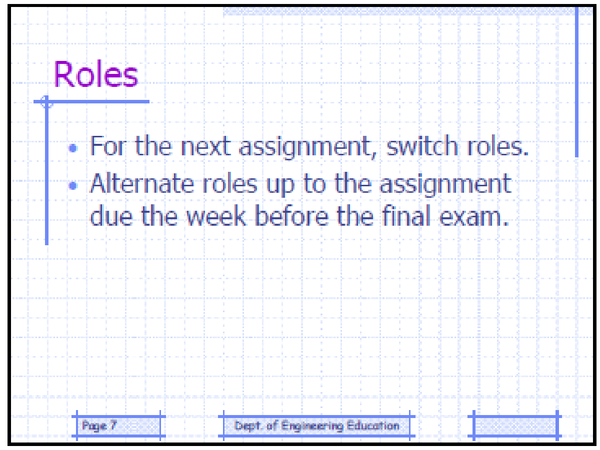









Roles
• Drafter
– Creates drawing as manager reads from tutorial and other materials
– Keeps track of assignment requirements
– Provides manager with final files for checking
Page 6
Dept. of Engineering Education


Roles
• For the next assignment, switch roles.
• Alternate roles up to the assignment due the week before the final exam.
Page 7
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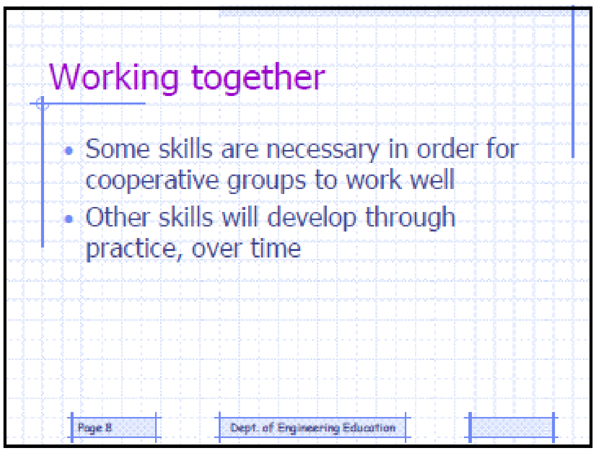
Working together
• Some skills are necessary in order for cooperative groups to work well
• Other skills will develop through practice, over time
Page 8
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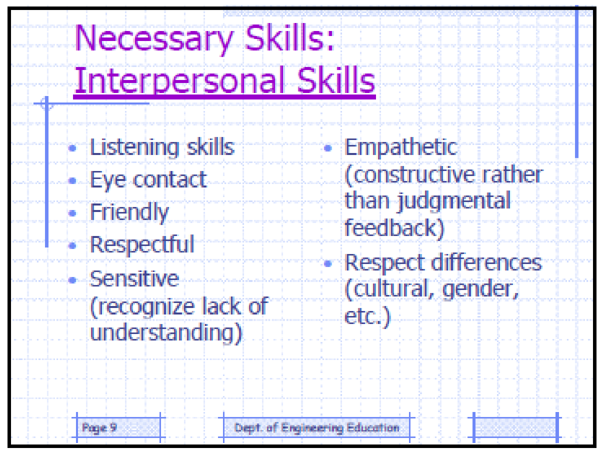
Necessary Skills: Interpersonal Skills
• Listening skills
• Eye contact
• Friendly
• Respectful
• Sensitive (recognize lack of understanding)
• Empathetic (constructive rather than judgmental feedback)
• Respect differences (cultural, gender, etc.)
Page 9
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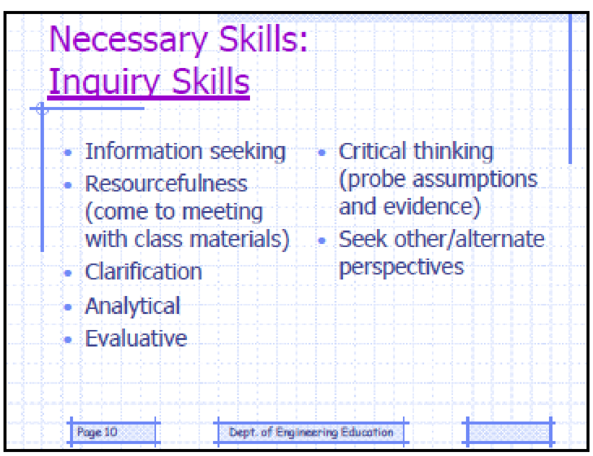
Necessary Skills: Inquiry Skills
• Information seeking
• Resourcefulness (come to meeting with class materials)
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• Critical thinking (probe assumptions and evidence)
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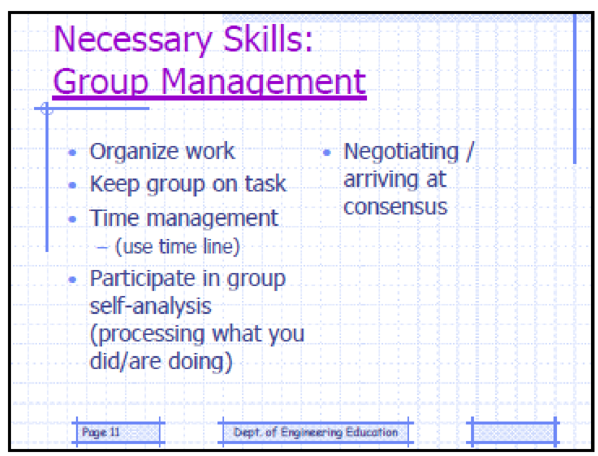
Necessary Skills: Group Management
• Organize work
• Keep group on task
• Time management
– (use time line)
• Participate in group self-analysis (processing what you did/are doing)
• Negotiating / arriving at consensus
Page 11
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Necessary Skills: Dealing with Conflict

- Prevention
  - Discuss issues and concerns openly
  - Try to solve group problems yourselves
- Mediation
  - Group meets with instructor
- Resolution

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Necessary Skills: Presentation/Communication

- Summarize
  - Review commands and procedures you just completed for the assignment
- Synthesize
  - Discuss how you can apply concepts to new assignments and how they relate to each other
- Review materials

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Necessary Skills: Dispositions

- Perseverance
- Desire to succeed as group
- High standards of achievement
- Intellectual curiosity
- Humility
- Modesty

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Working together

- Don't stop meeting after you finish the assignment
  - Help each other learn AutoCAD
  - Study together weekly
    - There is a final exam!

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Next class

- Sit with partner
- At the start of class, you will complete a peer evaluation form
  - Rate partner's contribution to assignment
    - Each week, even for 2-week long assignments
  - Discuss with partner
  - Answer questions about how you worked together

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Files and Plots

- **Files and plots contain names of both partners; one partner submits files**
- **On the final plot you submit, you and your partner must sign/initial by your name**
  - **Indicates that both of you worked on assignment**
    - **In industry, there is usually a "Checked by" field in a title block, and someone who signs-off on the drawing.**

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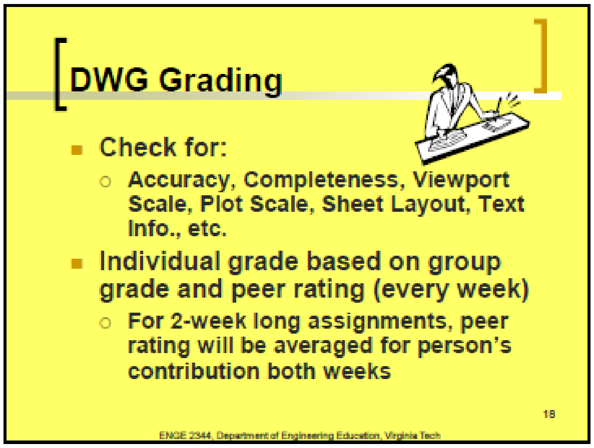
DWG Grading
Check for:
Accuracy, Completeness, Viewport Scale, Plot Scale, Sheet Layout, Text Info., etc.
Individual grade based on group grade and peer rating (every week)
For 2-week long assignments, peer rating will be averaged for person's contribution both weeks
18
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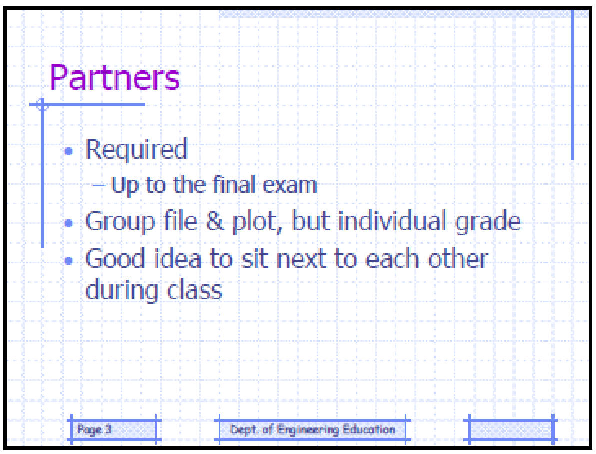
Week 9


Partners
Required
Up to the final exam
Group file & plot, but individual grade
Good idea to sit next to each other during class
Page 3
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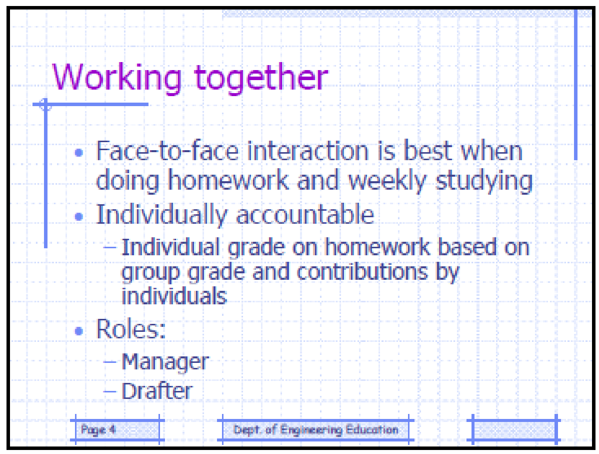
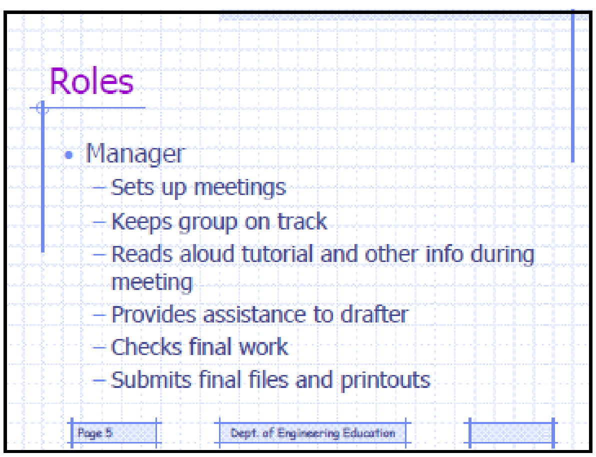
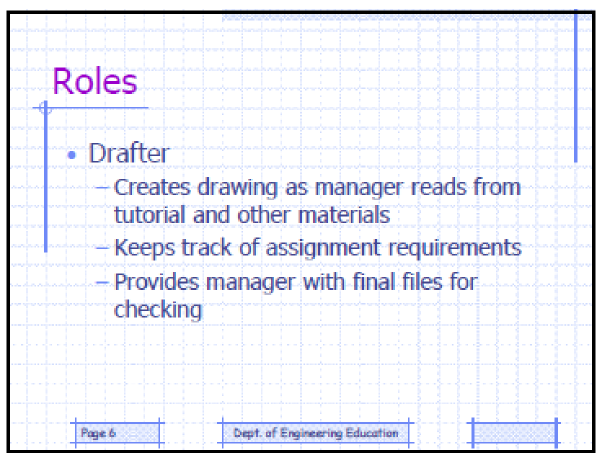

Working together
Face-to-face interaction is best when doing homework and weekly studying
Individually accountable
Individual grade on homework based on group grade and contributions by individuals
Roles:
Manager
Drafter
Page 4
Dept. of Engineering Education


Roles
Manager
Sets up meetings
Keeps group on track
Reads aloud tutorial and other info during meeting
Provides assistance to drafter
Checks final work
Submits final files and printouts
Page 5
Dept. of Engineering Education


Roles
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Page 6
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- For the next assignment, switch roles.
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Working together

- Some skills are necessary in order for cooperative groups to work well
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Necessary Skills: Interpersonal Skills

- Listening skills
- Eye contact
- Friendly
- Respectful
- Sensitive (recognize lack of understanding)
- Empathetic (constructive rather than judgmental feedback)
- Respect differences (cultural, gender, etc.)

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Necessary Skills: Inquiry Skills

- Information seeking
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- Clarification
- Analytical
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Page 10 Dept. of Engineering Education

Necessary Skills: Group Management

- Organize work
- Keep group on task
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  - (use time line)
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Page 13 | Dept. of Engineering Education

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Page 16 | Dept. of Engineering Education

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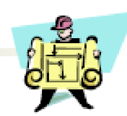
DWG Grading



- Check for:
  - Accuracy, Completeness, Viewport Scale, Plot Scale, Sheet Layout, Text Info., etc.
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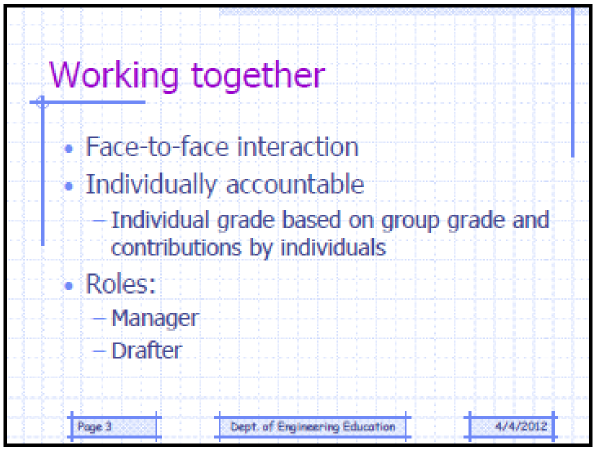
Week 10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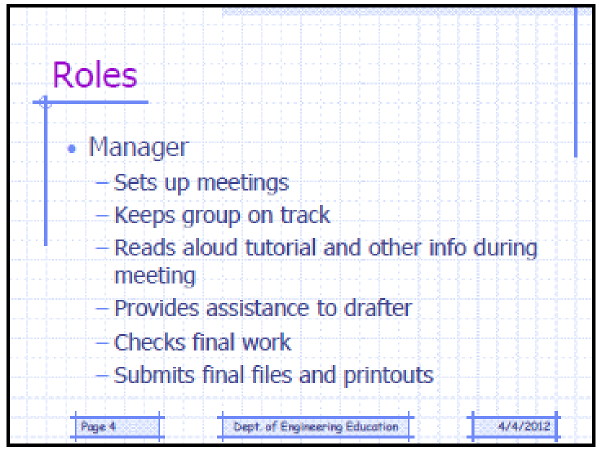
Page 3
Dept. of Engineering Education
4/4/2012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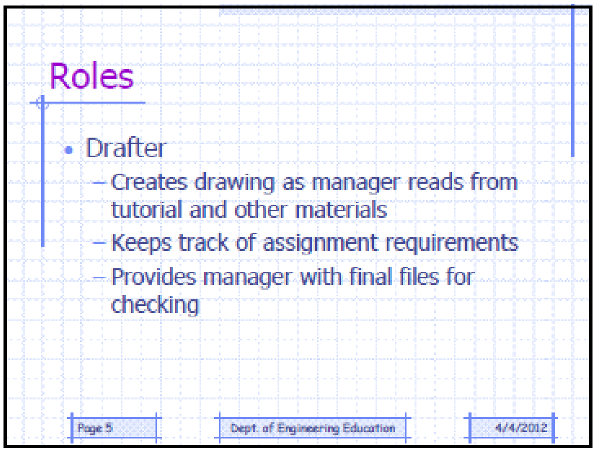
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Drafter
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Page 5
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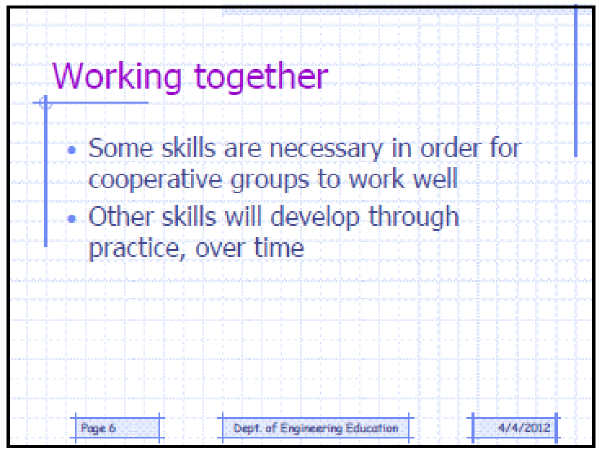
4/4/2012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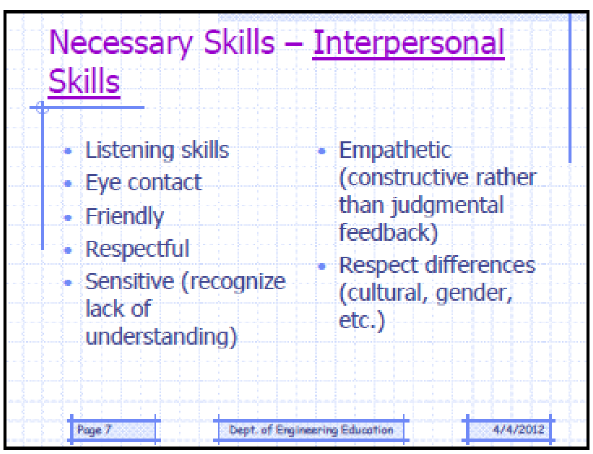
4/4/2012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Page 7
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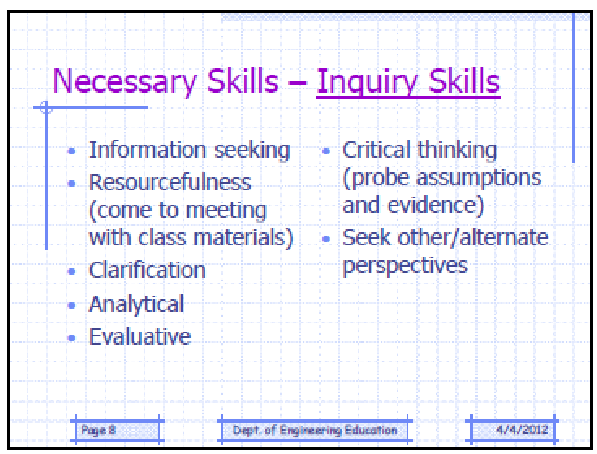
4/4/2012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Page 8
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4/4/2012

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Necessary Skills – Conflict

- Prevention
  - Discuss issues and concerns openly
  - Try to solve group problems yourselves
- Mediation
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- Resolution

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Necessary Skills – Presentation/Communication

- Summarize
- Synthesize
- Review materials

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Necessary Skills – Dispositions

- Perseverance
- Desire to succeed as group
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- Intellectual curiosity
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- Modesty

Page 12 Dept. of Engineering Education 4/4/2012

Working together

- Don't stop meeting
  - Help each other learn AutoCAD
  - Study together
    - There is a final exam!

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Questions

- Try to solve questions within group
  - Notes, textbook, AutoCAD's help menu, re-reading steps, try again
- Come to office with technical and/or procedural questions.
- Office hours or make appointment

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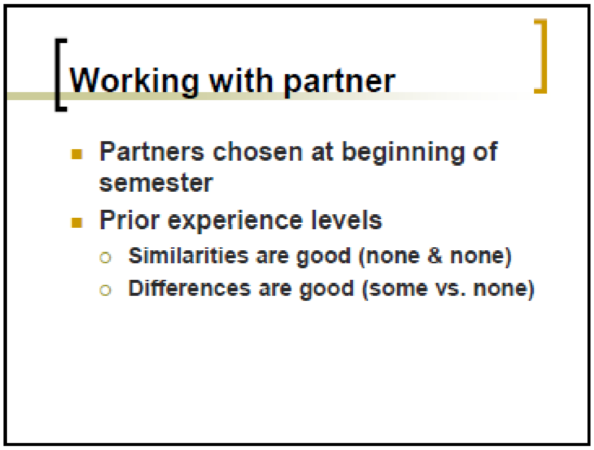
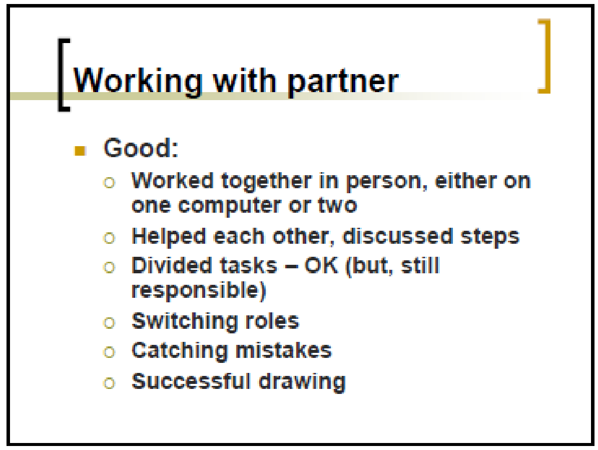
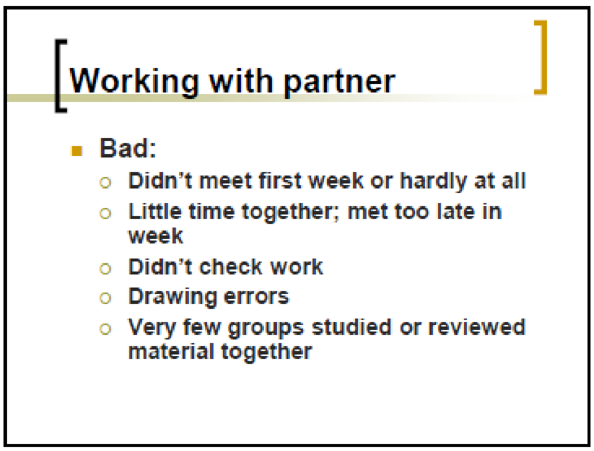
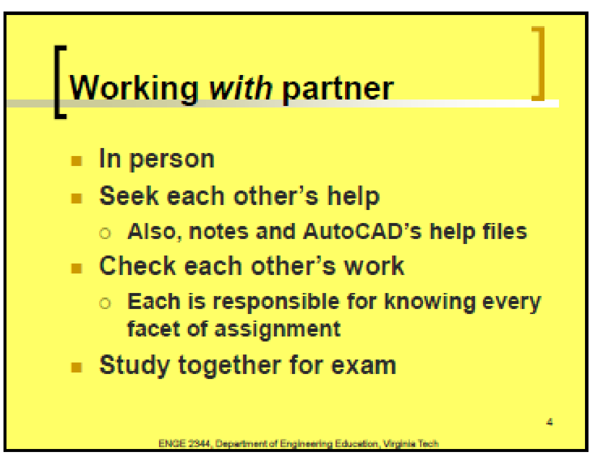
Week 11







Week 12



Appendix L

Dissertation Research
Task Schedule

		August	September				October				November					December		
WBS	**Task Name**	**week 1**	**week 2**	**week 3**	**week 4**	**week 5**	**week 6**	**week 7**	**week 8**	**week 9**	**week 10**	**week 11**	**week 12**	**week 13**	**week 14**	**week 15**	**week 16**	**week 17**
1	**Instruments & Surveys**	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒				
1.1	Sect. 1 - Introductory Survey	■																
1.2	Sect. 2 - Introductory Survey	■						■										
1.3	Pre-test		■															
1.4	Purdue ROT			■														
1.5	Learning Styles		■	■											T			
1.6	Mid-sem Course Eval							■	■						H			
1.7	Univ. final course eval ?													■	A			
															N			
2	**Homework Assignments**		▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	K			
2.1	Ch 1 Tutorial		■	■											S			
2.1	Ch 1 Ex 2		■	■											G			
2.3	Ch 2 Tutorial			■	■										I			
2.4	Ch 2 Ex 1			■	■										V			
2.5	Ch 3 Tutorial				■	■									I			
2.6	Ch 3 Ex 3				■	■									N			
2.7	Ch 5 Tutorial modified					■	■								G			
2.8	Ch 7 Tutorial modified						■	■										
2.9	Ch 4 Tutorial modified								■	■	■							
2.1	CAD Room										■	■						
3	**Project**											▒	▒	▒				
3.1	Project											■	■	■	B			
															R			
4	**Exams**								▒	▒	▒	▒	▒	▒	E	▒		
4.1	Mid-term Exam (Posttest 1)								■						A			
4.2	Final Exam (Posttest 2)														K	■		
5	**Interviews**				▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	
5.1	Sect. 1 - After 3 weeks				■	■												
5.2	Sect. 1 - Post treatment								■	■								
5.3	Sect. 2 - After 3 weeks											■	■					
5.4	Sect. 2 - Post treatment															■	■	
6	**Management Tasks**		▒	▒	▒	▒	▒	▒	▒									
6.1	Assign RID		■															
6.2	Sect. 1 - Assign Groups		■															
6.3	Sect. 2 - Assign Groups							■	■									

Appendix M

Tables

Table 1

Reported Race/Ethnicity by Gender Breakdown of Study Participants

Race	Frequency			Percent
	Male	Female	Total	
Multiracial	4	1	5	4.1
White, but not Hispanic or Latino	53	30	83	68.0
Hispanic or Latino	-	3	3	2.4
Black or African American	-	1	1	.8
Middle Eastern	2	-	2	1.6
American Indian or Alaska Native	2	1	3	2.4
Asian	11	5	16	13.1
Native Hawaiian and other Pacific Islander	-	-	-	-
No Indication	6	3	9	7.4
Total Reported	78	44	122	99.8

Note. Several participants (n = 9) chose not to indicate their race. The total percent is lower due to rounding. Hyphens indicate no reported values.

Table 2

Demographic Descriptions of Participants (N=122)

	Number	Percent
Gender		
Male	78	63.9
Female	44	36.1
Race		
White	83	68.0 (73.5)
Asian	16	13.1 (14.2)
All other races	14	11.5 (12.4)
Declined to answer	9	7.4
Major		
ISE	104	85.2
BSE	18	14.8
Academic Year		
Sophomore	61	50.0
Junior	46	37.7
Senior	15	12.3
Year As Engineering Major		
Second	80	65.6 (67.2)
Third	33	27.0 (27.7)
Fourth or Higher	6	4.9 (5.0)
Declined to answer	3	2.4
Prior Experience		
None	77	63.1 (64.2)
Little Exposure	20	16.4 (16.7)
Formal Coursework	11	9.0 (9.2)
Regular Use	12	9.8 (10.0)
Declined to answer	2	1.6
Prerequisite Grade		
A	14	11.5 (14.3)
B	53	43.4 (54.1)
C	31	25.4 (31.6)
Declined to answer	24	19.7
GPA		
4.00 – 3.50	27	22.1 (29.7)
3.49 – 3.00	29	23.8 (31.9)
2.99 – 2.50	18	14.8 (19.8)
2.49 – 2.00	16	13.1 (17.6)
< 2.00	1	.8 (1.1)
Declined to answer	31	25.4

Note. Percentages in parentheses are based on total responses given. The total percent might be higher due to rounding.

Table 3

Intercorrelations between Visualization and Tests

	Visualization	Pretest	Posttest 1	Posttest 2
Visualization	-	.261**	.282**	.356**
Pretest		-	.309**	.350**
Posttest 1			-	.467**
Posttest 2				-

** $p < .01$

Table 4

Intercorrelations between Visualization and Overall Homework Grades

	Visualization	HW–1st Half	HW–2nd Half
Visualization	-	.083	.402**
HW–1st Half		-	.259**
HW–2nd Half			-

** $p < .01$

Table 5

Class Percentages for Learning Style Preferences

		ILS Dimensions*							
Preference Level	Course Section	ACT	REF	SEN	INT	VIS	VRB	SEQ	GLO
Mild	1	27.6	15.5	27.6	25.9	13.8	15.5	43.1	19.0
	2	26.4	18.9	30.2	17.0	30.2	9.4	37.7	18.9
Moderate	1	48.3	1.7	31.0	1.7	31.0	6.9	29.3	5.2
	2	37.7	5.7	32.1	3.8	34.0	0.0	28.3	5.7
Strong	1	6.9	0.0	12.1	1.7	32.8	0.0	3.4	0.0
	2	7.5	3.8	11.3	5.7	26.4	0.0	9.4	0.0
Total	1	82.8	17.2	70.7	29.3	77.6	22.4	75.9	24.1
	2	71.7	28.3	73.6	26.4	90.6	9.4	75.5	24.5
Moderate + Strong Total	1	55.2	1.7	43.1	3.4	63.8	6.9	32.7	5.2
	2	45.2	9.5	43.4	9.5	60.4	0.0	37.7	5.7
Milds Combined Total	1	43.1		53.4		29.3		62.1	
	2	45.3		47.2		39.6		56.6	

Note. ACT = active, REF = reflective, SEN = sensing, INT = intuitive, VIS = visual, VRB = verbal, SEQ = sequential, GLO = global.

Table 6

ILS Dimensions Independent Samples Tests

	t-test for Equality of Means				
Dimension	*t*	*df*	Sig. (2-tailed)	*MD*	*SED*
ACT	.058	85	.954	.032	.551
REF	-2.349	24	.027*	-2.200	.937
SEN	-.568	80	.572	-.341	.601
INT	-1.306	29	.202	-1.471	1.126
VIS	1.419	93	.159	.818	.576
VRB	1.484	16	.157	1.446	.975
SEQ	-1.316	83	.192	-.759	.577
GLO	.000	26	1.000	.000	.754

Table 7

Means of Achievement Scores by Learning Method—Experiment 1

		Posttest 1		Homework	
Treatment	n	Mean	SD	Mean	SD
Cooperative	61	84.036	8.137	88.458	8.654
Individualistic	61	84.821	7.696	82.334	14.508

Table 8

Analysis of Variance of Achievement Data by Demographic (Gender)—Experiment 1

Source	*df*	SS	MS	F	p
Between-subjects	121				
Learning Method (LM)	1	12.913	12.913	.097	.756
Gender (G)	1	117.412	117.412	.885	.349
LM x G	1	25.073	25.073	.189	.665
Error-between	118	15652.442	132.648		
Within-subjects	122				
Time of Test (TT)	1	112667.549	112667.549	1681.346	.000
LM x TT	1	7.301	7.301	.109	.742
G x TT	1	734.505	734.505	10.961	.001
LM x G x TT	1	167.861	167.861	2.505	.116
Error-within	118	7907.220	67.010		
Total	243				

Table 9

Analysis of Variance of Achievement Data by Demographic (Race)—Experiment 1

Source	*df*	SS	MS	F	p
Between-subjects	112				
Learning Method (LM)	1	.912	.912	.009	.926
Race (R)	2	2195.587	1097.793	10.523	.000
LM x R	2	184.473	92.236	.884	.416
Error-between	107	11162.215	104.320		
Within-subjects	113				
Time of Test (TT)	1	52271.528	52271.528	698.271	.000
LM x TT	1	83.157	83.157	1.111	.294
R x TT	2	77.854	38.927	.520	.596
LM x R x TT	2	63.344	31.672	.423	.656
Error-within	107	8009.860	74.859		
Total	225				

Table 10

Analysis of Variance of Achievement Data by Demographic (Major)—Experiment 1

Source	*df*	SS	MS	F	p
Between-subjects	121				
Learning Method (LM)	1	1.826	1.826	.014	.907
Major (M)	1	112.481	112.481	.847	.359
LM x M	1	3.849	3.849	.029	.865
Error-between	118	15664.048	132.746		
Within-subjects	122				
Time of Test (TT)	1	61897.109	61897.109	840.034	.000
LM x TT	1	31.521	31.521	.428	.514
M x TT	1	41.811	41.811	.567	.453
LM x M x TT	1	6.632	6.632	.090	.765
Error-within	118	8694.716	73.684		
Total	243				

Table 11

Analysis of Variance of Achievement Data by Demographic (Academic Year)—Experiment 1

Source	*df*	SS	MS	F	p
Between-subjects	121				
Learning Method (LM)	1	.865	.865	.007	.935
Academic Year (AY)	2	652.809	326.404	2.544	.083
LM x AY	2	235.617	117.808	.918	.402
Error-between	116	14883.180	128.303		
Within-subjects	122				
Time of Test (TT)	1	76135.184	76135.184	1024.509	.000
LM x TT	1	21.507	21.507	.289	.592
AY x TT	2	106.203	53.102	.715	.492
LM x AY x TT	2	8.982	4.491	.060	.941
Error-within	116	8620.402	74.314		
Total	243				

Table 12

Analysis of Variance of Achievement Data by Demographic (Year As Engineering Major)—Experiment 1

Source	*df*	SS	MS	F	p
Between-subjects	118				
Learning Method (LM)	1	18.033	18.033	.134	.715
Engin. Year (EY)	2	347.158	173.579	1.292	.279
LM x EY	2	89.084	44.542	.332	.718
Error-between	113	15176.800	134.308		
Within-subjects	119				
Time of Test (TT)	1	35636.074	35636.074	493.561	.000
LM x TT	1	122.967	122.967	1.703	.195
EY x TT	2	265.824	132.912	1.841	.163
LM x EY x TT	2	176.832	88.416	1.225	.298
Error-within	113	8158.830	72.202		
Total	237				

Table 13

Analysis of Variance of Achievement Data by Demographic (Prior Experience)—Experiment 1

Source	*df*	SS	MS	F	p
Between-subjects	119				
Learning Method (LM)	1	103.035	103.035	1.006	.318
Experience (E)	3	3110.335	1036.778	10.124	.000
LM x E	3	471.267	157.089	1.534	.210
Error-between	112	11469.948	102.410		
Within-subjects	120				
Time of Test (TT)	1	50861.908	50861.908	913.883	.000
LM x TT	1	16.483	16.483	.296	.587
E x TT	3	1793.610	597.870	10.742	.000
LM x E x TT	3	378.808	126.269	2.269	.084
Error-within	112	6233.327	55.655		
Total	239				

Table 14

Analysis of Variance of Achievement Data by Demographic (Prerequisite Grade)—Experiment 1

Source	*df*	SS	MS	F	p
Between-subjects	97				
Learning Method (LM)	1	23.554	23.554	.174	.678
Prereq. Grade (PG)	2	227.627	113.814	.840	.435
LM x PG	2	235.027	117.514	.867	.424
Error-between	92	12468.787	135.530		
Within-subjects	98				
Time of Test (TT)	1	70261.365	70261.365	999.271	.000
LM x TT	1	7.511	7.511	.107	.745
PG x TT	2	5.841	2.920	.042	.959
LM x PG x TT	2	40.804	20.402	.290	.749
Error-within	92	6468.761	70.313		
Total	195				

Table 15

Analysis of Variance of Achievement Data by Demographic (GPA)—Experiment 1

Source	*df*		SS	MS	F	p
Between-subjects	90					
Learning Method (LM)		1	136.155	136.155	1.036	.312
GPA (GPA)		4	820.224	205.056	1.560	.193
LM x GPA		3	212.458	70.819	.539	.657
Error-between		82	10775.445	131.408		
Within-subjects	91					
Time of Test (TT)		1	26470.622	26470.622	382.281	.000
LM x TT		1	94.291	94.291	1.362	.247
GPA x TT		4	481.606	120.402	1.739	.149
LM x GPA x TT		3	56.222	18.741	.271	.846
Error-within		82	5677.993	69.244		
Total	181					

Table 16

Means of Achievement Scores by Learning Method—Experiment 2

		Posttest 2		Homework	
Treatment	n	Mean	SD	Mean	SD
Cooperative	61	74.787	9.840	83.281	13.618
Individualistic	59	73.534	10.720	74.634	22.961

Table 17

Analysis of Variance of Achievement Data by Demographic (Gender)—Experiment 2

Source	*df*	SS	MS	F	p
Between-subjects	119				
Learning Method (LM)	1	34.184	34.184	.205	.652
Gender (G)	1	159.998	159.998	.957	.330
LM x G	1	104.219	104.219	.624	.431
Error-between	116	19386.723	167.127		
Within-subjects	120				
Time of Test (TT)	1	63858.907	63858.907	825.729	.000
LM x TT	1	10.589	10.589	.137	.712
G x TT	1	478.637	478.637	6.189	.014
LM x G x TT	1	21.362	21.362	.276	.600
Error-within	116	8971.027	77.336		
Total	239				

Table 18

Analysis of Variance of Achievement Data by Demographic (Race)—Experiment 2

Source	*df*	SS	MS	F	p
Between-subjects	110				
Learning Method (LM)	1	28.314	28.314	.217	.642
Race (R)	2	2714.780	1375.390	10.394	.000
LM x R	2	435.727	217.863	1.668	.194
Error-between	105	13712.302	130.593		
Within-subjects	111				
Time of Test (TT)	1	29520.878	29520.878	350.573	.000
LM x TT	1	190.934	190.934	2.267	.135
R x TT	2	67.885	33.942	.403	.669
LM x R x TT	2	146.496	73.248	.870	.422
Error-within	105	8841.797	84.208		
Total	221				

Table 19

Analysis of Variance of Achievement Data by Demographic (Major)—Experiment 2

Source	*df*	SS	MS	F	p
Between-subjects	119				
Learning Method (LM)	1	7.876	7.876	.047	.829
Major (M)	1	5.399	5.399	.032	.858
LM x M	1	22.393	22.393	.133	.716
Error-between	116	19596.021	168.931		
Within-subjects	120				
Time of Test (TT)	1	34652.535	34652.535	426.548	.000
LM x TT	1	6.907	6.907	.085	.771
M x TT	1	.400	.400	.005	.944
LM x M x TT	1	28.057	28.057	.345	.558
Error-within	116	9423.776	81.239		
Total	239				

Table 20

Analysis of Variance of Achievement Data by Demographic (Academic Year)—Experiment 2

Source	*df*	SS	MS	F	p
Between-subjects	119				
Learning Method (LM)	1	1.134	1.134	.007	.993
Academic Year (AY)	2	546.381	273.190	1.716	.184
LM x AY	2	1007.913	503.957	3.166	.046
Error-between	114	18147.789	159.191		
Within-subjects	120				
Time of Test (TT)	1	44296.715	44296.715	546.261	.000
LM x TT	1	36.283	36.283	.447	.505
AY x TT	2	86.121	43.060	.531	.589
LM x AY x TT	2	129.384	64.692	.798	.453
Error-within	114	9244.349	81.091		
Total	239				

Table 21

Analysis of Variance of Achievement Data by Demographic (Year As Engineering Major)—Experiment 2

Source	*df*	SS	MS	F	p
Between-subjects	116				
Learning Method (LM)	1	102.605	102.605	.620	.433
Engin. Year (EY)	2	211.427	105.713	.639	.530
LM x EY	2	1014.861	507.431	3.067	.051
Error-between	111	18365.978	165.459		
Within-subjects	117				
Time of Test (TT)	1	22859.361	22859.361	291.010	.000
LM x TT	1	315.067	315.067	4.011	.048
EY x TT	2	88.202	44.101	.561	.572
LM x EY x TT	2	355.066	177.533	2.260	.109
Error-within	111	8719.259	78.552		
Total	233				

Table 22

Analysis of Variance of Achievement Data by Demographic (Prior Experience)—Experiment 2

Source	*df*	SS	MS	F	p
Between-subjects	117				
Learning Method (LM)	1	33.287	33.287	.263	.609
Experience (E)	3	4729.842	1576.614	12.441	.000
LM x E	3	462.482	154.161	1.216	.307
Error-between	110	13939.771	126.725		
Within-subjects	118				
Time of Test (TT)	1	30788.019	30788.019	423.053	.000
LM x TT	1	79.047	79.047	1.086	.300
E x TT	3	750.670	250.223	3.438	.019
LM x E x TT	3	304.016	101.339	1.392	.249
Error-within	110	8005.328	72.776		
Total	235				

Table 23

Analysis of Variance of Achievement Data by Demographic (Prerequisite Grade)—Experiment 2

Source	*df*		SS	MS	F	p
Between-subjects	95					
Learning Method (LM)		1	58.620	58.620	.364	.548
Prereq. Grade (PG)		2	1036.509	518.255	3.215	.045
LM x PG		2	718.333	359.167	2.228	.114
Error-between		90	14507.304	161.192		
Within-subjects	96					
Time of Test (TT)		1	38917.959	38917.959	492.887	.000
LM x TT		1	.031	.031	.000	.984
PG x TT		2	111.427	55.714	.706	.497
LM x PG x TT		2	30.515	15.257	.193	.825
Error-within		90	7106.322	78.959		
Total	191					

Table 24

Analysis of Variance of Achievement Data by Demographic (GPA)—Experiment 2

Source	*df*		SS	MS	F	p
Between-subjects	88					
Learning Method (LM)		1	225.413	225.413	1.333	.252
GPA (GPA)		4	596.109	149.027	.881	.479
LM x GPA		3	253.784	84.595	.500	.683
Error-between		80	13526.484	169.081		
Within-subjects	89					
Time of Test (TT)		1	13517.561	13517.561	177.183	.000
LM x TT		1	84.063	84.063	1.102	.297
GPA x TT		4	809.996	202.499	2.654	.039
LM x GPA x TT		3	75.127	25.042	.328	.805
Error-within		80	6103.337	76.292		
Total	177					

Appendix N

Interview Responses

The pages within this appendix contain the researcher’s transcribed notes from the interviews he conducted during the study. Interviewees were randomly selected cooperative groups representing three strata of performance (i.e., grades) on the assignments from the first two weeks of each treatment. The strata were created after the assignments were graded, and they were ultimately categorized as “A” grades (Group I), “B” grades (Group II), and “C or below” grades (Group III). One cooperative group from each stratum was chosen, totaling three pairs of students from each treatment.

Interviews with individuals from the selected groups—partners were interviewed separately—were conducted the week following the midpoint of the treatment. The post-treatment interviews—with the partners together—took place the week after the respective posttests/exams.

Interview Responses – Individual

Treatment 1, Interview 1 (Mid-treatment), Group I

Section I

1. **Research ID Number (RID)**: *201634*
2. **Section**: *Thursdays, 1:00pm*
3. **Major**: *ISE*
4. **Academic Year**: *Sophomore*
5. **Year As Engineering Major**: *2nd-year*
6. **GPA**: *3.0*
7. **Gender**: *Female*
8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *No*

Did your partner have prior AutoCAD experience?

- *"Not AutoCAD, but a parallel program. He knows more than me."*

Do you generally like learning something on your own or with other people?

3. *"With others, on everything"*.
4. Why?
    - *"I don't have good auditorial learning, and reading – in one ear, out the other. I hire tutors to help me.*"
    - *"….smaller groups are better."*

Section II

How do you feel you learn things best:

a. getting hands-on experience

- *"I learn backwards, hands-on, Google, with other people."*

Section III

How did it work out when working with a partner on the CAD assignments?

- *"Good. We meet every Tuesday at 11am…finish there…then e-mail each other to verify our work before sending it in."*

How often and when did you and your partner meet/communicate during each week to…

3. work on the homework assignments?
    - *Tuesdays at 11 for 2 hours total (set-up and leave)*

4. study?
    - *"No real studying…talk our way through homework."*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mail and IM, "…to verify work before sending it in."*
- *"E-mail file to each other."*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Both used computers and books, both do drawings, and pick which one to turn in*
- *But she frequently leaves without finishing her own*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*

- How would you feel about the time allotted if you had to work by yourself?
    - *"Enough, with help though."*

How did you feel about working with a partner on the CAD assignments?

- *Enjoy it*
- *One partner is good; more would be bad*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Benefits:

- *Ask partner questions (she asks him).*
- *They happen to be in the same classes.*
- *Likes it that partner knows more.*

Drawbacks:

- *"None."*

What is your level of confidence in knowledge of the software?

- *"Good."*
- *Thinks it would be the same as or better than by herself because they both did the drawings.*

Do you have any additional comments about your group experience so far?

- *Likes the format of this class so far.*
- *Happy with partner, "lucked out."*

Interview Responses – Individual

Treatment 1, Interview 1 (Mid-treatment), Group I

Section I

1. **Research ID Number (RID)**: *201633*

2. **Section**: *Thursdays, 1:00pm*

3. **Major**: *ISE*

4. **Academic Year**: *Sophomore*

5. **Year As Engineering Major**: *2nd-year*

6. **GPA**: ~*3.5*

7. **Gender**: *Male*

8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *No*
- *Used CAD programs in high school, didn't know names. It was a technology class—"Drafting"—board first semester, then CAD second semester.*

Did your partner have prior AutoCAD experience?

- *No. Not that he was aware of.*

Do you generally like learning something on your own or with other people?

1. *"On own at the beginning", and then "with others after that… to discuss and ask questions."*

2. Why?
   - *(see above)*

Section II

How do you feel you learn things best:

b. getting hands-on experience

- *"…Seeing it as it happens, progresses."*

Section III

How did it work out when working with a partner on the CAD assignments?

- *"So far, fine. The last one was a problem, but we solved it."*
- *Positive experience. "I'm enjoying it."*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *“One meeting a week. One and a half to two hours reading and doing.”*

2. study?
    - *Not together. On their own to refresh memories before or after meeting.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *AIM, to set up assignment before meeting and setting up location and time to meet.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Every week, own computer and book. Worked individually on same drawing. Helped each other out to match drawings.*
- *Going OK. Allows to work on own and ask questions for help.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*
        - *“Plenty of time.”*

- How would you feel about the time allotted if you had to work by yourself?
    - *Matches up the same because they are still working by themselves. “Together vs. alone.”*

How did you feel about working with a partner on the CAD assignments?

- *“I like it…that one extra resource along the way.”*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Benefits:

- *“Asking someone for help right away, so you don’t forget it.”*

Drawbacks:

- *“Balancing schedules…But it’s working, just later than I hoped.”*

What is your level of confidence in knowledge of the software?

- *“Confident, but not for a company.”*
- *Beneficial with a partner.*

Do you have any additional comments about your group experience so far?

- *No.*

Interview Responses – Group
Treatment 1, Interview 2 (Post-treatment), Group I

Section I

1. **Research ID Number (RID)**: *201634 (A), 201633 (B)*

Section III

How did it work out when working with a partner on the CAD assignments?

- A: *"Good."*
- B: *"Good."*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *For chapters 5 and 7, met on Tuesdays, 2 hours each.*

2. study?
    - *As they met in the library during the assignments. "…Kind of quizzed each other as we were doing that."*
    - *But not during week prior to exam. But did study by themselves. Quizzed each other before class.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mail and IM the next day, for fixing problems after meeting; for both assignments.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Worked on separate computers on their own. Asked each other questions. Tried to go at the same pace. Stopped/slowed down for each other.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*
        - *"…Slightly confused because the book didn't explain things fully."*

- How would you feel about the time allotted if you had to work by yourself?
    - *Would have taken longer alone because the work was a little confusing and there was more to do.*

How did you feel about working with a partner on the CAD assignments?

- A: *"Good. It was a good idea."*
- B: *"Good."*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

- Drawback:
    - *Scheduling—hardest part. But Tuesday was a good day for them.*

*End of treatment question:

~~How would you have felt about working with a partner for the entire semester?~~
How do you feel about working by yourself for the rest of the semester?

- A: *"OK."*
- B: *"I'll survive."*

What is your level of confidence in knowledge of the software?

- A: *"Average…Just as much as everyone…I'm comfortable with the material so far."*
- B: *"Same…Not a pro, but I'm confident."*

Do you have any additional comments about your group experience so far?

- A: *Liked two people working together; no more than two.*
- B: *"I'll survive."*

Performance on exam:

- A: *"I would have been lost without a partner, and procrastinated on the assignments…" in preparation for the exam.*
- B: *"Helping each other weekly helped, than by myself…" in preparation for the exam.*

Interview Responses – Individual

Treatment 1, Interview 1 (Mid-treatment), Group II

Section I

1. **Research ID Number (RID)**: *201927*
2. **Section**: *Thursdays, 1:00pm*
3. **Major**: *BSE*
4. **Academic Year**: *Junior*
5. **Year As Engineering Major**: *3rd-year*
6. **GPA**: *2.3*
7. **Gender**: *Male*
8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *No*

Did your partner have prior AutoCAD experience?

- *Yes. One or two years in high school. Strictly AutoCAD classes. "She is very good at it."*

Do you generally like learning something on your own or with other people?

1. *with others*
2. Why?
   - *"Bounce ideas off people," "Go faster on assignments."*

Section II

How do you feel you learn things best:

a. going to a lecture
c. getting hands-on experience

i. *"Lectures are fine, but…lecture followed by hands-on…"*

Section III

How did it work out when working with a partner on the CAD assignments?

- *"OK."*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *1st assignment: Once at her place.*
    - *2nd assignment: She first cancelled the meeting, and then he had computer problems. She did both drawings.*
    - *3rd assignment: Each did one drawing. Communicated via IM.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *Met in person once for the first drawing.*
- *IM communication for the 3rd.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *1st assignment: Used her computer. For both the tutorial and exercise, he read from the tutorial book out loud and she did the drawing.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*

- How would you feel about the time allotted if you had to work by yourself?
    - *"Yeah, probably. It may be better if I could ask someone a question."*

How did you feel about working with a partner on the CAD assignments?

- *"OK."*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Drawbacks:

- *Dependent on things that come up with your partner.*
- *Changing times. Someone else's schedule.*

Benefits:

- *"I'm learning the software better because of her experience."*
- *"We're working together better because of our schedules are fitting better."*

What is your level of confidence in knowledge of the software?

- *"Fair amount of practical knowledge. But terms, I don't know as well. But I'm confident I can do a drawing put in front of me."*

Do you have any additional comments about your group experience so far?

- *No.*

Interview Responses – Individual
Treatment 1, Interview 1 (Mid-treatment), Group II

Section I

1. **Research ID Number (RID)**: *201928*

2. **Section**: *Thursdays, 1:00pm*

3. **Major**: *ISE*

4. **Academic Year**: *Sophomore*

5. **Year As Engineering Major**: *2nd-year*

6. **GPA**: *3.18*

7. **Gender**: *Female*

8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *Yes.*
    - If yes, to what extent?
        - *"One year of straight AutoCAD."*
        - *"Two years integrated into other courses."*
            - *"Systems Engineering I (hands-on project with AutoCAD) and II (senior design).*
            - *New Jersey*

Did your partner have prior AutoCAD experience?

- *No.*

Do you generally like learning something on your own or with other people?

1. *On own—CAD. With others—projects.*

2. Why?
    - *…slows her down (if not working by herself on CAD)*

Section II

How do you feel you learn things best:

d. getting hands-on experience

- *See how to do it. Example: math problem—likes when professor has overheads.*
- *"I'm definitely a visual person."*

Section III

How did it work out when working with a partner on the CAD assignments?

- *Working better now.*
- *Problems before: 1st assignment – turned in his drawing, 2nd assignment – she did them. "After that, things are working better."*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *1st assignment: Together, for about 2 hours*
    - *2nd assignment: She did the drawings.*
    - *3rd assignment: Used IM and phone. Sent files back and forth, too (to modify a drawing before turning it in).*

2. study?
    - *None.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *In person, e-mail, IM, phone.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *1st assignment: On one computer (hers).*

- Was the amount of time allotted to you to complete each assignment:
    - *"Just right."*

- How would you feel about the time allotted if you had to work by yourself?
    - *"Just right."*

How did you feel about working with a partner on the CAD assignments?

- *He's slowing her down. "He doesn't know what he's doing."*
- *But they do help clarify things to each other.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Drawbacks:

- *Slows her down.*

Benefits:

- *"It's a refresher working with someone."*
- *She sees benefit of teaching someone and how it helps her learn. He's doing well now.*
    - *Example: TRIM command. She had to show him several times for each assignment and in class with the title block. "It gets annoying." He's still having problems with TRIM.*

What is your level of confidence in knowledge of the software?

- *“More confident now.” A refresher. Mostly on her own, though. On the pretest, she didn’t know a lot.*

Do you have any additional comments about your group experience so far?

- *No.*

Interview Responses – Group
Treatment 1, Interview 2 (Post-treatment), Group II

Section I

1. **Research ID Number (RID)**: *201928 (A), 201927 (B)*

Section III

How did it work out when working with a partner on the CAD assignments?

- B: "*Worked out pretty well." He thinks he performed better on mid-term because he worked with a partner. Problem—meeting time arrangement.*
- A: *"Overall, pretty good." Only worked with partner once, though.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *Own computers at own homes. Talked over phone and IM.*
    - *Chapter 5—two to three hours.*
    - *Chapter 7—He started it, sent file to her, she did some, and then they met and finished together. One to two hours each by themselves; finished together, about one hour.*

2. study?
    - B: *Not together, but on own.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *In-person, e-mail, IM, phone.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Chapter 7—When together, they worked on one computer.*

- o Was the amount of time allotted to you to complete each assignment:
    - *Just right*
    - *Too much time*

- o How would you feel about the time allotted if you had to work by yourself?
    - A: *OK. Would have done a little at a time.*
    - B: "*Probably OK". He notices now that on the individual assignments he should start earlier.*

How did you feel about working with a partner on the CAD assignments?

- B: *"Good experience regarding AutoCAD in general." "…Like the real world."*
- A: *"Pretty much the same."*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

- B: *None.*
- A: *None.*

What is your level of confidence in knowledge of the software?

- A: *"Really confident." More confident with stuff she didn't know before (she has prior experience).*
- B: *"Good working knowledge of the software. Just need to pay attention to details."*

Performance on exam:

- A: *Attributes success on exam mostly on her prior experience.*
- B: *Attributes success on exam to his studying mostly, but also to "groupwork on the mechanics of the software."*

Interview Responses – Individual
Treatment 1, Interview 1 (Mid-treatment), Group III

Section I

1. **Research ID Number (RID)**: *202418*

2. **Section**: *Thursdays, 1:00pm*

3. **Major**: *ISE*

4. **Academic Year**: *Sophomore*

5. **Year As Engineering Major**: *2nd-year*

6. **GPA**: *2.86*

7. **Gender**: *Female*

8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?
- *No*

Did your partner have prior AutoCAD experience?
- *No*

Do you generally like learning something on your own or with other people?
1. *With others*

2. Why?
    - *Share opinions, figure out the right way to do things, they will tell you when you make mistakes*

Section II

How do you feel you learn things best:
b. *getting hands-on experience*
    - *Retain information better; doing it while I'm told*

Section III

How did it work out when working with a partner on the CAD assignments?
- *Partner is great. We sort of rush, so it's a little bad. We should have done the first stuff by ourselves, then the harder stuff together. We get along well, but we rush. (I'm in volleyball, and she's a cheerleader.)*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *Every Tuesday night, about 2 hours. Half hour to 45 minutes on the tutorial, and then longer on the exercise problem. But rushing.*

2. study?
    - *Not together, but on own. "Maybe not her."*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *In-person.*
- *IM to verify that the assignment was turned in.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *1st assignment: Used both laptops, but only this interviewee had the book, until this week.*
- *2nd assignment: Interviewee read the book out loud, other partner did the computer work, because interviewee's computer went bad.*
- *3rd assignment: We'll start out on our own, then use one if someone is getting better results.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*
        - *Realize now because of errors. They think assignments are correct when they turn them in.*

- How would you feel about the time allotted if you had to work by yourself?
    - *Enough for herself.*

How did you feel about working with a partner on the CAD assignments?

- *Working out really well. Found a friend. Realized later (after working together for this class) that they have classes in common.*
- *Not sure about it on a CAD level because both partners don't have CAD experience.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Benefits:

- *Someone to talk to.*

Drawbacks:

- *Can't put 100% individual focus on assignments because you have to worry about the other person…*

What is your level of confidence in knowledge of the software?

- *"Average, not great. I could probably do it, but it may not be right."*
- *"I know how to use commands, but not putting everything together… Need both partners."*

Do you have any additional comments about your group experience so far?

- *May have preferred working on own first, and then with a partner later. Both would have experience by then.*

Interview Responses – Individual
Treatment 1, Interview 1 (Mid-treatment), Group III

Section I

1. **Research ID Number (RID)**: *202417*
2. **Section**: *Thursdays, 1:00pm*
3. **Major**: *ISE*
4. **Academic Year**: *Junior*
5. **Year As Engineering Major**: *2nd-year*
6. **GPA**: *2.9*
7. **Gender**: *Female*
8. **Race**: *Black or African American*

Did you have experience with AutoCAD before taking this class?
- *No*

Did your partner have prior AutoCAD experience?
- *No*

Do you generally like learning something on your own or with other people?
1. *With others*
2. Why?
   - *Easier to get together and put mindsets together, put ideas together*

Section II

How do you feel you learn things best:
c. getting hands-on experience
   - *Easier to remember something better after doing it, rather than read about it. For me, it's easier.*

Section III

How did it work out when working with a partner on the CAD assignments?
- *Liked it, especially because it's something new, get someone else's thought's on something, makes it easier.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *In-person, once a week, 2 hours at a time—reading, and then doing.*

2. study?
    - *None.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mailed to set up meeting for next week.*
- *IM if something wasn't finished. Plotting—one person tried; if it didn't work, the other person tried.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *1st assignment: Used both computers. Then realized it would be "more time efficient for one person to read and the other to do it."*
- *Chapters 1 and 2—separate computers. Chapter 3—one computer.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right—"Perfect."*
        - *"More time would have made us forget things."*

- How would you feel about the time allotted if you had to work by yourself?
    - *Enough, good.*

How did you feel about working with a partner on the CAD assignments?

- *Liked it. Better than working by myself.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Benefits:

- *Starting to learn software with partner.*
- *Good to have partner who didn't know software either.*

Drawbacks:

- *"None."*

What is your level of confidence in knowledge of the software?

- *"A couple weeks ago, probably not good. It helped working with a partner. I probably would have a tough time if we dropped partners a couple weeks ago."*

Do you have any additional comments about your group experience so far?

- *None.*

Interview Responses – Group
Treatment 1, Interview 2 (Post-treatment), Group III

Section I

1. **Research ID Number (RID)**: *202418 (A), 202417 (B)*

Section III

How did it work out when working with a partner on the CAD assignments?

- A: "*OK because we started to ask for help.*"
- B: *"It got a little easier because we knew the program better."*
- A: "*Buttons, etc.*"

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
   - *Tuesdays, at least 3 hours together. Finishing touches separately.*
2. study?
   - *Not together.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *Sometimes TXT (cell phone) each other about finishing touches.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Chapter 5—Together on same computer.*
- *Chapter 7—"A" read book, "B" did the drawing on the computer.*
- *Liked working together on one computer so they could troubleshoot together.*

- Was the amount of time allotted to you to complete each assignment:
  - *Just right*
- How would you feel about the time allotted if you had to work by yourself?
  - *Just right—Yes.*

How did you feel about working with a partner on the CAD assignments?

- A: "*Turned out OK. At the beginning it was harder because it was new."*
- B: *"I definitely think it was better for learning."*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

- A: *Benefit—easier to get through class, someone to ask questions.*
- A & B: *Drawback—time schedules. "Everything—classes, homework, sports."*

What is your level of confidence in knowledge of the software?

- A: *"Way better now."*
- B: *"Way better now." Working with partner helped learn software during the first half of the class. More relaxed when with a partner.*
- A & B: *Still a lot better up to mid-term.*

Interview Responses – Individual
Treatment 2, Interview 1 (Mid-treatment), Group I

Section I

1. **Research ID Number (RID)**: *102842*
2. **Section**: *Tuesdays, 1:00pm*
3. **Major**: *ISE*
4. **Academic Year**: *Sophomore*
5. **Year As Engineering Major**: *2nd-year*
6. **GPA**: *3.35*
7. **Gender**: *Female*
8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *No.*

Did your partner have prior AutoCAD experience?

- *No.*

Do you generally like learning something on your own or with other people?

1. *Mixed. By myself first, then talk with others.*
2. Why?
    - *I try to understand the concepts by myself, first. The problem with working with others first is that you don't know what questions to ask.*

Section II

How do you feel you learn things best:

b. getting hands-on experience

- *Going to a lecture can help and reading about it is OK, too. But, I have to do it to understand it.*

Section III

How did it work out when working with a partner on the CAD assignments?

- *"I like it a lot. We can figure out problems together. Someone can double-check the work."*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *Two times per week.*
    - *Chapter 4: 3 hours total, 1.5 hours at a time, brainstorming first*
    - *CAD Room: 3 times—2 hours, 2 hours, 1 hour*
    - *For these assignments, started on Wednesday during the day, then at night, and then on Thursday to finish.*

2. study?
    - *No.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *In-person*
- *IM and phone for setting up meetings, for setting up assignments, and making sure things were finalized at the end.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Mostly together, but both did a littler on their own.*
- *She did outside reading to prepare. He did small things, such as finishing the doors and working on blocks.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right for chapter 4 and CAD room.*
    - *"Plenty of time if you start early."*

  [Interviewer note: 5 hours on the CAD room assignment didn't seem to be a problem for her.]

- How would you feel about the time allotted if you had to work by yourself?
    - *Probably not. Would have spent more time on it by myself; put on the "back-burner" compared to a 3-credit class.*

*<u>Optional question for second treatment group</u>:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner
    - *She picks up concepts and commands more quickly because partner picks up concepts and commands more quickly.*

- By yourself
    - *Did not pick up concepts and commands quickly initially, but eventually.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Benefits:

- *Helping her grade.*
- *Feels like she is learning more.*

Drawbacks:

- *None for her.*

What is your level of confidence in knowledge of the software?

- *"On a scale of 1 to 10, a 7."*
- *"I definitely learned a lot."*

Do you have any additional comments about your group experience so far?

- *"I really liked working with a partner the second half of the semester."*
- *"It would have been cool to work with a partner all semester, but it wasn't necessary."*

[Interviewer note: This contradicts her earlier statement about liking to work by herself first.]

Interview Responses – Individual
Treatment 2, Interview 1 (Mid-treatment), Group I

Section I

1. **Research ID Number (RID)**: *102809*
2. **Section**: *Tuesdays, 1:00pm*
3. **Major**: *ISE, ME*
4. **Academic Year**: *Sophomore*
5. **Year As Engineering Major**: *2nd-year*
6. **GPA**: *3.89*
7. **Gender**: *Male*
8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?
- *No.*

Did your partner have prior AutoCAD experience?
- *No.*

Do you generally like learning something on your own or with other people?
1. *On own.*
2. Why?
   - *Work at a faster pace.*

Section II

How do you feel you learn things best:
- *b. getting hands-on experience*
- *c. reading about it on your own*
  - *Read first, then do—combination.*

Section III

How did it work out when working with a partner on the CAD assignments?
- *"Pretty well."*
- *Scheduled to meet early in the week.*

[Interviewer note: i.e., shortly after day of class.]

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *Usually Wednesday afternoons for 2 hours, and then on Thursday or Friday for 1 hour to finish before the weekend.*
    - *CAD Room—3 hours.*
    - *Chapter 4—less, 2 – 3 hours per week.*

2. study?
    - *None.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *In-person.*
- *E-mail and IM, just to schedule meetings*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Took turns at his computer. He was good at multilines, she was good at doors.*
- *One person read from tutorial book, other person did the drawing; then they switched.*

- o Was the amount of time allotted to you to complete each assignment:
    - *Too much time.*
        - *"More than enough."*

- o How would you feel about the time allotted if you had to work by yourself?
    - *"May have gone quicker, or the same, because you would do your own thing. But a partner would check for mistakes."*

How did you feel about working with a partner on the CAD assignments?

- *"Good."*
- *Good to work individually for the first several chapters, and then with a partner for the second half of the semester because you would be better prepared for group work.*

*<u>Optional question for second treatment group</u>:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- o Time with partner
    - *A little less because understanding individually was needed.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Drawbacks:

- *If one is not actively participating, then you would not keep track of everything going on. It would work if you actively participate.*

Benefits:

- *Someone to help you. "Two heads are better than one."*

What is your level of confidence in knowledge of the software?

- *"Pretty high."*
- *"Huge gain."*

*Optional question for second treatment group:

- o Do you think you learned more about the software by working with a partner or by yourself?
    - *By myself, overall.*

Do you have any additional comments about your group experience so far?

- *Suggestions: Do the tutorials individually, and then work with partners on exercise problems.*

Interview Responses – Group

Treatment 2, Interview 2 (Post-treatment), Group I

<u>Section I</u>

1. **Research ID Number (RID)**: *102842 (A), 102809 (B)*

<u>Section III</u>

How did it work out when working with a partner on the CAD assignments?

- A: *Liked working on the last few drawings with a partner because they were harder, vs. the first half of the semester.*
- B: *He is a more independent worker; generally likes working by himself. But liked working with a partner on the project.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *Both worked on his computer for CAD Room and project, then asked me for help, then met again to fix problems, and then finished both before the weekend.*
    - *CAD Room—3 – 4 hours. Project—closer to 4 hours per week.*

2. study?
    - *No.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mail and phone. Phone and TXT messages when clarifying drawings or setting up meetings.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *For both assignments, he spent the most time on the computer; she did some. She would have the tutorial book out, read the steps, and keep track. On the project, both spent time working on it.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*
        - *For CAD Room and project. Both agreed.*

- How would you feel about the time allotted if you had to work by yourself?
    - A: *Project would have been fine.*
    - B: *Would have been fine because he would have more time by himself.*

*Optional question for second treatment group:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner
  - *…good to have partner so you can ask for clarification.*

- By yourself
  - *More apt to learn more, but… (see above)*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

- A: *No problem working with (partner).*
  - Benefit: *Worked well together and both wanted to finish early.*
- B:
  - Benefit: *Worked well together and get along well.*

*End of treatment question:
How would you have felt about working with a partner for the entire semester?

- A: *Not necessary. First half of semester, better/easier to learn fundamentals on own.*
- B: *Agreed.*

What is your level of confidence in knowledge of the software?

- B: *"…went from no experience to very confident." Good to go from 2D to 3D.*
- A: *"Learned a lot, but I don't think I would be able to do a project on my own in the future." Reason: Has background now, but needs more practice because this was a 1 credit course.*

Exam studying:

- B: *Not much studying.*
- A: *Studied with note cards, etc.*

Interview Responses – Individual
Treatment 2, Interview 1 (Mid-treatment), Group II

Section I

1. **Research ID Number (RID)**: *101927*

2. **Section**: *Tuesdays, 1:00pm*

3. **Major**: *BSE*

4. **Academic Year**: *Sophomore*

5. **Year As Engineering Major**: *2nd-year*

6. **GPA**: *2.8*

7. **Gender**: *Male*

8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *No*

Did your partner have prior AutoCAD experience?

- *No.*

Do you generally like learning something on your own or with other people?

1. *mixed*

2. Why?
    - *For CAD, "two different minds help."*

Section II

How do you feel you learn things best:

b. getting hands-on experience
    - *Comprehend things better, instead of reading about how other people do it.*

Section III

How did it work out when working with a partner on the CAD assignments?

- *Difficult at first because it was hard to meet (for chapter 4 and CAD Room). Then it got better after meeting with the person.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *For both assignments, met on weekends once. Chapter 4—couple hours, hour or two. Just sat down to get it done because didn't want to meet more than that. So didn't meet during the week because of busy schedule as an engineering major.*

2. study?
    - *No. "Easier to learn just doing it."*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *In-person to work.*
- *E-mail and IM to coordinate when to meet and to answer questions back and forth to fix details.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Bulk of hard stuff together and details on own; check with each other about mistakes.*
- *Most assignments—one computer when meeting. Then CAD Room assignment—2 computers, so one had PDF files on screen.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*

- How would you feel about the time allotted if you had to work by yourself?
    - *Same, because I can spread out work over the week instead of all at once. That's how I did it the first half of the semester—work on it a couple days, then walk away for a while. Usually plotted and submitted later in the week.*

How did you feel about working with a partner on the CAD assignments?

- *"Well."*
- *"But a little different. If we got stuck, we had to solve the problem at that time, as opposed to the first half of the semester—you can figure things out later."*

*<u>Optional question for second treatment group</u>:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner
    - *Not so much because we met once a week, but we still learned new commands and buttons.*

- By yourself

- *More because I worked more often during the week.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Drawbacks:

- *Scheduling.*
- *Don't see mistakes right away because the only met once a week, as opposed to working individually.*

Benefits:

- *"Each person doesn't remember the same thing, so it's good to have another person there."*

What is your level of confidence in knowledge of the software?

- *"Fairly comfortable. Pretty solid with the basics."*

Do you have any additional comments about your group experience so far?

- *Having Inventor experience helped—buttons and commands like Inventor. Hard at first, then a piece of cake.*

Interview Responses – Individual
Treatment 2, Interview 1 (Mid-treatment), Group II

Section I

1. **Research ID Number (RID)**: *101928*
2. **Section**: *Tuesdays, 1:00pm*
3. **Major**: *ISE*
4. **Academic Year**: *Junior*
5. **Year As Engineering Major**: *2nd-year*
6. **GPA**: *2.5*
7. **Gender**: *Female*
8. **Race**: *Asian (Includes: Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, or other Asians)*

Did you have experience with AutoCAD before taking this class?

- *No.*

Did your partner have prior AutoCAD experience?

- *Yes.* [NO.]
  - If yes, to what extent?
    - "A little bit, because he knew what he was doing."
- CLARIFICATION [Interviewee volunteered a clarification to this question later in the interview.]
  - "It seemed he had a better grasp of the software as a result of the individual work the first half of semester."

Do you generally like learning something on your own or with other people?

1. *Mixed.*
2. Why?
   - *Liked this class because they worked on their own first, then met someone (partner) because she didn't know anyone.*

Section II

How do you feel you learn things best:

b. getting hands-on experience

- *"I'm a visual learner. I remember more when we do hands-on stuff."*

Section III

How did it work out when working with a partner on the CAD assignments?

- *OK. Both busy, so hard to meet.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
   - *Chapter 4: Met Friday after 12pm to go over assignment. Split and did individual work.*
   - *CAD Room: Met for 3 hours, mostly finished. She finished the rest.*

2. study?

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mail: Clarifying things when she got stuck finishing the CAD Room assignment. Same with chapter 4 during individual phase.*
- *He had three tests that week.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *CAD Room—one computer*
- *Chapter 4—worked individually.*

- Was the amount of time allotted to you to complete each assignment:
  - *Too much time.*

- How would you feel about the time allotted if you had to work by yourself?
  - *Same.*

How did you feel about working with a partner on the CAD assignments?

- *Good. Could ask each other questions.*

*Optional question for second treatment group:

How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner
  - *Same*

- By yourself
  - *Same.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Drawbacks:

- *Managing time.*

Benefits:

- *He corrected her mistakes by talking her through them.*

What is your level of confidence in knowledge of the software?

- *“Average.”*
- *“Not much changed these last two weeks.”*

Do you have any additional comments about your group experience so far?

- *“No. Thought it was good.”*

Interview Responses – Group
Treatment 1, Interview 2 (Post-treatment), Group II

Section I

1. **Research ID Number (RID)**: *101927 (A), 101928 (B)*

Section III

How did it work out when working with a partner on the CAD assignments?

- A: *Scheduling problems, but helped overall.*
- B: *Agreed.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *For both assignments—met only once for each assignment.* [They could not remember how much time for each assignment.]

      [Group proceeded to provide more info, which answered a later question.]
    - A: *Would have been better to work with partner the first half of semester instead because of the need of trying to figure things out.*
    - B: *Liked this method because you learn on your own first, and then got help when needed during the second half of the semester.*

2. study?
    - *No, not for group, due to scheduling.*
    - *Not individually during the week, either. But a little for the exam.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mail: would e-mail file back and forth to fix things.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Worked on one computer. Had another open for PDF files.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right*

- How would you feel about the time allotted if you had to work by yourself?
    - *Same. OK.*

How did you feel about working with a partner on the CAD assignments?

- *Good, overall.*

*<u>Optional question for second treatment group</u>:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner
  - A: *Same or similar. Maybe less during the second half because of blocks, 3D, etc.*

- By yourself
  - B: *A little more the first half.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

- B: *Benefits—Good to help each other out.*
- A: *Benefits—Working with someone because need it for career. "…A new angle in working with someone, because you do group projects in other classes, but not with software."*

*<u>End of treatment question</u>:
How would you have felt about working with a partner for the entire semester?

- A: *Helpful. "But it has its pros and cons."*
- B: *Likes working by herself.*

What is your level of confidence in knowledge of the software?

- A: *Confident with basics and basic sketching, and not so confident with blocks and attributes.*
- B: *"Yeah, me too."*

Performance on exam:

- *Both studied for exam individually.*

Interview Responses – Individual
Treatment 2, Interview 1 (Mid-treatment), Group III

Section I

1. **Research ID Number (RID)**: *101045*
2. **Section**: *Tuesdays, 1:00pm*
3. **Major**: *ISE*
4. **Academic Year**: *Junior*
5. **Year As Engineering Major**: *2nd-year*
6. **GPA**: *~3.15*
7. **Gender**: *Male*
8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *No*

Did your partner have prior AutoCAD experience?

- *Yes.*
  - o If yes, to what extent?
    - *4 years in high school*

Do you generally like learning something on your own or with other people?

1. *On own*
2. Why?
   - *Work at own pace, "so I can understand things," unless it's a huge project, so other people can do things.*

Section II

How do you feel you learn things best:

a. going to a lecture
- *Not a lecture, "because I might forget how to do something.".*

b. getting hands-on experience
- *Read instructions and do it at the same time, and can reference back to the instructions.*

Section III

How did it work out when working with a partner on the CAD assignments?

- *Would have rather done own work. Mostly watched partner do things, rather than interviewee reading steps from tutorial book. Did not read directions for first assignment.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
   - *Every Sunday, couple hours each time until finished.*

2. study?
   - *"A little on one, blocks and stuff." Reading through CAD Room instructions.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *In-person.*
- *E-mail and phone: With printing problem, partner e-mailed file to interviewee for printing, and then interviewee would call partner about set-up.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Chapter 4: Partner already did walls when they met. But during the second week, interviewee did the bathroom, windows, and door; but it took him longer.*
- *CAD Room: They worked on it together, but partner did most of the drawing tasks. Interviewee would have like to have done some of the drawing.*
- *For both assignments, partner did most of the drawing. Interviewee would try to figure out problems. Interviewee didn't have a computer; he mostly did work in a computer lab because he didn't have AutoCAD installed.*

- Was the amount of time allotted to you to complete each assignment:
  - *Just right*

- How would you feel about the time allotted if you had to work by yourself?
  - *CAD Room—could have been tough, especially if he had tests in other classes. His advice: maybe chapter 4 should be 1 week, and CAD room should be 2 weeks.*

How did you feel about working with a partner on the CAD assignments?

- *Thinks he was better on his own.*
- *But, it might have been better if his computer worked.*

*<u>Optional question for second treatment group</u>:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner
  - *less*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Drawbacks:

- *Doesn't particularly like it when someone tries to teach something when he could do it on his own.*

What is your level of confidence in knowledge of the software?

- *First half—OK. Second half—needs to review that material.*

Do you have any additional comments about your group experience so far?

- *No.*

Interview Responses – Individual
Treatment 2, Interview 1 (Mid-treatment), Group III

Section I

1. **Research ID Number (RID)**: *101046*
2. **Section**: *Tuesdays, 1:00pm*
3. **Major**: *ISE*
4. **Academic Year**: *Sophomore*
5. **Year As Engineering Major**: *2nd-year*
6. **GPA**: *~3.0*
7. **Gender**: *Male*
8. **Race**: *White, but not Hispanic or Latino*

Did you have experience with AutoCAD before taking this class?

- *Yes.*
    - If yes, to what extent?
        - *High school. AutoCAD with the blue background. One course freshman year, one course senior year. They were in the engineering department, but didn't know course names because he just took the courses for the teacher.*

Did your partner have prior AutoCAD experience?

- *No*

Do you generally like learning something on your own or with other people?

1. *On own.*
2. Why?
    - *Because he doesn't have to stop and wait for the other person.*

Section II

How do you feel you learn things best:

c. hands-on

a. going to a lecture? *No, because he can forget things.*
c. reading about it on your own? *Can drift in and out, unless he will actually use it.*

<u>Section III</u>

How did it work out when working with a partner on the CAD assignments?

- *OK.*
- *Usually meet once to do the tutorial, and then meet again to finalize.*
- *Inconvenience to set up time to meet.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *Chapter 4: Partner didn't have computer, but he did work in a lab. Both met and did individual work. Same with CAD Room.*

2. study?
    - *Go through tutorial before starting work.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mailed files to each other to check work.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *In person. Put files together on one computer (interviewee's). Same for all assignments because partner hasn't had a computer.*
- *Sundays—met for final drawing.*
- *Met a day before that for the tutorial.*
- *For two-week assignment, just met on Sunday.*

- Was the amount of time allotted to you to complete each assignment:
    - *Just right—"Time was correct."*
        - *Biggest problem though, finding time to meet because of group work.*

- How would you feel about the time allotted if you had to work by yourself?
    - *Same.*

How did you feel about working with a partner on the CAD assignments?

- *"Indifferent."*
- *Both can do same material.*

*<u>Optional question for second treatment group</u>:

How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- *"...not a fair question…because the content during the first half was the basics, and now it's application."*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

Drawbacks:

- *Setting up times.*

What is your level of confidence in knowledge of the software?

- *I can do it; not mastered; I can do it to the extent it needs to be done.*

Do you have any additional comments about your group experience so far?

- *No.*
- *AutoCAD would be better with freshman year, not sophomore.*

Interview Responses – Group
Treatment 2, Interview 2 (Post-treatment), Group III

Section I

1. **Research ID Number (RID)**: *101045 (A), 101046 (B)*

Section III

How did it work out when working with a partner on the CAD assignments?

- A: *Worked separately.*
- B: *Turned out decent, but better if alone.*

How often and when did you and your partner meet/communicate during each week to…

1. work on the homework assignments?
    - *Sundays—couple hours or how long it took. If not finished, then e-mailed each other to finish separately.*

2. study?
    - *No.*

Describe how you communicated with each other (e.g., in person, e-mail, IM, phone).

- *E-mail: Interviewee A could finish or plot.*

Regarding the assignments, how did you and your partner do the work (or divide the work)?

- *Used B's computer because A's didn't work.*
- B: *B did computer work, A followed, kept track so it "didn't get screwed up."*

- o Was the amount of time allotted to you to complete each assignment:
    - *Just right—Because need to schedule with partner, which made them "push it."*

- o How would you feel about the time allotted if you had to work by yourself?
    - B: *Same.*
    - A: *Agreed.*

How did you feel about working with a partner on the CAD assignments?

- B: *Scheduling was an issue because of group work in other classes. But would prefer to work on own anyway.*
- A: *Better on own because can work on own pace and a little each day, and go back and fix mistakes.*

*<u>Optional question for second treatment group</u>:
How would you rate your gains in learning the software when comparing the time you spent working with a partner over the last few weeks to the time you spent learning the software on your own? (higher, same, lower)

- Time with partner
    - A: *Less.*
    - B: *Less because 2nd half of semester was application.*
    - A: *Agreed.*

Describe any benefits or drawbacks that you realized after working with someone for the purpose of learning the software.

- B: *Benefits—help with troubleshooting, someone to check mistakes. Probably no more benefits because this was basic AutoCAD, but there would have been more benefits if 3D or more in-depth AutoCAD.*

*<u>End of treatment question</u>:
How would you have felt about working with a partner for the entire semester?

- A: *No, because it was better to learn basics by himself.*
- B: *Agreed.*
- Both: *Maybe a different opinion if A's computer worked, so would switch roles each week.*

What is your level of confidence in knowledge of the software?

- A: *Good with the basics.*
- B: *Good with the basics, can do a drawing.*

Exam Performance:

- A: *Not well. Did study, but didn't have group material because B had them, and B was out of town.*
- B: *Decent. Did study.*

Appendix O

Selected Weekly Peer Reviews

This appendix contains the weekly peer reviews by the participants who were interviewed. The information was rekeyed from the originals by the researcher and contains spelling errors, punctuation, and certain symbols as they appeared in the originals. The group labels correspond to the interview strata. Also, the tables herein contain simplified versions of the questions asked on the weekly peer review sheets; see Appendix H for the full questions.

Weekly Peer Reviews—Experiment 1

Group I

Chapter 1–Tutorial & Chapter 1–Exercise 2

Student:	201634	201633
Partner's Participation:	Normal	Normal
Time Working Together:	1:30	1:30
Time Studying Together:	30 min	0:30
How They Worked:	We both did the assignment next to each other. Split responsibilities.	We did the assignment congruently.
Computer Use:	Both	We each used our own computer.
They Did Well:	Scheduling and communication	Scheduling & communication
They Need to Improve:	Nothing except use of CAD	Our skills with CAD

Chapter 2–Tutorial & Chapter 2–Exercise 1

Student:	201634	201633
Partner's Participation:	Normal	Normal
Time Working Together:	1:20	1:20
Time Studying Together:	15 mins	0:15
How They Worked:	Both used computers and worked on assignment, [Partner] submitted & printed due to email problems.	We made the drawings together on our own computer & due to circumstances I printed & submitted.
Computer Use:	Both	We each used our own computer
They Did Well:	Communication	Communication
They Need to Improve:	Sending files; figure out what is wrong with our email.	Sending files via e-mail

Chapter 3–Tutorial & Chapter 3–Exercise 3

Student:	201634	201633
Partner's Participation:	Normal	Normal
Time Working Together:	1:30	1:30
Time Studying Together:	20 mins	0:20
How They Worked:	Both used our computers and completed the assignment.	We did the project together on our own computers, while [Partner] submitted and I printed
Computer Use:	Both	Each used our own
They Did Well:	Communicating and helped each other	Communicating & helping each other
They Need to Improve:	Writing study guide	Writing study guide

Chapter 5–Tutorial Modified

Student:	201634	201633
Partner's Participation:	Normal	Normal
Time Working Together:	3 hrs	3:00
Time Studying Together:	20 mins	20 min
How They Worked:	both used computer and finished through aim and email	We met together @ the library working concurrently for two hours then worked online together for another hour
Computer Use:	Both	We each used our own
They Did Well:	Communication	Communication
They Need to Improve:	Note taking/preparing for test	Studying & note taking

Chapter 7–Tutorial Modified

Student:	201634	201633
Partner's Participation:	Normal	Normal
Time Working Together:	1:30	1:30
Time Studying Together:	20	0:20
How They Worked:	Both did the assignment together.	We worked together in the library & then [Partner] submitted the assignment while I printed.
Computer Use:	Both used comp.	We each used our own, working through the project together.
They Did Well:	Communication	Communication
They Need to Improve:	Studying more for test	Studying more

Group II

Chapter 1–Tutorial & Chapter 1–Exercise 2

Student:	201927	201928
Partner's Participation:	Above normal	Normal
Time Working Together:	50 minutes	50 minutes
Time Studying Together:	0	0 minutes
How They Worked:	With one computer I went to her apartment and together we discussed the drawing and drew them.	We sat down at one computer and just worked through the assignment together.
Computer Use:	Share one, mine was in the shop	We shared one.
They Did Well:	Communicating what was needed to be done	We worked efficiently.
They Need to Improve:	My computer working, which it is now	I know more about CAD than [Partner], and I am afraid that I move too fast for him.

Chapter 2–Tutorial & Chapter 2–Exercise 1

Student:	201927	201928
Partner's Participation:	Above normal	No participation
Time Working Together:	0 minutes	0 minutes together; I worked for about 2 hours
Time Studying Together:	50 minutes I studied on my own	0 minutes
How They Worked:	We discussed what was due and how to do the project and when to do it	My partner had computer problems yesterday, so I had to do the entire assignment on my own.
Computer Use:	None, computer had serious problems and could not perform in the homework	We were going to work from separate computers, before he had computer problems.
They Did Well:	[Partner] was very understands with my computer problems	We communicated well throughout the week.
They Need to Improve:	Planning to get it done sooner	My partner needs to make sure his computer works properly.

Chapter 3–Tutorial & Chapter 3–Exercise 3

Student:	201927	201928
Partner's Participation:	Normal	Normal
Time Working Together:	1 hours online	60 minutes
Time Studying Together:	0	0 minutes
How They Worked:	We worked at the same time online talking on im the entire time through im	We each generated one drawing, but communicated with each other throughout the whole process
Computer Use:	I did my drawing on my computer and she did her drawing on hers	Each used one computer
They Did Well:	We communicated very well	We communicated better than ever
They Need to Improve:	Get it done earlier in the week	This week worked out very well

Chapter 5–Tutorial Modified

Student:	201927	201928
Partner's Participation:	Normal	Normal
Time Working Together:	1 hour	1 hour
Time Studying Together:	0	0 minutes
How They Worked:	I started the assignment on my own while talking online with her	He did the first half of the drawing, I did the second half.
Computer Use:	I used my computer and then emailed my drawing to her. And we worked on hers	We each used our own computers.
They Did Well:	Communicating	Communicated well
They Need to Improve:	Sticking with original meet times	Meet when we originally say we will meet (not cancelling on each other)

Chapter 7–Tutorial Modified

Student:	201927	201928
Partner's Participation:	Normal	Normal
Time Working Together:	1 hour	1 hour
Time Studying Together:	0	0 minutes
How They Worked:	I went over to her apartment and together we worked on the assignment.	[Partner] started the dwg on his own & then came to my place & we worked together.
Computer Use:	I started the assignment on my own at my home, setting up the drawing. And then	He started on his computer, then we both shared mine.
They Did Well:	finishing the final drawing together	We did the majority of the dwg together.
They Need to Improve:	getting done earlier	Doing the dwg earlier in the week.

Group III

Chapter 1–Tutorial & Chapter 1–Exercise 2

Student:	202418	202417
Partner's Participation:	Above normal	Above normal
Time Working Together:	1 hour 30 min	1 ½ or 1:30
Time Studying Together:	1 hour	an hour
How They Worked:	We worked well together. [Partner] worked with the computer while I read all the instructions to her.	We worked together to read the book & perform actions on the comp. @ the same time.
Computer Use:	We used both in the beginning but for the one HW assignment we her computer.	Even share
They Did Well:	We figured out how the different components of AutoCAD worked. We gave each other positive feedback.	Figured out how to work some of the components in CAD.
They Need to Improve:	We could definitely improve our knowledge of AutoCAD.	Our knowledge of AutoCAD.

Chapter 2–Tutorial & Chapter 2–Exercise 1

Student:	202418	202417
Partner's Participation:	Above normal	Above normal
Time Working Together:	1 hour 30 min	1:30
Time Studying Together:	30 mins	30 min
How They Worked:	We shared the assignment equally. We both read out of the book + both worked on the computer.	We worked together on the comp. assignment & read out of the book at the same time.
Computer Use:	We both used our own computers.	We both used our own comp's.
They Did Well:	We communicated well on how to do certain parts of the assignment.	Good communication for understanding
They Need to Improve:	Printing problems	Printing/plotting problems

Chapter 3–Tutorial & Chapter 3–Exercise 3

Student:	202418	202417
Partner's Participation:	Above normal	Above normal
Time Working Together:	2 hours	2 hours
Time Studying Together:	1 hour	an hour
How They Worked:	One read while the other created the projects.	One read while the other worked on the computer
Computer Use:	We used one computer	We used one computer
They Did Well:	Communicate	Communicate
They Need to Improve:	Small details/double checking the assignments.	Little details, double checking

Chapter 5–Tutorial Modified

Student:	202418[a]	202417
Partner's Participation:	-	Above normal
Time Working Together:	-	1:30
Time Studying Together:	-	an hour
How They Worked:	-	We worked to understand each part individually, then combine knowledge to complete assignment.
Computer Use:	-	each [indiscernible] there own, then combined to one.
They Did Well:	-	Read carefully to ensure maximum points
They Need to Improve:	-	Promptness

[a]Student did not complete the peer rating sheet this week.

Chapter 7–Tutorial Modified

Student:	202418	202417
Partner’s Participation:	Above normal	Above normal
Time Working Together:	2 hours	2 hours
Time Studying Together:	2 hours	2 hours
How They Worked:	Did the assignment as best as we could then went to office hours for help.	We worked to do the assignment as best we could, then went in for help.
Computer Use:	Shared a comp.	Shared a computer
They Did Well:	Completed the assignment early + successfully	Completely the assignment early & successfully
They Need to Improve:	Little details	Little details

Weekly Peer Reviews—Experiment 2

Group I

Chapter 4–Tutorial Modified—Week 1

Student:	102809	102842
Partner's Participation:	Normal	Normal
Time Working Together:	1:30	1 hour 30 min
Time Studying Together:	0:00	0:0
How They Worked:	We worked together on the same computer. She followed along in the book while I listened to her instructions and completed them in CAD.	We worked on the same computer. I followed along in the book while he listened to my instructions & completed the design
Computer Use:	We shared a computer.	We shared one computer
They Did Well:	We delegated tasks appropriately and got along well personally.	We delegated tasks appropriately & got along personally
They Need to Improve:	We need to make sure that we both understand the material sufficiently	Making sure we both completely understand what the other is doing.

Chapter 4–Tutorial Modified—Week 2

Student:	102809	102842
Partner's Participation:	Above normal	Above normal
Time Working Together:	1:00	1 hour
Time Studying Together:	0:00	0:0
How They Worked:	She communicated the problem and instructions, while I performed the necessary tasks in AutoCAD.	I communicate the problem, instructions, & calculations while [Partner] performed the tasks in AutoCAD
Computer Use:	We shared a computer	We shared a computer
They Did Well:	We were proficient in completing the task according to our own knowledge and communication skills.	We accurately finished the task & worked together to figure out the problem we were having with the windows
They Need to Improve:	All went well.	All went well

CAD Room

Student:	102809	102842
Partner's Participation:	Above normal	Above normal
Time Working Together:	4:00	4:0
Time Studying Together:	0:00	0:0
How They Worked:	She translated the instructions from the tutorial while I completed the appropriate actions in AutoCAD.	He followed my instructions on the computer while I read & translated the tutorial & dictated the measurements
Computer Use:	We both worked on one computer	one computer
They Did Well:	We were efficient in double-checking each other's work	We double checked each others work
They Need to Improve:	All went well.	All went well

Project—Week 1

Student:	102809	102842
Partner's Participation:	Above normal	Above normal
Time Working Together:	2:00	2:0
Time Studying Together:	0:00	0:0
How They Worked:	she communicated the instructions, and we worked together an producing them in AutoCAD	We discussed how we were going to design our project. I read the specifications & he followed along with my directions
Computer Use:	we shared one computer	Shared a computer
They Did Well:	we planned and formulated our design efficiently	We worked together to formulate an appropreiate design
They Need to Improve:	All went well	All went well

Project—Week 2

Student:	102809	102842
Partner's Participation:	Above normal	Above normal
Time Working Together:	4:00 per week	4 per week
Time Studying Together:	0:00	0:0
How They Worked:	We both did the readings and performed the instructions together.	We discussed our plan of attached & performed the reading & command together
Computer Use:	We both worked on one computer.	shared
They Did Well:	We were efficient in decision making.	efficient in decision making
They Need to Improve:	All went well.	all went well

Group II

Chapter 4–Tutorial Modified—Week 1

Student:	101927	101928
Partner's Participation:	Normal	Normal
Time Working Together:	0	We split the work but did not meet.
Time Studying Together:	0	N/A
How They Worked:	We split the work for these first two weeks.	We split the work.
Computer Use:	Own computers.	N/A
They Did Well:	Split the work, weren't together.	We were able to communicate even though we did not meet this week but we will be able to meet this weekend.
They Need to Improve:	We will need to get together this week.	We need to meet even though we are both very busy.

Chapter 4–Tutorial Modified—Week 2

Student:	101927	101928
Partner's Participation:	Normal	Normal
Time Working Together:	10 minutes	10 minutes
Time Studying Together:	0	10 minutes
How They Worked:	Went over powerpoint slides.	We split the work up.
Computer Use:	Used own computers.	We used our own computers.
They Did Well:	Communicated well.	We communicated and talked to each other if either of us had any problems.
They Need to Improve:	Nothing.	Nothing.

CAD Room

Student:	101927	101928
Partner's Participation:	Normal	Normal
Time Working Together:	2 hours 30 mins.	2 Hours, 30 Minutes
Time Studying Together:	0	0
How They Worked:	Met at a common location and worked on one computer.	We both worked on it together.
Computer Use:	Used one computer at a time.	Share computer.
They Did Well:	Working together instead of independently.	Helped each other when stuck.
They Need to Improve:	Scheduling.	Could work longer?

Project—Week 1

Student:	101927	101928
Partner's Participation:	Normal	Normal
Time Working Together:	30 mins.	30 minutes
Time Studying Together:	0	0
How They Worked:	Organized logistics	We organized what we were going to do with the drawing.
Computer Use:	Own computers.	Used our own.
They Did Well:	Communicated well.	Helped each other when one ran into problem.
They Need to Improve:	Get the project done!	Manage time better.

Project—Week 2

Student:	101927	101928
Partner's Participation:	Normal	Normal
Time Working Together:	2 hrs.	2 Hours
Time Studying Together:	30 mins.	30 Minutes
How They Worked:	Constructed our building together, each doing small parts.	We split up the work.
Computer Use:	Shared a computer and used individual computers.	We used our own computers.
They Did Well:	Working effciently	Asked for help when needed.
They Need to Improve:	Organization.	Time management.

Group III

Chapter 4–Tutorial Modified—Week 1

Student:	101045	101046
Partner's Participation:	-	-
Time Working Together:	-	-
Time Studying Together:	-	-
How They Worked:	-	-
Computer Use:	-	-
They Did Well:	-	-
They Need to Improve:	-	-

Note. Group did not complete peer rating sheets this week.

Chapter 4–Tutorial Modified—Week 2

Student:	101045	101046
Partner's Participation:	Above normal	Above normal
Time Working Together:	2 hours	2 hours
Time Studying Together:	0 hours	0 hr.
How They Worked:	[Partner] took the initiative to make the walls, then we got together and put in everything else and touched up some walls	I worked on walls, we got together + did windows and bathroom together.
Computer Use:	Only used [Partner]'s computer, mine is broken	Shared my computer
They Did Well:	troubleshooting each other, told the other what they were doing wrong	Completed Drawing/ troubleshooted each other.
They Need to Improve:	I need to get my computer fixed	nothing

CAD Room

Student:	101045	101046
Partner's Participation:	Above normal	Above normal
Time Working Together:	2:30	2:30
Time Studying Together:	1:00	1:00
How They Worked:	Met and worked through the project together	Got together + did tutorial, then did drawing, took turns drawing features
Computer Use:	Shared a computer	Shared my computer/individual computers
They Did Well:	communication	communication
They Need to Improve:	pay better attention to instructions	instructions

Project—Week 1

Student:	101045	101046
Partner's Participation:	Normal	Normal
Time Working Together:	1:30	2 hr.
Time Studying Together:	15 – 30 min	30 min
How They Worked:	come up for a design and made it	we designed the floor layout for the final.
Computer Use:	shared a comp	used my computer.
They Did Well:	designed as a team	bounced design ideas off each other
They Need to Improve:	meet earlier	-

Project—Week 2

Student:	101045	101046
Partner's Participation:	Above normal	Normal
Time Working Together:	2:30	2 hr 30 min
Time Studying Together:	1:00	1 hr
How They Worked:	worked on most of it seperatly after discussing what to do when checked each other's work	I did the Blocks/Bathroom/ office/Windows/doors/Design center stuff Basically the drawing. [Partner] did the viewports and 3d and zoom in stuff and the print layout
Computer Use:	used seperate computers	used my computer for the drawing, emailed to [Partner] who finished the 3d + printing.
They Did Well:	communicated over long distance	did floor layout, bounced ideas off each other
They Need to Improve:	figuring out the final product as a group	following directions

Appendix P

Selected Grades

The following pages contain portions of the instructor-researcher's gradebook for the participants who were interviewed. The first set of five pages is for first treatment group. The second set of six pages is for the second treatment group. When reviewing the gradebook sections, one can discriminate between treatment and control conditions by the particular half of the semester that contains columns for weighted grades—the treatment conditions contain the weighted grades columns. The cooperative groups/pairs are listed together, and the lists are in descending order from highest achieving groups (during the first two weeks of the respective treatments) to the lowest achieving groups.

Section 1

	Week 1	Week 2	Week 3	Week 3	Week 3	Week 4	Week 4	Week 4	Week 5	Week 5	Week 5
	Attend	**Attend**	**Ch01-Tutorial**	**Ch01-Ex02**	**Attend**	**Ch02-Tutorial**	**Ch02-Ex01**	**Attend**	**Ch03-Tutorial**	**Ch03-Ex03**	**Attend**
RID	**1**	**1**	**22**	**20**	**1**	**30**	**41**	**1**	**38**	**53**	**1**
102842	1	1	18.7	15	1	30	41	1	38	48.35	1
102809	1	1	22	20	1	30	41	1	38	53	1
101927	1	1	9	7	1	30	31	1	36.1	45.35	1
101928	1	1	22	20	1	30	30.9	1	38	48	1
101045	0	1	20.9	17	1	30	39	1	38	52	1
101046	1	1	11	10	1	0	0	0	27.4	36.4	1
			Red = not submitted								
			Yellow = missing either file or plot								
			Blue = corrections or changes								

Section 1

Week 6	Week 6	Week 7	Week 7			Week 8			Week 8	1st	1st
Ch05-Tutorial	**Attend**	**Ch07-Tutorial**	**Attend**	**HW%-1stHalf**		**Mid-term Exam**		**M.Ex. %**	**Attend**	**Attend**	**Att. %**
100	**1**	**100**	**1**	0.300	1.000	**84**	1.000	0.150	**1**	**8**	0.050
64	1	63.5	1	**0.242**	0.806	64	0.762	**0.114**	1	**8**	**0.050**
100	1	97	1	**0.298**	0.994	72	0.857	**0.129**	1	**8**	**0.050**
58.5	1	74	1	**0.209**	0.697	74	0.881	**0.132**	1	**8**	**0.050**
70	1	69	0	**0.253**	0.844	66	0.786	**0.118**	1	**7**	**0.044**
0	1	95.5	1	**0.229**	0.764	66	0.786	**0.118**	1	**7**	**0.044**
29.5	1	66	1	**0.130**	0.432	60	0.714	**0.107**	1	**7**	**0.044**

Section 1

1st Half %	Week 9 Attend	Week 10 Ch04-Tutorial	weighted	Week 10 Attend	Week 11 CAD Room	weighted	Week 11 Attend	Week 12 Attend	Week 13 Project	weighted	Week 13 Attend
0.500	**1**	**223**		**1**	**284**		**1**	**1**	**100**		**1**
0.406	1	221		1	282		1	1	93.5		1
0.477	1	221		1	282		1	1	93.5		1
0.391	1	184		1	209.65		1	1	53.50		1
0.415	1	184		1	209.65		1	1	53.5		1
0.391	0	123.2		1	209.15		1	1	35		0
0.280	0	123.2		1	209.15		1	1	35	**36.75**	1

Section 1

		Week 15			Week 15	2nd	2nd	2nd Half			Week 2		Week 3		
HW%-2ndHalf		Final Exam		F.Ex.%	Attend	Attend	Att.%	%	Course %		Pretest		Vis.	ILS	
0.300	1.000	68	1.000	0.150	1	6	0.050	0.500	100.0		68		20	ACT	REF
0.291	0.969	44	0.647	0.097	1	6	0.050	0.438	84.4		18		19	7	
0.291	0.969	60	0.882	0.132	1	6	0.050	0.473	95.0		24		13	3	
0.206	0.686	42	0.618	0.093	1	6	0.050	0.348	74.0		22		19	7	
0.206	0.686	30	0.441	0.066	1	6	0.050	0.322	73.7		20		15	3	
0.156	0.521	46	0.676	0.101	1	4	0.033	0.291	68.2		24		14		1
0.158	0.528	48	0.706	0.106	1	5	0.042	0.306	58.6		24		20		

Section 1

SEN	INT	VIS	VRB	SEQ	GLO	Major	Gender	Race	Prereq.	GPA	Experi.	Academ. Year	Engin. Year	Other Survey Notes	Int'l
3		9		1		1	1	2	3	3.35	0	2	2		
3			5	1		1	2	2	3	3.89	0	2	2		
7		9		3		2	2	2		2.9	0	2	2		
9		9		9		1	1	7	3		0	3	2		
	3		1	7		1	2	2	3	3.28	0	3	3		
						1	2		3		3	2	2	4 yrs in h.s.	

Section 2

	Week 1	Week 2	Week 3		Week 3		Week 3	Week 4		Week 4	
	Attend	**Attend**	**Ch01-Tutorial**	**weighted**	**Ch01-Ex02**	**weighted**	**Attend**	**Ch02-Tutorial**	**weighted**	**Ch02-Ex01**	**weighted**
RID	**1**	**1**	**22**		**20**		**1**	**30**		**41**	
201634	1	1	22		20		1	30		41	
201633	1	1	22		20		1	30		41	
201928	1	1	16.5	**18.15**	18	**19.8**	1	30	**33**	36	**39.6**
201927	1	1	16.5		18		1	30	**0**	36	**0**
202418	1	1	11.5		15		1	21.5		26	
202417	1	1	11.5		15		1	21.5		26	
			Red = not submitted								
			Yellow = missing either file or plot								
			Blue = corrections or changes								

Section 2

Week 4 Attend	Week 5 Ch03-Tutorial	weighted	Week 5 Ch03-Ex03	weighted	Week 5 Attend	Week 6 Ch05-Tutorial	weighted	Week 6 Attend	Week 7 Ch07-Tutorial	weighted
1	**38**		**53**		**1**	**100**		**1**	**100**	
1	38		53		1	81		1	87	
1	38		53		1	81		1	87	
1	34.1		53		1	82.5		1	81.5	
1	34.1		53		1	82.5		1	81.5	
1	30.4		28.1		1	97.5		0	95	
1	30.4		28.1		1	97.5		1	95	

Section 2

Week 7 Attend	HW%-1stHalf		Week 8 Mid-term Exam		M.Ex. %	Week 8 Attend	1st Attend	1st Att. %	1st Half %	Week 9 Attend	Week 10 Ch04-Tutorial	Week 10 Attend
1	0.300	1.000	**84**	1.000	0.150	**1**	**8**	0.050	**0.500**	**1**	**223**	**1**
1	**0.281**	0.936	78	0.929	**0.139**	1	**8**	0.050	**0.470**	1	208.5	1
1	**0.281**	0.936	76	0.905	**0.136**	1	**8**	0.050	**0.467**	1	222	1
1	**0.272**	0.906	80	0.952	**0.143**	1	**8**	0.050	**0.465**	1	222	1
1	**0.205**	0.683	72	0.857	**0.129**	1	**8**	0.050	**0.383**	1	141.2	1
1	**0.234**	0.780	68	0.810	**0.121**	1	**7**	0.044	**0.399**	1	207.5	0
1	**0.234**	0.780	70	0.833	**0.125**	1	**8**	0.050	**0.409**	1	200.7	1

Section 2

Week 11 CAD Room	Week 11 Attend	Week 12 Attend	Week 13 Project	Week 13 Attend	HW%-2ndHalf		Week 15 Final Exam		F.Ex.%	Week 15 Attend	2nd Attend	2nd Att.%
284	**1**	**1**	**100**	**1**	**0.300**	1.000	**68**	1.000	**0.150**	**1**	6	**0.050**
264	1	1	91.0	1	**0.277**	0.924	52	0.765	**0.115**	1	**6**	0.050
275.5	1	1	92.0	1	**0.288**	0.959	56	0.824	**0.124**	1	**6**	0.050
228.7	1	1	85.5	1	**0.267**	0.889	48	0.706	**0.106**	1	**6**	0.050
100.65	1	1	70.5	1	**0.176**	0.588	44	0.647	**0.097**	1	**6**	0.050
154.1	1	1	55.5	1	**0.203**	0.677	48	0.706	**0.106**	1	**5**	0.050
207.9	1	1	94.0	1	**0.261**	0.871	50	0.735	**0.110**	1	**6**	0.050

Section 2

2nd Half		Week 2	Week 3													
%	**Course %**	**Pretest**	**Vis.**	**ILS**								**Major**	**Gender**	**Race**	**Prereq.**	**GPA**
0.500	**100.0**	**68**	**20**	ACT	REF	SEN	INT	VIS	VRB	SEQ	GLO					
0.442	**91.2**	12	16									1	1	2	2	3
0.461	**92.8**	28	19	1		1		9		5		1	2	2	3	3.54
0.422	**88.7**	36	14		1	3		9		1		1	1	2	3	3.1
0.323	**70.7**	24	13	11			11	7		3		2	2	2	2	2.4
0.359	**75.8**	20	15	11		5		7		7		1	1	2	3	2.86
0.422	**83.1**	20	14	3		7		5		9		1	1	4	3	3.3

Section 2

Experi.	Academ. Year	Engin. Year	Other Survey Notes	[redacted]	Int'l	[redacted]
0	2	2		[redacted]		[redacted]
1	2	2	a class in h.s. 3 yrs. ago	[redacted]		[redacted]
3	2	2	1 yr. AutoCAD class in h.s.; used in 2 other classes	[redacted]		[redacted]
0	3	3		[redacted]		[redacted]
0	2	2		[redacted]		[redacted]
0	3	2		[redacted]		[redacted]
				[redacted]		[redacted]
				[redacted]		[redacted]
				[redacted]		[redacted]

Appendix Q

Summaries of Interviewees' Statements, Weekly Peer Reviews, and Grades

Statements from selected students during the interviews provided some insight on the aspects of their group efforts that might have affected group homework performance and exam grades. The interviewees were three pairs of students from each treatment group. These pairs represented three achievement levels ("A" group grades, "B" group grades, and "C" or lower group grades) after they worked together for two weeks.

In a few cases, there was conflicting information between interview responses and weekly peer reviews. For example, interviewees might have indicated that they did not study together, but they indicated some amount of time on the weekly peer reviews. Overall, though, the interviews confirmed most of the information provided in the weekly peer reviews. (See Appendix N for the interview responses, Appendix O for their weekly peer reviews, and Appendix P for their corresponding grades.)

Group 1, Experiment 1

Partner 1—RID: *201634,* Major: *ISE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd*, GPA: *3.0,* Gender: *Female,* Race: *White, but not Hispanic or Latino,* Prior Experience: *No Experience,* Prerequisite Grade: *C*

Partner 2—RID: *201633,* Major: *ISE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd*, GPA: *3.5,* Gender: *Male,* Race: *White, but not Hispanic or Latino,* Prior Experience: *Little Exposure,* Prerequisite Grade: *B*

Out of the three groups interviewed in this experiment, this was the highest performing group on the first two assignments. At the midpoint of the experiment, Group 1 interviewees indicated that they spent about two hours together once a week—two days prior to the assignment due date—and no time studying together. They believed that the amount of time allotted to complete the assignments was just right. Rather than follow the instructor's recommended procedure for cooperative group work, these partners worked on their own laptop computers while they were together and each created the drawings. Both partners enjoyed working with a partner and thought it was a positive experience and beneficial. Also, both partners indicated that they had a good level of confidence with using the software at that time.

In the final interview (with the partners together), they indicated that they followed the same work arrangement. They believed that the last two assignments were more difficult ("confusing"), so they thought they would have taken longer on the assignments if they had worked by themselves. They did not spend time studying together, but they occasionally quizzed each other while working together. As a result of working together, they both indicated a good level of confidence with the software. They both believed it was helpful working with a partner because it helped them prepare for the exam.

This group's overall homework grade was 93.6%. Partner 1 (RID #201634) earned a 92.9% on posttest 1, while Partner 2 (RID #201633) earned a 90.5% on posttest 1. During the control phase of the second experiment, Partner 1 earned a 92.4 % on the homework and a 76.5% on posttest 2, while Partner 2 earned a 95.9% on the homework and an 82.4% on posttest 2. It is possible that Partner 1 exhibited carry-over effects during the second experiment and/or the partners continued to work together. This was indicated by the first partner's lower posttest 2 score, but her high performance on the first exam suggests that she knew the material well enough to perform well during the second half of the semester.

Group 2, Experiment 1

Partner 1—RID: *201927,* Major: *BSE,* Academic Year: *Junior,* Year As Engineering Major: *3rd*, GPA: *2.3,* Gender: *Male,* Race: *White, but not Hispanic or Latino,* Prior Experience: *No Experience,* Prerequisite Grade: *C*

Partner 2—RID: *201928,* Major: *ISE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd*, GPA: *3.18,* Gender: *Female,* Race: *White, but not Hispanic or Latino,* Prior Experience: *Formal Coursework (in high school.),* Prerequisite Grade: *B*

This group was selected from the middle strata of achievement on the first two assignments. In the midpoint interview of the first experiment, Group 2 interviewees indicated that they spent different amounts of time together on the assignments and in different ways. For the first assignment, they spent between one and two hours together on one computer and no time studying together. For the second assignment, they did not work together and, in fact, Partner 1 (RID #201927) did not participate at all, leaving Partner 2 (RID #201928) to do the assignment on her own. She spent about two hours on the assignment. After this was revealed to the instructor on the weekly peer review, the instructor contacted both partners about ways to avoid this situation again. For the third assignment, they worked remotely and communicated with instant messaging (IM) software as they were working on their respective computers. They e-mailed their respective files back and forth to compare solutions and for modifications. (Note that this was not the recommended procedure for working together.) They indicated that this process took them about one hour.

They believed that the amount of time allotted to complete the assignments was just right. Both partners thought that the experience so far was beneficial, but for different reasons. Partner 1 believed that he was learning the software better because of his partner's prior experience. Partner 2 saw the value of helping someone else because it helped her learn the content and the other partner was improving. The drawbacks they indicated were distinctly different. Partner 1 indicated that scheduling meeting times was difficult, in addition to his computer problems. Partner 2 indicated that her partner's lack of experience was slowing her down. Regardless of these differences, both partners indicated that they had increased levels of confidence with using the software at that time.

In the final interview, they indicated a slightly different work arrangement. For the chapter 5 assignment, Partner 1 completed the first half of the assignment, e-mailed the drawing file to Partner 2, and Partner 2 completed the assignment. For the chapter 7 assignment, Partner 1 started the assignment and then met with Partner 2 to complete the assignment on her computer; Partner 2 performed the rest of the drawing tasks. They did not spend time studying together. By the end of the treatment, Partner 1 indicated that he had a "good working knowledge" of the software, while Partner 2 indicated that she was really confident with the software. They both agreed that it was pretty much a good experience. Partner 1 attributed his success on the mid-term exam mostly to his studying and to the group work. Partner 2 attributed her success on the exam mostly on her prior experience.

This group's overall homework grade was 87.1%, but they received weighted individual grades due their different participation levels. Partner 1 (RID #201927) earned an 85.7% on posttest 1, while Partner 2 (RID #201928) earned a 95.2% on posttest 1. During the control phase of the second experiment, Partner 1 earned a 58.8% on the homework and a 64.7% on posttest 2, while Partner 2 earned an 88.9% on the homework and a 70.6% on posttest 2. It is difficult to determine whether or not carry-over effects were present during the second half of the semester for this group. The large difference in homework grades and the somewhat closer grades on posttest 2 for the second half of the semester, which is similar to their results in the first treatment-control phase, indicate that Partner 1 not only had a difficult time working with a partner, but he also might have experienced resentful demoralization in the second half of the semester while he was working on the more difficult homework assignments by himself. However, as stated previously, the data showed that Partner 1 had difficulty in working with a partner cooperatively (hence, their weighted grades) and also had difficulty working by himself later in the semester—another phenomena besides resentful demoralization might have been a factor for him.

Group 3, Experiment 1

Partner 1—RID: *202418,* Major: *ISE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd,* GPA: *2.86,* Gender: *Female,* Race: *White, but not Hispanic or Latino,* Prior Experience: *No Experience,* Prerequisite Grade: *B*

Partner 2—RID: *202417,* Major: *ISE,* Academic Year: *Junior,* Year As Engineering Major: *2nd,* GPA: *2.9,* Gender: *Female,* Race: *Black or African American,* Prior Experience: *No Experience,* Prerequisite Grade: *B*

This was the lowest performing group of the three groups interviewed, based on the first two assignments. Both partners provided matching information in their interviews, but that information contradicted what they indicated in the weekly peer reviews; this was also the case for the final/group interview. For example, Partner 1 indicated in the interview that they followed the recommended cooperative group procedure for the chapter 2 assignment, but both partners indicated in the weekly peer reviews that they used that procedure in the chapter 3 assignment, not the chapter 2 assignment.

At the midpoint of the experiment, Group 3 interviewees indicated that they spent between one and a half and two hours working together once a week—two days prior to the assignment due date—and between 30 minutes and one hour studying together. However, Partner 1 indicated that they rushed through the assignments due to athletic commitments. They believed that the amount of time allotted to complete the assignments was just right. Rather than follow the instructor's recommended procedure for cooperative group work, these partners started working on separate computers during earlier assignments and then worked together on one computer for later assignments. As indicated previously, though, Partner 1 stated in the interview that they used the procedure recommended by the instructor for one of the assignments. Both partners enjoyed working with a partner and thought it was beneficial. Also, both partners indicated that they were somewhat confident with using the software at that time.

In the final interview, they indicated that they followed roughly the same work arrangement. They worked together for about three hours each week, including studying time, but they did add final touches to the drawings independently. As a result of working together, they both indicated an increased level of confidence with the software ("way better now"). They both liked working with a partner and thought that the experience was beneficial.

This group's overall homework grade was 78.0%. Partner 1 (RID #202418) earned an 81.0% on posttest 1, while Partner 2 (RID #202417) earned an 83.3% on posttest 1. Note that Partner 1 did not attend one class during this phase. During the control phase of the second experiment, Partner 1 earned a 67.7% on the homework and a 70.6% on posttest 2, while Partner 2 earned an 87.1% on the homework and a 73.5% on posttest 2. Note that Partner 1 did not attend one class during this phase and performed very poorly on the final project. It is doubtful that carry-over effects were present during the second experiment for this group.

Group 1, Experiment 2

Partner 1—RID: *102842,* Major: *ISE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd*, GPA: *3.35,* Gender: *Female,* Race: *White, but not Hispanic or Latino,* Prior Experience: *No Experience,* Prerequisite Grade: *B*

Partner 2—RID: *102809,* Major: *ISE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd*, GPA: *3.89,* Gender: *Male,* Race: *White, but not Hispanic or Latino,* Prior Experience: *No Experience,* Prerequisite Grade: *B*

Group 1 of the second experiment earned the highest grades on the first assignment, which was a two-week assignment. At the midpoint of the experiment, Group 1 interviewees provided contradictory information in the individual and group interviews and the weekly peer reviews about how much time they spent together on the assignments. Roughly, they spent about three hours total on the chapter 4 assignment and four hours in the CAD Room assignment. They did not spend any time studying together. They generally believed that the amount of time to complete the assignment just right; Partner 2 indicated that it was more than enough time. Though they basically followed the recommended structure for cooperative group work, the partners did not switch roles each week. Both partners indicated that working with a partner was a good experience so far. Partner 1 indicated a relatively good level of confidence with the software, and Partner 2 indicated a much higher level of confidence.

In the final interview, they indicated that they followed the same work arrangement, except for the final project, during which Partner 1 performed some of the drawing tasks. They believed that the amount of time allotted to work on the assignments would have been adequate if they had worked by themselves. Both partners indicated that working with a partner helped them learn more about the software compared to when they were working by themselves earlier in the semester. They stated that they worked well together and they got along well. Even though they enjoyed working together the second half of the semester, they believed that working individually during the first half of the semester was appropriate. They agreed that it was better to learn the introductory material on their own. As a result of working together, Partner 1 believed that she learned a lot about the software, but was not confident in being able to complete a project on her own in the future. Partner 2 stated that he became very confident with the software, and added that it was “good to go from 2D to 3D.” As with the first half of the experiment, they did not spend time studying together.

This group’s overall homework grade was 96.9%. Partner 1 (RID #102842) earned a 64.7% on posttest 2, while the Partner 2 (RID #102809) earned an 88.2% on posttest 2. Going back to the control phase of the first experiment, Partner 1 earned an 80.6 % on the homework and a 76.2% on posttest 1, while Partner 2 earned a 99.4% on the homework and an 85.7% on posttest 1. It is possible that the first partner (RID #102842) exhibited carry-over effects during the treatment phase, as shown by the low posttest 2 score and the peer reviews that indicated the other partner did most of the drawing tasks. Her relatively good performance on the individually completed homework assignments and the close posttest 1 score suggest that she knew the material well enough to perform well during the second half of the semester. Partner 2 (RID #102809) had consistently high homework and exam grades throughout the semester.

Group 2, Experiment 2

Partner 1—RID: *101927,* Major: *BSE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd*, GPA: *2.8,* Gender: *Male,* Race: *White, but not Hispanic or Latino,* Prior Experience: *No Experience,* Prerequisite Grade: *(not provided)*

Partner 2—RID: *101928,* Major: *ISE,* Academic Year: *Junior,* Year As Engineering Major: *2nd*, GPA: *2.5,* Gender: *Female,* Race: *Asian (Includes: Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, or other Asians),* Prior Experience: *No Experience,* Prerequisite Grade: *B*

Of the three groups interviewed during the second experiment, this group was selected from the middle strata of achievement on the first assignment. In the midpoint interview, Group 2 interviewees provided contradictory information. Partner 1 indicated that they met once on the weekends for each assignment. For the first assignment (a two-week long assignment), they met for a couple of hours and used one computer. For the second assignment, they met once and used one computer for drawing and another computer for displaying the assignment instructions. This partially contradicted the information that they provided in the weekly peer reviews. In the peer reviews for the first assignment, both partners indicated that they divided the work and did not meet the first week, and then met for 10 minutes the second week. Later in the interview, Partner 1 indicated that they worked on the “bulk of the hard stuff together” and the “details” on their own.

Partner 2 indicated that for the first assignment they met once to go over the assignment, divided the work, and then worked individually. When they worked individually, they communicated using e-mail to discuss difficult parts. For the next assignment, they met for about three hours, and she “finished the rest.” These descriptions of their work and meetings more closely matched the weekly peer reviews than what Partner 1 indicated in his interview.

Partner 1 believed that the amount of time provided to complete the assignments was just right, and Partner 2 indicated that the time allotted was too much. Both partners thought that the experience so far was beneficial, but they indicated that trying to arrange meetings was difficult and a drawback. Partner 1 indicated that working with a partner so far did not provide higher gains in learning the software as working alone during the first half of the semester because he could spread out working on the assignments over several days as opposed to working with a partner just once a week. But, he did acknowledge that they “still learned new commands and buttons.” Also, both partners indicated that they were confident with using the software at that time, but they did not note a change in their confidence as a result of working with a partner. They stated that they did not spend any time studying together.

In the final interview, they indicated that they only met once for each of the last two assignments, but they could not recall how much time they spent together. (We discussed the second to the last assignment in the previous individual interviews.) In the weekly peer reviews for the final project, they indicated that they spent 30 minutes together the first week and two hours together the second week. In the interview, they indicated that they used one computer to do the work; yet, in the weekly peer reviews, they indicated that they used separate computers because they divided the work. They indicated in the interview that they did not spend time studying together. They believed that the allotted amount of time to work on the assignments was just right and felt the same if they had to create the assignments by themselves. Both partners thought that working with a partner on the CAD assignments was a good experience and beneficial. However, Partner 1 stated that it would have been better to work with a partner during the first half of the semester because “of the need of trying to figure things out.” Partner 2 disagreed and thought it was better work individually the first half of the semester and with a partner during the second half of the semester. Both partners indicated that they were confident with the software “basics,” but not so confident with the more advanced material in the course, such as working with blocks and block attributes. Though they did not study together during the cooperative treatment, they did study individually for the final exam.

This group’s overall homework grade was 68.6%. Note that this was largely due to the group receiving a very low grade on the final project. Partner 1 (RID #101927) earned a 61.8% on posttest 2, while the Partner 2 (RID #101928) earned a 44.1% on posttest 2. From the control phase of the first experiment, Partner 1 earned a 69.7 % on the homework and an 88.1% on posttest 1. For the first assignment in the control phase, he failed to submit either the drawing file or plot, which resulted in an automatic half-credit deduction. Partner 2 earned an 84.4% on the homework and a 78.6% on posttest 1. Note that Partner 2 missed the last class before posttest 1, but still submitted the assignment that was due. It is difficult to characterize either partner as a slacker in the group effort because of their low project group grade and their low posttest 2 scores. Though Partner 2 earned a considerably lower posttest 2 score than Partner 1, Partner 2 also experienced a decline on posttest 1 compared to her homework grade during the control phase.

Group 3, Experiment 2

Partner 1—RID: *101045,* Major: *ISE,* Academic Year: *Junior*, Year As Engineering Major: *2nd*, GPA: *3.15 (or 3.28),* Gender: *Male,* Race: *White, but not Hispanic or Latino,* Prior Experience: *No Experience,* Prerequisite Grade: *B*

Partner 2—RID: *101046,* Major: *ISE,* Academic Year: *Sophomore,* Year As Engineering Major: *2nd*, GPA: *3.0,* Gender: *Male,* Race: *White, but not Hispanic or Latino,* Prior Experience: *Regular Use,* Prerequisite Grade: *B*

Group 3 of the second experiment earned the lowest grades on the first assignment of the groups that were interviewed. Both interviewees indicated at the beginning of their midpoint interviews that they generally preferred working by themselves. Neither partner attended the first class of the treatment and did not complete the peer reviews for that week at any other time. Partner 1 indicated that he would have preferred to have worked by himself and that the other partner performed most of the drawing tasks for the group. Partner 2 indicated that the group experience was fine so far, but both partners were capable of doing the work. For the first assignment, Partner 2 completed the first half of the assignment, and then Partner 1 completed the next part of the assignment when the pair met. However, Partner 1 indicated that the other partner completed most of the drawing. For the second assignment, they worked on the assignment together on one computer, but Partner 2 performed most of the drawing tasks. For both assignments, they met once for each assignment—two days before the assignment due date—and for about two hours. After they met, they e-mailed files to each other to check their work and discussed over the phone the plotting procedures.

They both indicated that their studying together consisted of only going over the tutorials before they worked. Both partners believed that the amount of time allotted to complete the assignments was just right, though Partner 1 indicated that it might be a good idea to make the first assignment a one-week assignment and the second assignment a two-week assignment. Regarding their gains in learning the software when comparing the time spent working with a partner and the time working individually earlier in the semester, Partner 1 indicated that his gains were less, while Partner 2 stated that the question was not fair because the content "during the first half was the basics and now it's application." Both partners described drawbacks to working with a partner, but no benefits. They both thought they were confident with the software; Partner 1 believed he needed more time to review the material in the second half of the semester, and Partner 2 indicated that he can do the work, but has not mastered the material.

In the final interview (with the partners together), they indicated that they worked separately on the final project. Partner 2 stated that it "turned out decent" and it would have been better if they had worked alone. For the next question, they indicated that they worked together on Sundays for a couple of hours. If they did not finish an assignment while together, they e-mailed each other and finished separately. On their weekly peer reviews, they indicated that they met for two and a half hours on the second to last assignment, 30 minutes for the first week of the final project, and then two hours for the second week of the final project. (Note that Partner 1 did not attend the last class of the semester, but he was able to complete the weekly peer review for the second week of the project.) In the interview, they indicated that they worked on one computer and both helped complete the assignments. They believed that the amount of time allotted to complete the assignments was just right and felt the same if they had to work on the assignments by themselves. Regarding how they felt about working with a partner on the CAD assignments, Partner 2 felt that scheduling their meetings was a problem and would have preferred to work by himself anyway, and Partner 1 felt that it would have been better for him to work on his own because he could work at his own pace and a little each day. Both partners agreed that their grains in learning the software was less when working with a partner than when they worked by themselves the first half of the semester. When asked about any benefits and drawbacks that they realized, Partner 2 indicated that the benefits included help with troubleshooting problems and having someone check for mistakes. He further stated that there probably were “no more benefits” than that because the course was about “basic AutoCAD,” but “there would have been more benefits if [the course covered] 3D or more in-depth AutoCAD.”

Both partners agreed that they would not have wanted to work with a partner the entire semester because they learned the basics better by themselves. They also agreed that they might have formed a different opinion if Partner 1’s computer had worked, so that they could switch cooperative group member roles each week. Regarding their levels of confidence in knowledge of the software, both partners indicated that they were “good with the basics.” Regarding final exam performance, Partner 1 indicated that he did not do well, but he did study; he indicated that he did not have the group material because Partner 2 was out of town. Partner 2 indicated that his exam performance was “decent” and that he also studied.

This group’s overall homework grade was 52.1%. This was largely due to their extremely low final project grade. Partner 1 (RID #101045) earned a 67.6% on posttest 2, while the Partner 2 (RID #101046) earned a 70.6% on posttest 2. Going back to the control phase of the first experiment, Partner 1 earned a 76.4 % on the homework and a 78.6% on posttest 1. Note that he did not attend the first day of class (though he was registered) and did not submit one of the homework assignments. Partner 2 earned a 43.2% on the homework and a 71.4% on posttest 1. This partner earned only half credit for the first assignment due to only submitting either the drawing file or the plot, did not submit the second assignment, and did not attend the week 4 class, for which the second assignment was due.