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Using the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, and McKeachie, 1991) and supported by interviews with the participants, this study compared the learning strategies and motivations used by engineering students participating in a self-study Engineering Fundamentals course and a lecture-based Operating Systems course at three nuclear power plants in the United States. The results of this study determined that while the self-study and the lecture-based instructional delivery methods promoted the use of different motivations and learning strategies for the engineers, the learning outcomes were not affected. The dominant factor that contributed to the student success in both courses was the practice of effective self-regulation strategies by the learners.

A COMPARISON OF THE MOTIVATIONS AND LEARNING STRATEGIES EMPLOYED BY ADULT LEARNERS IN INDUSTRIAL TRAINING PROGRAMS

by

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Approved by

Dr. Samuel D. Miller
Committee Chair

To Kay, the love of my life.

On a hot summer night . . .

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

This study examined the motivations and learning strategies used by engineers in two initial training courses in the commercial nuclear industry to determine if the instructional delivery methods used in the two courses promoted different self-regulation practices. One of the courses presented fundamental engineering topics over a period of three months using a self-study delivery method. The second course introduced the engineers to the operating systems at commercial nuclear facilities using a traditional classroom, lecture-based format having an intense, four-week duration.

Feedback from previous students and their supervisors indicated that the students in the self-study program were focused on passing the examinations and were not preparing to apply the information in future job activities. As part of the first-year introductory experience for new engineers in the nuclear industry, the two courses were not only intended to introduce the engineers to the technical aspects of nuclear power, but to also introduce the engineers to the expectations for rigorous job performance. The expected performance characteristics of the students bear the hallmarks of self-regulated learning, which include: the ability to assess personal capabilities regarding performance of a task, the ability to establish goals for task completion, the ability to establish and maintain schedules, and the ability to evaluate performance for future modification.

Most students successfully completed the examinations in both courses, which require a passing score of 80 for each examination, but displayed differing approaches and attitudes towards the learning. The first question to be answered in this study was: How does student achievement in a self-study training program differ from student achievement in a lecture program? To gain some insight into factors that may affect achievement, follow-up questions sought to determine: (a) How are the motivations and learning strategies exhibited by the students in the self-study training programs different from the motivations and learning strategies exhibited by the students in the lecture programs? and (b) What factors in the two educational programs contributed to those differences?

The Engineering Fundamentals course and the Operating Systems course are required components of the accreditation criteria for the initial training of the engineers to prepare them for service at the nuclear power plant. Those accreditation criteria were established by the Institute of Nuclear Power Operations (INPO), which is a nuclear industry oversight organization sponsored by the owners of nuclear electric power generation facilities. The training requirements established by INPO are founded on the premise that "Training and qualification of engineering personnel are essential to the conduct of safe and reliable nuclear power plant operations" (Institute of Nuclear Power Operations, 2003, p. iii). In recent years, INPO has become increasingly interested in the long-term influence of all nuclear industry training programs, and revised the accreditation criteria (Institute of Nuclear Power Operations, 2002) to address post-training effectiveness from multiple perspectives, including human performance.

Identification of the differences in achievement, motivation, and learning strategies between the two courses, followed by identification of causal factors for those differences, will provide evidence to support revisions to the programs to promote more effective learning. The results of this study will be used to recommend changes to the initial engineering training programs to promote the establishment of more desirable motivations and learning strategies.

Those results, and the recommendations spawned from those results, will be of interest to a diverse audience. The supervisors and managers of the students enrolled in the Initial Training Program will be interested in the results of this study because those supervisors and managers clearly influence student motivations and their learning environment. The instructors and managers of the training programs will be able to use the results of this study to identify strengths and weaknesses of the delivery methods and content to produce revisions that can enhance the potential for learning. The accreditation agency, INPO, may be able to use the results of this study to make recommendations to other nuclear power plant training organizations or to identify the need for additional studies at other facilities. Ultimately, the outcomes of this study should prove beneficial to perhaps the most important audience members, the students, by recommending and supporting revisions to their training programs.

Description of the Two Instructional Formats

Engineers reporting for their initial employment in the commercial nuclear industry are enrolled in training programs to prepare them to perform independent work at the nuclear plants. The Initial Training Program includes the Engineering

Fundamentals course and the Operating Systems course, and both courses were historically presented in a traditional, instructor-led, lecture format. The effort to reduce the cost of those programs drove some electric utilities to provide some portions of that training using a self-study delivery method.

Anecdotal evidence of student and employer dissatisfaction with the self-study format raised questions regarding the effectiveness of the self-study delivery method. Viewed from a motivational perspective, the students may struggle to identify the value of the self-study courses when the work assignments for their new jobs present competing interests. From the perspective of learning strategies, the students, engaging in the first months of their post-college employment, must integrate their self-study educational activities with the rigorous demands of their new jobs.

Identification of factors that may influence the achievement, motivation, and learning strategies of the students in the Initial Training Program first requires identification of the environmental factors associated with the Engineering Fundamentals course and the Operating Systems course.

Engineering Fundamentals Course

The Engineering Fundamentals course is a self-study program, covering two or three engineering topics every three weeks. There are nine topics in the Fundamentals program: Mechanical Engineering, Civil Engineering, Chemistry, Materials, Electrical Sciences, Process Controls, Reactor Theory, Core Protection, and Thermodynamics. The students are encouraged to utilize study time while at work, and are provided with a classroom in which they can study alone or can study in groups. The classroom serves as a satellite study location for most of the students, as they are not divorced from their routine work activities and must still spend significant time in their normal office environments. Not all students confine their studies to the work hours, as some students must study beyond the normal work schedule to promote their success in the Fundamentals course.

A review session is provided on Thursday in the second week following the assignment of the topics, with examinations in those topics presented on Thursday in the third week. Each of the nine topics is assessed in a separate examination. Depending on the number of topics covered in any given three week period, the students will take either two or three examinations in one classroom sitting. Each examination will contain ten or twenty multiple-choice test items; the number of items is based on the complexity of the material in the workbook. The Mechanical Engineering, Electrical Sciences, Thermodynamics, and Reactor Theory examinations each consist of twenty test items; all other examinations contain ten test items.

Basic engineering information is covered in the Fundamentals course, and each topic is a stand-alone topic with no connection to the other topics. This allows an engineer who is well-versed in one engineering discipline to minimize the amount of time spent studying a familiar topic and devote more time to a new or unfamiliar topic. Subject-matter-experts are also available to assist any student who wants or needs more information for any topic.

The information for each Fundamentals topic is provided to the engineers in workbooks that also contain exercises the students can perform to self-evaluate their learning. The exercises intentionally mimic the format of the examinations to provide practice for the students. The review sessions also provide some opportunity for evaluation, as the subject-matter-experts attend the sessions to answer questions for the students. The students are encouraged to offer questions in the review sessions, and to measure their understanding of the subject material relative to the information discussed in the review sessions.

Operating Systems Course

The Operating Systems course offered at the participating utility is a four-week, lecture-based course. The course presents the design and operating characteristics of many of the systems at the specific nuclear plant at which the engineers are employed. Three nuclear power plants will participate in this study, and while each power plant has lesson content that is unique to that power plant, there are similarities in the structure and objectives of the Operating Systems lessons. Approximately 75 different system lessons are presented to the students in the four-week course, with an examination presented at the end of each week on Friday. The lessons are concentrated on Monday through Thursday, with the lectures typically lasting seven hours each day, followed by a one hour study period. A study period of approximately two hours is available on Friday morning before each weekly examination. Many students must spend a few hours each week studying beyond the normal work schedule in order to be successful in the course.

The Operating Systems course is considered to be challenging by most of the students, notably because the course is comprised of information that was not included in their undergraduate engineering studies. The system lessons include mechanical, electrical, chemical, and nuclear systems, focusing on the design and operation of the systems, with frequent reference to actual operating experience with the systems. The terminology necessarily employed in these system lessons is also quite new for the students, as the names of the systems, the system components, and the operational alignments are often unique to the nuclear industry and unique to the nuclear power plant. This immersion in the practical application of engineering is a departure from the theoretical focus of undergraduate engineering.

The novelty of the systems requires some use of memorization learning strategies for the students, particularly for learning system names, component names, and complex acronyms used at each nuclear plant. Moving into different learning strategies, the students must use somewhat more comprehensive learning strategies in learning the system functions, because most systems interact with several other systems. The complex interactions among the systems are also reflected in the examinations, which assess student knowledge of those interactions, so each weekly examination in the Operating Systems course necessarily includes evaluation of information presented in the preceding weeks.

Comparison of the Engineering Fundamentals and Operating Systems Courses

Previous students offered contrasting views of the self-study training program, with frequent comparisons to the lecture program. Most students felt the three month self-study program was too long, but appreciated the scheduling flexibility for their studies that was afforded by the extended duration of the course. From a contrary perspective, most of the students felt the four week lecture series was too short, with too much material compressed into the four-week period. The difference in the program durations provides the most objective contrast for those two programs.

From a more subjective perspective, the previous students spoke quite favorably of the lecture series, offering that the lectures provide the opportunities to receive immediate feedback to questions during the class. Furthermore, the relevance of the lesson material to the jobs of the students was clearly supported during the lectures and the interactive discussions during those lectures. The self-study lessons, however, did not receive such glowing tribute from the students, who struggled to identify the relevance of the material to their jobs.

This study compared the achievement of the students in the self-study course to their achievement in the lecture-based course. The motivations and learning strategies used by students in the self-study course were also compared to the motivations and learning strategies used by those same students in the lecture-based course to determine if the achievement differences, if present, were attributable to the use of different motivations and learning strategies. Those motivations and learning strategies are representative of the self-regulatory behaviors of the students. Successful job performance in the nuclear industry requires effective self-regulation. As a major component of the job repertoire for new engineers, the training programs provide the opportunity to acquire, maintain, and apply those self-regulatory practices.

The students were all employed by the same electric utility, although at three different nuclear power plants, The content and objectives of the Engineering Fundamentals self-study courses are identical at all three plants. The commonality of the

Engineering Fundamentals course content was driven, in part, by the effort to reduce the costs of the initial training program.

Because the operating systems courses are intended to present the specific operating system characteristics for a nuclear power plant, the technical content of the operating systems courses necessarily differs between the three sites. Still, the operating systems at the three nuclear power plants are quite similar. The objectives for those operating systems courses are clearly linked to the accreditation criteria established by the Institute of Nuclear Power Operations (INPO, 2003) for all nuclear utilities in the United States, therefore the comparisons, based on content and objectives, were quite strong.

Literature Review

The supervisors, managers, and instructors in the nuclear industry want to offer training programs that encourage the learners to regulate their learning in a manner that supports effective long-term application of the learning. The development of a learning environment that supports and sustains self-regulation in nuclear industry training programs requires understanding of the fundamental principles of self-regulation, motivation, and learning.

Investigation of the effects of motivations and learning strategies on student achievement in the self-study and the lecture-based initial training programs requires recognition of the differences imposed by those two delivery methods on the learners. The motivations and learning strategies used by the students will also influence, and be influenced by, the self-regulation strategies used by the students. The multi-directional relationships of these three characteristics will ultimately affect student performance. The relationships between self-regulation, motivations, and learning strategies are complex, but have been explored extensively in previous research. A review of that previous research in such diverse fields as education, psychology, and medicine was performed for the areas of motivation, learning strategies, and self-regulation to establish a framework for the investigation of the potential effects of the instructional delivery method on those components of learning.

The most effective learning outcomes occur for the students who are intrinsically motivated and effectively self-regulate their learning through effective application of appropriate learning strategies. While some learners may be prone to exhibit those desired characteristics, those behaviors are not stable, as they are influenced by the contextual factors associated with the learning experience (Cole and Denzine, 2004). The nature of the tasks associated with the learning experience, the belief of the students in the value of those tasks, and the belief of the students in successful outcomes for participation in those tasks can influence the motivations and learning strategies employed by the students in addressing those tasks. In a fundamental way, the method used for delivery of an instructional program will affect the approach of the students to that learning experience.

A preliminary examination of the differences between the self-study and the lecture-based programs reveals some components of learner characteristics that may be affected by the delivery method. Those components can be effectively segregated into two categories: motivation and learning strategies. The potential influence of the instructional delivery method was examined from the perspective of those two categories. Before examining the specifics of the influence of motivation and learning strategies, a review of the fundamental characteristics of self-regulation will provide a foundation for those characteristics within this study.

Self-regulation

Zimmerman (2000) describes self-regulation as the thoughts and behaviors initiated by an individual to drive the achievement of a personal goal. Self-regulation is not a construct isolated in the field of education, rather it is a product of the field of psychology in the 1980s (Boekaerts, Pintrich, and Zeidner, 2000) that, perhaps because of the broad applicability of self-regulation strategies, allowed self-regulation to be readily adopted by the education community.

A fundamental tenet of self-regulation requires that the quest for the achievement of goals through implementation of strategies must be driven and controlled by the individual. Capturing the essence of self-regulation theory, Rheinberg, Vollmeyer, and Rollett (2000) describe self-regulated learning as "intentional and deliberate learning activities that are free from external guidance and control" (p. 524). The involvement of self is the foundation of self-regulation. While a teacher may establish a deadline for the completion of a product, the self-regulated learner will establish the intermediate goals, self-assessment criteria, and methods that will form the strategy for accomplishing the desired learning outcome. The goals, processes, and strategies should be products of the motivations of the individual, and the individual must have autonomy in the choice of those goals and control of the processes (Zimmerman, 1994).

The "role of self" is challenged with marked contrasts when viewed from the diverse perspectives of a self-study course and a lecture-based course. The students in the self-study course must establish their own study schedules not only for the purposes of the review of the course materials, but also for the initial presentation of the course materials. The self-study students must also establish goals for the depth of their initial studies and subsequent reviews. They must also determine and implement their own goals and methods for evaluation of the progress of their studies without the benefit of frequent feedback from more knowledgeable individuals. In contrast, the students in a lecture-based program are driven by the goals established by the teacher for the scheduling of delivery and depth of presentation of the course material. The differences between the impositions of the self-study and lecture-based delivery methods on the self-regulation requirements of the students can be viewed in more detail within the framework for self-regulation as described by Demetriou (2000) and Zimmerman (1998).

Self-Regulation as a Three Phase System

Self-regulation is generally described as system comprised of three components: (a) a feed-forward function used to set goals, (b) a self-monitoring function that compares the present state with the established goals, and (c) a negative feedback function that determines the corrective actions for the goal disparities (Demetriou, 2000). Those fundamental characteristics of self-regulation are presented by Zimmerman (1998) as components in a three-phase cycle: forethought, performance, and self-reflection.

Forethought phase.

The forethought phase is the planning phase in which goals for the learning are established and methods to achieve those goals are identified. Two interacting elements comprise the forethought phase: task analysis and motivational beliefs (Zimmerman, 2000).

In task analysis, the individual first engages in goal setting, in which the desired outcomes of the activity are identified. Having established the high level goals for the activity, the self-regulated individual will then construct a hierarchy of intermediate goals that can be used to support the achievement of the ultimate goal (Zimmerman, 2000). These intermediate goals are based on proximal, rather than distal outcomes, and serve to provide more immediate feedback of progress. Once established, the goals become the foundation for the processes that are to follow in self-regulation, as the goals provide the standards for evaluation of progress and provide the targets for subsequent revisions of the processes (Schunk and Ertmer, 2000).

Prior experiences of the individual become a factor in the identification of the goals. Accurate knowledge of self supports the identification of goals that are achievable and meaningful (Zimmerman, 2000). Furthermore, an accurate internal representation of the desired goal is necessary to allow critical monitoring of performance relative to that goal (Vancouver, 2000).

Each instructional delivery method presents unique challenges to the students, still, each method can provide a support structure, commensurate with the environmental conditions imposed by the delivery method, to allow the students to successfully achieve the learning and performance goals desired by the nuclear industry. While the students in both the self-study Fundamentals course and the lecture-based Operating Systems course are likely to have similar goals that are focused on test performance, the proximal goals necessary to support achievement of those distal goals will differ. The students in the lecture-based course must establish study times outside of the classroom and must establish some self-evaluation mechanism to aid them in identifying which lesson materials must be reviewed outside the classroom. When difficult material is encountered, the students in the lecture-based course can either seek clarification outside the classroom or can await the next lecture period to engage the instructor.

The students in the self-study course must establish goals for the initial presentation of the course material, in effect, they must establish their own “classroom” schedules. Furthermore, they must establish their own evaluation mechanisms to identify material that may be troublesome, as they do not have routine contact with an instructor to provide external evaluation of their progress. Similar to the students in a lecture-based course, when students in the self-study course encounter difficult material, they must then develop a recovery plan to acquire outside assistance to improve their understanding of the material. For the self-study students, however, acquiring that assistance in the classroom on the following day is not an option.

Having identified distal and proximal goals, the individual must also identify the processes and methods to be utilized to enable the achievement of the goals. An individual pursuing a learning activity should implement learning processes that are appropriate for that learner and support achievement of the learning goals. Progress throughout the implementation of the plan should be monitored and adjusted through the use of a feedback mechanism (Zimmerman, 2000). Engineers in the Operating Systems course can refer to technical materials that are more complex than the materials presented in the classroom. Some engineers may have used those more complex materials in the workplace, some others may have been referred to those materials by their peers. This action demonstrates that the engineers have developed, and implemented a strategy for learning. By studying the more complex, and in some cases more familiar materials, the ability of the engineers to comprehend the lesson material is enhanced.

Considering the critical involvement of the individual in self-regulation, the motivational beliefs of the individual are a factor in the forethought process. The self-efficacy of the individual regarding a proposed learning activity influences the nature of the goals for that learning activity (Zimmerman, 2000). As will be discussed in the presentation of motivation scales, a student with high self-efficacy in an activity will likely establish higher goals for the outcome of that activity.

Performance phase.

Implementation of the processes and strategies for achieving the established goals occurs in the performance phase of self-regulation. Just as the establishment of goals is a critical component of the forethought phase, self-monitoring of progress is a critical component of the performance phase. The self-regulation sub-processes and proximal goals are incrementally monitored and adjustments made to ensure distal goal achievement.

Rather than focus on the ultimate goals for an activity, effective self-monitoring requires the individual to establish and monitor proximal goals. During the performance phase, self-monitoring of proximal goals provides immediate indication of progress and allows early intervention if the desired progress is not realized. A skilled self-regulated learner will develop proximal goals that have established viable linkage with the distal goals, enhancing the validity of the self-monitoring process (Zimmerman, 1994).

The proximal goals established by the learners are inherently associated with the instructional delivery method employed by the educators. Regardless of the instructional delivery method used in the Initial Training Programs for the engineers, the nuclear industry educators intend to ensure the delivery method provides the students with opportunities to seek proximal goals that will support effective outcomes for the training programs.

After establishing the rather objective goals regarding expectations for progress through the course materials, the students in the self-study program may also establish somewhat more subjective goals for the completion of course exercises. This may involve simply achieving a desired success rate on the exercises, or may involve establishing more complex exercises that can be performed in peer groups with other students in the self-study program. The peer groups can then be used to provide feedback regarding the performance of the individual students.

The students in the lecture-based program may rely on feedback from the instructors as the principal measure of achievement of proximal goals prior to taking the examinations. The lecture-based students may also incorporate periodic review of their understanding of the course objectives as one measure of performance monitoring. Some students in the lecture-based program may join peer study groups to provide additional evaluation of performance.

Self-monitoring also inserts a potential for detrimental effects in the learning process. If the student is engaged in self-monitoring activities that place demands on cognitive processing capabilities, then learning may be diminished because the working memory is burdened (Rheinberg, Vollmeyer, and Rollett, 2000). Even a self-monitoring activity that is seemingly straightforward, such as self-monitoring of study time, can detract from the learning processes (Zimmerman, Greenberg, and Weinstein, 1994). This is particularly likely if detrimental state-oriented thinking such as worry and anxiety serve as drivers in the self-monitoring process (Lan, 1998). Students in the lecture-based Operating Systems course may face such affective distractors because the lack of available study time during their normal work hours imposes demands on them to study the complex lesson materials extensively during their off-hours.

A factor that may detract from the learning activity by taxing the cognitive processes is the student perception of the activity. If the student finds an activity undesirable, then implementation of self-regulation strategies requires more volition control, thereby increasing the load on the cognitive processes (Rheinberg, Vollmeyer, and Rollett, 2000). Some of the engineering students may find the self-study program undesirable because it competes with their other work activities for their time and resources. For those students, effective self-regulation is challenged by their desire to be engaged in work activities rather than study activities. Additionally, the absence of a supportive social framework for their learning in the self-study program may detract from their interest in the materials.

Self-reflection phase.

The self-monitoring aspects of self-regulation provide the critical analysis of the current state of achievement compared to the desired goals. The results of this comparison are utilized in a negative feedback process to determine if the current strategy is providing the expected results and to modify the proximal goals, processes, and strategies to ensure the desired goals are attainable (Vancouver, 2000, Demetriou, 2000).

This self-reflection phase is an evaluation phase in which the outcomes are evaluated to provide input into future efforts (Zimmerman, 2002). The generation of effective feedback is increased through conscious awareness and application of self-reflection using the evaluation information obtained through self-monitoring (Shapiro and Schwartz, 2000). The feedback should not be limited to the learning processes or the learning goals. The feedback derived in self-reflection may also identify components in the self-regulation processes that should be modified (Vancouver, 2000). Expanding the scope of self-reflection provides the learner with insights into the effectiveness of the self-regulation processes and strategies to allow determination of the suitability of those components in future self-regulated activities.

Self-reflection for the engineers in the Operating Systems course may occur daily during the lectures and during their evening studies, as well as weekly following their examinations. The engineers in the Fundamentals course hopefully utilize self-reflection during their studies and through the performance of the exercises in their lesson materials. The review sessions with the subject-matter experts also provide opportunities for self-reflection, and, similar to the students in the lecture-based course, the self-study students can self-reflect following their examinations.

Self-reflection has been demonstrated by the engineers who choose to refer to more complex technical manuals in their studies of nuclear plant systems. The use of the manuals was spawned by previous experience with the manuals outside of the classroom environment. This use of prior knowledge and prior experience with the manuals as a factor in developing the learning strategies is, in a sense, an act of self-reflection used in the forethought phase. The decisions to continue use of the technical manuals following the deployment of those manuals in the learning activities hints at student recognition of the value of the use of those manuals. Similarly, those same students may employ their undergraduate texts and notes to support their studies in the self-study Fundamentals course.

Motivational Factors

Learning motivation occurs in the presence of four cumulative factors: (a) the desired outcome can not occur without action by the individual, (b) the actions of the individual can influence the outcome, (c) the consequences of the outcome have high value for the individual, and (d) the consequences are closely linked to the outcome (Rheinberg, Vollmeyer, and Rollett, 2000). Those factors, which bear the hallmark of expectancy-value motivation theory, will determine whether or not the individual elects to take action and persist in that action. In academic settings, those factors influence both the learning motivation of the learner and the self-regulation of the learner.

The three phase system of self-regulation and the motivational system employed by an individual should enjoy a bi-directional relationship. As described by Vancouver (2000), the outputs from various systems can serve as inputs to other systems, or may be used to alter the standards and goals in other systems (Vancouver, 2000). In the relationship between self-regulation and motivation, those influences between the two systems can occur in multiple areas. The factors described by Rheinberg, Vollmeyer, and Rollett (2000) contain several aspects of motivation theories that will have some bearing on self-regulation, including motivation characteristics, task value, and self-efficacy.

Motivation Characteristics

The students in the Engineering Fundamentals course and the Operating Systems course are influenced by nearly identical external factors that establish some of the extrinsic motivators for the students. The performance of the students in both courses may be considered by their supervisors during their periodic performance appraisals, resulting in larger or smaller pay increases relative to their performance. The use of those tangible rewards may prompt initial student engagement, but the benefits of tangible rewards are rather short-lived. Beyond the initial engagement, tangible rewards may adversely affect self-regulation at different stages of the self-regulation process. In the earliest stages, tangible rewards may cause some students to avoid a task, as the offer of the reward may imply that the task, valued solely for its own merit, is not worthy of the effort of the student (LaGuardia and Ryan, 2002). Task avoidance was not likely to occur in either the Engineering Fundamentals course or the Operating Systems course, as failure in either course would result in loss of employment. Still, the tangible rewards of pay increases may, in the absence of intrinsic motivation, reduce the persistence of effort by the students (Covington, 2002).

The use of external reinforcements not only influences the students during the learning process, but may also provide influence during the examinations. If successful performance on the examinations can result in pay increases, or worse, loss of employment, those extrinsic motivators can create cognitive distractions that adversely affect test performance.

An alternative to the compliance-based motivation driven by operant conditioning is to help the learners develop intrinsic motivation for the performance of the task. Ryan and Deci (2001) proposed that students will be intrinsically motivated when they feel their outcomes are self-determined. This self-determination can be encouraged by providing an environment that: (a) allows the student to exert some control and responsibility in the environment, (b) promotes student affective security and social belonging, and (c) supports feelings of competence in the performance of the activity.

From the perspective of self-determination, the self-study course and the lecture-based course promote intrinsic motivation in different ways. The self-study course certainly immerses the student in an environment in which autonomy reigns supreme. The student controls the pace of learning as well as the strategies for learning. Stipek (2002) argues that the academic tasks utilized in the classroom should include consideration of the motivational effects of those tasks and should be constructed and presented to promote intrinsic motivation. Providing the students with increased control and responsibility for their learning not only enhances their intrinsic motivation, but serves to establish the foundation for self-regulation of their learning. Additionally, the presentation of basic engineering topics should promote feelings of competence among the students, as they have encountered most of the material previously. Still, the self-study course, by design, does not establish an environment of social relatedness, unless the students engage themselves in study groups.

The lecture-based course affords the students with minimal control of their academic environment, thereby detracting from feelings of autonomy. Efforts are made to provide some student control during the course, such as giving the students the choice of start times for the examinations, or giving them some choice in altering the schedule for lesson presentations. Still, the course is fairly rigid in design. The lecture-based course also challenges the feelings of the students regarding their competence, as the course presents all new material, and includes a vernacular that is foreign to the students. Perhaps the positive attribute of the lecture-based course, from the self-determination perspective, is that the students are in it together, all facing the same challenges, promoting social relatedness and forming a community of learners during the four-week course.

Student interest in the lesson material also has an influence on intrinsic motivation. The student is more likely to be intrinsically motivated to perform well in an activity that is of interest to the student and has value for the student. Even though the students have successfully completed their undergraduate engineering studies, as recent graduates of those studies they likely have little interest in participating in a review of basic engineering material. The Operating Systems course, however, may stir the interest of the students as the course provides an early introduction to the equipment design and operating characteristics that will become the focus of the work activities for the students beyond the classroom. Wigfield and Tonks (2002) demonstrated that the enthusiasm of the learner can be maintained through the use of engaging tasks. While the Operating Systems course may not offer creative tasks for student performance, the novelty and unique nature of this new material certainly provides a greater spark to the interest of the students than does the review of fundamental engineering topics.

Task Value

Feedback from previous students in the self-study course has indicated that the students place little value on the Engineering Fundamentals self-study course. This perception is influenced by several factors. One contributor to the perception of low value for the Fundamentals course may be the delivery method. By presenting the material in a self-study format, the students may feel that the organization has determined that the material does not merit the expenditure of classroom presentation. Another factor that may contribute to the perception of low value for the Fundamentals course is the content of the lessons, as the students do not consider the review of the undergraduate material to be worthwhile. Finally, the students may place lower value on the Fundamentals lesson material in a comparative sense, because their Fundamentals lesson studies are competing with their normal jobs for their time and energy.

Feedback from the same students regarding the Operating Systems course has generally been positive, with the students indicating that the instructors have helped the students understand the relevance of the course material to the jobs of the students.

The perception of value of a course has an impact on the performance of the students in that course. An individual will generally expend greater effort and persist for a longer duration of time in pursuit of outcomes that are perceived as having a high value in comparison to outcomes having low value (Schunk and Ertmer, 2000). Again, the effort and persistence applied to the self-regulation processes and strategies will also be enhanced. The perceptions of the value of the outcomes have also been determined to influence the willingness of the individual to self-regulate the pursuit of that outcome. Wigfield and Tonks (2002) proposed that students are more likely to implement and maintain thoughtful, effective self-regulation practices when the outcomes of an activity have high value. Clearly, the Operating Systems lessons have higher value for the students, which should promote greater persistence by the students and enhance their learning.

The value of an outcome is not a magic constant in determining motivation and self-regulation. The effort and persistence employed by an individual in pursuit of a goal are not always directly linked to the value of the goal. Some students fail to engage in aversive activities even when the outcomes of those activities have high value and high consequences (Rheinberg, Vollmeyer, and Rollett, 2000). The relationship between motivation and self-regulation becomes critical in this scenario, as the use of self-regulation strategies may be inefficient because volition control must be maintained to enforce the self-regulation strategies. This intense effort to sustain the activity burdens the cognitive processes, thereby diminishing the learning (Rheinberg, Vollmeyer, and Rollett). Even for some students who may place high value on the Engineering

Fundamentals course, the demands placed on the students to schedule, implement, and monitor their learning in the self-study course may counter the positive motivational effects of the perceived value of the course.

While one goal of this study is to determine if the instructional delivery method influences the performance of the students in the self-study Fundamentals course and the lecture-based Operating Systems course, task value is one component of motivation for which factors beyond the instructional delivery method may influence the students. Those factors include: (a) previous exposure to the lesson materials in undergraduate studies, and (b) relevance of lesson materials to the jobs of the students. Factors other than the instructional delivery method merit consideration as confounding factors in the analysis of the results of this study.

Self-efficacy

The belief of a student in his or her ability to successfully complete an academic task will influence the approach of the student towards that task. The students in the Engineering Fundamentals course have already demonstrated understanding of most of the material offered in the self-study lessons by successful completion of their undergraduate engineering courses. Those students will probably exhibit high self-efficacy in the Engineering Fundamentals learning activities. In contrast to the high self-efficacy experienced in the Engineering Fundamentals course, the Operating Systems course offers academic challenges to the students. The Operating Systems course presents information that is not typically included in an undergraduate engineering program, and the material is presented in a compressed schedule. Lack of familiarity with the material and the preponderance of material presented during the course establishes a challenging load for the students.

The goals established for learning activities from the perspectives of motivation and self-regulation are clearly affected by the belief of the learner that those goals can be accomplished. A critical component in establishing this belief is the perception of the learner regarding the capabilities of the learner. Thus, self-efficacy has a role in the establishment and pursuit of the goals.

Previous experience with the lesson material serves as one input into the perception of self-efficacy that will be established by a learner, and certainly merits consideration as a potential confounding factor in this study. The instructional delivery method will also influence the self-efficacy of the learners, notably due to the differences in the social nature of learning between a self-study course and a lecture-based course.

Students develop self-efficacy by comparing their performance to the performance of others (Schunk and Ertmer, 2000) and through feedback provided by instructors, supervisors, and more-competent peers. In contrast to the isolated self-study course, feedback is readily available in the lecture-based course. The learner uses this information to establish an internal representation of the skills and talents of the learner. This internal representation serves as a standard used by the learner to determine likely outcomes of engagement in an activity. The likely outcomes, or expectancies, influence not only the motivation of the learner, but the application and persistence of self-regulation strategies.

A student having high self-efficacy will translate that self-efficacy to the establishment of higher goals during the forethought phase of self-regulation. The achievement of those higher goals will subsequently serve to boost the sense of self-efficacy (Zimmerman, 2002). Students having high self-efficacy exhibit greater use of self-regulation strategies. When experiencing either success or failure, an individual will assign causes to those outcomes, and those causes will ultimately influence future motivation. Schunk and Ertmer (2000) have identified a rather positive relationship between higher self-efficacy and self-regulation: Effective self-regulators develop the ability to assign those causes to factors that will support self-efficacy. Contrast this to the finding of Zimmerman (1998) who determined that inexperienced self-regulators attribute lack of interest to external factors, such as teachers or tasks.

Through their influence on self-efficacy, the evaluation strategies employed by the teacher also have an effect on the learning motivation and self-regulation of the students. The development of self-regulated learners is enhanced by rewarding self-improvement, providing opportunities to improve grades, using a variety of evaluation methods, and avoiding social comparisons (Meece, 1994). Interestingly, those same education strategies were identified by Covington and Teel (1996) as effective tools to help students overcome fear of failure. In addition to those strategies, Garcia and Pintrich (1994) identified task characteristics that promote self-regulation. The academic tasks should be within the range of the capabilities of the students, thereby promoting a higher sense of self-efficacy regarding the task and the belief that the student can affect the outcome of the task. To sustain the self-efficacy of the students, the teacher should provide performance evaluation that directs the students to view errors as opportunities for performance improvement (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, and Palincsar, 1991). By circumventing the introduction of the fear-of-failure and by presenting failures as opportunities for self-improvement rather than social comparisons, the teacher can protect and nurture the self-efficacy of the student.

Such teaching strategies obviously have greater opportunity for application in a lecture-based program than in a self-study program, primarily due to the frequent contact between the teacher and the students in the lecture-based programs. Comparison of student self-efficacy in the Fundamentals course and the Operating Systems course may be rather interesting. The students in the Fundamentals course will feel confident in their abilities to succeed academically in the Fundamentals course, yet even if they may have lower self-efficacy in the Operating Systems course, they will nevertheless be supported by nearly constant interface with a teacher and with peers.

Learning Strategies

The fundamental difference between the self-study and the lecture-based delivery methods is the presence of an instructor during the delivery of the lectures. The instructor provides an immediate source of information in response to student questions, and can use the student questions to gauge the progress of the students. Naturally, the instructor can also ask questions of the students as an on-going evaluation method, and can use that evaluation to alter the pace or direction of the lesson presentation. The self-study course does not provide such a dynamic learning environment, as the student is required to read the lessons, generally in isolation, and seek clarifying information at a later time. The ease of acquisition of immediate feedback when the student encounters difficult material is substantially reduced. This strikes at the heart of the concept of cognitive self-regulation, placing increased demands on the students to assume responsibility for their own learning, and to establish appropriate goals and learning strategies to meet those goals.

Metacognitive Self-regulation

In a study of the self-regulation techniques of community college students, Trawick and Corno (1995) identified four predominant strategies used by the students: (a) control of the learning environment, (b) control of the influence of other people, (c) self-monitoring, and (d) control of motivation. The absence of prompt feedback from an instructor should steer the students in the self-study program towards increased use of self-evaluations rather than external evaluations to effectively self-monitor their learning efforts.

Self-monitoring of academic progress serves to compare actual student performance to the performance goals established by that student (Zimmerman, 2002). Regular and proximal monitoring of performance relative to incremental goals provides more timely feedback in comparison to the monitoring of distal goal achievement (Lan, 1998). For the students in the self-study course, they should establish distal goals to support successful completion of the examinations on a three-week cycle, and should utilize proximal goals to monitor and evaluate their performance on a more frequent duration.

The students in the lecture-based course have a more compressed schedule in which to implement and monitor goals since their examinations occur weekly. Their classroom schedule is also arranged for them, so their exposure to the lesson material occurs at a time and in a place established by an external agent. While the pacing of the intake of new material is beyond their control, the students in the lecture-based program must still establish their own study schedules, although the dearth of available study time during the normal work hours surely forces the students to spend their evening hours engaged in study.

Morgan (as cited in Zimmerman, Greenberg, and Weinstein, 1994) demonstrated the relative significance of the monitoring of proximal goals. College students in an educational psychology course who monitored proximal goal attainment out-performed students who monitored multiple self-regulation components, including distal goal attainment, study time, and study activities. From this perspective, the lecture-based Operating Systems course may provide some advantage for the students when compared to the self-study Engineering Fundamentals course, as the compressed schedule of the Operating Systems course requires that the students focus on the learning objectives rather than the establishment and maintenance of study schedules.

The initial training programs in the nuclear industry utilize objective-based instruction and evaluation (Mager, 1984). Some students self-monitor their academic progress by using the instructional objectives in the role of test questions. The students may simply establish proximal goals that require successful completion of an established number of objectives in a specific time period. The instructors in the lecture-based courses encourage that behavior by periodically reviewing the objectives during the course of study to ensure the objectives are being met. The students in the self-study course do not enjoy the benefit of instructor-led reviews at the end of each lesson, so they must implement their own monitoring scheme.

Time Management

The scheduling of the examinations for the two courses also provides a rather objective difference. The students are examined every three weeks in the self-study course, whereas the lecture-based course presents a weekly examination to the students on Fridays. The content of the self-study course does not require that students study for the entire three week period, particularly when the lesson presents a topic that the student has already encountered in the undergraduate curriculum. Compression of the schedule of lesson presentation in the lecture-based course typically demands that the students perform their studies in their off-hours, Monday through Thursday, to prepare for the Friday examinations. Comparing the two courses, the self-study course provides significant fluidity in the study schedule, with the students clearly defining their study schedule over a three week period. Each student in the self-study program also has varying levels of need for study, depending on the topic. The students in the lecture-based course, however, are required to study rigorously during the evening hours to prepare for their end-of-week examinations.

Time management has proven to influence academic performance. College students asked to record the amount of time devoted to their studies not only improved their use of study time, but also achieved higher scores on examinations in the related courses (Mount and Terrill, as cited in Zimmerman, Greenberg, and Weinstein, 1994). Lest monitoring of study time be proposed as a remedy for academic weakness, the Morgan study (as cited in Zimmerman, Greenberg, and Weinstein, 1994) determined that students who monitored study time studied longer, but that was not reflected in academic performance. As with any other aspect of self-regulation, self-monitoring of study time can detract from other learning processes if too much emphasis is placed on the monitoring process (Zimmerman, Greenberg, and Weinstein, 1994).

Lan (1998) introduced a tool for time management as a self-regulation component in a college statistics course. The students recorded the time and frequency in which they engaged in the study of concepts from the statistics course. Lan found that the use of self-monitoring of time expenditure increased the use of other self-regulation strategies such as self-evaluation, environmental structuring, and reviewing previous tests and assignments. An additional benefit of the use of the self-monitoring tool was increased engagement in self-reflection.

A study by Britton and Tesser (as cited in Zimmerman, Greenberg, and Weinstein, 1994) sought to determine the relationship between self-regulation, intelligence, and grade-point average (GPA) for college students. The Scholastic Aptitude Test (SAT) scores of the students were used to provide a general measure of intelligence. The short-range planning and time aptitude aspects of self-regulation were shown to be better predictors of GPA than was the SAT.

The students in the lecture-based Operating Systems course have the demands for study time and scheduling practically thrust upon them; they must either study after work, Monday through Thursday, or risk failure on the examinations. The students in the self-study Fundamentals course, however, have substantial freedom of choice in pursuing their studies, particularly since their supervisors are encouraged to allow ample study time in the normal work schedule. Still, for some of the students in the self-study course, autonomy in the structuring of study schedules has led to undesirable results. Some students have been observed to spend almost the entire three-week period studying one engineering topic, then realizing, too late, that a second topic looms ahead with less than one week for examination preparation.

Cognitive Strategies

The operating systems course introduces material to the students that is not typically presented in undergraduate engineering programs. The lessons not only cover the design and function of the nuclear power plant operating systems, but also present the diverse interactions among those systems. Integrating the specific functions of the systems and their numerous interactions with other systems is promoted by the examinations, which include some memorization components along with more comprehensive items. As much of the lesson material in the Fundamentals course consists of basic material from the undergraduate engineering curriculum, the students frequently encounter topics that simply refresh their existing knowledge. The Fundamentals examinations contain questions that focus on basic engineering principles confined to a specific topic, and offer no comprehensive linkages between the various engineering topics.

Examinations, like any other tasks in the classroom, provide direction to the students that define the expectations for their learning. The tasks employed in the academic environment influence the motivation of the students and the self-regulation of the students. Tasks that promote understanding will likewise promote self-regulation (Doyle, 1983). Engaging the students in learning activities that challenge them to comprehensively evaluate the study material will promote the development of learning strategies that are essentially self-regulation strategies. Conversely, the use of tests that assess memory only will not effectively engage the students in metacognitive analysis of their learning.

Students employ diverse learning strategies (Ormrod, 1999) that can be applied in different learning conditions. Pintrich (2002) focuses on three general categories of learning strategies: rehearsal, elaboration, and organization that receive broad application in the learning environment. Rehearsal strategies are generally confined to repetition of information numerous times to oneself. While the repetition can occur in many forms: mental, aural, written, or kinesthetic, such repetition is generally considered to be the least effective of the learning strategies. Elaboration strategies require the learner to expound the information to be learned by summarizing or paraphrasing the information, which establishes the new information within the knowledge framework of the student. Organization strategies are exemplified by outlining and concept mapping, in which connections are established between new and existing information.

Considering the comprehensive characteristics of the Operating Systems lesson material and examinations, the students in the lecture-based course likely rely on the use of the organization and elaboration learning strategies to integrate the various lessons as the course progresses from week to week. The students in the self-study Fundamentals course, however, are likely to rely more heavily on a less-comprehensive memorization learning strategy, although connecting the Fundamentals material with their existing knowledge of the engineering topics may promote the use of organization and elaboration strategies.

Summary

Existing research in the areas of self-regulation, motivation, and learning strategies supports the proposition that the instructional delivery method influences those learner characteristics. This study examined the differences in self-regulation, motivation, and learning strategies in an Initial Training Program for engineers in the nuclear industry to identify the nature of those characteristics in two courses that used different instructional delivery methods. Recognizing the substantial influence that these initial learning experiences can have on the attitudes, morale, and motivations of the students towards their new jobs, a desired outcome for this study was to identify attributes of the two courses that promote the most effective learning experience possible. The learning experience should support the maintenance of high self-efficacy for learning, steer the students to be intrinsically motivated to acquire knowledge of the nuclear power plants, and should promote the use of effective self-regulation strategies. The establishment of an effective learning experience should engage the students in a training program that introduces them to the high standards of the nuclear industry and supports their efforts to adopt those standards.

The first question to be answered in this study: How does student achievement in a self-study training program differ from student achievement in a lecture program?, will be answered from a comparison of student examination scores in the self-study and lecture-based courses. This study intends to answer questions beyond that achievement question: (a) How are the motivations and learning strategies exhibited by the students in the self-study training programs different from the motivations and learning strategies exhibited by the students in the lecture programs? and (b) What factors in the two educational programs contributed to those differences? Identification of the relationships between self-regulation, motivations, and learning strategies from the perspectives of previous research in those areas will support the achievement of the goals of this study.

CHAPTER II

METHODS

Environmental Context

Ethical Issues

The principal investigator for this study was the administrator of one of the initial engineering training self-study programs at one of the participating nuclear training academies, interacting frequently with the students in the Engineering Fundamentals course, and with their supervisors and managers. The principal investigator also provided a management oversight function for the lecture-based Operating Systems course at that same nuclear training academy.

To reduce the potential for coerced participation in the study, the study was presented in compliance with policies established by the University of North Carolina – Greensboro Institutional Review Board (UNCG IRB) and the students were informed that participation was voluntary. All students who were asked to participate at all three nuclear training academies consented to participate in the study.

Study Goals

The nuclear electric power industry has modeled its training programs on those offered by the United States Navy nuclear fleet, with a strong preference for lectures in the classroom and task-based application in the field. The move towards a self-study delivery method was driven largely by a desire to reduce costs rather than by a desire to improve the learning experiences of the students. A comparison of the motivations and learning strategies associated with the self-study programs and the lecture programs provides insight into the effects of the use of the self-study methods. A primary goal of the study was to determine if the implementation of a self-study training program is detracting from the student learning experience. Not to discount a contrary possibility, the design of the study also allowed for the potential determination that the use of the self-study method may serve to enhance the student learning experience.

A secondary goal of the study was to examine specific components of motivation and learning strategies to determine if the instructional delivery method may be related to the strength of those components.

Study Site

Nuclear power plants in the United States have been hiring a small number of engineers in the past few years to prepare for the loss of aging engineers who will be retiring. Still, a single nuclear site does not have enough engineers entering the initial engineering training program to support this study, so engineers at three sites were recruited to participate. The three nuclear sites that were solicited for participation are members of the National Academy for Nuclear Training, which is the accredited training branch of INPO.

Participants

Because the Engineering Initial Training program is presented only to recently-hired engineers, an obvious limitation on the number of participants was driven by the hiring practices of the organization supporting the research. Each of the three participating sites had at least ten engineers who participated in both the Engineering Fundamentals course and in the Operating Systems course, providing a total of thirty-four engineers who completed both courses. An additional twenty-three engineers, who completed only one of the two courses, also participated in the study. The self-study Engineering Fundamentals course had a total of fifty participants, while the lecture-based Operating Systems course had forty-one participants. Table 1 displays the distribution of the participants relative to the courses and locations.

Table 1

Number of Participants, Location, and Course of Study

Nuclear Plant	Self-study	Lecture	Enrolled in Both Courses	Self-study Only	Lecture Only
A	18	17	14	4	3
B	20	14	10	10	4
C	12	10	10	2	0
Total	50	41	34	16	7

Considering the limited number of participants, coupled with the use of an instrument requiring analysis based on descriptive statistics, no attempt was made to select a random sample of participants. Instead, the entire population of students who enrolled in either the Engineering Fundamentals course or the Operating Systems course in the Fall 2006 and Spring 2007 sessions were asked to participate in the study. The socio-cultural diversity of the population was assured through the corporate hiring practices of the sponsoring organization, which has rigorously implemented policies to ensure fair employment practices relative to age, race, gender, ethnicity, health, and sexual orientation. Furthermore, the hiring of the new engineers occurred before any of the hiring personnel were made aware of this study, so participation in the study was not a factor in the selection of the engineers for employment.

Measures

The performance of the students in the self-study and the lecture-based courses was measured using the examination scores for both courses. The motivations and learning strategies used by the students were measured via a quantitative questionnaire. Using an explanatory process for mixed-methods research described by Creswell, Plano Clark, and Garrett (2007), potential causes for the motivations and learning strategies were investigated using one-on-one interviews with a limited number of students.

Course Examinations

The self-study Engineering Fundamentals course consisted of nine engineering topics, with two or three topics presented simultaneously in a three-week period. The examinations for the two or three topics were presented in a single session on Thursday in the third week after the students had received the lesson materials. All of the test items for the examinations were multiple-choice items. The Reactor Theory, Thermodynamics, Electrical Sciences, and Mechanical Engineering examinations each contained twenty test items, and the Chemistry, Materials, Core Protection, Process Controls, and Civil Engineering examinations each contained ten test items.

The lecture-based Operating Systems course presented an examination to the students on Friday at the end of each week of the four-week training program. Each Operating Systems examination was comprised of fifty multiple-choice test items. The examinations presented in the second, third, and fourth weeks of the Operating Systems course contained some test items that were drawn from the information presented in the preceding weeks.

Quantitative Instrument

Accurate identification and sorting of the motivations, learning strategies, and self-regulatory behaviors of the students may be enhanced through the use of a survey (Pintrich, 1989). Desirable characteristics for an assessment instrument were established as criteria for the selection of an instrument, including: (a) suitability of the instrument for adults who are recent college graduates, (b) minimum time required for administration of the instrument, (c) ability to present the instrument in the classroom, and (d) ability of the instrument to capture changes in specific components of learning style. The Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, and McKeachie, 1991) satisfies all of the criteria proposed for the selection of an instrument for this study. While the items in the MSLQ are written from the perspective of the college learner, relatively few of the items are affected by transition to the adult workplace. Considering that most of the engineers who participated in the study are recent graduates of undergraduate engineering programs, the MSLQ construction is applicable to these recent graduates. With minor adaptation, the language of the MSLQ was translated to address comparable issues in the industrial training environment. The estimated thirty-minute completion time for the MSLQ satisfies the minimal time requirement, and the MSLQ is suited for completion in the classroom. Finally, the MSLQ is specifically designed to identify and measure subtle changes in a variety of motivation and learning dimensions.

Motivated Strategies for Learning Questionnaire

The Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, and McKeachie, 1991) is an 81 item, self-report questionnaire that can be used to identify characteristics of the student respondents in two categories: motivation and learning strategies. Motivation is measured in six scales: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety. Learning strategies are measured in nine scales: rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking. The Motivated Strategies for Learning Questionnaire (MSLQ) is used to assess those components of learning in addition to assessing strategies to regulate cognition, placing the MSLQ squarely in the self-regulated learning perspective. While the MSLQ does not assess strategies for the control of motivation, it does recognize the influence of motivation on learning and identifies the motivational characteristics of the learner (Pintrich, 2004).

Previous Applications of the Motivated Strategies for Learning Questionnaire

Designed for use with undergraduate college students, the MSLQ has enjoyed application with diverse educational audiences, including college students in their first year of medical school (Barker and Olson, 2006), undergraduate students in computer courses (Chalupa, Chen, and Charles, 2001), undergraduate students experiencing difficulty in their college curriculum (Cole and Denzine, 2004), and pre-service teachers in an educational psychology course (McClendon, 1996). The MSLQ demonstrated its suitability as a measure of student motivations and learning strategies in these studies. Comparing the purposes of those studies to the goals of this current study, the MSLQ serves as a suitable measure of the motivations and learning strategies of the adult learners in the Engineering Initial Training Program.

This study also provided an opportunity to extend the use of the MSLQ into the realm of adult learning in the workplace. The MSLQ has received extensive application in undergraduate college programs, but has seen limited application beyond the college environment.

Potential Applications of the Results from the Motivated Strategies for Learning Questionnaire

While the influence of the instructional delivery method on motivations and learning strategies of the learners was the principle focus of this study, some scales within the MSLQ are of practical interest to the diverse stakeholders in the Initial Training Program. The supervisors and managers of the students enrolled in the Initial Training Programs can use the results from the evaluation of extrinsic motivation as an indicator of the effectiveness of external reinforcements for the students. Those same external reinforcements may also play a role in test anxiety, particularly if poor test performance receives strong negative reinforcement. The task value scale can be used by the supervisors and instructors to determine if changes in the preparation of the students for the courses or application of the course material in the workplace may be necessary to improve the learning experience. While the self-efficacy of the learners may initially be deemed to be within the province of the interest of the instructors, the supervisors and managers may have an influence in this area. Weaknesses in student self-efficacy potentially require the support of the supervisors to ensure the students are prepared to meet the expectations of the parent and training organizations.

Similar to the self-efficacy scale in the motivation arena, many of the learning strategies scales have meaning for both the training staff and the plant staff. The time and study environment scale of the MSLQ may have applicability to the supervisors and instructors to ensure the students have the time and facility resources to promote their studies. The help seeking and peer learning scales of the MSLQ can also be influenced by the training staff and plant staff. The measures of those scales can indicate if adequate technical expertise is available to support the learners and can provide insight into the opportunities for peer learning in the workplace.

Finally, the rehearsal, organization, and elaboration scales in the MSLQ learning strategies arena are not limited to offering insights to the instructors regarding the student approaches to learning in the two different instructional delivery methods, but may also reveal strengths or weaknesses of the lesson material and assessment methods.

This identification of the motivations and learning strategies of the students was intended to provide support for proposing changes to the instructional delivery methods that should enhance the development and maintenance of intrinsically-motivated, self-regulated learners. Any program revisions proposed as a result of this study will, of course, be subject to further evaluation, and can use this current study to establish the basis for future evaluation.

Interviews

The interview questions (see Appendix A) were designed relative to the components of the MSLQ, seeking to identify the differences in those components in the two different instructional delivery environments. Specific components of the MSLQ that were addressed in the interviews included: time and study environment, self-regulation, learning strategies, goal orientation, self-efficacy, and task value. Recognizing that the content of the questions may influence the responses by introducing information that would not have been considered by the respondents (Brophy, 2005), the questions intentionally circumvented reference to specific factors in the areas of motivation and learning strategies. This strategy proved beneficial, as the generation of the diverse student responses during the interviews was spared the introduction of bias by the interviewer.

To facilitate the potential for identification of the dominant drivers for differences between the student motivations and learning strategies in the two courses, selection of the interview participants was performed using a matrix that categorized the students using two criteria: (a) the level of difference in their individual responses to each of the scales of the MSLQ, and (b) their performance on the examinations in the self-study and lecture-based courses. This maximum variation sampling method (Patton, 1990) supports the identification of common themes across the diverse spectrum of students, which will be the goal of the constant comparison analysis of the interviews.

The level of difference in the student responses to each of the scales of the MSLQ was separated into two categories: large difference and minimal difference. The large difference category was populated by calculating the difference between self-study responses and the lecture-based responses for each student in each scale of the MSLQ. The students, usually four or five in each scale, with the largest differences were identified. After the differences for all students in all sixteen scales were identified, the number if appearances of each student in the group with the largest differences was summed.

A similar process was followed to identify the students who presented minimal differences in the scales of the MSLQ. For each scale, the students who presented zero difference or the lowest mathematically possible difference were identified. The number of appearances of each student in the group with the smallest differences was then summed.

Student examination scores were then used to select five interview participants from the respondents who offered the highest number of appearances in the summed totals in each of the MSLQ scale differences categories. For each differences category, one student in the lowest quartile of examination scores was selected, one student in the highest quartile of examination scores was selected, and two students in the two middle quartiles were selected. To bring the total number of interview participants to ten, two more interview participants were selected, one from the high quartile examination scores and one from the low quartile examination scores, and each in a different category for MSLQ scale differences.

One student was intentionally excluded from the interviews. The student had the highest number of minimal differences scores for all respondents, but unfortunately had failed five of the nine examinations in the self-study course and failed three of the four examinations in the lecture-based course. After the examination failures, the management team responsible for the performance of that student wanted the student to focus on study efforts to prepare the student to take remediation examinations. Furthermore, being fully aware of the legal issues associated with the potential for termination of employment of the student if the remediation efforts were unsuccessful, the principal investigator elected to forego an interview with that student to avoid jeopardizing the success of the student and to eliminate corporate challenges to the successful completion of the study.

Exclusion of that student from the potential interview group provided an opportunity to engage in the opportunistic sampling method (Patton, 1990). After identifying a suitable replacement for the excluded student in the lower quartile, a total of nine interview participants were selected who met the desired criteria for selection: three participants in the lower quartile, a total of three participants in the two middle quartiles, and three participants in the upper quartile. To gain the perspective of a student who presented an equal-balance for all of the interview participant selection criteria, an engineer was selected who had examination scores in the middle quartiles and who did not present a high number of scores in the MSLQ scales large differences category or minimal differences category.

Procedures

Recruitment of Participants

Recruitment of participants was performed through an Engineering Training Working Group that represents the interests of the electric utility that provided participants for this study. The engineering instructors at the three targeted nuclear sites are members of that working group, and provided access to the participants along with the appropriate schedules for the training courses that were included in the study. The participating organizations were asked to deliver the MSLQ to the engineers in their initial training program, specifically the engineers who were participating in the programs that consist of the topics described by INPO as "Fundamentals Training" and “Plant Systems and Component Training” (INPO, 2003).

The MSLQ was delivered via one of two methods: (a) hard-copies via interoffice courier to the students in the Operating Systems course that was completed in September 2006, and (b) hard-copies presented to the students in the classroom for all of the remaining courses. The students receiving the MSLQ via interoffice courier were contacted by the principal investigator via e-mail prior to the distribution of the questionnaires to provide early notice of the study and to garner support for participation in the study.

Following completion of the MSLQ by the participants, their responses were reviewed to identify any items that may have been omitted. If an item was omitted, the involved participant was notified of the omission by the principal investigator to determine if the omission was, or was not, intentional. This follow-up contact resolved all omitted items and resulted in a 100 per cent completion rate for all items of the MSLQ for all participants.

Following analysis of the MSLQ, interviews were conducted with ten of the respondents with the goal of identifying causal relationships for the strengths or weaknesses of the responses to the scales of the MSLQ. The ten interview participants were selected using the process described in the Interviews section of this report.

Schedule

The scheduling and sequencing of the Engineering Fundamentals courses and the Operating Systems courses at the three participating nuclear sites were based on the operational needs of those nuclear plants. The first course included in this study was an Operating Systems course that concluded in September 2006. The MSLQ was presented to the participants in that first course three weeks after the completion of the course. Quantitative data collection from participants in all subsequent courses occurred either during the courses or on the final day of class. The final course included in this study was an Operating Systems course that was completed on 15 June, 2007.

Following acquisition of the final quantitative data from the June 2007 Operating Systems course, analysis of the responses to the MSLQ was performed. That analysis was used to identify the desired participants for the interviews. A total of ten participants were selected using the process described in the Interviews section of this paper, then were interviewed over a three week period in July 2007, with the final interview occurring on 25 July, 2007.

Descriptive Statistics

The analysis of the data from the presentations of the MSLQ to the self-study group and the lecture-based group intentionally mimicked the analysis utilized by Pintrich, Smith, Garcia, and McKeachie (1991). The mean value for each scale in the MSLQ was calculated, along with the Cronbach's alpha for each of those scales and the overall reliability for each administration of the MSLQ. Comparison of the analysis of the self-study and lecture-based MSLQs for the engineers was then performed to determine if differences were present between the two instructional delivery methods. The comparison included one-way analysis of variance, comparing each of the MSLQ scale means for the self-study and lecture-based courses, with the application of the Bonferroni correction to account for the number of similar comparisons being performed. The responses to each MSLQ were also evaluated to determine the effects of the MSLQ revisions on the validity of the MSLQ

All of the MSLQ responses from the students were segregated into the same component categories used by Pintrich et al. (1991), then were sub-divided into categories of motivation, value, expectancies, affective measure, cognitive strategies, and self-regulation. The motivation category included intrinsic goal orientation and extrinsic goal orientation. The value category contained only the task value scale. The expectancies category included control of learning beliefs and self-efficacy. The test anxiety scale of the MSLQ stood as the lone component in the affective measure category. The rehearsal, elaboration, and organization scales of the MSLQ were placed in the cognitive strategies category. The remaining scales of the MSLQ: critical thinking, meta-cognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking, were placed in the self-regulation category. Those categories were used to establish the number of similar items in each category for calculation of the Bonferroni correction.

Utilizing the analysis methodology of Pintrich et al. allowed the comparison of the results of the MSLQ for the engineers in the self-study, Engineering Fundamentals program to the results of the MSLQ for the engineers in the lecture-based, Operating Systems training program to identify any differences that may have existed in the student motivations and learning strategies in those two programs.

Interview Analysis

The interviews, each with a duration of approximately one hour, followed a structured interview format (Guba and Lincoln, 1985) using the interview questions from Appendix A as a template. However, the interviewees were encouraged to stray off-topic, akin to an unstructured interview format, to promote the revelation of unsuspected insights into student behaviors. With those considerations, the format of the interviews is best described as semi-structured. The interviews were conducted one-on-one in conference rooms at the offices of the participants and were recorded for later transcription.

The student responses from the interviews were evaluated using constant comparison (Creswell, 2005) to determine if themes were present in the responses and to identify potential relationships between those themes. This was accomplished by clustering similar responses together in thematic categories (Dye, Schatz, Rosenburg, and Coleman, 2000, Maxwell, 2005) based on singular qualities of the responses.

Identification of the categories occurred in multiple venues. Following the guidance of Guba and Lincoln (1985) as recommended by S. D. Miller (personal communication, August 01, 2007), some themes were identified during the interviews and while listening to the recordings of the interviews. Some categories were identified while transcribing the interviews, as suggested by H. B. Carlone (personal communication, July 28, 2007). Finally, some categories emerged, as expected, during the constant comparison process.

Categorization of the respondent comments occurred throughout the interview phase of this study. Some categories emerged while the interviews were in progress, others emerged while the interview recordings were being reviewed and transcribed, and other categories emerged during the constant comparison process. Given the foundation of the interview questions, some comments were rather naturally inclined to be linked to the scales of the MSLQ. The categories related to the MSLQ included: time and study environment, extrinsic goal orientation, intrinsic goal orientation, and rehearsal.

Characterization of each comment was not limited to one category, resulting in some comments that were placed in as many as three different categories. An example of this multiple-listing occurred when a student commented, regarding studying for the self-study course: “I went to the library for the difficult topics.” That comment neatly fit into three categories: metacognitive self-regulation, effort regulation, and time and study environment.

During the interviews, the past experience of the students with topics contained in the Engineering Fundamentals lesson materials was identified as an influence on their studies for that self-study course, so a "previous student experience with the lesson material" category was created. During the interviews the students also commented on their focus on the learning objectives that had been provided by the instructors for both of the courses evaluated in this study. Their remarks referred to the course objectives, both as a motivational goal and as a tool that served as the foundation for the selection and implementation of learning strategies. This resulted in the creation of an "objective" category for the extracted comments.

Finally, reviews of the interview transcripts led to a recognition that the extrinsic goal orientations of the students could be cleanly sub-divided into the processes encountered in extrinsic motivation that identify varying degrees of internalization of motivation (Ryan and Deci, 2001, Deci and Moller, 2005): (a) external regulation, (b) introjection, (c) identification, and (d) integration, so categories were established for those processes.

Once identified, the categories were then compared to the other categories to identify relationships among the categories. After the initial sorting of the comments into the categories defined by the structure of the interview questions (see Appendix A), comparison of the comments gathered during the interviews produced the following categories for further evaluation: (a) time and study environment, (b) motivations, (c) instructional delivery method, (d) learning strategies, (e) previous experience with the lesson material, and (f) objectives. The information attributed to those categories is discussed in the Results section of this report. Those final, higher-level categories established the thematic foundation to explain the causal factors for the information revealed in the analysis of the Motivated Strategies for Learning Questionnaire as presented in the Discussion section of this report.

Validity Issues

The terminology used in some items of the 1991 MSLQ may not be suitable for use in a workplace training program, therefore those items were revised to tailor the presentation of the MSLQ to the engineers. Revision of those items required validation of the MSLQ, notably from the perspective of construct validity, in an assessment performed at a nuclear facility in 2006.

The following specific items from the questionnaire required translation for application in the industrial learning environment:

11. The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.
24. When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.
70. I make sure that I keep up with the weekly readings and assignments for this course.
73. I attend this class regularly.

Those items were translated for use in the industrial learning environment as follows:

11. The most important thing for me right now is improving my overall course average, so my main concern in this class is getting a good score in this course.
24. When I have the opportunity in this class, I choose reading materials that I can learn from, even if they don't guarantee a good grade.
70. I make sure that I keep up with the readings and assignments for this course.
73. I use the established study time for this class regularly.

The validation of the MSLQ in the 2006 assessment utilized a multi-faceted approach that included qualitative feedback from the students, calculation of the reliabilities for the scales, and calculation of inter-item correlations for the items. Particular attention was provided to the inter-item correlations for the revised items and to the reliabilities for the scales containing those revised items. The validation determined that the revised MSLQ is suitable for use in the engineering training programs to be evaluated in this study.

Validation of the MSLQ continued in this study through the analysis of inter-item correlations and scale reliabilities of the MSLQ. The scope of the validation was extended in this study by comparison of the results from the MSLQ to the comments received from the students during the interviews.

CHAPTER III

RESULTS

The analysis of the data from the presentations of the MSLQ to the self-study group and the lecture-based group included one-way analysis of variance, with the application of the Bonferroni correction to account for the number of similar comparisons being performed. All of the MSLQ responses from the students were segregated into the same component categories used by Pintrich et al. (1991).

Research Questions

Question One: Differences in Achievement

The first research question examined the differences in achievement of the students on the content tests across the two instructional formats. No differences were found between the performances ($F(1,89) = 3.757$, $p = 0.056$). The means (with standard deviations in parentheses) for the self-study and lecture formats were 91.483 (4.458) and 89.560 (4.765), respectively. These scores show the students, overall, scored quite highly on the examinations in both formats.

Question Two: Differences in Motivations and Learning Strategies

The second research question examined the differences between the motivations and learning strategies of the students in the self-study format and the lecture-based format. The mean values, variances, and reliabilities for each of the motivation scales of the MSLQ from both the self-study course and the lecture-based course are presented in

Table 2, along with the mean values and variances for the student examination scores in both courses. The same information for each of the learning strategies scales is presented

in Table 3. The significance of the differences between the MSLQ scale means for the two courses was determined by one-way analysis of variance and is presented in Table 4.

As indicated in Table 4, only three of the fifteen scales of the MSLQ produced significantly different values between the self-study and lecture-based courses: task value, rehearsal, and time and study environment. Task value had a mean value of 5.487 in the self-study course, but presented the highest mean value, 5.911, for all scales in the lecture-based course. The rehearsal scale generated the greatest difference between the two courses, with a mean of 4.540 in the self-study course and a mean of 5.226 in the lecture-based course. The increased use of the rehearsal strategy was of interest, particularly when the motivation scale means were favorably high. The time and study environment scale also produced one of the larger, statistically significant differences between the two courses. The mean for the time and study environment scale in the self-study course was 4.668, which was 0.652 less than the mean of 5.320 in the lecture-based course. The interviews sought to identify the drivers behind these differences.

Table 2

Motivated Strategies for Learning Questionnaire

Motivation Scales: Mean Scores, Variances, and Reliabilities

	Mean		Variance		Reliability	
Scale	Self-study	Lecture	Self-study	Lecture	Self-study	Lecture
			Motivation			
Intrinsic Orientation	5.170	5.128	0.475	0.513	0.671	0.810
Extrinsic Orientation	5.355	5.427	0.150	0.097	0.703	0.630
			Value			
Task Value	5.487	5.911	0.150	0.076	0.896	0.871
			Expectancies			
Learning Beliefs	5.770	5.494	0.416	0.439	0.716	0.747
Self-efficacy	6.080	5.710	0.073	0.121	0.937	0.914
			Affective Measure			
Test Anxiety	3.608	3.815	0.588	0.447	0.790	0.917
			Examination Results			
Scores	91.483	89.560	19.871	22.702	-	-

Table 3

Motivated Strategies for Learning Questionnaire

Learning Strategies Scales: Mean Scores, Variances, and Reliabilities

	Mean		Variance		Reliability	
Scale	Self-study	Lecture	Self-study	Lecture	Self-study	Lecture
	Cognitive Strategies					
Rehearsal	4.540	5.226	0.672	0.206	0.735	0.749
Elaboration	4.693	4.959	0.779	0.474	0.617	0.696
Organization	4.055	4.573	1.690	0.813	0.763	0.731
	Self-regulation Strategies					
Critical Thinking	4.232	4.249	0.290	0.257	0.800	0.868
Self-regulation	4.503	4.738	0.555	0.424	0.721	0.784
Environment	4.668	5.320	0.589	0.244	0.793	0.780
Effort Regulation	5.365	5.415	0.475	0.334	0.716	0.526
Peer Learning	3.360	3.610	0.069	0.387	0.871	0.592
Help Seeking	4.280	4.604	0.719	0.857	0.619	0.640

Table 4

Motivated Strategies for Learning Questionnaire

Analysis of Variance Comparing the Self-study and Lecture-based Scale Means

Scale	F Critical	F Calculated	Significance	Bonferroni Correction
Intrinsic Orientation	3.960	0.040	0.842	0.025
Extrinsic Orientation	3.960	0.111	0.740	0.025
Task Value	3.960	5.307	0.024*	0.050
Learning Beliefs	3.960	1.712	0.194	0.025
Self-efficacy	3.960	3.669	0.059	0.025
Test Anxiety	3.960	0.428	0.515	0.050
Rehearsal	3.960	6.205	0.015*	0.016
Elaboration	3.960	2.073	0.153	0.016
Organization	3.960	3.111	0.081	0.016
Critical Thinking	3.960	0.004	0.948	0.008
Self-regulation	3.960	1.910	0.170	0.008
Environment	3.960	10.085	0.002*	0.008
Effort Regulation	3.960	0.067	0.797	0.008
Peer Learning	3.960	0.725	0.397	0.008
Help Seeking	3.960	1.845	0.178	0.008

* F is significant at the 0.05 level.

Tables B1 through B30 in Appendix B provide a more detailed item-by-item comparison of the composite item means, composite item variances, and reliability values for each of the scales in the self-study MSLQ, along with the individual item means and standard deviations.

Question Three: Causes of the Differences

The third research question investigated the likely causes of the differences identified in the motivations and learning strategies used in the self-study and lecture-based courses. Analysis of the interviews identified multiple causes for the differences in the task value, rehearsal, and time and study environment scales of the MSLQ.

Task Value

The repetition of undergraduate engineering lesson material in the self-study course was the primary contributor to the lower perceived value of that course. Contributing to that lower value was the absence of promotion of the value of the course by the supervisors and managers of the students. While those management representatives were providing generous support for the students in the self-study course, they were not vigorously promoting the Engineering Fundamentals course as a valuable component of the Initial Training program. The Operating Systems course was promoted to the current students by managers, supervisors, and previous students as a worthwhile learning experience, notably from the perspective of the applicability of the lesson material for future purposes.

Rehearsal

The students in the self-study course had ample time to employ diverse learning strategies, using tools such as the review questions in the lesson material to support their learning. Contrary to that experience, the use of the rehearsal learning strategy was significantly higher in the lecture-based course due to the time constraints placed on the students and due to the focus of the presentations on the learning objectives. The students altered their learning strategies for the lecture-based course to focus on memorizing the material covered in the objectives in as short a time period as possible.

Time and Study Environment

Again, the students in the Engineering Fundamentals course had relative freedom in the selection of their study environment and the scheduling of their study time. This freedom also presented opportunities to digress from study to engage in other activities. The students in the lecture-based course however, were forced into rigorous study schedules and did not have the liberty of routine pursuit of outside interests during the four-week Operating Systems course.

The following analysis provides support for the preceding results.

Interviews

The interviews were conducted using the format contained in Appendix A, Interview Questions. The student comments were initially segregated into the major categories defined by that interview protocol: (a) time and study environment, (b) goal-setting, (c) learning strategies, (d) goal orientation, (e) self-efficacy, and (f) task value.

Time and Study Environment

The students in the self-study Engineering Fundamentals course conducted most of their studies at work. The selection of the work study environment during the self-study course was associated with two factors: distractions at home and resource availability at work. Two Engineering Fundamentals students elected to study at home, one because of distractions at work, another because studying in the dormitory during her undergraduate college years had been successful. One student evenly divided study time between home and office. While there was no consistency to the selection of a specific study location for the students in the self-study course, the locations were selected based on student evaluations of the study sites as beneficial to their studies.

The students in the lecture-based Operating Systems course presented a balanced split: four students studied at work, four studied at home, one student split time between work and home, and one student studied in the public library. The work location was selected because of the convenience of staying in the classroom. One student studied at work as a carryover from the college days, when he stayed on campus for study rather than returning home. Likewise, the library was the primary choice for one student because that was a successful practice during her college days. The home study location was favored by some students because the comforts of home contributed to a relaxed study environment. Again, as with the self-study course, there was no preferred study location for the lecture-based course, but again, the selection decision was based on the belief of the students that the location would support their study efforts.

The instructional delivery method played no role in the selection of the study environment. The selection process, however, for both courses reflects effective self-regulation practices by the learners, as they used previous experiences and evaluation of the current situations to chose a location that was beneficial to each learner.

Goal-setting

The students in the self-study course focused their study efforts on successful performance on the examinations, with four students indicating that they simply wanted to pass the tests, and three students wanted to score high grades on the tests. Learning the information presented in the lesson materials was the primary goal for two students, and one student wanted to achieve personal satisfaction from the learning and to support personal goals beyond the classroom. In short, successful examination performance was the ultimate goal for seven of the students in the self-study course.

The students selected those goals based on the contextual influences of the learning environment. The perceived value of the self-study learning experienced was relatively low, as two students indicated that their managers had not expressed any sense of importance of the Engineering Fundamentals course, and three students considered the course to be a review of their undergraduate curriculum. Two of the students who were seeking high scores on the examinations were clearly driven by competitive desires.

The learner goals in the lecture-based course were similar to the goals in the self-study course: three students wanted to pass the examinations, three students wanted to score high grades, two students focused on learning the material for the sake of learning, one wanted to use performance in the Operating Systems course to advance other causes, and one student wanted to satisfy the expectations of a supervisor. Relevance of the material to the jobs and career aspirations of the learners contributed to the establishment of the goals in the lecture-based course, as five students reported that the goals were tied to their perception that the information covered in the Operating Systems lessons would have application in their jobs. This recognition by five students of the usefulness of the Operating Systems lessons in future applications, coupled with the desire of six students for successful performance on the examinations created a dichotomy for goal setting that was still grounded in extrinsic goal orientation.

Self-regulation played a key role in the self-monitoring of goal achievement during the self-study course, where three students indicated that they adjusted the goals based on the amount of material to be covered in preparation for the examination, two students adjusted their efforts based on past experience with the lesson material, and two students studied until they considered their efforts to be successful. The goals of the students in the lecture-based course were also subject to similar influences, where three students reported their level of effort was adjusted as they gained familiarity with the challenges offered by the examinations.

The students established mildly different goals for the two courses from different facets of extrinsic goal orientation. The introjected regulation of the students in the self-study course had its roots in the view of the Engineering Fundamentals course as a review of the undergraduate engineering curriculum, but the perceived value of the self-study course also had some influence on the goal orientation of the students. The identified regulation of the students in the Operating Systems course was based on the perceived value of the course material. The instructional delivery method was not a dominant driver for goal setting.

Goal Orientation

The goal orientation of the students presented some interesting dispersion of motivation characteristics. In the self-study course, six students reported extrinsic goal orientation as their primary orientation, two students reported intrinsic goal orientation as their primary orientation, and two students reported a mixture of goal orientations. Extrinsic goal orientation prevailed in the Engineering Fundamentals course. The goals established by the self-study students were clearly centered in extrinsic goal orientation, focused on examination performance from the introjected regulation perspective identified by Ryan and Deci (2001) and Deci and Moller (2005).

The extrinsic and intrinsic goal orientations experienced a role-reversal in the lecture-based course, where three students reported extrinsic goal orientation as their primary orientation, five students reported intrinsic goal orientation as dominant, and two students revealed a mixture of extrinsic and intrinsic goal orientations. The goals in the lecture-based course moved beyond the ego-centered goals of the students in the self-study course, as the students exhibited some internalization of the goals established for the lecture-based course. This shift towards identified regulation (Ryan and Deci, 2001, Deci and Moller, 2005), while still retaining the ego-centered introjected regulation provided a nice balance of goal orientation for the students in the lecture-based course, though still grounded in extrinsic goal orientation.

The origins of the goal orientations in both courses were spawned from a diverse array of student characteristics. Competitive spirits drove the extrinsic goal orientations for two students in both courses. Rewards from the supervisors promoted extrinsic goal orientation for four students in the lecture-based course. The desire to achieve goals beyond the learning experience oriented one student in the self-study course and two students in the lecture-based course, and two students hinted at fear of failure as a driving force for their extrinsic goal orientation in both courses. As discussed in Goal Setting, the instructional delivery method did not have a strong influence on the goal setting or on the goal orientation of the students.

Learning Strategies

The learning strategies used in the self-study course were centered on the review questions provided in each of the workbooks for the Engineering Fundamentals course, as seven students reported that the review questions became their primary study aid. The PowerPoint presentations delivered by the subject-matter experts one week prior to each examination were cited by four students as a key tool in their preparation for the examinations.

The objectives for the lecture-based course dominated the study activities of the students. Eight students revealed that use of the objectives was the centerpiece for their learning, whether creating note-cards featuring the objectives, or using the objectives in the role of sample test questions. The objectives were used to support memorization strategies to acquire the necessary knowledge to be successful on the examinations.

While the students used two different tools: the review questions in the self-study course and the objectives in the lecture-based course, those tools were employed primarily in the application of rehearsal strategies for each course. The instructional delivery method was not a factor in the use of those strategies.

Self-efficacy

The self-efficacy of the students in the Engineering Fundamentals course was quite high, with eight students indicating they felt assured of success in the program and two students reporting high, but varied beliefs in their potential for success. The variations for those two students were based on their past experience with the material.

The students in the Operating Systems course were not quite as confident of their potential for success, although they still felt they would be successful in the course. Four students revealed that they were concerned about being introduced to completely new material, but their confidence rose as the weeks progressed. Four other students approached the lecture-based course with relatively high self-efficacy for various reasons, including the excitement of one student to learn about nuclear power plants, the previously-acquired knowledge of a second student, and the recognition of one student that there would be only one course to study, in contrast to the multiple-course load in college.

The rather subdued difference in self-efficacy of the students between the two courses was attributable to the material presented in the two courses: some review material in the Engineering Fundamentals course and all new material in the Operating Systems course. The instructional delivery method had no effect in self-efficacy.

Task Value

Three students felt the self-study course was of little value because it was a review of undergraduate material. Two students had received no deliberate message from their management regarding the importance of the Engineering Fundamentals, so they inferred the course must have little value. Two other students felt the Engineering Fundamentals course must have less value than the Operating Systems course because it was presented using the self-study instructional delivery format. Still, two students thought the course was valuable. So, the self-study course was generally perceived to have low value by a total of seven students, although for three different reasons, one of which was the instructional delivery method.

The lecture-based course was generally perceived to have high value. The application of the lesson material to their jobs led two students to assign a high value to the Operating Systems course, while three other students thought the course provided valuable insight into the operation of nuclear power plants. Interestingly, two students indicated the lecture-based course must have high value because it was presented in the classroom rather than as a self-study course. Conversely, two students thought the course had low value. One of those students felt the course did not have direct application to her job function and the other student felt that the overwhelming amount of material presented in the four week course detracted from the value of the course. Overall, the lecture-based course was perceived to have high value, primarily because of the usefulness of the material presented in the course.

While the instructional delivery method was not the dominant driver that governed the perceptions of the students regarding the value of the Engineering Fundamentals and Operating Systems courses, there was a smattering of evidence indicating the instructional delivery method had some influence on perceived value.

CHAPTER IV

DISCUSSION

Self-regulation

Self-regulation of the learners functioned as the catalyst that governed student behaviors in the self-study Engineering Fundamentals course and in the lecture-based Operating Systems course. In both courses, the students exerted self-regulatory behaviors that were commensurate with their perceived value of the training courses and were driven by the environmental constraints that framed the two learning scenarios. As indicated by their examination performance and revealed in the results of the MSLQ and the interviews, the learners possess the attributes necessary to achieve the goals of the nuclear industry regarding long-term effectiveness of the training programs. Comments from the interviews, however, indicate that the success of the students was the result of their effective self-regulation behaviors when facing less-than-desirable influences from the design of the two courses, notably the inclusion of review material in the self-study course and the compressed presentation schedule of the lecture-based course.

The significance of the role of self-regulation was exhibited in the quantitative data from the Motivated Strategies of Learning Questionnaire and in the qualitative data from the interviews. Evaluation of that data from the perspective of the relevant literature also supports the proposition that self-regulation was the dominant factor in the two courses.

Analysis of the Interviews

The comments from the interviews were first sorted according to the structure of the interview. Subsequent comparison of the student responses determined the comments could be categorized as follows: (a) time and study environment, (b) motivations, (c) instructional delivery method, (d) learning strategies, (e) previous experience with the lesson material, and (f) objectives.

Time and Study Environment

The scheduling of studies, the locations of studies, and the durations of those studies were marvelously diverse for all of the students, and were based on previous student experience in educational programs and on student evaluation of present environmental conditions. Those environmental study factors were sculpted to help each student achieve the desired outcomes for their studies. Unfortunately, those outcomes were clearly driven by the objective-based design of the self-study and lecture-based courses.

Motivations

The students described strong extrinsic and intrinsic goal orientations. The extrinsic goal orientation included: (a) external regulation, driven by the expectations of supervisors, (b) introjected regulation, exemplified by either the competitive nature of some of the students or the desire to produce the best possible performance, and (c) identified regulation, promoted by the recognition of the value of the training courses in achieving other goals. One student confessed to wanting to learn the material simply because he wanted to learn: an intrinsically-motivated student. Both extrinsic and intrinsic goals co-mingled wonderfully, driven by multiple factors such as external rewards for passing the examinations and internal desires for learning to promote career success.

Instructional Delivery Methods

While the students provided mixed reviews of the two different instructional delivery methods, the differences in those two methods did not contribute to differences in student performance in the two courses as determined by the quantitative analysis. Still, the variety of student comments regarding the role of the instructional delivery methods indicated that the students judged the instructional delivery methods according to multiple factors. Those factors included: (a) the intangible signals provided by the managers and supervisors regarding the value of the two courses, and (b) the ability of the instructional delivery method to help the students achieve their learning goals. Some students thrived on social interaction with teachers and peers to support their learning, other students appreciated the flexibility and freedom of self-regulated studies.

Learning Strategies

The strong use of the rehearsal learning strategy in the self-study and the lecture-based courses, while somewhat surprising, was still driven by the recognition of the students that the evaluation of their performance in both courses was measured by their ability to demonstrate knowledge of the objectives. In the self-study course, much of the material was considered to be review material, so the rehearsal strategy ensured the students achieved the objectives for those lessons. The compressed schedule of the lecture-based course drove the students to attempt to condense maximum learning into minimal time. That time constraint, coupled with the introduction of new concepts and terminology in the Operating Systems course, drove the students to rely heavily on the rehearsal learning strategy.

Previous Experience with the Lesson Material

Previous exposure to the lesson material for some of the Engineering Fundamentals topics encouraged most students to adopt a minimalist approach to those studies, seeking to meet the minimum criteria via memorization of the objectives. The lack of previous exposure to the material in the Operating Systems course, coupled with the compressed schedule for lesson presentation, drove some students to the use of rehearsal learning strategies.

Objectives

Finally, the objective-based construction of the Engineering Fundamentals and Operating Systems courses established a learning environment that compelled the students to address the objectives as motivational tools and as study aids.

While the objective-based nature of the courses appeared to be the dominant factor in defining the motivations and learning strategies used by the students, another, somewhat more subtle thread emerged: Student self-regulation connected all of the major categories that were identified in the interview data. Their application of previous experience to the current learning situation is consistent throughout the categories, and includes their responses to the objective-based design of both training courses. The students presented themselves as a savvy group of learners who were able to recognize opportunities for using behaviors that have been successful in the past. The study environment, the involvement of peers, the seeking of help, the choice of learning strategy, the value of the learning activity, and their belief in their potential for success, are clearly tied to their knowledge of their own learning attributes.

Combining the MSLQ Data and the Interview Data

Self-Study

The students in the self-study course presented themselves with wonderfully high self-efficacy for their learning experiences, primarily attributable to their recognition that most of the material in the self-study course was a review of their undergraduate engineering material. The high mean value for the self-efficacy scale in the Motivated Strategies for Learning Questionnaire was also supported by student comments indicating that the students felt confident they could be successful in any training scenario.

The motivations for the students were relatively high, as documented in the intrinsic goal orientation and extrinsic goal orientation scales of the MSLQ, and was driven, to some extent, by the autonomy of the self-study learning format as reported in the interviews. This was, in turn, reflected in their fairly strong control of their time and study environment as identified in the MSLQ. The strength of their control of the time and study environment factors was well-documented in the interviews, with the students utilizing past study experience to address existing study needs.

The perceived value of the self-study learning experience was also fairly high, but almost by default, as the students commented that the Engineering Fundamentals course must have been important, otherwise they would not have been expected to participate in the course. Despite the relatively high mean value for the task value scale in the self-study program, the students provided indication that the review of undergraduate material and the lack of promotion of the course by their management reduced the perceived value of the self-study course.

The Engineering Fundamentals course provided the opportunity to review some familiar material and to be introduced to some information that was new to the students. This contrast allowed the students to use diverse learning strategies to prepare for the examinations. The Engineering Fundamentals students delivered mean values for the rehearsal, elaboration, and organization scales of the MSLQ that were quite comparable in absolute and relative values to the mean values produced by the university students in the Pintrich, Smith, Garcia, and McKeachie (1991) study.

Lecture-based

The MSLQ scales of task value, rehearsal, and time and study environment changed significantly in the lecture-based Operating Systems course. The self-efficacy of the students remained high, although with a slight, non-significant decrease. Again, the students were confident in their learning abilities. Their motivations remained high and relatively stable when compared to their motivations in the self-study course. Student comments for the lecture-based course suggested their motivations were driven by two factors: (a) interest in the lesson material, and (b) external incentives.

The student control of the time and study environment was substantially higher in the lecture-based course. The significantly higher time and study environment MSLQ scale mean value was substantiated by the student responses in the interviews indicating the students were compelled to use diverse study locations and increased study time. The total amount of time studied for the lecture-based course increased by a factor of two compared to the self-study course, with most of that increase found in a shift to the home environment for study. The need for increased focus on time and study environment was driven by the compressed presentation schedule of the Operating Systems lessons and the delivery of unfamiliar material in those lessons.

The presentation of new material also accounted for an increase in the perceived value of the lecture-based course compared to the self-study course. The mean value for the task value scale in the lecture-based MSLQ experienced a significant increase over that same value in the self-study MSLQ. This increase in task value was supported by student comments indicating that they believed the information presented in the Operating Systems course would be useful later in their careers.

The use of rehearsal learning strategies was significantly higher in the lecture-based course than in the self-study course. Interview comments revealed that the students evaluated the large amount of material presented in the Operating Systems lessons, then implemented strategies to absorb as much of that material as possible in a short period of time.

The students implemented a shift in their behaviors from the self-study course to the lecture-based course. That shift was observed in their study schedules, study locations, and learning strategies, and was driven by the change in the learning scenario from an autonomous self-study program to a strenuous lecture-based program. The ability of the students to recognize and implement those changes in their learning behaviors is indicative of learners who utilize effective self-regulation.

Student Behavior Viewed from the Perspective of the Literature

The strength of the self-regulation characteristics of the students is supported by the literature used to develop this study. Returning to Rheinburg, Vollmeyer, and Rollett (2000), who describe self-regulated learning as "intentional and deliberate learning activities that are free from external guidance and control" (p.524), the students in the self-study and the lecture-based courses were certainly guiding their own performance. While the lecture-based course provided some rather difficult constraints, the students were still able to exercise the control of the processes that Zimmerman (1994) presented as the definition for self-regulation.

As predicted by Zimmerman (2000), in their first encounters with the lesson material in both of the initial training courses, the students evaluated the difficulty of that material and, with consideration for the time available for study, established goals for learning the material. Prior experiences of the students served as critical mediators in the identification of suitable goals (Zimmerman, 2000). Their previous experience with some topics in the Engineering Fundamentals course allowed some students to reduce the time spent on those topics, whereas engagement with unfamiliar topics prompted some students to change the location and duration of their studies. In the Operating Systems course, the density of the lesson presentation not only drove the students to change the location and duration of studies, but also caused a shift in the selection of learning strategies.

The change in learning strategies produced a change in self-monitoring during the performance phase (Zimmerman, 1994) for the students in the lecture-based course. The rehearsal learning strategy was the dominant strategy used by those students, with heavy emphasis on the objectives for the lessons. Those objectives were not only used to establish the learning goals, but were also used to monitor the progress of the learning.

In both the self-study Engineering Fundamentals course and the lecture-based Operating Systems course, the students evaluated their performance on the first examination to make adjustments to their study behaviors and goals. This self-reflection is a critical component for promoting the success of future efforts (Vancouver, 2000, Demetriou, 2000).

Trawick and Corno (1995) identified four predominant self-regulation strategies used by a group of community college students: (a) control of the learning environment, (b) control of the influence of other people, (c) self-monitoring, and (d) control of motivation. The students in the Engineering Fundamentals and Operating Systems courses neatly utilized three of those strategies. Their control of the learning environment was evident in their selection of study locations using criteria that had been successfully used in the past, such as: (a) the comfort of the environment, (b) the accessibility to study materials, and (c) the presence of distracting influences. By seeking study environments that avoided distractions from other people, the students also demonstrated control of the influence of other people. Similarly, by engaging peers in study groups, or by seeking peer assistance when the lesson material became difficult, the students extended their control of the influence of other people as a constructive tool. Their use of the objectives as measures to gauge their knowledge of the lesson material was an example of self-monitoring. While no specific examples of their control of motivations were identified, the students were, nevertheless, highly motivated at varying levels of extrinsic and intrinsic motivation.

Applications for the Conclusions

The prominence of the role played by self-regulation in the student behaviors in the Engineering Fundamentals course and the Operating Systems course hints at some course revisions that may enhance the learning experience for the students in the two courses. Two key recommendations for revisions to the training programs include: (a) eliminate the duplication of the engineering undergraduate material in the Engineering Fundamentals course, and (b) relax the pace of the Operating Systems course.

The duplication of engineering undergraduate material in the Engineering Fundamentals course received conflicting views from the students. While some used the opportunity to gauge their knowledge of previously-learned material, and others used the opportunity to relax their studies, requiring all students to complete all of the self-study materials was still viewed as unnecessary by most students. The lessons could be revised to include more nuclear plant-specific applications for the material, but that would further widen the comfort-gap for the students who were experiencing the material for the first time.

A more effective solution, certainly from the perspectives of cost and motivation, would be to exempt students from the requirements to complete self-study topics they had successfully studied in college. According to the Institute of Nuclear Power Operations (2002), if a student already has the knowledge required by the learning objectives for a training course, then the student can receive an exemption from that course. The burden is on the electric utility to justify the reason for that exemption. The Institute of Nuclear Power Operations concurs with the exemption from specific topics in the Engineering Fundamentals course based on successful completion of related undergraduate engineering courses.

Considering the self-regulatory nature of the engineering students, the potential for exemption from participation in some Engineering Fundamentals topics will likely increase the perceived value for the topics that must be studied, because the review of previously-learned material will no longer detract from the overall Engineering Fundamentals experience.

The Operating Systems course presented a challenge to the self-regulated engineering students by requiring them to implement less-effective learning strategies to allow coverage of all of their study materials in a limited time. The obvious solution to this dilemma is to provide more time for study. Extending the duration of the course by one week, without changing the course content, will provide almost forty hours of additional study time for the duration of the course. Some of that time could be devoted to classroom discussions, peer group studies, or plant visits to provide for more diverse and interactive learning experiences.

Comments from the students pointed to the lesson objectives as a critical influence on the motivations and learning strategies used by the students in both courses. The objectives are primarily of a declarative nature, and do not promote the analysis or synthesis of the material that is presented. The use of the those objectives was spawned from the early days of the nuclear industry when the utilities and the federal regulators wanted an efficient, consistent method for ensuring the students learned the material presented in the classroom. This was primarily driven by the examinations for the reactor operators, who were examined by the Nuclear Regulatory Commission. For the self-regulated learners in the initial engineering training programs, revision of those objectives to allow more creative learning scenarios will encourage those students to adopt more creative learning strategies.

One aspect of both courses should continue: the strong support of the supervisors for the learning activities of the students. Some supervisors adjusted work schedules of the students to allow the students to leave work to study at home, while other supervisors provided incentives for exemplary student performance on the examinations. Comments from the students indicated that the actions of their supervisors generally increased their desire to perform well on the examinations and provided the students with the autonomy to control their own learning.

Potentially Confounding Factors

The lesson material presented in the self-study course was substantially different from the lesson material presented in the lecture-based course. The differences in the material obviously drove some of the differences in the motivations and learning strategies used by the students in the two courses. A more accurate evaluation of the effect of the instructional delivery method on the motivations and learning strategies of the students could have been performed by presenting the same lesson material in both the self-study and the lecture-based course, thereby eliminating the influence of the lesson material.

Some of the self-study Engineering Fundamentals topics covered lesson material that was part of the undergraduate engineering curriculum. Students from each engineering discipline, whether, mechanical, electrical, civil, nuclear, or chemical, had various levels of knowledge of the various topics in the Engineering Fundamentals course. These differences were not consistent across disciplines or across the topics, as each student brought their personal experiences from the undergraduate curriculum to the Engineering Fundamentals course. These differences affected the student approaches to learning in the self-study course in multiple, diverse ways.

For some, the material that was a review of undergraduate material was boring, for others, the review material was an opportunity to gauge the effectiveness of their undergraduate learning. In the case of the material that was new, some students felt it to be challenging, other students were intimidated by the material, and some students, having chosen careers in other engineering disciplines, considered the material to be unnecessary to their success in their new jobs. Those diverse perspectives clearly could have influenced the student behaviors that were being evaluated in this study.

Recommendations for Future Research

An obvious recommendation for future research can be derived from the confounding factors. A future study should be implemented that compares student performance, motivations, and learning strategies in two courses that use different instructional delivery methods for the same course material. Such a study is possible in the nuclear industry, because the Engineering Fundamentals topics are common to all nuclear electric generating facilities in the United States. Some facilities use the self-study delivery method, while others use the lecture-based delivery method. The nuclear industry is quite interested in achieving a cost-effective, yet instructionally-effective format for the Engineering Fundamentals, and has funded an effort by a peer agency to develop computer-based delivery modules for each of the Engineering Fundamentals topics.

Considering that the participants in this study were all graduates of collegiate engineering programs, the finding of their strong self-regulatory characteristics may not be surprising to some educators. Studies of goal orientation and self-regulation in learners in primary schools, secondary schools, and higher education institutions have been numerous, but those studies have not been extended in the world of adult learners (Pintrich, 2000). With that consideration, coupled with the recognition that the students in this current study were a somewhat tailored group, future studies should include adult learners having other educational backgrounds.

Again, the nuclear industry could provide fertile ground for such studies, because initial training programs are presented to new employees in diverse fields, such as mechanical maintenance, electrical maintenance, and chemistry. Those adult learners bring varied educational experience to their new training environments, ranging from learners who have not completed their high school education to learners who have graduate degrees. Coincidentally, the nuclear industry has launched an initiative to deliver basic nuclear worker training to all personnel working in the nuclear plants using a computer-based delivery method. For students who have little or no computer experience, the new instructional delivery method has proved to be problematic.

Validation of the MSLQ

The validation of the MSLQ utilized a multi-faceted approach that included qualitative feedback from the students, calculation of the reliabilities for the scales, and calculation of inter-item correlations for the items. Particular attention was provided to the inter-item correlations for the revised items and to the reliabilities for the scales containing those revised items.

One aspect of the validation was performed by requesting that the study participants record any concerns or uncertainties they may have regarding any of the MSLQ items. Those items identified by the participants were reviewed to determine if the concerns exerted an adverse effect on the scoring for those items.

An opportunity emerged during the interviews for qualitative validation of the MSLQ data. Some student responses during the interviews provided clear linkage to the MSLQ scales of intrinsic goal orientation, extrinsic goal orientation, and task value, so the interview comments were compared to the MSLQ responses for those students to determine if their perceptions of their motivations were consistent with the data in the MSLQ.

Despite the small number of participants in the study, N = 91, the validation of the changes to the MSLQ produced insightful results.

Quantitative Validation of the Self-study MSLQ

The overall reliability of 0.918 for the eighty-one item revised MSLQ presented to the students in the self-study course was quite sound, with most of the scales producing rather impressive Cronbach's alpha coefficients. As shown in Tables 2 and 3, thirteen of the fifteen MSLQ scales had reliabilities of 0.671 to 0.937. The elaboration scale had the lowest Cronbach's alpha coefficient of 0.617, followed closely by the help seeking scale with Cronbach's alpha of 0.619. Neither the elaboration scale nor the help seeking scale contained any of the four items that were revised for this presentation of the MSLQ.

The intrinsic goal orientation scale contained one of the items that was revised for the engineers; item 24, which was revised to read: "When I have the opportunity in this class, I choose reading materials that I can learn from, even if they don't guarantee a good grade." That item exhibited consistent, although low, inter-item correlation with the other items in the scale, and contributed to the comparably low overall reliability of the intrinsic goal orientation scale 0f 0.671. Two students also noted concerns with item 24 via the qualitative feedback process, indicating that they are provided reading materials for the course and did not feel that other reading materials were necessary. That logic should have prompted those students to score that item at a lower value, detracting from the measure intended for that item. Excluding item 24 from the analysis of the intrinsic goal orientation scale: (a) increased the scale mean from 5.170 to 5.453, increased the reliability from 0.671 to 0.756, and (c) decreased the variance from 0.475 to 0.231. From those indicators, item 24 may warrant further revision if used in the evaluation of a similar program in the future. For the purposes of this current study, item 24 did not present a challenge to the results and was retained in the final analysis.

The other items that were revised for this use of the MSLQ in a self-study program produced satisfactory results.

Quantitative Validation of the Lecture-based MSLQ

Validation of the lecture-based MSLQ was conducted in the same fashion as the validation of the self-study MSLQ. The overall reliability for the eighty-one items in the lecture-based MSLQ was 0.897, with twelve of the fifteen items exhibiting sound Cronbach's alphas, ranging from 0.696 to 0.917. The lowest reliability, 0.526, was identified for the effort regulation. The extrinsic goal orientation scale produced a Cronbach's alpha coefficient of 0.630, followed by the help seeking scale that produced a Cronbach's alpha of 0.640.

The lower reliability for the effort regulation scale was indicative of the generally lower correlations between all of the items in the effort regulation scale. No single item contributed to the lower reliability, and all of the items in that scale retained the original wording from the Pintrich, Smith, Garcia, and McKeachie (1991) version of the MSLQ. The Cronbach's alpha coefficient of 0.526 was not a cause for alarm.

The low inter-item correlation that was identified for item 24 in the self-study MSLQ was strengthened in the lecture-based MSLQ, lending some credence to the possibility that the assignment of reading materials in the self-study course may have contributed to a diversity of interpretations for item 24.

The extrinsic goal orientation scale contained one of the items that was revised for the engineers; that was item 11, which was revised to read: "The most important thing for me right now is improving my overall course average, so my main concern in this class is getting a good score in this course." That item exhibited strong inter-item correlation with two of the other three items in the scale. The reliability of the extrinsic goal orientation scale is likely attributable to item 13: "If I can, I want to get better grades in this class than most of the other students." That item exhibited extremely low correlation with all items in the scale, including item 11, so the comparatively lower reliability of the extrinsic goal orientation scale is attributable to item 13.

Based on the strengths of the Cronbach's alphas for the individual scales, coupled with the overall reliability of the revised MSLQ, the reliability of the revised MSLQ in the engineering training environment is acceptable.

Qualitative Validation of the MSLQ

While categorizing the student interview comments during the analysis of the interviews, clear linkage was identified between the comments and some scales of the MSLQ. The student comments were then compared to the data they provided in the MSLQs to determine if the practices described in the interviews matched the numbers obtained in the MSLQ.

The primary learning goal for one student was expressed simply as a desire to learn; grades were not important for that student, although the wife of that student was pleased with the production of high scores on the examinations. The preference for a learning goal over a performance goal was reflected in the values produced by that student on the MSLQ, where the mean values for the intrinsic goal orientation scale were substantially higher than the mean values for the extrinsic goal orientation scale in both courses.

Competition with other students was a strong motivator for some interview participants. One student remembered that competition has been a motivational factor in her studies since she had been in elementary school, where she competed with a friend by counting the number of pages read in a book. This competitive nature was revealed in her responses on the MSLQ, where the extrinsic goal orientation scale means were higher than the intrinsic goal orientation scale means for both courses. Similarly, another student established a personal goal for producing the highest grades in the class. This competitive characteristic was captured in her MSLQ, where she produced higher mean values for the extrinsic goal orientation scale than the intrinsic goal orientation scale for both the self-study and lecture-based courses. The competition extended beyond the workplace, as she wanted to score higher on the examinations than her husband, who had completed both courses one year earlier.

Interestingly, the goal orientation for another student experienced a noticeable role-reversal between the self-study and the lecture-based courses. The self-study course intrinsic goal orientation scale mean was higher than the self-study course extrinsic goal orientation scale mean. This relationship was reversed in the lecture-based course, where the extrinsic goal orientation scale mean had the maximum value of 7. That student reported that his supervisor placed no goals on the student for the self-study course other than for successful completion of the course. That same supervisor then expected that student to produce an average examination score of greater than 90 on the lecture-based examinations, and included that expectation in the Annual Performance Appraisal for the engineer. The student commented that his primary goal in the lecture-based course was to meet the expectations of the supervisor.

One student indicated he was much more willing to spend extra time studying the lecture-based course than the self-study course. This contrast was mirrored in his responses on the MSLQ, where the mean value for the task value scale was much higher for the lecture-based course than for the self-study course.

Comparison of the comments provided by the students during the interviews to the quantitative data provided by the students in the Motivated Strategies for Learning Questionnaire neatly indicated that the MSLQ scales of intrinsic goal orientation, extrinsic goal orientation, and task value accurately reflected the motivations of the students.

Conclusion

The purpose of this study was to determine if the instructional delivery method for the courses in the initial engineering training program affected the performance of the students. No significant effect on performance, as measured via examination scores, was identified. Still, three components of the motivations and learning strategies were determined to have been significantly different between the two courses: task value, rehearsal learning strategy, and time and study environment. Evaluation of those differences led to the identification of self-regulation of learning as the primary factor that governed the student performance in the two courses.

The students in the initial engineering training programs evaluated in this study were a highly-motivated group of learners who believed strongly in their potential for successful performance in the programs. Whether presented with a lesson that was predominantly a review of material they had learned in an undergraduate curriculum, or facing a barrage of lessons containing new material that had limited connection to previous material, the students adapted their study environment and study strategies to achieve success in their learning. The nuclear industry should capitalize on the capabilities of the students by providing training courses that promote the effective application of the self-regulatory behaviors of the students.

REFERENCES

Barker, J. R. & Olson, J. P. (2006). Medical students' learning strategies: Evaluation of first year changes. Retrieved November 28, 2006 from University of Mississippi Medical Center, Department of Institutional Research Web site: http://www.msstate.edu/org/MAS/ejour2.html

Blumenfeld, P. C., Soloway, E., Marx, R. W. Krajcik, J. S., Guzdial, M., & Palincsar, P. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational psychologist, 26(3&4),* 369-398.

Boekaerts, M., Pintrich, P., & Zeidner, M. (2000). Self-regulation: An introductory overview. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 1-9), San Diego, CA: Academic Press.

Brophy, J. (2005). Goal theorists should move on from performance goals. *Educational Psychologist, 40*(3), 167-176.

Chalupa, M., Chen, C., & Charles, T. (2001). An analysis of college students' motivations and learning strategies in computer courses: A cognitive view. *Delta Pi Epsilon Journal, 43(4),* 185-199.

Cole, J. S. & Denzine, G. M. (2004). "I'm not doing as well in this class as I'd like to": Exploring achievement motivation and personality. *Journal of College Reading and Learning, 34*(2), 29-44.

Covington, M. V. (2002). Rewards and intrinsic motivation. In F. Pajares & T. Urdan (Eds.), *Academic motivation of adolescents* (pp. 169-192). Greenwich, CT: Information Age Publishing.

Covington, M. V. & Teel, K. M., (1996). *Overcoming student failure: Changing motives and incentives for learning.* Washington, DC: American Psychological Association.

Creswell, J. W. (2005). Educational research: Planning, conducting, and evaluating quantitative and qualitative research. Upper Saddle River, NJ: Pearson Education.

Creswell, J. W., Plano Clark, V. L., & Garrett, A. L. (2007, April). *Methodological issues in conducting mixed methods research designs.* Paper presented at the meeting of the American Educational Research Association, Chicago, IL.

Deci, E. L. & Moller, A. C. (2005). The concept of competence: A starting place for understanding intrinsic motivation and self-determined extrinsic motivation. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 579-597). New York: Guilford.

Demetriou, A. (2000). Organization and development of self-understanding and self-regulation: Toward a general theory. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 209-251), San Diego, CA: Academic Press.

Doyle, W. (1983). Academic work. *Review of Educational Research. 53*(2), 159-199.

Dye, J. F., Schatz, I. M., Rosenberg, B. A., & Coleman, S. T. (2000). Constant comparison method: A kaleidoscope of data. The Qualitative Report, 4 (1/2).

Retrieved December 13, 2006 from: http://www.nova.edu/ssss/QR/QR4-1/dye.html

Garcia, T. & Pintrich, P. R. (1994). Regulating motivation and cognition in the classroom: The role of self-schemas and self-regulatory strategies. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 127-153). Hillsdale, NJ: Erlbaum.

Guba, E. C. & Lincoln, Y. S. (1985). *Naturalistic Inquiry*. Beverly Hills, CA: Sage Publications.

Institute of Nuclear Power Operations. (2002). *ACAD 02-002. The Objectives and Criteria for Accreditation of Training in the Nuclear Power Industry.* Atlanta, GA: Author.

Institute of Nuclear Power Operations. (2003). *ACAD 98-004, Rev. 1: Guidelines for training and qualification of engineering personnel.* Atlanta, GA: Author.

La Guardia, J. G. & Ryan, R. M. (2002). What adolescents need: A self-determination theory perspective on development within families, school, and society. In F. Pajares & T. Urdan (Eds.), *Academic motivation of adolescents* (pp. 193-219). Greenwich, CT: Information Age Publishing.

Lan, W. Y. (1998). Teaching self-monitoring in statistics. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 86-105). New York: The Guilford Press.

Mager, R. F. (1984). *Preparing instructional objectives*. Belmont, CA: Lake Publishing.

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach*. Thousand Oaks, CA: Sage Publications.

McClendon, R. C. (1996). Motivation and cognition of preservice teachers: MSLQ. *Journal of Instructional Psychology, 23,* 216-220.

Meece, J. L. (1994). The role of motivation in self-regulated learning. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 25-44). Hillsdale, NJ: Erlbaum.

Ormrod, J. E. (1999). *Human learning*. Upper Saddle River, NJ: Prentice Hall.

Patton, M. Q., (1990). *Qualitative evaluation and research methods*. (2nd ed.). Newbury Park, CA. Sage.

Pintrich, P. (1989). The dynamic interplay of student motivation and cognition in the classroom. In M. L. Maehr & C. Ames (Eds.), *Advances in motivation and achievement: Vol. 6. Motivation enhancing environments* (pp. 117-160). Stamford, CT: JAI Press.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451-502), San Diego, CA: Academic Press.

Pintrich, P. R. (2002). The role of metacognitive knowledge in learning, teaching, and assessing. *Theory Into Practice, 41*(4), 219-225.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review, 16*(4), 385-407.

Pintrich, P., Smith, D., Garcia, T., & McKeachie, W. (1991). *A manual for the use of the motivated strategies for learning questionnaire* (Technical Report 91-B-004). The Regents of the University of Michigan.

Rheinberg, F., Vollmeyer, R., & Rollett, W. (2000). Motivation and action in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 503-529), San Diego, CA: Academic Press.

Ryan, R. M. & Deci, E. L. (2001). Intrinsic and extrinsic motivations: Classic definitions and new directions. In K. M. Cauley, F. Linder, & J. H. McMillan (Eds.), *Educational psychology* (16th ed., pp. 148-155).

Schunk, D. H. & Ertmer, P. A. (2000). Self-regulation and academic learning: Self-efficacy enhancing interventions. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 631-649). San Diego, CA: Academic Press.

Shapiro, S. L. & Schwartz, G. E. (2000). The role of intention in self-regulation: Toward intentional systemic mindfulness. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 253-273), San Diego, CA: Academic Press.

Stipek, D. (2002). Good instruction is motivating. In A. Wigfield & J. Eccles (Eds.), *The development of achievement motivation* (pp. 309-332). San Diego, CA: Academic Press.

Trawick, L. & Corno, L. (1995). Expanding the volition resources of urban community college students. *New Directions for Teaching and Learning, 63,* 57-70.

Vancouver, J. B. (2000). Self-regulation in organizational settings: A tale of two paradigms. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 303-341), San Diego, CA: Academic Press.

Wigfield, A. & Tonks, S. (2002). Adolescents' expectancies for success and achievement task values during the middle and high school years.. In F. Pajares & T. Urdan (Eds.), *Academic motivation of adolescents* (pp. 53-82). Greenwich, CT: Information Age Publishing.

Zimmerman, B. J. (1994). Dimensions of academic self-regulation: A conceptual framework for education. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 3-21). Hillsdale, NJ: Erlbaum.

Zimmerman, B. J. (1998). Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instruction models. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 1-19). New York: The Guilford Press.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13-39), San Diego, CA: Academic Press.

Zimmerman, B. J. (2002). Achieving self-regulation: The trial and triumph of adolescence. In F. Pajares & T. Urdan (Eds.), *Academic motivation of adolescents* (pp. 1-27). Greenwich, CT: Information Age Publishing.

Zimmerman, B. J., Greenberg, D., & Weinstein, C. E. (1994). Self-regulating academic study time: A strategy approach. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications* (pp. 181-199). Hillsdale, NJ: Erlbaum.

Appendix A

Interview Questions

Prior to the presentation of the interview questions, each participant will be presented with the consent form. The researcher will inform the participant that the purpose of the interview is to obtain qualitative information to support the analysis of the data from the Motivated Strategies for Learning Questionnaire. The researcher will remind the participant that anonymity of the participant will be maintained in perpetuity.

Time and Study Environment

1. Please describe the study environment(s) you used for studying during the Fundamentals Course.
2. What factors influenced your choice of these study environment(s)?
3. Please describe the study environment you used for studying during the Site-specific Course.
4. What factors influenced your choice of these study environment(s)?
5. Your responses on the questionnaire indicated that you spent __ hours per week studying during the Fundamentals Course. What factors influenced the amount of time you studied?
6. Your responses on the questionnaire indicated that you spent __ hours per week studying during the Site-specific Systems Course. What factors influenced the amount of time you studied?

Goal-setting

1. What were your primary study goals in the Fundamentals Course?

2. What were your primary study goals in the Site-specific Systems Course?

3. If some study goals were different, why?

4. If some study goals were similar, why?

Learning Strategies

1. Please describe your learning strategies for the Fundamentals Course.

2. Please describe your learning strategies for the Site-specific Systems Course.

3. What are the differences in these learning strategies for the two courses?

4. Why were there differences in these learning strategies for the two courses?

Goal Orientation

1. What factors were involved in establishing goals for the Fundamentals Course?

2. What factors were involved in establishing goals for the Site-specific Sytems Course?

3. What defined success for you in the Fundamentals Course?

4. What defined success for you in the Site-specific Systems Course?

5. If some success criteria were different, why?

6. If some success criteria were similar, why?

Self-efficacy

1. What beliefs did you have regarding your potential for success in the Fundamentals Course?

2. What beliefs did you have regarding your potential for success in the Site-specific Systems Course?

3. If those beliefs were similar, why?

4. If those beliefs were different, why?

Task Value

1. What value did you place on the Fundamentals Course?

2. What value did you place on the Site-specific Systems Course?

3. If the values of the two courses were similar, why?

4. If the values of the two courses were different, why?

Appendix B

Scale and Item Statistics of the

Motivated Strategies for Learning Questionnaire

Motivation Component: Intrinsic Goal Orientation

The intrinsic goal orientation scale measures the degree to which a student engages in a task because the student is driven by desires directly associated with performance of the task, such as enjoyment of the activity or mastery of learning.

Item

1. In a class like this, I prefer course material that really challenges me so I can learn new things.

16. In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.

22. The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.

24. When I have the opportunity in this class, I choose reading materials that I can learn from even if they don't guarantee a good grade.

Table B1

Intrinsic Goal Orientation Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	5.170	5.128
Alpha	0.671	0.810
Scale Items Variance	0.475	0.513

Table B2

Intrinsic Goal Orientation Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
1	5.10	1.298	5.37	1.260
16	6.00	1.107	5.76	1.241
22	5.26	1.259	5.29	1.327
24	4.32	1.544	4.10	1.513

Motivation Component: Extrinsic Goal Orientation

The extrinsic goal orientation scale measures the degree to which a student engages in a task because the student is driven by desires indirectly associated with performance of the task, such as ego goals and external rewards.

Item

7. Getting a good grade in this class is the most satisfying thing for me right now.

11. The most important thing for me right now is improving my overall course average, so my main concern in this class is getting good test scores.

13. If I can, I want to get better grades in this class than most of the other students.

30. I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.

Table B3

Extrinsic Goal Orientation Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	5.355	5.427
Alpha	0.703	0.630
Scale Items Variance	0.150	0.097

Table B4

Extrinsic Goal Orientation Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
7	5.14	1.355	5.41	1.322
11	4.92	1.602	5.02	1.557
13	5.72	1.107	5.78	1.509
30	5.64	1.439	5.49	1.660

Value component: Task Value

The task value scale measures the student perceptions regarding the interest or usefulness of the learning activity.

Item

4. I think I will be able to use what I learn in this course in other courses.

10. It is important for me to learn the course material in this class.

17. I am very interested in the content area of this course.

23. I think the course material in this class is useful for me to learn.

26. I like the subject matter of this course.

27. Understanding the subject matter of this course is very important to me.

Table B5

Task Value Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	5.487	5.911
Alpha	0.896	0.871
Scale Items Variance	0.150	0.076

Table B6

Task Value Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
4	5.14	1.212	5.59	1.414
10	6.02	0.979	6.20	0.872
17	5.30	1.093	5.88	1.029
23	5.62	1.210	6.17	0.919
26	5.04	1.177	5.59	1.183
27	5.80	0.969	6.05	0.921

Expectancy Component: Control of Learning Beliefs

The control of learning beliefs scale measures the belief of the student that the outcomes for the learning activity will be successful if the student exerts the appropriate effort to promote that success.

Item

2. If I study in appropriate ways, then I will be able to learn the material in this course.

9. It is my own fault if I don't learn the material in this course.

18. If I try hard enough, then I will understand the course material.

25. If I don't understand the course material, it is because I didn't try hard enough.

Table B7

Control of Learning Beliefs Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	5.770	5.494
Alpha	0.716	0.747
Scale Items Variance	0.416	0.439

Table B8

Control of Learning Beliefs Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
2	6.16	1.057	5.85	1.152
9	5.72	1.526	5.34	1.493
18	6.32	0.913	6.15	0.963
25	4.88	1.745	4.63	1.639

Expectancy Component: Self-Efficacy for Learning and Performance

The self-efficacy scale measures the belief of the student in his ability to be successful in the learning activity in consideration of the skills and previous experiences of the student.

Item

5. I believe I will receive an excellent grade in this class.
6. I'm certain I can understand the most difficult material presented in the readings for this course.
12. I'm confident I can learn the basic concepts taught in this course.
15. I'm confident I can understand the most complex material presented by the instructor in this course.
20. I'm confident I can do an excellent job on the assignments and tests in this course.
21. I expect to do well in this class.
29. I'm certain I can master the skills being taught in this class.
31. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.

Table B9

Self-efficacy Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	6.080	5.710
Alpha	0.937	0.914
Scale Items Variance	0.073	0.121

Table B10

Self-efficacy Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
5	6.02	0.958	5.20	1.487
6	5.66	1.349	5.54	1.206
12	6.54	0.676	6.44	0.776
15	5.86	1.355	5.66	1.196
20	6.08	1.066	5.61	1.202
21	6.28	0.904	5.78	1.351
29	5.98	1.040	5.78	1.107
31	6.22	0.910	5.68	1.254

Affective Component: Test Anxiety

The test anxiety scale measures the level of cognitive preoccupation induced by performance anxiety while taking examinations.

Item

3. When I take a test, I think about how poorly I am doing compared to other students.

8. When I take a test, I think about other parts of the test that I can't answer.

14. When I take tests, I think of the consequences of failing.

19. I have an uneasy, upset feeling when I take an exam.

28. I feel my heart beating fast when I take an exam.

Table B11

Test Anxiety Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	3.608	3.815
Alpha	0.790	0.917
Scale Items Variance	0.588	0.447

Table B12

Test Anxiety Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
3	2.90	1.681	3.17	1.974
8	4.40	1.678	4.17	2.036
14	4.48	1.887	4.80	1.965
19	3.08	1.614	3.56	2.025
28	3.18	1.746	3.37	2.034

Cognitive and Metacognitive Strategies: Rehearsal

The rehearsal strategies scale measures the use of rote memorization strategies to engage short-term memory in the learning process.

Item

39. When I study for this class, I practice saying the material to myself over and over.
46. When studying for this course, I read my class notes and course readings over and over again.
59. I memorize key words to remind me of important concepts in this class.
72. I make lists of important items for this course and memorize the lists.

Table B13

Rehearsal Learning Strategy Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	4.540	5.226
Alpha	0.735	0.749
Scale Items Variance	0.672	0.206

Table B14

Rehearsal Learning Strategy Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
39	3.90	1.940	4.83	1.801
46	4.88	1.624	5.37	1.593
59	5.54	1.328	5.80	1.327
72	3.84	2.084	4.90	2.035

Cognitive and Metacognitive Strategies: Elaboration

The elaboration strategies scale measures the use of learning strategies intended to make connections between new information and existing information in long-term memory.

Item

53. When I study for this class, I pull together information from different sources, such as lectures, readings, and discussions.

62. I try to relate ideas in this subject to those in other courses whenever possible.

64. When reading for this class, I try to relate the material to what I already know.

67. When I study for this course, I write brief summaries of the main ideas form the readings and my class notes.

69. I try to understand the material in this class by making connections between the readings and the concepts from the lectures.

81. I try to apply ideas from course readings in other class activities such as lecture and discussion.

Table B15

Elaboration Learning Strategy Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	4.693	4.959
Alpha	0.617	0.696
Scale Items Variance	0.779	0.474

Table B16

Elaboration Learning Strategy Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
53	3.90	1.717	4.34	1.783
62	5.22	1.093	5.27	1.119
64	5.88	0.961	5.73	1.049
67	3.48	2.131	3.95	2.049
69	5.02	1.078	5.49	1.075
81	4.66	1.319	4.98	1.313

Cognitive and Metacognitive Strategies: Organization

The organization strategies scale measures the use of strategies such as outlining and webbing that identify connections among the material to be learned.

Item

32. When I study the readings for this course, I outline the material to help me organize my thoughts.
42. When I study for this course, I go through the readings and my class notes and try to find the most important ideas.
49. I make simple charts, diagrams, or tables to help me organize the course material.
63. When I study for this course, I go over my class notes and make an outline of important concepts.

Table B17

Organization Learning Strategy Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	4.055	4.573
Alpha	0.763	0.731
Scale Items Variance	1.690	0.813

Table B18

Organization Learning Strategy Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
32	3.64	2.068	4.27	2.133
42	5.98	0.892	5.88	1.229
49	3.14	2.041	3.80	1.820
63	3.46	2.111	4.34	2.045

Self-regulation Strategies: Critical Thinking

The critical thinking scale measures the use of existing knowledge to evaluate new information to make decisions regarding the validity, worth, and applicability of that information.

Item

38. I often find myself questioning things I hear or read in this course to decide if I find them convincing.

47. When a theory, interpretation, or conclusion is presented in class or in the readings, I try to decide if there is good supporting evidence.

51. I treat the course material as a starting point and try to develop my own ideas about it.

66. I try to play around with ideas of my own related to what I am learning in this course.

71. Whenever I hear or read an assertion or conclusion in this class, I think about possible alternatives.

Table B19

Critical Thinking Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	4.232	4.249
Alpha	0.800	0.868
Scale Items Variance	0.290	0.257

Table B20

Critical Thinking Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
38	3.78	1.810	4.24	1.827
47	4.80	1.400	5.05	1.396
51	3.58	1.472	3.66	1.477
66	4.32	1.504	4.05	1.746
71	4.68	1.362	4.24	1.670

Self-regulation Strategies: Metacognitive Self-regulation

The metacognitive self-regulation scale measures the extent of student use of key self-regulation processes: forethought, performance, and self-reflection.

Item

33. During class time I often miss important points because I'm thinking of other things.
36. When reading for this course, I make up questions to help focus my reading.
41. When I become confused about something I'm reading for this class, I go back and try to figure it out.
44. If course readings are difficult to understand, I change the way I read the material.
54. Before I study new course material thoroughly, I often skim it to see how it is organized.
55. I ask myself questions to make sure I understand the material I have been studying in this class.
56. I try to change the way I study in order to fit the course requirements and the instructor's teaching style.
57. I often find that I have been reading for this class but don't know what it was all about.
61. I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying for this course.
76. When studying for this course I try to determine which concepts I don't understand well.

78. When I study for this class, I set goals for myself in order to direct my activities in each study period.

79. If I get confused taking notes in class, I make sure I sort it out afterwards.

Table B21

Metacognitive Self-regulation Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	4.503	4.738
Alpha	0.721	0.784
Scale Items Variance	0.555	0.424

Table B22

Metacognitive Self-regulation Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
33	4.72	1.356	4.44	1.689
36	2.72	1.499	3.27	1.803
41	5.86	1.143	6.02	0.790
44	4.12	1.288	4.20	1.453
54	4.34	1.858	4.83	1.745
55	4.20	1.829	4.76	1.786
56	4.50	1.581	4.80	1.874
57	4.38	1.602	4.56	1.803
61	4.82	1.240	4.71	1.123
76	5.30	1.233	5.22	1.492
78	4.44	1.500	4.93	1.766
79	4.64	1.651	5.12	1.615

Self-regulation Strategies: Time and Study Environment

The time and study environment scale measures the efforts of the students to plan and schedule time for studying and to select and manage an effective environment for those studies.

Item

35. I usually study in a place where I can concentrate on my course work.

43. I make good use of my study time for this course.

52. I find it hard to stick to a study schedule.

65. I have a regular place set aside for studying.

70. I make sure that I keep up with the readings and assignments for this course.

73. I use the instructor-established study time for this class regularly.

77. I often find that I don't spend very much time on this course because of other activities.

80. I rarely find time to review my notes or readings before an exam.

Table B23

Time and Study Environment Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	4.668	5.320
Alpha	0.793	0.780
Scale Items Variance	0.589	0.244

Table B24

Time and Study Environment Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
35	5.58	1.052	6.07	0.877
43	4.92	1.496	5.41	1.322
52	4.06	1.671	4.88	1.631
65	4.72	1.841	5.17	1.548
70	5.40	1.385	5.39	1.376
73	4.10	1.717	4.68	2.055
77	3.36	1.882	5.00	1.323
80	5.20	1.512	5.95	1.378

Self-Regulation Strategies: Effort Regulation

The self-regulation scale measures the effort employed by the students to engage in learning when presented with distractions and when engaged in learning activities that have minimal interest.

Item

37. I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do.

48. I work hard to do well in this class even if I don't like what we are doing.

60. When course work is difficult, I either give up or only study the easy parts.

74. Even when course materials are dull and uninteresting, I manage to keep working until I finish.

Table B25

Effort Regulation Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	5.365	5.415
Alpha	0.716	0.526
Scale Items Variance	0.475	0.334

Table B26

Effort Regulation Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
37	4.42	1.630	4.68	1.422
48	5.72	1.179	6.05	0.947
60	6.00	1.262	5.63	1.178
74	5.32	1.406	5.29	1.209

Self-regulation Strategies: Peer Learning

The peer learning scale measures the extent of engagement of peers in support of the learning activities of the student.

Item

34. When studying for this course, I often try to explain the material to a classmate or friend.

45. I try to work with other students for this class to complete the course assignments.

50. When studying for this course, I often set aside time to discuss course material with a group of students from the class.

Table B27

Peer Learning Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	3.360	3.610
Alpha	0.871	0.592
Scale Items Variance	0.069	0.387

Table B28

Peer Learning Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
34	3.64	1.601	4.24	1.428
45	3.32	1.684	3.59	1.760
50	3.12	1.814	3.00	1.732

Self-regulation Strategies: Help Seeking

The help seeking scale measures the use of more-knowledgeable personnel to support the learning activities of the student.

Item

40. Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone.

58. I ask the instructor to clarify concepts I don't understand well.

68. When I can't understand the material in this course, I ask another student in this class for help.

75. I try to identify students in this class whom I can ask for help if necessary.

Table B29

Help Seeking Scale Comparison

Statistic	Self-study	Lecture-based
Scale Items Mean	4.280	4.604
Alpha	0.619	0.640
Scale Items Variance	0.719	0.857

Table B30

Help Seeking Item Comparison

	Self-study		Lecture-based	
Item	Mean	Standard Deviation	Mean	Standard Deviation
40	3.26	1.639	3.29	1.601
58	5.32	1.133	5.46	1.502
68	4.40	1.807	4.90	1.729
75	4.14	1.841	4.76	1.800