RELATIONSHIP OF GENERAL ABILITY, DOMAIN-SPECIFIC KNOWLEDGE, SELF-REGULATION, EPISTEMOLOGICAL BELIEFS, AND MOTIVATION TO PERFORMANCE OF PHYSICAL THERAPY STUDENTS DURING CASE-BASED LEARNING

By

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To my father
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By

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Case-based learning (CBL) is being utilized in medicine, nursing, and physical therapy educational programs as a method to improve problem solving, critical thinking, and decision making. Although the use of CBL has increased, the student characteristics that predict performance during case-based instruction have not yet been determined. To advance understanding of important predictors, the purpose of this study was to determine whether students’ cognitive ability, motivation, and self-regulation predict their performance on case-based domain-specific knowledge and critical thinking.

Participants included 135 students from two professional programs of physical therapy in Florida in the second year of a Doctor of Physical Therapy program. Prior to participating in a 16-week case-based course, students completed the Motivated Strategies for Learning Questionnaire (MSLQ), the California Critical Thinking Skills Test (CCTST), the Epistemological Belief Questionnaire, and a multiple-choice test of domain-specific knowledge. Students then analyzed 10 case studies during the course. Each case study contained knowledge questions, and four of the cases included critical
thinking questions requiring critical thinking. Then two hypotheses were tested: (a) Students’ general abilities (GPA and GRE—Verbal), prior knowledge, general critical-thinking skills, epistemological beliefs, self-regulation and motivation predict performance in case-based learning as assessed by an outcome measure of case-specific knowledge and (b) students’ general abilities (GPA and GRE—Verbal), prior knowledge, general critical-thinking skills, epistemological beliefs, self-regulation and motivation predict performance in case-based learning as assessed by an outcome measure of case-specific critical thinking.

The results of the tests of the hypotheses showed that GPA was the only predictor of case-based knowledge, and GPA, GRE—Verbal, CCTST, and the critical thinking measure of the MSLQ predicted case-based critical thinking. Self-regulation contrary to the hypothesis, did not predict case-based critical thinking. The predictors only account for a small percentage of the variance in the outcome measures suggesting that other variables may account for case- specific knowledge and case-based critical thinking. These results emphasize the need for more research and the development of more sensitive tools for measurement of the variables assessed in this study.
CHAPTER 1
INTRODUCTION

Statement of the Problem

The rapid growth of health-care knowledge and increasing need for skills of problem solving, critical thinking, and clinical decision making have created a crisis in physical therapy education. New graduates no longer have the opportunity to spend their first years of practice developing these skills under the mentorship of senior practitioners. Students in physical therapy are expected to enter the health-care profession already proficient in these skills, as well as skills of collaboration and self-regulated learning. Attention to the development of these skills escalated when the physical therapy profession raised their entry-level degree to the Doctor of Physical Therapy, a degree that requires increased autonomy in practice and increased responsibility for diagnosis. To enable graduates to assume these responsibilities, accreditation standards for physical therapy programs require that students attain problem-solving skills and that educators adopt learning activities that develop these skills as well as outcomes measures to assess their students’ achievement of these skills specific to the domain of physical therapy.

One pedagogical method that has been touted as an effective tool for developing the skills of problem solving and critical thinking is case-based teaching or case-based learning (CBL), a derivative of the problem-based learning (PBL) approach widely used in educational programs in medicine (Barrows, 1986). CBL begins with some instruction for knowledge acquisition. Cases are then given to students requiring them to think critically in applying and synthesizing their knowledge as they make clinical decisions about the case. Case-based teaching methods have been increasingly used in helping
medical students develop the skills of higher-level thinking and decision making about ambiguous problems, skills required of today's health-care professionals (Knirk, 1991). The beliefs that case studies are motivating and can transform learners into effective problem solvers and critical thinkers is widely held among educators (Shulman, 1992) as well as students (Dochy, Segers, van den Bossche, & Struyven, 2005). However, these beliefs have been challenged by research findings suggesting that students’ personal characteristics can impede their ability to learn from cases (Dutton, 2003; Ertmer, Newby, & MacDougall, 1996). To explore this problem, the purpose of this study is to determine if students’ characteristics of general ability, domain-specific knowledge, epistemological beliefs, motivation, and self-regulation skills are related to student motivation and performance in case-based learning in physical therapy.

**Factors Related to Performance During Case-Based Learning**

Although case-based learning is believed to be a promising way to promote problem solving and critical thinking, some problems may exist with this approach. After 100 years of using the case-based approach we still lack evidence that case-based methods are more effective than lecture or discussion approaches in promoting problem solving and critical thinking (Shulman, 1992). The research of Ertmer et al. (1996) suggested that some students lack motivation for case-based learning and raises questions about whether case-based instruction is the most effective way for all students to learn information and applications. Ertmer et al. found that when cases were used as an instructional method with veterinary students, some students learned better than others. Specifically, a group of 58 students in a biochemistry class in their first-year of a veterinary program completed two measures of self-regulation skills prior to beginning the course. On the basis of their performance, five students scoring high and
four students scoring low on the self-regulation measure were interviewed three times over the semester to investigate their reactions to the case-based learning in the course. In the Ertmer study, eight of the nine veterinary students reported an increase in interest, value, and motivation when case studies were used in biochemistry class. Students with high levels of self-regulation were able to maintain their motivation, interest, and value throughout the course, whereas those students rated as low self-regulating experienced lower motivation due to other academic pressures. In a similar study of case-based learning in a physical therapy program, Burnett and Pierson (1988) looked at two groups of 35 first-year students taking a problem-solving course. Although more than 75% of the students believed that the course would help them develop problem-solving skills and rational decision-making abilities, only 31% believed that the course was important. As students shifted into the second half of the course, they found that many students became unenthused, uncomfortable, and less motivated as they attempted to shift to the higher level of cognitive thinking required in problem solving.

On the basis of qualitative data, Ertmer et al. (1996) concluded that the case-based method was highly motivating for students who were high self-regulating, that is, for those students who possessed “the ability and motivation to implement, monitor, and evaluate various learning strategies for the purpose of facilitating knowledge growth” (p. 721). Students who were low in self-regulation skills experienced motivational and learning problems. Case-based learning presents students with demands that require them to regulate their own learning. That is, they must complete a variety of complex tasks including analyses of problem situations, in which they must make judgments about the relative importance of competing pieces of evidence, make decisions with
multiple alternatives, use others as resources, and project possible outcomes of proposed recommendations—skills that are generally considered part of self-regulation (Zimmerman, 1990). Consequently, self-regulation may be a critical skill required for success in case-based learning. Any attempt to explore the self-regulation strategies necessary to succeed in case-based learning must also explore the motivation and task value that students associate with authentic and real life cases. A link appears to exist between the motivation and value that is attributed to domain-specific cases and the self-regulation that is required for using skills of problem solving and critical thinking to solve a case.

Although attitudes and self-regulation have been studied in relation to case methods (Ertmer et al., 1996; Hayward & Cairns, 1998), little evidence is available regarding the relationship between self-regulation and problem solving during case-based learning. Ertmer et al. (1996) proposed that motivation (interest, task value, and efficacy) was related to the veterinary students' learning from cases. Of greatest relevance to the study proposed here, Dutton (2003), in a quantitative study of 171 occupational therapy students, investigated the relationships suggested in the qualitative study of Ertmer et al. Dutton examined the relationship of epistemological beliefs, motivation, and metacognition (self-regulation) to the students' performance in case-based courses in occupational therapy. From a path analysis of her data, Dutton found that grade point average (GPA) in prerequisite courses, the epistemological beliefs that knowledge is simple and that cases are protocols predicted students’ grades on case assignments in their classes, but motivation and metacognitive beliefs did not predict those grades. Several weaknesses in Dutton’s study may have accounted for
the failure of motivational and metacognitive variables to predict students’ performance on cases: (a) Students differed in their year in their program (Some were in the first year of their program and others were in the second year of their program, and some were undergraduates and others were master’s students. The difference in year in the program was related to differences in metacognition, motivation, and students’ scores on the outcome measure.); (b) the outcome measure of students’ performance on cases differed in different classes and, most important, (c) ceiling effects on measures may have limited the ability to detect relationships. Dochy et al. (2005), in a study of educational science, economics, and law students at various stages of their education, noted that educational phase or year had a large influence on students’ perception of CBL and outcomes and in a previous meta-analysis (Dochy, Segers, Vander Bossche, & Gijbels, 2003) found that the type of assessment and the more accurately it evaluated specific student skills, the more capable it was of ascertaining effects of CBL. The National Board of Medical Examiners (NBME) Step II exam assessed clinical knowledge rather than clinical performance and both the essay question and oral examination part of the NBME evaluated integration of knowledge rather than application. Although the previous three tests did not adequately assess problem-solving skills, other assessment tools such as the standardized patient simulations and authentic cases were classified as successfully measuring skill of the students to apply their knowledge in authentic situations. The study proposed here is designed to address these weaknesses by (a) studying students at the same point in their program, (b) using the same outcome measures for all students, and (c) the use of outcome measures that are more sensitive to student differences.
**Purpose of the Study**

The purpose of this study was to investigate the relationships of the predictor variables of general ability (GRE and GPA), domain-specific knowledge, problem solving ability, epistemological beliefs, self-regulation, and motivation for case-based methods to the outcome measures of general and specific problem solving performance and domain-specific knowledge of physical therapy students engaged in case-based learning. To study this relationship, several focus questions guide this research. What is the relationship among students’ general cognitive abilities (verbal and analytical GRE), their epistemological beliefs, motivation, and self-regulation prior to and following a course in which students analyzed 10 case studies? Do students’ general abilities, prior knowledge, epistemological beliefs, motivation, and self-regulation predict their performance in case-based learning specific to domain-specific knowledge and domain-specific problem solving performance.

**Significance of the Study for Theory**

Several studies have linked motivational variables (Angel, Duffey, & Belyea, 2000; Demarco, Hayward, & Lynch, 2002; Ertmer et al., 1996; Hayward & Cairns, 1998) and self-regulation to the optimal performance on the analyses of cases and to increases in academic performance. Links also exist between general cognitive ability, sophisticated epistemological beliefs, and academic performance (Dutton, 2003; Hofer, 1994), but there is inadequate development of theory about the interrelationships of motivation, self-regulation, and epistemological beliefs to problem solving performance when using case-based instruction. Identifying predictors of prior ability, epistemological beliefs, motivational constructs, self-regulation, and problem-solving performance when using case studies will provide a basis for conducting experimental research in this area.
Many of these relationships have not been clearly identified due to some critical flaws in the research. Weaknesses in the research include comparison of students at different stages of their respective programs, utilization of outcome measures not sensitive or specific enough to detect differences in student self-regulation, problem-solving, and performance outcomes, and lack of utilization of the same outcome measure across classes. Addressing these weaknesses could provide the basis for development of studies in which factors related to problem-solving performance are enhanced for the purpose of increasing students’ ability to learn from case-based instruction.

**Significance of the Study for Practice**

With the increasing movement to adopt case-based instruction in professional education programs, including programs in physical therapy, it is imperative that researchers identify effective instructional strategies to enable all students to develop the skills of critical thinking and problem solving necessary to benefit from case-based instruction. Research has shown that some students lack motivation for and have difficulty learning from cases. Identification of variables related to students’ performance in a course in which they complete analyses of case studies has the potential to suggest ways to increase students’ motivation for engaging in case-based learning and their performance on standardized tests of knowledge and in critical thinking skills. In this dissertation I sought evidence of such predictors. Specifically, if prior ability, skills of critical thinking, epistemological beliefs, motivation, and self-regulation are found to be related to students’ performance during case-based instruction, this information will be useful in developing experiments that can determine effective ways to improve motivation and performance in students who have lower ability, less sophisticated
epistemological beliefs, and limitations in their motivation and ability to regulate their own learning.
Critical Thinking and Problem Solving as Crucial Outcomes of Physical Therapy Programs

The practice of physical therapy has shifted tremendously over the past 30 years. Paralleling the change of practice is the change in skills necessary to effectively and efficiently manage patient care. In the past, physical therapists were the receivers and implementers of specific orders written by a physician. Currently, physical therapists receive orders from physicians to “evaluate and treat,” often unaccompanied by a formal medical diagnosis and are expected to determine a physical therapy diagnosis, prognosis, and appropriate interventions and management. Unlike a medical diagnosis, physical therapists must determine how the disease or injury affects the individual patient in regard to structural impairments, functional deficits, and impact on the person’s participation in society. Once the intervention is determined, the therapist must deliver this intervention within the scope of the patient’s individual limitations (physical, emotional, and cognitive) as well as financial limitations (cost containment). The scope of physical therapy practice has expanded to include acutely ill patients (lung and heart transplants, neonates at risk, trauma and critical care patients), those in rehabilitation who will have permanent disabilities (stroke, spinal cord, brain injury, joint replacements, degenerative or progressive diseases), patients in recovery who intend to return to their previous lifestyle (back, neck, arm and leg injuries, job-related, sports-related), and a new population of clients who seek education in wellness and health promotion. The demand for physical therapists is high and is expected to increase as the population ages, and therapists are challenged to use multiple resources, including
delegation, group treatment, and seeing several patients at the same time, to meet the high demand for services.

In response to necessary changes in educational practices to meet the needs of the entry-level practitioner, the American Physical Therapy Association (APTA, 2007) voted to change the entry-level degree to the level of doctor by the year 2020. Over 70% of the 210 programs in the United States have already made the shift from the Master of Physical Therapy (MPT) to the Doctorate of Physical Therapy (DPT). The rationale for awarding the DPT is based on at least three primary factors: (a) The level of practice inherent to the client management model in the Guide to Physical Therapist Practice (APTA, 2001) requires considerable breadth and depth in educational preparation, a breadth and depth not easily acquired within the time constraints of the typical MPT program; (b) the fully autonomous healthcare practitioner with a scope of practice consistent with the Guide to Physical Therapist Practice is expected to be a clinical doctor, and (c) the realization of the profession's goals in the coming decades, including direct access, "physician status" for reimbursement purposes, and clinical competence consistent with the preferred outcomes of evidence-based practice, will require that practitioners earn the clinical doctorate (consistent with medicine, osteopathy, dentistry, veterinary medicine, optometry, and podiatry).

Major changes in curriculum are occurring with development of the Doctorate of Physical Therapy. The number of courses devoted to evidence-based practice has increased and have been organized in ways to review the available literature for best practice. The addition of courses dedicated entirely to diagnostic imaging (radiology, MRI), pharmacology, and differential diagnosis demonstrate the expectations for
increased responsibility of the physical therapist as a diagnostician. The addition of 8 to 20 additional weeks of clinical experience provides additional practice with patients. Courses devoted to health promotion, wellness, and community service address the rising need for physical therapy for prevention. Business administration, billing, and marketing have been added to health care management curricula to better prepare graduates to supervise and direct clinical services.

Three of the major skills that underlie all information, concepts, and theories presented in physical therapy education are critical thinking, problem solving, and clinical reasoning. The term critical thinking is used in many disciplines to describe the inductive and deductive reasoning processes that form the basis of decision making. Critical thinking has been related to clinical decision making and clinical judgment in health profession education as a component of clinical reasoning. Professional education in physical therapy focuses on the development of clinical decision making skills. Critical thinking has been identified as one of seven factors in a model of professional behavior recently developed for physical therapy (Jette & Portney, 2003). It is also included in a list of 10 generic abilities developed by physical therapy educators at the University of Wisconsin—Madison (May, Morgan, Lemke, Karst, & Stone, 1995). The list includes critical thinking as a separate ability and several additional abilities that are often considered to be components of critical thinking, such as problem solving and use of constructive feedback. In many physical therapy programs these skills have been adopted as benchmarks that students must achieve prior to graduation. Development of the abilities of problem solving and critical thinking are promoted by the national organization of physical therapy, the APTA (1997), which introduced the Physical
Therapist Clinical Performance Instrument (PT CPI) that assesses 24 skills and is used by clinical instructors and physical therapy education programs to assess students’ clinical performance. Not only are students’ skills of problem solving and critical thinking explicitly rated on this instrument, but they are also implicitly assessed in more than 15 of the 24 skills.

Skills that implicitly demonstrate problem-solving and critical thinking are items such as clinical decision making within the context of ethical practice and informed consent, demonstration of ability to make decisions in ambiguous situations, and recognition of practice differences based on traditional versus scientific beliefs. After pilot work and the compilation of both national and internally generated APTA grading tools, over 1,300 instructors from over 350 sites participated in a study to obtain evidence of the validity and reliability of the Student Clinical Performance Instrument. On the basis of this work, the APTA (1997) recommended the voluntary adoption of the tool by all physical therapy programs in the U. S. The initial emphasis on problem-solving and critical thinking has not changed in updates of the document (APTA, 2004).

The Commission for the Accreditation of Physical Therapy Education (CAPTE) (APTA, 2006) has endorsed the Doctor of Physical Therapy in their new accreditation standards (APTA, 2007). The Normative Model for Physical Therapy Education (APTA, 2004) was revised to define the academic expectations as well as clinical expectations for educational programs. Physical therapy accreditation standards require that programs demonstrate that their students attain these skills, and educators are charged with identifying learning activities that develop these skills and outcomes measures related specifically to the domain of physical therapy (APTA, 2006).
Definition of Critical Thinking and Problem Solving Ability

Problem solving and critical thinking are considered two of the essential skills for the effective practice of physical therapy (APTA, 2006). The need for these skills in medical practice has been long recognized (Barrows & Tamblyn, 1980), with nursing running a close second to medicine in curriculum planning and outcomes research to develop these skills (Demarco et al., 2002). These two abilities encompass the skills of reflection, clinical judgment, and decision making. The terms problem solving, critical inquiry, and reflective decision making are used collectively to describe a process of problem solving that is combined with an underlying attitude or habit of thinking. Critical thinking refers to the ability to utilize skillful and responsible thinking as well as good judgment throughout the steps of the problem solving process. The process of problem solving includes (a) awareness of a problem, (b) development of a hypothesis or hypotheses (e.g., multiple diagnoses in physical therapy), (c) bringing knowledge and values together in a solution or test of the hypothesis, and (d) finally making a judgment that offers a solution to the problem (Kitchener, 1983). Many educators, both in and out of the medical arena (Gagné, 1985; Hayes, 1978; May & Newman, 1980) have proposed the same basic steps to problem solving as Kitchener (1983). Robertson (1996) acknowledged that the most crucial element of problem solving is problem representation, or identifying the specific problem(s) in the context of the individual client. The problem is identified as the need to achieve a goal without the knowledge of how to achieve it (Good & Brophy, 1985). Janey (1991) noted that to qualify as a problem needing critical thinking, the problem cannot be familiar; it must be novel. If the problem situation is familiar to the learner, then prior solutions may be known, and the
therapist is practicing at the higher level of practice known as *pattern recognition* rather than problem solving (Jensen & Givens, 1999).

Robertson’s (1996) medical model parallels the educational model of Gagné (1985) and Hayes (1978). In the first step of Robertson’s model, current information about the patient and the disability is integrated with information stored in long-term memory. The second step is to consider the intended outcome, which is the integration of the patient’s goals, the realistic constraints and recovery from the disease or injury, while also considering patient age and medical history. To consider possible actions and solutions, the student must be able to develop a number of plausible actions or solution paths. Consideration of restrictions, such as funding, patient priorities, and time constraints, will limit options. Only after students have limited the problem options are they able to use a combination of prior knowledge and decision making to choose the solution that has the least risk and most benefit (best evidence) for the patient.

According to Robertson (1996), effective problem-solving requires the underlying use of the ability to think critically. The student must raise relevant questions and critique solutions without necessarily posing solutions. The analyses required in critical thinking call for the student to observe, infer, draw relationships, and integrate information. Problem solving in nursing education is complicated by complex relationships between different cognitive processes. Robertson identified four key components that must occur with critical thinking: (a) assumptions are identified, (b) assumptions are challenged, (c) the context of the problem is recognized, and (d) all alternatives are explored. May (1983), an educator in one of the first problem-based learning programs in physical therapy in the U. S, defined critical thinking as “the ability
to question logically; to identify, generate, and evaluate elements of logical argument; to recognize and differentiate facts, illusions, assumptions, and hidden assumptions, and to distinguish the relevant from the irrelevant” (p. 807).

Problem solving may be the simple application of a heuristic or algorithm. Critical thinking is decidedly different because it requires judgment and the use of values. Paul (1985) criticized approaches that treat critical thinking as a discrete set of technical skills without values and consequences. Paul suggested that there are two stages of critical thinking, the first involving the logical analytical thinking skills, such as recognizing assumptions and evaluating arguments, that we associate with standardized tools like the Watson Glaser (as cited in McMillan, 1987, p. 11). The second stage that Paul described is most similar to Perry’s (1970) higher stage of commitment in which the student uses the opinions of others in a specific context to develop a personal construct of meaning.

One of the most commonly used heuristics for developing critical thinking and problem solving in physical therapy is the Hypothesis Oriented Algorithm for Clinicians (HOAC) first proposed by Rothstein and Echternach (1986). The algorithm contains eight logically sequenced steps: (a) collect initial data,(b) generate a list of problems identified by the patient,(c) formulate an examination strategy,(d) conduct the examination and analyze the data, (e) generate hypotheses about why each problem exists, (f) for each problem identify goals and testing criteria, (g) establish a plan to reassess testing and predictive criteria and establish a plan to assess problems and goals, and (h) plan intervention strategies and tactics. Although each step appears to follow a logical and straightforward progression, each one includes underlying critical
thinking processes. Take for example the step of formulating an examination strategy. This step does not mean the student or clinician is to follow a preset list of tests and measures identified as appropriate for the injury or pathology as in the APTA Guide to PT Practice (APTA, 2001), rather it requires that each examination procedure is justified on the basis of previously determined hypotheses about the patient’s primary problem. The tests are organized to confirm or refute the hypotheses in the most efficient manner. The student or clinician must suspend judgment, resisting a rush to the quickest solution, raise relevant questions during the examination process, and add or remove testing measures as results are collected. The process is not quick and immediate but rather requires reflective thought that occurs while the patient is awaiting a diagnosis and prognosis from the therapist. Jensen and Givens (1999) identified critical thinking or clinical reasoning as an internal dialogue that involves problem-solving strategies that are individualized, contextualized, and sometimes both conscious and unconscious. They concluded that this reasoning process embraces many of the elements of self-regulation.

**Case-Based Methods as a Means to Develop Critical Thinking and Problem Solving**

The case method involves a process of studying a problem situation that requires students to participate in real or hypothetical problem situations, reflecting the kind of experiences naturally encountered in the discipline under study. According to Meyers and Jones (1993), a case study “is a narrative of an actual event that brings students and teachers together in an attempt to examine, discuss, and advance solutions to a realistic problem situation” (p. 24). The problem tends to be more vivid and contextual, similar to real-life situations than textbook presentations, and it reflects a more
disciplined and more manageable piece of reality than actually doing the work (Shulman, 1992). Because case studies are constructed to have more than one viable solution (Christensen, 1987), they present students with ambiguity. As Ertmer and Russell (1995) noted, “cases, like practice, are ambiguous, messy, and recalcitrant. They rarely have one correct answer. They are ideal for inducting the novice into a work of practice characterized by unpredictability, uncertainty, judgment” (p. 25).

In the literature on teacher education, cases are described as a vehicle for stimulating reflection among novices who are learning to become problem solvers within a profession (Shulman, 1992). Cases are advocated as powerful in that they require the use of both practical and theoretical knowledge, bridging the theory-to-practice gap, and encourage the application of professional judgment and decision making, providing opportunities for the novice to reflect on a variety of situations and analyze and solve dilemmas characteristic of their profession. Case-based methods make a variety of demands on students that differ from other instructional approaches, requiring in particular the skill of executing the problem solving steps combined with the skill and attitudes required in critical thinking. Case-based learning may require individual or group analyses of problematic situations. Case-based learning requires judgments about the relative weight of competing pieces of evidence, decisions about multiple alternatives, involvement of others as resources, and projections of possible outcomes based on constraints and attributes of the problem (Ertmer et al., 1996). Case-based learning requires students to use strategic thinking skills to integrate knowledge and to engage in self-regulation by assessing their own learning, identifying any additional learning that might be necessary and developing research competency. The patient
problems used in case-based learning are multifaceted, do not lead to one right answer, require analysis and reflection, and therefore should be a good way to develop the skills needed by an independent practitioner.

In summary, case-based learning requires the motivation, skills, behaviors, and attitudes that characterize problem solving and critical thinking. They require the students to regulate and evaluate their ability to competently address the problem, make corrections, and ask for assistance when necessary. Blumenfeld et al. (1991) identified three personal characteristics students need for successful case-based learning: (a) interest in and valuing of the case, (b) a perception of competence to complete the case, and (c) a focus on the learning process rather than on the outcome (e.g., grades).

The problem-solving processes and underlying attitude of critical thinking must be practiced within specific domains of knowledge for this ability to increase (Alexander, White, Haensly, & Crimmins-Jeanes, 1987). Transfer of problem solving skills to specific domains has been unsuccessful unless accompanied with practice in the specific domain (Lohman, 1983). Physical therapy knowledge is unique in that it includes specific pathology, age-related changes, and their impact on functional movement. Relationships among impairments, functional limitations, and disabilities of the specific disease and its impact on the individual patient must be correlated with individualized goals for each patient. Scientific research of outcomes provides realistic goals that must be modified within the constraints of realistic treatment, available finances, personal values, ethics, and legal considerations. Because the physical therapist’s decisions
affect quality of life, a sound basis of current knowledge must be present before effective reflection and decision making can occur.

**Case-Based Methods: A Historical Overview**

For over 100 years, case-based methods have been used in conjunction with traditional lecture methods to link clinical applications and classroom didactic material. In 1965, McMaster University became the first medical school to adopt an entirely case-based curriculum. This new program was referred to as a problem based learning (PBL) curriculum (Hayward & Cairns, 1998). Case-based learning, a derivative of problem-based learning (PBL), seems to be well suited to help students develop the essential skills of problem solving and critical thinking. Dissatisfied with outcomes from traditional lecture formats, medical schools initially started the use of case studies in problem-based learning educational programs as early as 1950, and its popularity as a teaching methodology was reinforced when adopted by Harvard Medical School in 1980. PBL programs or hybrids now constitute approximately 70% of the teaching formats in medical schools (Morris, 2003). It is believed that clinical teaching and reasoning with cases can help students become reflective practitioners who critically analyze and reassess interventions in a systematic manner and it is believed that reflection on thoroughness, multiplicity of possible outcomes, and individual case characteristics can engage metacognitive strategies and result in self-regulation of learning (i.e., the ability to implement, monitor, and evaluate learning strategies for the purpose of facilitating knowledge growth). Motivation can also be enhanced by similarity of authentic cases to actual practice. Although case-based learning was initially developed for use in medicine (Barrows & Tamblyn, as cited in Morris, 1980), the desirable attributes of problem-solving, lifelong learning, and self-directed learning are the same skills required
of all health professionals. Since the 1990s, with the increased responsibility of nurses, physical therapists, and occupational therapists, this teaching method, in varying formats, has been increasingly used in the allied health professions. As Tichenor, Davidson, and Jensen (1995) concluded,

> rapid changes in today's health care environment, in response to new science and external influences, can lead to a practitioner's knowledge quickly becoming obsolete. There is a compelling need to educate professionals to become lifelong learners, willing to seek and critically evaluate new information, and to apply new knowledge in problem solving with the decision making process. (p. 57)

Numerous studies have been conducted to determine the positive outcomes of various case-based learning interventions. Tavakol and Reicherter (2003) analyzed the foundational principles and educational models underlying over 75 studies using case-based learning published since 1980 in the allied health professions. They concluded that overall students who used CBL were more capable of determining their own learning needs (self-regulating) and were more satisfied and motivated to learn. When Demarco et al. (2002) interviewed 7 of the 35 students in a senior nursing Managing and Leading course, they found that they all reported that cases helped them develop skills of critical thinking, problem solving, prioritization, and working with others. The nursing students in their study demonstrated both intrinsic and extrinsic motivation, claiming that the cases were real world, relevant, and stimulated interest and self-directed learning. These findings were similar to those of Hayward and Cairns (1988) who found that physical therapy students reported that case-based instruction stimulated critical thinking, clinical thinking, and self-directed learning. When the faculty of the School of Nursing at the University of Wisconsin, Oshkosh, chose the case method as a method to ensure that all students had exposure to a variety of similar
patient situations, they cited positive outcomes as opportunities to develop analytical abilities, problem-solving, and the identification of a multiplicity of viable outcomes (Johnson & Purvis, 1987).

But case-based learning does not result in positive outcomes for everyone. Student satisfaction, increased motivation, increased self-regulation, and increased problem-solving performance have been cited as positive outcomes for some students, but many questions have not been addressed about how this method of teaching affects the individual learner. We do know that many students are uncomfortable with this teaching method and may not persist and maintain motivation to achieve positive outcomes. Despite enthusiasm for case-based learning, Biley (as cited in DeMarco et al., 1999) found that some nursing students reported that they experienced significant tension with PBL. In an interview study of eight students (Hayward & Cairns, 1998), one student preferred lectures to case study and three reported increased stress and anxiety with case-based learning.

Few quantitative data are available about student characteristics associated with case-based learning. Ertmer et al. (1996) and Hayward and Cairns (1998) examined student attitudes and self-regulation in relation to case-based learning in qualitative studies, but quantitative research on the relationships of self-regulation and motivation to performance in problem solving and critical thinking is lacking. The findings of Ertmer et al. suggested that students who are low in self-regulation skills may experience motivational and learning problems with case-based instructional methods. On the basis of their qualitative data, Ertmer et al. proposed that self-regulation is related to the motivational outcomes of interest, task value, and perceived self-efficacy, and research
on motivation has consistently demonstrated a relationship between motivation and learning (Pintrich & DeGroot, 1990). The question of the relationship between motivation and problem-solving still remains.

**Self-Regulation Abilities Necessary for Case-Based Learning**

Zimmerman (1990) defined academic self-regulation as the degree to which individuals are metacognitively, motivationally, and behaviorally active participants in their own learning process. Although self-regulation theory is not a unified perspective, a growing body of research suggests optimal academic performance is tied to the degree of self-regulation that the learner is capable of exercising, especially at the college level (Zimmerman, 1990). Whether researchers hold a social-cognitive, social-cultural, or information processing orientation to self-regulation, the consensus is that self-regulated learners are purposive and goal oriented, incorporating and applying a variety of strategic metacognitive behaviors. Metacognitive strategies include activities such as attending to instruction, processing and integrating knowledge, and rehearsing information. The employment of these activities is based on the individuals’ beliefs concerning their capabilities for learning. Self-regulated learning is the highest level of cognitive engagement that students can use to learn. It involves a systematic effort by students to develop a meaningful understanding of academic material by setting learning goals, planning strategies to achieve those goals, and monitoring their progress.

Research has shown that self-regulation skills enhance learning in a wide range of instructional approaches (Linder & Harris, 1992; Weinstein, Goetz, & Alexander, 1988; Zimmerman, 1990), but these skills seem to be especially important to the success of case-based learning because students need self-regulatory strategies to deal with the
epistemological shift from seeking one right answer to proposing and evaluating multiple possible solutions that are associated with case-based learning. Problem-solving and critical thinking pose many challenges to students’ affective and cognitive processes. Students may find reflective thought and higher-order thinking frustrating because they must resist the tendency to impulsively choose the first answer that occurs to them, and they must deal with the ambiguity of the possibility of more than one correct answer (Robertson, 1996). Students may rush to the first viable solution and not consider important elements of the problem, if they lack sufficient motivation, interest, and desire to learn the process of problem solving. Student must use self-regulation skills to help them monitor and control their behavior in light of uncertainty and possible anxiety. Self-regulation has been proposed as the skill that allows students to persist and develop the skills of problem solving and critical thinking (Zimmerman, 1994). On the basis of course evaluations and observational analysis, Burnett and Pierson (1988) concluded that students who are more successful in controlling their behavior by exerting independent decision-making and exerting effort were more likely to use effective cognitive strategies in analyzing case studies.

In sum, research has shown that self-regulated learners are intrinsically motivated, self-directed, self-monitoring, and self-evaluating (Zimmerman, 1994). They attempt to control their behavior, motivation and affect, and cognition to achieve their goals. Using self-regulatory skills, they take active control of the resources available to them. They control their time, their study environment, and the use of peers and faculty for assistance, and they control and change their motivational beliefs as well as their use of metacognitive strategies for learning as needed.
Motivational Characteristics Necessary for Case-Based Learning

In addition to self-regulation, Blumenfeld et al. (1991) identified student interest and valuing of the task, perception of competence, and a focus on the underlying process of problem-solving (as opposed to product or grade) as the four critical factors necessary for successful case-based learning. Belief in one’s competence and the value and relevance of the task are all components of motivation. Research has shown that most students find case studies interesting and motivating and praise them for their authenticity, relevance, and value (Burnett & Pierson, 1989; Ertmer et al., 1996; Hayward & Cairns, 1998; Slaughter, Brown, Gardner, & Perritt, 1999). For example, 70% of the students in Burnett and Pierson’s (1988) study reported that case studies were more interesting than traditional academic work and that cases helped in developing their problem solving and decision making skills in physical therapy. Although Slaughter et al. did not find any differences in critical thinking scores as a result of case-based learning, students did comment that the heuristics they used were of value and allowed them to think in a “more logical and orderly fashion” (p. 444).

Senior nursing students using cases (Demarco et al., 2002) reported that the cases were real world, relevant, and stimulated their interest and self-directed learning. Ertmer et al. studied the effect of case-based learning on veterinary students and presented evidence that the case-based method was more motivating for some students, than traditional methods, especially for students with high self-regulation.

Motivational attitudes will only affect performance if they are linked to greater use of metacognitive strategies (Pintrich, Smith, Garcia, & McKeachie, 1993). The idea that cognitive processes can be influenced by students’ motivational beliefs is not new. Piaget (1972) proposed that affect (especially interest) provides the incentive for action.
Pintrich et al. were interested in how the three components of self-regulation (metacognitive activity, cognitive strategy use, and effort) were related to student (intrinsic) motivation and interest. With a sample of 173 seventh-grade students from eight science and seven English classrooms, they obtained correlations between motivational orientation, self-regulated learning, and classroom academic performance. Although intrinsic value was not directly related to performance, it was strongly related to self-regulation ($r = .73$) and cognitive strategy use ($r = .63$).

Beliefs in personal control are also an essential part of the perception of the intrinsically motivated learner. Pintrich et al. (1993) found that positive internal control beliefs were related to deeper processing of information and lab performance in college students. Student perceptions of how much control they have over a situation may affect their level of learning as well as their willingness to try to master the material. It has been proposed that the environment of case-based learning allows students the control to work on what they choose, how they want to do it, to be involved in deeper levels of engagement, and to be creative in their solutions (Pintrich et al., 1993). Research has linked greater intrinsic motivation to increased use of self-regulation skills (Ertmer et al., 1996). Intrinsic motivation and mastery goals focus on understanding, use of deeper processing strategies, and require more self-regulation. In contrast, extrinsic goals (usually grade or performance oriented) lead to a greater focus on memorization of facts and shallow processing of information. Students with intrinsic motivation are determined to master the information and to understand the process and therefore are more willing to continue to practice and study in the absence of direct control by teachers and parents (Schunk & Zimmerman, 1994).
Summary

Considerable evidence has indicated a relationship between the motivation and value that students bring to analyses of domain-specific cases and the self-regulation that is required for using skills of problem solving and critical thinking to effectively solve a case. Students’ self-reports have suggested that interest, value, and motivation are increased with the use of case studies, and it has been established that there is a strong relationship between motivational constructs and self-regulation (Pintrich et al., 1993). Although attitudes and self-regulation have been studied in relation to case methods (Ertmer et al., 1996; Hayward & Cairns, 1998), research of the relationships between self-regulation and actual outcomes (performance) of problem solving is lacking. In addition to lack of empirical research on the correlation of self-regulation with problem solving outcomes, some evidence suggests that case-based methods may not be the best instructional method for all students. Qualitative research by Ertmer et al. suggested that students who are low in self-regulation skills may experience motivational and learning problems with case-based instructional methods. Although three out of four of the students with low self-regulation in this study stated that they gained confidence and began to see the relevance of the case-based instruction; however, by the end of the semester their motivation and confidence decreased as other pressures overcame them. Despite the enthusiasm and interest that nursing students demonstrated in working with cases (Demarco et al., 2002), several transcripted interviews suggest that anxiety was associated with completing the cases. Ertmer et al. (1996) proposed that self-regulation is related to motivational constructs.
(interest, valuing of the task, and efficacy beliefs) and motivational research has demonstrated a relationship between motivation and learning.

**Epistemological Beliefs and Case-Based Learning**

Epistemological beliefs, that is, the individual’s beliefs about the nature of knowing, may influence learning from cases. Kuhn (1999) proposed that to explore critical thinking and problem solving in a more developmental manner, it is necessary to clarify metaknowing, which includes three categories: (a) metacognition—What do I know and how do I know it? (b) metastrategies—the knowledge of procedures or strategies for knowing that can be used to employ and select strategies for knowing, and (c) epistemological beliefs—What is it I know about my knowing? She proposed that these metastrategies are critical because of their potential effect on the employment of metacognitive knowing and metastrategic strategies. Understanding the nature of knowledge may be the most fundamental basis for critical thinking as students must understand what knowing is if they are to be motivated to engage in it and to regulate strategies for knowing.

Although the development of epistemological beliefs has been studied since the early ‘70s, the investigation of relations between students’ epistemological beliefs and their cognition and learning is relatively new (Hofer & Pintrich, 1997; Schommer, 1994). Perry (1970) was the first to suggest that students’ beliefs about knowledge and knowing might fit into a developmental scheme. Interested in how students in a university setting make sense of their educational experiences, he developed a checklist of educational values based on the premise that personality is the factor responsible for varied student responses. Perry administered this checklist to 313 male Harvard students and then interviewed 31 of the group. Interested in how these
students described their educational experience in their own terms, he determined that instead of personality, a hierarchical cognitive developmental process was responsible for their epistemological views. Perry went on to outline a scheme of intellectual and ethical development consisting of nine positions. Applying Piaget’s (1972) theory of cognitive development, Perry postulated that students experience cognitive disequilibrium when confronted by new experiences. To resolve the disequilibrium students either assimilate new information or accommodate it by developing more sophisticated views of knowledge. Perry’s four major stages are dualism, multiplicity, relativism, and commitment within relativism. In the dualistic stage, he proposed students characterize knowledge as right or wrong and believe that the experts know what is correct and will convey that to them. As students begin to recognize diversities of opinion and uncertainty about truth, they enter the stage of multiplicity. Students who advance to the stage of relativism believe that knowledge depends on the individual and the context, as individuals are the makers of the meanings of knowledge. The most advanced intellectual and ethical developmental stage is that of commitment with relativism. In this final stage students make a commitment to relativism focused on responsibility, values, and personal identity. Although Perry did not conduct empirical research on his developmental stages and students’ knowledge acquisition, he postulated that as students revise their understanding of knowledge, they might change their approach to seeking it.

Following Perry’s (1970) work, King and Kitchener (1994), interested in how epistemological beliefs affect thinking and reasoning, expanded Perry’s stages with a focus on reflective thinking. King and Kitchener further defined epistemological beliefs
as rules about the nature of knowledge, which includes one’s view of knowledge, right versus wrong, legitimacy of different viewpoints, and the nature of justification, which includes one’s concept of justification, use of evidence, and the role of authority in making judgments. King and Kitchener proposed that these beliefs evolve through seven qualitatively different stages subsumed by the three categories of pre-reflective, quasi-reflective, and reflective thinking. Research has indicated that higher levels of education are correlated with higher levels of judgment, and developmental spurts are correlated with college attendance (Ryan, 1984a). Ryan’s (1984b) original work in this area demonstrated change in levels of comprehension of a psychology textbook chapter associated with movement from Perry’s cognitive levels of dualism to relativism. Like Ryan, Schommer (1990) was interested in the influence of epistemological beliefs on comprehension as well as academic performance. However, unconvinced by the work of stage theorists, Schommer proposed that epistemological beliefs do not develop in fixed stages and are not unidimensional. In creating an Epistemological Belief Questionnaire (SEQ), Schommer identified five distinct beliefs that lie on continua from simple to more sophisticated: (a) knowledge is simple, (b) knowledge is certain, (c) knowledge is omniscient, (d) ability is innate, and (e) learning is quick. Schommer’s major contribution has been a pen-and-pencil method to measure epistemological beliefs as an alternative to the time consuming interview process employed in earlier research, as evident in her conclusion that, “epistemological beliefs are related to students’ persistence, active inquiry, integration of information, and coping with complex and ill-structured domains. All of these attributes are related to higher level learning” (Schommer, 1994, p. 33). Following her early research, numerous researchers have
explored the relationship of epistemological beliefs to motivation, previous achievement, self-regulated learning, and performance.

**Epistemological Beliefs and Motivation**

Kruglanski (1990) suggested that people’s motivation towards knowledge influences their information processing, knowledge, learning, and classroom life in general. He postulated that individuals act as scientists developing and testing hypotheses about knowledge and knowing as a function of both their cognitive and motivational processes. Kruglanski proposed two general dimensions of epistemological motivation. His dimension of seeking and avoiding closure consists of a continuum ranging from students who seek a quick answer to the question, thus ending hypothesis generation and testing, to students on the other end who resist premature resolution in the service of the need for accuracy in decision making. His second dimension ranges from non-specificity in which any answer will suffice, to specificity, in which the single best answer is sought. He proposed that students are not constantly developing and testing hypotheses about knowledge and knowing. Rather, students are influenced by the consequences of their educational decisions—wishing to avoid closure when the costs of being wrong are high—and by their previous knowledge—that is, students with higher levels of knowledge are more likely to already possess the answer. Kruglanski proposed that epistemological motivation may explain why more authentic tasks lead to greater cognitive activity and suggested that further empirical data be collected about student goals, cognition, and conceptual change.

Several researchers have linked epistemological beliefs to cognitive engagement and self-regulated learning in the classroom. Schutz, Pintrich, and Young (1993) had college students respond to six of Perry’s (1970) original items as either true or false.
Each item was coded as either absolutist or multiplist. Information about motivation and learning strategies was obtained with the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1993). Students with a more sophisticated perspective on knowledge and knowing adopted mastery goals and deeper processing. Hofer (1994) in an unpublished study of college students in first-year calculus found a positive correlation between sophisticated epistemological beliefs, beliefs about mathematics, intrinsic motivation, self-regulated learning, and academic performance. In summary, students who possess more sophisticated epistemological beliefs may be more intrinsically motivated to resist premature resolution of problems, more likely to adopt mastery goals and engage in the deeper processing when afforded authentic tasks.

**Epistemological Beliefs and Self-Regulated Learning**

Both Schommer (1993) and Zimmerman (1994) have suggested that epistemological beliefs may have an indirect effect on academic performance, as beliefs about knowledge may affect study strategies. These beliefs may serve as a basis for determining how students approach learning. If students believe that knowledge is simple, they do not need to use deeper processing or engage in self-regulated learning strategies. In support of this claim, Hofer (1994) found a positive correlation between more sophisticated epistemological beliefs and intrinsic motivation, self-regulation, and academic performance. Zimmerman (as cited in Braten & Stromso, 2005, p. 544), when exploring the cyclical nature of self-regulation, proposed that epistemological beliefs may function in the forethought phase of activation of personal beliefs about (a) being capable to learn, (b) performing effectively, (c) mastering the task, and (d) intrinsic
interest. Epistemological beliefs may be primary in motivating students to plan and select self-regulatory strategies to acquire and attain skill.

In a study exploring the relationship between epistemological beliefs, implicit theories of intelligence, and self-regulated learning in a Norwegian culture, Braten and Stromso (2005) demonstrated that naïve epistemological beliefs were negatively related to self-efficacy beliefs, mastery goals, study interest, and self-regulation. Braten and Stromso compared first-year college students in business administration and teacher education. Using Schommer’s SEQ and various items from the MSLQ, they found that the belief about whether knowledge is certain did not relate to any measure of motivation or self-regulation in preservice teachers but did relate significantly to all the measures of motivation completed by the business administration students. The researchers concluded that the role of epistemological beliefs in predicting motivation and self-regulation may vary depending on the academic context. They emphasized that this contextual difference may have important implications for instruction such that in some instructional settings it may be to challenge student epistemological beliefs if they are incongruent with goals of the academic context, and in other settings such intervention may be unnecessary. Given the potential importance of the epistemological belief that knowledge is certain in relationship to motivation and self-regulation, this belief was examined in this dissertation study as a predictor of knowledge and critical thinking about cases.

**Epistemological Beliefs and Performance**

Strong evidence has long existed for the impact of epistemological beliefs on performance. In a study of college undergraduates in psychology, Schommer (1990) found that the belief that learning is quick was related to oversimplified conclusions, low
scores, and overconfidence, whereas the belief that knowledge is certain was related to more inappropriate and absolute conclusions. When examining epistemological beliefs and performance with a smaller sample of the same group, Schommer found that students who held the belief that learning is quick performed poorly on the psychology mastery test due to their overestimation of their understanding of the passage.

Rukavina and Daneman (1996) expanded this research with a sample of 10th and 12th grade students and college undergraduates. Using the SEQ and measures designed to assess their acquisition of scientific knowledge, they found that although students did not differ in mastery of the information, students at higher levels of epistemology were more able to integrate materials from various texts than students with less mature epistemological beliefs.

**Epistemological Beliefs and Domain Specificity**

Hofer and Pintrich (1997), in their review of research on epistemological beliefs, proposed that the question of whether epistemological beliefs differ by subject matter or are consistent across subjects needs exploration. In early research in this area, Schommer and Walker (1995) asked students to think about a specific domain (e.g., mathematics, social science) when completing a questionnaire about epistemological beliefs. Schommer and Walker (1995) found that the epistemological beliefs of both groups were similar across domains. Lonka and Lindblom-Ylanne (1996) investigated beliefs of students in psychology and medicine in the first and fifth years of education who rated 71 statements about learning style, regulation, and conception of learning. Embedded in these statements were seven items from Perry’s (1970) stages of cognitive development to measure dualism or relativism. High dualism was much more representative of first-year students than fifth-year students, especially those in
medicine. Advanced psychology students were much more constructivist, whereas medical students held more naïve epistemological beliefs, equating learning with the ability to memorize and reproduce information. These findings provided preliminary evidence suggesting that epistemological beliefs are domain-specific.

Hofer (2000) addressed some of the concerns from Schommer’s (1990, 1993) original work by developing a tool to measure domain-specific beliefs. Her Discipline Focused Epistemological Belief Questionnaire (DEBQ) consists of 27 items that refer to a specific field or subject matter as a frame of reference. When Hofer administered the DEBQ to 326 introductory psychology students with items specific to the domains of psychology and science, she obtained significant differences for the two domains with science conceived more as certain knowledge and less justified by personal experience than psychology. Students perceived authority and expertise as sources of knowledge in science and considered truth to be more attainable. Students with lower cumulative semester grades and lower psychology grades were more likely to hold the belief in certainty and simplicity of knowledge. Buehl, Alexander, and Murphy (2002) also developed a Domain Specific Belief Questionnaire (DSBQ) and investigated the differences in beliefs between a well-structured domain (mathematics) and an ill-structured domain (history). Results from an administration of the DBSQ to 633 college students indicated that epistemological beliefs were largely domain specific with students expecting to expend more effort in gaining knowledge in mathematics, providing stronger evidence of the domain-specificity of epistemological beliefs.

Limited work has been done in exploring the relationship of epistemological beliefs and performance in case-based instruction. The relationships between epistemological
beliefs and variables related to learning and performance are much greater than first anticipated (Hofer & Pintrich, 1997). Epistemological beliefs have been found to be related to cognitive processes, motivation, strategy selection and use, achievement, and may be interpreted differently in various domains and instructional contexts. Personal epistemological beliefs have been proposed to exist not as a single entity but as a “system embedded within other systems” (Schommer-Aikens, 2004, p. 413) that may affect constructs related to learning and performance. Original research exploring the relationship of self-regulation to performance during case-based instruction (Ertmer et al., 1996) did not include the question of an association between epistemological beliefs and case-based instruction. However, Dutton (2003), in her study of 171 occupational therapy students found that the epistemological belief that knowledge is simple predicted students’ grades on case assignments. It is expected that this epistemological belief that knowledge is simple will also predict learning in this study.

**Predictor Variables of General Ability (GRE and GPA)**

General ability (GRE and GPA) have been regularly used as admission criteria and predictors of success in physical therapy programs. Day (1986), in a study of 522 physical therapy students, found that pre-professional GPA and GRE (analytical) scores accounted for 33% in the variance for final GPA. Dockter (2001) analyzed data for 107 physical therapy students from four physical therapy programs and found that the best predictor of success on the National Physical Therapy Examination (NPTE) was the GPA following the first year of physical therapy school \( r = .65 \). It was expected that general ability would predict success of students in the case-based learning in this study.
Summary. Despite claims that the use of the case-based approach would increase students’ skills of problem solving and critical thinking, examination of the literature yields little evidence to support these claims. Some researchers have suggested that the reason that many classroom interventions do not result in increased scores in critical thinking and problem-solving is that standardized measures of these skills are not sensitive enough to detect small changes in a homogenous group of pre-selected students with high ability (Angel et al., 2000). A study of nursing students, however, indicated that a domain-specific measure did detect changes in critical thinking and problem-solving skill (Angel et al., 2000).

Examination of available evidence on case-based learning reveals significant issues in the research literature that have important consequences for the individual learner as well as for programs claiming that the use of case-based learning produces positive outcomes in the skills of critical thinking. In particular, not all students benefit equally from case-based learning. Some students have reported negative attitudes toward case-based learning and outcome measures that are domain general may not be sufficiently sensitive to detect changes in critical thinking and problem solving as a result of case-based learning. Further research is needed to address these issues. In this dissertation, I examined whether the student characteristics of general ability (GRE and GPA), epistemological beliefs, self-regulation, and motivation predicted students’ performance on domain-specific outcome measures of knowledge and critical thinking about cases during case-based instruction. A better understanding of these relationships may provide guidance for the design of experimental studies to determine
which of the factors can be manipulated to improve performance in case-based learning.
CHAPTER 3
METHOD

Introduction

The purpose of this study was to investigate the relationships of general ability, domain specific knowledge, critical thinking ability, epistemological beliefs, self-regulation, and motivation to performance on cases using case-based learning activities. The main focus of this study was to assess these relationships as students were challenged by the higher level of thinking required during case-based learning.

Participants

The participation of 150 physical therapy students in the second year of their professional program was solicited from two similar physical therapy programs in Florida. All students had a minimum overall GPA of 2.5 and a combined GRE (verbal and quantitative) of 1000 to enter the program. All students have maintained an overall GPA of 3.0 during their first year of the academic program. Students were enrolled in coursework that includes application of therapeutic skills to patients with primary neurological injuries. The courses were similar in objectives, teaching methods, required texts, and readings, case studies, and grading.

The physical therapy program of the University of Florida in Gainesville, Florida, and the University of St. Augustine in St. Augustine, Florida, have similar curricula for neurological populations. The faculties of these two universities have developed a consortium of educators to develop the most effective curriculum based on current available evidence (APTA, 2005: III STEP:Neurology Section).
Predictor Measures

General Ability (GPA, GRE, Knowledge)

Students' pre-professional GPA and GRE scores (verbal and quantitative), and first-year GPAs were collected on all students. Prior knowledge about curriculum content was assessed using a battery of questions study guides for national board exams (O'Sullivan & Siegelman, 2007). The accrediting body for physical therapy education, the Commission on Accreditation in Physical Therapy Education (CAPTE), has developed evaluative criteria for all physical therapy education programs (APTA, 2006). These criteria encompass the expected entry-level skills that graduates should possess and are evaluated through the National Physical Therapy Examination administered by the Federation of State Boards of Physical Therapy (FSBPT). The FSBPT works closely with CAPTE to develop valid and reliable scores on the national licensure exam. Various study guides with multiple-choice questions similar to those on the national exam have been developed. Each study guide has explicit questions focused on (a) the four practice areas of physical therapy: musculoskeletal, integumentary, cardiopulmonary, and neuromuscular and (b) the essential elements of physical therapy practice as specified by the Guide to Physical Therapy Practice (APTA, 2001): examination, evaluation, diagnosis, prognosis, and intervention. A battery of knowledge questions (total of 50) representative of the information contained in the neurology coursework were selected for this study from the study guides to cover the practice area of neurology and the two essential elements of evaluation and intervention in physical therapy.
**Epistemological Beliefs**

Schommer (1990) developed a 63-item Likert-type scale that identifies five dimensions of epistemological beliefs (simple knowledge, certain knowledge, omniscient authority, innate ability, and learning is quick). Hofer and Pintrich (1997) questioned the validity of innate ability and quick learning as dimensions of epistemological beliefs. Other researchers questioned Schommer’s original factor analysis and validation of the 63-item Likert scale measure (Schraw & Sinatra, 2004). In response, Qian and Alverman (1995) used 53 of Schommer’s original 63 items in a factor analysis of the Epistemological Belief Questionnaire and developed a revised 32-item instrument measuring a three-factor model with factors named (a) Learning Is Quick, (b) Knowledge Is Simple and Certain, and (c) Ability to Learn Is Innate. Items are scored on a 6-point Likert-type scale ranging from (0) strongly disagree to (5) strongly agree.

Qian and Alvermann (1995) found that responses to Knowledge Is Simple and Certain subscale (11 items, alpha = .68) were inversely related to conceptual change in high school physics students. I used the Knowledge is Simple and Certain subscale devised by Qian and Alvermann as a measure of epistemological beliefs in this study.

**Motivation and Self-Regulation**

The Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1993) is a self-report questionnaire designed to assess college students’ motivational beliefs and use of learning strategies for a specific course. The 81-item, Likert-type survey is divided into 15 subscales; students in this study responded to items on the subscales assessing motivation and self-regulation using a 7-point scale, ranging from 0 (not at all true of me) to 6 (very true of me). The motivational scales included the three value...
components of intrinsic goal orientation (4 items, alpha = .74), extrinsic goal orientation (4 items, alpha = .62), and task value (6 items, alpha = .90). Scales to measure self-regulation included critical thinking (5 items, alpha = .80) and metacognitive self-regulation (12 items, alpha = .79) from the cognitive and metacognitive strategies subscales. This questionnaire was chosen because it was designed for use with college students (Garcia & Pintrich, 1996; Vanderstoep, Pintrich, & Fagerlin, 1996) and the introductory statement in each item, “In this course, . . .”, makes the measure specific to the case-based course.

**Domain-General Critical Thinking Measures**

The California Critical Thinking Skills Test (CCTST) (Facione, 1990; Facione & Facione, 1992) was used to measure students’ domain-general skills of critical thinking. This measure was designed for use with college students. The test consists of 34 multiple-choice items that test takers must complete in 45 minutes. In four studies with 1,169 college students, Facione (1990) reported internal consistency coefficients for respondents’ scores on the CCTST ranging from .68 to .70. Content validity of the CCTST is based on the consensus definition of critical thinking agreed upon by the American Philosophical Association (APA, 1990). In a 5-year study of critical thinking skills and dispositions with over 7,900 nursing students from 50 colleges and universities, Facione and Facione (1997) obtained correlations between the CCTST and grade point averages (r = .20, p < .001) and the GRE (r = .72, p < .001). Facione and Facione (personal communication, July 2008) speculated that the low correlation with GPA was probably due to the lack of emphasis on critical thinking in most coursework. Evidence of concurrent validity consists of correlations between the scores on the CCTST and the Watson Glaser Critical Thinking Appraisal (WGCTA) (r = .41, p < .001)
and the GRE ($r = .72, p < .001$). Results of studies using the CCTST with physical therapy students have been mixed. Although Zettergren and Beckett (2004) found statistically significant differences in mean scores of third-year’ and fifth-year students, and fourth-year’ and fifth-year students in their cross-sectional study, neither Wilson (2000) nor Vendreley (2005) found significant changes in students’ CCTST scores when measured over 8 months and 27 months respectively in their longitudinal study.

**Outcome Measures**

Students responded to three knowledge questions related to hypothesizing underlying systems for key movement dysfunctions, selection of outcome measures, and selection of interventions after analyzing case studies number 1, 4, 7, and 10 (see Appendix A). The scoring system is similar to that of Angel et al. (2000) in that scores are calculated for each question and summated for a composite score. Correctness of response for all knowledge items was determined by the investigator prior to administering the questionnaire. There was no penalty for an incorrect response. The knowledge-measurement questions are designed to represent the curriculum content, integration of previous curriculum content that is explicitly discussed, and common clinical experiences that are shared by students. Preliminary reliability estimates for two of the four knowledge questions using a sample of two cases were moderately high, ranging from .75 to .95. Mean score for the first knowledge question was 19.2 with SD of $\pm\ 1.2$. Mean score for the second knowledge question was 9.75 with a SD of $\pm\ .90$.

**Domain-Specific Critical Thinking Outcome Measure**

Students responded to two critical thinking questions related to (a) hypothesis generation and selection and (b) the generation of interventions after analyzing case studies 1, 4, 7, and 10 (see Appendix A).
A scoring rubric for assessing students’ responses describing their thinking process was used to assess the phrases within the student responses to the critical thinking questions similar to that employed by Angel et al. (2000) with nursing students (See Appendix). The phrases were categorized by the following behaviors:

1. Transmits facts and truths from an authoritative source
2. Accepts uncertainty and ambiguity of knowledge; personal opinions are equally valid
3. Recognizes that though uncertainty exists, all opinions are not equal
4. Independently makes and commits to choices of ideas and action applying the methods and criteria of the discipline in the context of consciously identified values

These four criteria are congruent with Nelson’s (as cited in Thoma, 1993) adaptation of Perry’s (1970) stages of cognitive development, which are considered reflective of the epistemological transitions in critical thinking (Angel et al., 2000). Each phrase of the students’ responses that could be classified were assigned a numerical value according to the category system; the sum of the value was divided by the number of phrases classified, yielding a total score that was used as an indicator of the level of critical thinking behavior exhibited in the case analysis. Preliminary inter-rater reliability estimates for the two critical thinking questions using a sample of two cases were moderately high, ranging from .81 to .95. Mean score for the first critical thinking question was 5.25 with SD of .70 and scores ranged from 4.00 to 10.00. Mean score for the second critical thinking question was 5.55 with a SD of .90 and scores ranged from 4.00 to 9.00.

Procedures

This study took place during a 12-week semester. IRB approval was procured prior to testing. Prior to the use of case-based methods, students completed measures
of domain-specific knowledge (standardized questions from practice exams in physical therapy reflecting course content), epistemological beliefs, self-regulation, motivation, and the CCTST, a domain-general critical thinking skills.

Prior to beginning work with case-based learning, students received verbal and written objectives of the course that explain expected outcomes. Heuristics used in problem solving with domain-specific cases were explained and practiced with a sample case study. Each case focused on two aspects of evaluation and treatment of the neurological client with motor control problems as discussed by Hedman, Rogers, and Hanke (1996). Part one of the Case Study Questionnaire required the student to develop hypotheses for each of the key movement problems identified in the case. The second part of the Case Study Questionnaire required the student to use domain specific knowledge and critical thinking to answer questions about inconsistencies in the case, additional desired information and underlying rationale, expected functional outcomes and standardized measures and rationale for choices, and to name the three most critical interventions needed with rationales. This questioning process is similar to that of Angel et al. (2000) but adapted to a conceptual practice framework commonly used with neurological clients in physical therapy (Hedman et al., 1996).

All students completed 10 cases over the 12-week curriculum. Cases were selected and sequenced to match the curriculum content. All cases are authentic cases collected within the past 5 years prior to presentation. Cases were completed weekly except for weeks of practical exams. Cases were presented and worked on individually on a computer. All students have access to the patient video, written description of the case, and key observations. Once the students generated and listed their underlying
hypotheses for key movement dysfunctions (first knowledge question), they accessed
the examination portion of the case. From the examination information, the students had
sufficient data to answer the remaining knowledge and critical thinking questions.
Students documented the time spent answering the questions in part two. Questions
were answered for all 10 cases, critical thinking questions were only answered for cases
1, 4, 7, and 10.

Analysis

I used multiple regression to determine whether scores on the measures of
general ability, prior knowledge, epistemological beliefs, self-regulation, and motivation
predict the two outcome measures: scores on the domain-specific measure of
knowledge and scores on the domain-specific measure of critical thinking.
CHAPTER 4
RESULTS

This study was designed to investigate the relationships of the predictor variables of general ability (GPA and GRE), domain-specific knowledge, problem solving ability, epistemological beliefs, self-regulation, and motivation for case-based methods to the outcome measures of case-specific knowledge and case-specific critical thinking. Primarily, the aim of this study was to determine the variables that predict student outcomes when using a case-based format for education. Further, the relationships among the variables of GPA, GRE, prior knowledge, critical thinking, motivation, self-regulation, and student outcomes of case-specific knowledge and case-specific critical thinking were examined.

This chapter provides a description of the statistical results of this investigation. First, I present a description of the statistical results of this investigation. Second, I include an examination of the suitability of the measures used in this research by providing Cronbach alpha reliability results for the respondents’ scores on each of the scales. Finally, I present the results of the statistical tests for each of the research hypotheses and summarize the results of the analyses.

Characteristics of the Sample

The participants were volunteers from two professional programs of physical therapy located in Florida. The students were all in their second year of a Doctor of Physical Therapy program (DPT) and were all enrolled in coursework that includes application of therapeutic skills to patients with primary neurological injuries. The courses at both institutions were similar in objectives, teaching methods, required texts, and readings, case studies, and grading. Of the 135 students who completed the study,
132 were included in the analyses after two cases with missing data were omitted by SAS and one student’s score was eliminated as an outlier that skewed the data.

The means and standard deviations for all scale scores are shown in Table 4-1. The items on the intrinsic goal orientation scale of the Motivated Strategies for Learning Questionnaire (MSLQ) did not load on a factor and was not included in the regression analyses. A correlation matrix for all variables is displayed in Table 4-2. Most of the correlations were small, but some were moderate. With regard to the standardized measure of critical thinking, the CCTST, the most notable relationship was with GRE—Verbal \( (r = .46) \) and less robust relationships with GPA \( (r = .23) \) and prior knowledge \( (r = .26) \). Both CCTST \( (r = -.24) \) and the critical thinking portion of the MSLQ \( (r = -.21) \) had a negative relationship with epistemological beliefs, indicating that students who believe that knowledge is certain have lower scores on measures of their ability to think critically. Prior knowledge also had a small relationship with GRE—Verbal \( (r = .25) \) and with GPA \( (r = .20) \). The two outcomes measures, case-specific critical thinking \( (r = .30) \) and case-specific knowledge \( (r = .29) \), were significantly correlated with GPA but not with GRE—Verbal, and the outcome of case-specific critical thinking had a small relationship with case-specific knowledge \( (r = .25) \). Of motivational variables, self-regulation had moderate relationships with students’ self-reported use of critical thinking \( (r = .58) \) and task valuing of the course \( (r = .32) \), and critical thinking had a small relationship with task value \( (r = .25) \). Several findings were unexpected. Task value had two negative relationships, one with GRE—Verbal \( (r = -.21) \) and the other with CCTST \( (r = -.18) \). Self-regulation had a small negative relationship with prior knowledge \( (r = - \)
.18) and extrinsic goal orientation has a small relationship with epistemological beliefs \((r = .19)\).

**Reliability of the Scales**

I calculated Cronbach alpha coefficients for the respondents’ scores on all the scales used in this research (see Table 4-3). All of the Cronbach reliability estimates were above .70.

**Tests of the Hypotheses**

Following are the results for the tests of hypotheses. Table 4-4 and Table 4-5 show the results of the two regression analyses. The GRE—Quantitative score was not significantly related to the outcome variables and was dropped from the analysis.

**Hypothesis 1:** Students’ general abilities (GPA and GRE—Verbal), prior knowledge, general critical thinking skills, epistemological beliefs, self-regulation, and motivation predict case-specific knowledge during case-based learning.

Inspection of Table 4-4 indicates that the model is significant with adjusted \(R^2\) of .06, \(F(9,132) = 1.97, p < .05\). Of the predictors of interest, GPA was the only significant predictor accounting for 8% of the variance of total knowledge of case studies. Previous knowledge was not a significant predictor of total knowledge scores.

**Hypothesis 2:** Students’ general abilities (GPA and GRE—Verbal), prior knowledge, general critical thinking skills, epistemological beliefs, self-regulation and motivational predict case-specific critical thinking during case-based learning.

Inspection of Table 4-5 indicates that the model was significant with adjusted \(R^2\) of .21, \(F(9,131) = 4.90, p < .001\). Of the predictors of interest, GPA scores accounted for the greatest amount of variance (13%) in total critical thinking scores. Students’ scores on the GRE-Verbal accounted for 3% of the variance. Note however, that the
relationship between the students’ critical thinking skills and their performance on the critical thinking component of their case analyses was negative. Self-regulation scores were not a significant predictor of critical thinking scores.

Summary of Results for Tests of Relationships: Tests of relationships between variables in the proposed model and the outcome variables of case-specific knowledge revealed that GPA was the only significant predictor of total knowledge in case-specific learning. The test of the relationships of the predictors to the outcome measure of critical thinking about cases showed that GPA was a significant predictor of critical thinking as well as the GRE—Verbal and the general measure of critical thinking skills, and the Critical Thinking subscale of the MSLQ. However, students’ scores on the critical thinking skills test were negatively related to their scores on the case-specific measure of critical thinking.
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Table 4-2. Intercorrelations of variables

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Table 4-4. Regression of predictor variables on total knowledge in case studies

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Table 4-5. Regression of predictor variables on total critical thinking in case studies

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CHAPTER 5
DISCUSSION AND CONCLUSIONS

The purpose of this study was to determine if students’ cognitive and motivational characteristics predict student performance in case-based learning as measured by outcomes of case-specific knowledge and critical thinking. Critical thinking is considered one of the essential skills for entry-level physical therapists. Rapid growth of health-care knowledge combined with increased acuity in patient status, earlier discharge from multiple settings, and greater autonomy of the physical therapist to make decisions has led to a requirement that all graduates enter their practice with effective problem-solving skills and clinical judgment, which are both supported by the habit of critical thinking. One pedagogical method that has been used extensively in medical and nursing programs to develop critical thinking skills is case-based learning. Although case-based learning is believed to be an effective method to develop these skills, the research of Ertmer et al. (1996) suggests that students with lower levels of initial self-regulation may not be able to sustain the levels of motivation needed to complete cases successfully over time. Dutton (2003), however, examined the relationship of epistemological beliefs, motivation, and self-regulation to students’ performance in a case-based course in occupational therapy and found that average GPA in prerequisite courses and the epistemological beliefs that knowledge is simple and that cases are protocols predicted case performance. Motivation and self-regulation did not predict performance in a case-based course. To further examine the predictors of performance in a case-based course, I investigated predictors of student performance in knowledge and critical thinking about cases, measured by domain-specific knowledge and domain-specific critical thinking. Identifying student characteristics that positively or negatively affect
student performance can provide the basis for experiments to determine effective ways to improve performance of students in analyzing cases.

In this chapter, I discuss the results of the statistical analyses presented in Chapter 4. Second, I discuss some of the limitations of this investigation and propose some recommendations for future research. Then, I provide conclusions based on these results. Finally, I discuss the implications of the findings of this study.

Tests of Hypotheses

In this study I examined whether students’ cognitive ability, motivation, and self-regulatory ability predict their performance on domain-specific knowledge and domain-specific critical thinking. Specifically, I tested two hypotheses:

**Hypothesis 1:** Students’ general abilities (GPA and GRE—Verbal), prior knowledge, general critical-thinking skills, epistemological beliefs, self-regulation and motivation predict performance in case-based learning as assessed by an outcome measure of case-specific knowledge.

The three knowledge questions include (a) hypothesizing systems responsible for underlying movement dysfunctions, (b) selection of outcome measures, and (c) selection of interventions. Students are encouraged to be thorough, and there is no penalty for an incorrect response. The knowledge outcome measure was designed to assess curriculum content, integration of previous curriculum content explicitly discussed in class, and common clinical experiences shared by students.

The test of this hypothesis reveals that of the predictors of interest, only students’ pre-professional GPA is a significant predictor of case-based outcomes, as measured by case specific knowledge. This finding is consistent with earlier research. Balogun (1988), in a study of 42 physical therapy students, found significant correlations
between pre-professional GPA and academic performance \((r = .55, p < .01)\), and pre-professional GPA was the best predictor of students’ academic performance at the end of their professional program, accounting for 30.5% of the total variability in performance. Day (1986) found similar results in an investigation of whether the GRE—Analytical combined with GPA to predict final GPA in four different professional physical therapy programs. On average, GPA alone accounted for 15% of the variance in prediction of final GPA. Dockter (2001) analyzed data for 107 physical therapy students from four physical therapy programs and found that the best predictor of success on the National Physical Therapy Examination (NPTE) was the GPA following the first year of in a physical therapy program \((r = .65)\). In a more recent study with greater relevance to this study, Dutton (2003) found that domain-specific prior knowledge, as measured by the GPA in prerequisite courses, predicted not only final grade in the case-based learning course but also predicted the case-based learning grades within the course.

The epistemological belief knowledge is simple and certain does not predict students’ case-based knowledge in this study. This finding is in direct contrast to the findings of Schommer (1990) who reported that naïve beliefs about knowledge were negatively related to grades for junior-high students in introductory psychology as well as college freshman and sophomores in introductory statistics (1993). In Dutton’s (2003) study with occupational therapy students, the naïve epistemological belief that knowledge and learning are simple was negatively related to grades in case-based learning \((b = -27)\). The contradictory finding in this study might be a consequence of the way in which the knowledge questions are stated. As explained previously, the primary objective in the knowledge questions is for the students to be thorough, to identify the
most common reasons for movement dysfunction, outcomes measures that could be feasibly used to measure progress, and appropriate interventions. Almost all of these answers could be located in materials from previous courses, research articles, texts, and previous lectures that reflected expert opinion. This format may not require that students believe that knowledge is complex and uncertain to be successful.

In previous studies, motivational and metacognitive beliefs have predicted grades in traditional lecture-based courses for seventh-grade science and English (Pintrich & DeGroot, 1990) and grades for reading comprehension of a psychology passage for junior-college students (Schommer, 1990). However, in this study, beliefs about task value, goal orientation, and metacognitive strategies do not predict case-specific knowledge. In this study, in a factor analysis of the motivational items from the MSLQ, intrinsic goal orientation, which is defined as learning to learn rather than to achieve a high grade, the items do not load on a separate factor so intrinsic motivation is not included in the regression analysis. It appears that although this group of students values the importance of their work, they are not concerned about learning for the sake of learning. This finding is most likely related to the students’ decision to enter a professional program and to seek information that prepares them for their future career. As was the case in Dutton’s (2003) study, beliefs about goals, interest, self-regulation, and critical thinking do not predict case-based knowledge. Similar to this study, Dutton attributed her lack of significant findings to the lack of variability in MSLQ scores and the restricted range of case-based learning grades. Similar to the Dutton findings, in this study the variability in the scores for task value ($SD = .92$), critical thinking ($SD = .99$), and self-regulation ($SD = .70$) is smaller than the normative values in the Pintrich et al.
(1993) study. In the normative sample, the standard deviation for task value was 1.23, 1.28 for critical thinking, and .90 for self-regulation. This difference in variability is not unexpected. These students are in the fifth semester of their professional program. They were accepted into this professional program through a competitive process with high standards for GPA and GRE scores, and prerequisite coursework. Students were required to complete a minimum of 40 hours of volunteer work in four different areas of physical therapy (e.g., acute hospital, outpatient, inpatient rehabilitation, pediatrics, sports) and write a letter of intent that clearly stated their reasons to pursue a degree in entry-level physical therapy. Each student had also successfully completed one full-time eight-week clinical internship. It is not surprising that these students are more motivated and interested than the students in the Pintrich et al. study that included undergraduate students in generic areas of natural sciences, human sciences, social sciences, computer science, and foreign language. The students in this study and that of Dutton (2003) might be more similar to students in accelerated nursing programs. Mullen (2007) examined self-regulation in nursing students in the second and third trimester of an advanced nursing program. All students had bachelor’s degrees and had self-selected to enter an intensive 18-month nursing program. Mullen (2007) reported mean critical thinking scores of 4.27 (SD =1.06) and mean self-regulation scores of 4.79 (SD = .75) for the third semester students. The students in physical therapy in this study, those in occupational therapy in the Dutton study, and those in accelerated nursing programs were more likely to see the personal relevance of their course work than undergraduates.
In addition, in this study the lack of significant findings for self-regulation and motivation for critical thinking may be related to the format of the knowledge questions. Students’ performance on the case-based knowledge questions may not have required the type of self-regulation and critical thinking assessed by the measures on the MSLQ.

**Hypothesis 2:** Students’ general abilities (GPA and GRE—Verbal), prior knowledge, general critical thinking skills, epistemological beliefs, self-regulation and motivation predict performance in case-based learning as measured by the outcome measure of case-specific critical thinking.

The two critical thinking questions include describing the reasoning process that the student used to (a) select three standardized outcomes measures relevant to the patient desired outcomes and (b) selection of the three most important interventions for the case-study patient. Students were encouraged to describe their reasoning process using (a) evidence, (b) information encountered through texts and lectures, (c) personal experience in the clinic (each student had each had one full time clinical experience), (d) opinions of self and peers, and (e) expert opinions of faculty and clinicians. Students were asked to be as explicit as possible when describing this reasoning process. The more explicit the description, the easier it is to use the scoring rubric to assign critical thinking levels that replicate those used in the original work of Angel et al. (2000) with nursing students. Angel et al. used Nelson’s (as cited in Thoma, 1993) adaptation of Perry’s (1970) stages of cognitive development, which are considered to be reflective of the epistemological transitions in critical thinking (Angel et al., 2000) to give a critical thinking score to each students’ response to the critical thinking questions.
Tests of this hypothesis reveal that GPA, GRE—Verbal, general critical thinking skills (CCTST), and the critical thinking component of the MSLQ are all significant predictors of the outcome of case-specific critical thinking. On the basis of previous research cited above for Hypothesis 1, there is considerable evidence supporting the premise that GPA (in this case, pre-professional GPA) is a predictor of performance in physical-therapy programs (Balogen, 1988), final GPA in physical-therapy programs (Balogen, 1988; Day, 1986), and performance on the National Physical Therapy Exam (NPTE) (Dockter, 2001). Because faculty are invested in helping students to develop critical thinking and problem-solving skills before graduation and the NPTE, it was expected that measures of performance in the physical therapy programs include critical thinking. O’Sullivan and Siegelman (2009), in their NPTE Review and Study Guide, explicitly explained the role of critical reasoning on the national exam process:

Although factual knowledge is important and a foundation to the exam, the NPTE also tests your ability to reason out challenging circumstances correctly and to make prudent decisions about the situations described in each question. . . . This means that you will be given clinical scenarios in which you will need to draw conclusions about a patient’s symptoms, diagnosis, response to therapy, and expected outcomes. You must draw on your knowledge to take your reasoning to the next level—application of information. (p. xxxviii)

The authors continued with an explanation of the five subskills of critical reasoning (a) inductive reasoning, (b) deductive reasoning, (c) analysis, (d) inference, and (e) evaluation, and explained how each student can analyze their practice test results to determine their areas of weakness. Research from Facione (1990a; 1990b) is used to support these guidelines.

As hypothesized, GRE—Verbal predicts critical thinking outcomes. This finding is not surprising, as the GRE—Verbal is described as a measure of verbal reasoning
(GRE Verbal, 2010). The two critical thinking questions of the case study ask students to describe the reasoning process that they used to make their decisions about outcome measures and interventions. Explicitly, students are asked to describe the evidence, information, personal experience, and expert opinions they used to make their decisions. These skills appear related to those of the GRE—Verbal.

As predicted, both the general critical thinking scores (CCTST) and the critical thinking measure of the MSLQ predict critical thinking outcome scores. However, it was not expected that The California Critical Thinking Test (CCTST) (Facione, 1990; Facione & Facione, 1992) would have a negative relationship with the case-based critical thinking measure. The CCTST is described as a measure of students’ domain-general skills of critical thinking designed for use with college students. The measure consists of 34 multiple-choice questions purported to assess five subskills of critical reasoning: (a) inductive reasoning, (b) deductive reasoning, (c) analysis, (d) inference, and (e) evaluation. In a 5-year study of critical thinking skills and dispositions with over 7,900 nursing students from 50 colleges and universities, Facione and Facione (1997) obtained correlations between GPA ($r = .20$) and GRE ($r = .72$). Although researchers have studied changes in critical thinking scores over time in physical therapy programs (Wilson, 2000; Zettergren & Beckett, 2004), there is a need to further investigate whether the CCTST predicts domain-specific critical thinking outcomes in physical therapy, especially those related to the use of case-based learning. Angel et al. (2000) examined change in critical thinking scores when case-based learning was used with nursing students but did not investigate whether the CCTST predicted change in their scores. Using a rubric she developed, Angel assigned levels and total scores to critical
thinking statements made by the nursing students. The negative relationship found in this study may have been due to the difficulty in assigning critical thinking levels to the statements written by students. Students often confuse expert opinion with high levels of evidence. For example, if the course instructor presents several research studies or meta-analyses in a lecture, students may misinterpret that evidence as expert opinion, which is rated lower on the critical thinking rubric than evidence. Alternatively, the negative relationship is small and may be due to chance.

The scoring rubric for assigning a critical thinking score to each student phrase within the critical thinking question was developed to parallel that of the rubric used by Angel et al. (2000) with nursing students. Each phrase is given a code based the following rubric:

1. Transmits facts and truths from an authoritative source
2. Accepts uncertainty and ambiguity of knowledge; personal opinions are equally valid
3. Recognizes that though uncertainty exists, all opinions are not equal
4. Independently makes and commits to choices of ideas and action applying the methods and criteria of the discipline in the context of consciously identified values

Each phrase of the students’ responses that could be classified was assigned a numerical value according to the category system; the sum of the value is divided by the number of phrases classified yielding a total score that is used as an indicator of the level of critical thinking behavior exhibited in the case analysis.

The difficulty with this rubric is further defined by examples below. I was present in both courses given at the University of St. Augustine and was the primary instructor for the course given at the University of Florida. The following is a sample student phrase in response to the second critical thinking question, “For these three interventions,
describe the reasoning process that you used in arriving at these three interventions. That is, what evidence, information, personal experience, opinions of clinicians, teachers, self, and/or peers led you make these three choices out of the many interventions you could have selected?” One student response to this question was:

We learned that you cannot strengthen a weak muscle until you stretch out a tight muscle….We have always been taught always make your interventions towards a functional goal.

Assessment of this student response would place this phrase as a (1) or “transmits facts and truths from an authoritative source. In class, students are presented with level 4 evidence from randomized control trials (Sackett, 1986) that support the need to stretch prior to strengthen and the use of specificity of training. The primary instructor presented levels of evidence, strength of the study, as well as application of the information, but students may confuse the instructor’s presentation with expert opinion. If this student had referenced the actual studies that supported these concepts of treatment and described the level of the study, as well as given a reason for the choice, this answer could be coded at level 4, “independently makes and commits to choices of ideas and action applying the methods and criteria of the discipline in the context of consciously identified values.” This dilemma of distinguishing between students’ Level 1 and Level 4 responses was encountered frequently during coding of students' responses for critical thinking.

The Critical Thinking factor of the MSLQ described as assessing the degree to which students report applying prior knowledge to new situations in order to solve a problem, reach a decision, or make a critical evaluation (Pintrich et al., 1993) also predicts the case-based outcome of critical thinking. This factor is a self-report of behaviors similar to the skills described as critical thinking on the NPTE and the
CCTST. However, the students’ scores on the Critical Thinking factor are not significantly related to their scores on the CCTST, which may be due to restrictions in range on the Critical Thinking factor. The mean values and variability that Pintrich et al. (1993) reported for the critical thinking factor of the MSLQ with undergraduate students was 4.16 ($SD = 1.28$) while the scores in this study was 4.25 ($SD = .99$).

With regard to students’ epistemological beliefs, Dutton (2003), in her work with 170 occupational-therapy students using case-based learning as an outcome, found that the naïve epistemological belief that knowledge and learning are simple was negatively related to grades in case-based learning ($b = -.27$). I expected to find a similar result in this study, but the epistemological belief that knowledge is simple and certain (Qian & Alvermann, 1995) does not predict case-based critical thinking. In contrast, Hofer (1994) found a positive correlation between more sophisticated epistemological beliefs and intrinsic motivation, self-regulation, and academic performance. The assumption underlying the hypothesis is that if students hold naïve beliefs, that is, if they believe that knowledge is simple and certain, they do not engage in the deeper processing of information that is necessary in critical thinking about case studies. Schommer (1990) found that belief in quick learning was related to oversimplified conclusions, low academic achievement scores, and overconfidence. Schommer found that students who held a belief in quick learning performed poorly on psychology mastery tests due to their overestimation of understanding of the passages. Hofer (2002), in addressing concerns that epistemological beliefs may be domain-specific, developed the Disciplined Focused Epistemological Belief Questionnaire (DEBQ), which included 27 items specific to a field or subject matter.
Although limited work has been done in the exploration of epistemological beliefs and case-based learning, I expected the results to parallel those of Dutton (2003) in her work with students of similar backgrounds in health-care education. Differences in the epistemological scales used in the two studies may have contributed to the differences in the results of the studies. In creating her measure, Knowledge and Learning Are Simple, Dutton used seven items from the second draft of Schommer’s SEQ for college students (personal communication, August 31, 2009) as well as two items from the Beliefs About Knowledge and Learning (BAKKS). Dutton explained, “BAKKS was created to assess two dimensions of epistemology that are crucial for clinical practice in occupational therapy: the beliefs that knowledge is contextual and self-constructed” (p. 52). Only 2 of the items in the 9-item scale that Dutton used to measure Knowledge and Learning are Simple are the same as those in the 11-item subscale by Qian and Alvermann (1995) that was used in this study. In response to the concern of researchers about Schommer’s original factor analysis of the SEQ, Qian and Alverman (1995) used 53 of Schommer’s original 63 items in a factor analysis of the Epistemological Belief Questionnaire and developed a revised 32-item instrument measuring a three-factor model with subscales named (a) learning is quick, (b) knowledge is simple and certain, and (c) ability to learn is innate. Qian and Alvermann found that responses to this subscale (11 items, alpha = .68) were inversely related to conceptual change in high-school physics students. I used the knowledge is simple and certain subscale in my study to measure epistemological beliefs about case-based learning.
Several explanations are feasible for why Qian and Alvermann’s (1995) subscale does not predict case-based critical thinking in this study. First, students may perceive case studies as protocols—that is, they may have thought they were learning an algorithm to apply to cases. Throughout their education as physical therapists, students are exposed to algorithms that contain logically sequenced steps that assist the student to define diagnosis, prognosis, and interventions (APTA, 2001; Rothstein & Echternach, 1986). These algorithms are intended to give students a stepwise process to logically evaluate each case, but what may not be obvious to students is that each step requires the underlying skill of critical thinking. Student or clinicians must suspend judgment, resisting a rush to the quickest solution, raise relevant questions during the examination process, and add or remove testing measures as results are collected. The process is not quick but rather requires reflective thought that occurs while that patient is awaiting a diagnosis, prognosis, or adaptation to the intervention. This explanation is consistent with Dutton’s (2003) finding of a positive relationship between the Cases are Protocols factor and grades in case-based learning ($b = .29$). Dutton (2003) speculated that students may think of cases as protocols if they expect to accumulate treatment plans in school to be used with specific diagnoses. Students may perceive that the logical stepwise process to move through each case is more of a protocol than a series of critical thinking events. In this study, the tendency to respond to cases as protocols may have been increased because the same questions were asked in each case study, even though the diagnosis, context, and circumstances of each of the 10 cases differed.

The second possible explanation for the finding that epistemological beliefs do not predict case-based critical thinking is students may confuse expert opinion (ranked as
Level 1 on the critical thinking rubric) with a high level of evidence such as randomized control trials (ranked Level 4 on the critical thinking rubric). Third, the difference in items on the epistemic belief questionnaire used by Dutton (2003), with additional items taken from the BAKKS, assessing whether knowledge is self-constructed and contextual, may have made the measure used by Dutton much more sensitive than the measure created by Qian and Alvermann and used in this study.

On the basis of the qualitative work on motivation and self-regulation (Ertmer et al., 1996; Hayward & Cairns, 1998) and the quantitative work of Zimmerman (1994), I hypothesized that task value and self-regulation predict critical thinking outcomes in case-based learning. But similar to the outcomes in Dutton’s study, motivational and metacognitive strategies do not predict case-based critical thinking in this study. Research has shown that self-regulation skills enhance learning in a wide range of educational contexts (Linder & Harris, 1992; Weinstein, Goetz, & Alexander, 1988; Zimmerman, 1990), and I expected that self-regulation would be essential at the higher levels of thinking required in case-based learning. I also expected that the extent to which students valued authentic cases would also predict outcomes in case-based critical thinking. Senior nursing students using cases (Demarco et al., 2002) reported that the cases were real world and relevant, and stimulated their self-directed learning. Although Pintrich et al. (1993) found a relationship between motivational constructs and self-regulation, physical-therapy students may differ from students in previous studies. With mean GPA scores of 3.52 (SD = .34) and self-selection to attend a professional program, these students may all possess higher levels of motivation and self-regulation that the undergraduates in the Pintrich et al. study. That these students had already
attended an eight-week internship immediately prior to this course might also have influenced their desire to learn the material.

**Limitations of the Study and Recommendations for Future Research**

This study addressed flaws in the study of Dutton (2003). Students were studied at the same point in their program, the courses in which the data were collected were very similar, the same two outcome measures were given to all the participants, and outcome measures were specific to the subject matter of the course. One limitation of this study, however, is that the scoring algorithm for the measure of case-based critical thinking is based on the original work of Angel et al. (2000) who may have given more explicit instructions in how to answer the critical thinking questions: (a) “For these statements or questions, describe the reasoning process that you used in arriving at these three among the many you might have included” and (b) “Describe the basis on which you made the decision for each of the problems” (p. 224). Angel described the coding process as follows:

The scoring system for responses describing the thinking process used in answering the questions was developed to focus on the phrases within the student responses to the two critical-thinking questions. The phrases were rated by the investigator to represent one of the following behaviors…Each phrase within the students’ responses that could be classified was assigned a numerical value. (pp. 224-225)

The four coding categories that I used in my study are the same as those of Angel et al. These four categories are Nelson’s (as cited in Thoma, 1993) adaptation of Perry’s (1970) stages of cognitive development, which Angel considered reflective of the epistemological transitions in critical thinking. These four categories may be inadequate for describing the thinking behaviors of physical-therapy students in their second year of professional curriculum. The categories may not be sensitive enough to
detect change and may not be explicit enough to identify behaviors associated with levels of thinking. When coding students’ responses for physical therapy, I noted a wide variety of responses, and the most difficult distinction to make in coding was between level 1, low critical thinking, transmission and facts from an authoritarian source with level 4, high critical thinking, independently makes and commits to choices of ideas and action applying the methods and criteria of the discipline in the context of the student’s consciously identified values. A more specific rubric for evaluating critical thinking behavior may be necessary to identify students’ levels of thinking. Facione (1996), one of the developers of the CCTST, described four levels of thinking that are similar to Nelson’s stages but specified detailed descriptors of each stage. Other universities (Bismark State University, 2010; Northeastern Illinois University, 2010) have developed specific critical thinking rubrics to evaluate critical thinking. Some of these rubrics have up to 10 categories of thinking and 4 levels of thinking within each category which may markedly increase the sensitivity of the tool if reliable distinctions among so many categories can be made (Northeastern Illinois University, 2010).

Another method to address the limitation of the case-based critical thinking tool is explicit explanation of expectations. Explanation of expectations of the thinking process as well as expected outcomes in thinking need to be explicit for the students. For example, Facione (1986) illustrated how to be more explicit in asking students to think critically about the impact of a laryngectomy on a patient.

Students (clinicians) will assess and examine the severe disruption in Mr. Jackson’s ability to earn a living selling automobiles, conjecturing about possibilities and drawing warranted conclusions about his needs for short vs. long term disability, interactions with his employer, and handling his health care expenses. (p. 13)
Providing such explicit directions regarding what to think about may lead to more detailed written answers and coding that accurately reflects students’ thinking.

A second limitation is the assessment of epistemological beliefs. Exposure to heuristics including the Guide to PT Practice, Preferred Practice Patterns, Clinical Decision Making Algorithm for Low Back Pain, and general case study guidelines may lead students to believe that cases are protocols and if knowledge is correctly applied, solutions are easily attainable. Focus on such heuristics may be a problem with the structure that is generally a part of the initial formative year of the program. Future research can include explicit education of students about where critical thinking is appropriate in case studies as well as working through examples with student discussion in large and small groups.

The third limitation is that each of the 10 cases asked the same knowledge and critical thinking questions, although the actual cases were dissimilar in diagnosis, patient problems, possible outcome measures, and potential interventions. Because data were collected on these cases over the course of the semester, the repetition of the same questions for each case may have reinforced the idea that cases are protocols and can be easily solved if knowledge is accessible. Future research comparing questions that are specific to the case versus generic questions may be useful. Students may be prompted to give a specific example of “facts from an authoritarian source” versus “independently makes and commits to choices of ideas and action.” The use of fewer cases (i.e., 5 versus 10) may encourage students to expound on their thoughts in greater detail and give more time for reflection.
Several other limitations may restrict the significance of the study including students from two physical therapy programs might have confounded the results. A remedy to this problem would be a multi-level study of several schools in which the effect of school is examined. Use of self-report questionnaires may also have affected the results in that participants might have given socially desirable responses rather than accurate reflections of their feelings, thus, lowering the variability in scores and the validity of the results. Another limitation is that these results might not generalize to other disciplines or other physical therapy programs, as predictors may be program and school specific.

**Conclusion**

In this study I examined the relationships between the cognitive abilities and motivational characteristics of students in graduate physical therapy programs to determine if these specific abilities and characteristics predict students’ performance on assessments of their knowledge and critical thinking in the analysis of cases of physical therapy-patients while participating in a case-based course. Although case-based instruction has been purported to be effective in developing practical and theoretical knowledge, bridging the gap between theory and practice and encouraging the application of professional judgment and decision making, it places demands on students that differ from other instructional methods. Several studies have linked motivational and self-regulation variables (Angel et al., 2000; Demarco et al., 2002; Ertmer et al., 1996) to the optimal use of case studies and academic performance. In a qualitative study, Ertmer et al. found that veterinary students with lower initial scores in self-regulation lost motivation near the end of the case-based course. Links also have been found between general cognitive ability, sophisticated epistemological beliefs, and
academic performance in case-based courses (Dutton, 2003). The first goal of this study was to identify the variables that predict success on student performance with case-based studies. Clarification of these relationships could provide a basis for experimental studies in which the variables identified as predictors of knowledge and critical thinking about cases might be enhanced. To explore this possibility, I proposed that general cognitive abilities, domain-specific critical thinking, prior knowledge, sophisticated epistemological beliefs, motivation, and self-regulation predict student performance in case-based learning as measured by outcomes of domain-specific knowledge and critical thinking about cases. Although some research on academic outcomes in case-based learning has been conducted, more specific research of variables that predict critical thinking outcomes is needed. In light of the need for outcome measures to assess domain-specific critical thinking (Vendreley, 2005; Wilson, 2000;), I constructed a critical thinking outcome measure similar to that used with nursing students (Angel et al., 2000). By studying students who were (a) in their same year and same semester of a professional physical therapy program, (b) taking a course similar in objectives, materials, and cases and (c) using the same outcome measure for domain specific knowledge and critical thinking weaknesses of previous research were addressed.

Summary of Findings

Results of this study show that although GPA is the only predictor of case-based knowledge, the variables of GPA, GRE—Verbal, CCTST, and the critical thinking measure of the MSLQ all predicted case-based critical thinking. However, the small amount of total variance accounted for by these variables indicates that further research is needed to identify other variables that account for case-specific knowledge and
critical thinking about cases and to develop more sensitive tools for measurement of these variables.

**Implications for Theory**

The findings of this study have several implications for refining theories relevant to the successful use of the pedagogical method of case-based learning. One of the primary theoretical purposes of this research was to identify personal characteristics of students that impede their ability to learn from cases. The qualitative study of Ertmer et al. (1996), guided by self-regulation theory and instructional methods (Zimmerman, 1990), suggested that student motivation and self-regulation affect success in case-based learning. In this study and in the work of Dutton (2003), neither motivation nor self-regulation strategies predict case-based knowledge, measured by either case-based grades (Dutton) or case-based critical thinking (this study). Dutton’s study was flawed because her students were at different points in the occupational-therapy curriculum and the outcome measure for case-based learning varied from class to class. These limitations were rectified in my study. One interpretation of the findings in my study is that motivation and self-regulation of students in physical-therapy professional programs are not characteristics that impede success in case-based learning. Students who have chosen to pursue a professional career in physical therapy have already demonstrated high levels of self-regulation in preparing to meet the requirements of admission to a professional program, which are reflected in their scores on the motivation and self-regulation measures. Consequently, they are likely to exhibit similar beliefs about the need to be motivated to regulate their own learning. However, it is likely that the high scores on these measures reduced the possibility of obtaining significant results. Given these two potential explanations for results, further research is
needed to determine whether the high level of motivation and self-regulation of students entering physical therapy programs is sufficient to support their learning from cases or whether a more sensitive measure will detect significant relationships between motivation and self-regulation and performance on case-based critical thinking.

Another purpose of this research designed to contribute to theoretical understanding of case-based learning was to examine the relationship between students’ beliefs about knowing and critical thinking about cases. In my study, epistemological beliefs that knowledge is simple and certain does not predict case-based outcomes for either knowledge or critical thinking about cases. Explanation for this outcome may be similar to the explanation that Dutton offered for the positive correlation she found between the epistemological belief Cases are Protocols and grades in a case-based course. Having encountered various heuristics and algorithms for solving cases in courses prior to this study, students may hold a belief that, if they have the correct algorithm and the correct knowledge, cases may be simple and certain.

Another possible explanation for the lack of a relationship between the epistemological belief that knowledge is simple and certain is based on the work of Jehng, Johnson, and Anderson (1993). Jehng et al. examined the epistemological beliefs of 1,000 university students at five educational levels (freshmen, sophomores, juniors, seniors, and graduate students) and four academic fields (engineering and natural sciences, arts and humanities, social sciences, and business). They found that students in hard fields (engineering, business) had a stronger tendency to believe that knowledge is certain than students in soft fields (arts/humanities, social sciences). They also found that students at higher levels of education (graduate students) had more
sophisticated epistemological beliefs. The field of physical therapy was once considered a “soft” field and for many years the “art” of physical therapy was emphasized (Guccione, 1990). By 1990 (APTA, 1991), the field of physical therapy had taken a sharp turn towards hard evidence. The APTA Vision 2020 (APTA, 2007) explicitly explained how the doctoral entry-level physical therapist should practice in 2020:

Evidence-based practice is access to, and application and integration of evidence to guide clinical decision making to provide best practice for the patient/client. Evidence-based practice includes the integration of best available research, clinical expertise, and patient/client values and circumstances related to patient/client management, practice management, and health care policy decision making. Aims of evidence-based practice include enhancing patient/client management and reducing unwarranted variation in the provision of physical therapy services. (p. 2)

The shift to greater use of best evidence, algorithms, and clinical practice guidelines, and investigation of validity, reliability, and predictability of tests and measures are all signs that physical therapy is becoming more of a hard science. This new focus may explain why sophisticated beliefs in knowledge as complex and uncertain do not predict critical thinking about cases. Although students of physical therapy have always understood the need for clinical expertise and the consideration of individual patients' values and preferences, the emphasis on evidence (three to eight evidence courses in each physical therapy curriculum) and the increase in hard science courses in curriculum (pharmacology, radiology and imaging, differential diagnosis) may lead students to have a greater belief that knowledge is simple and certain. The other possibility is that a professional program in physical therapy does not focus on sophisticated views of knowledge as might a graduate program. Graduate programs emphasize advanced knowledge in a specific field of study. Students are often required to produce original research. Jehng et al. described graduate-level learning as follows:
Instructional methods and social discourse change. The content of advanced courses becomes less structured. Complex discussions frequently occur in the classroom and contradictory viewpoints are more frequently presented. Students become more aware that the nature of knowledge is uncertain, that truth is open to interpretation. (p. 33)

This focus on the uncertainty of knowledge is not the case for physical therapy students. Although students have completed an undergraduate degree as well as many prerequisites, the curriculum of physical therapy can be a step-wise process with foundational sciences in the first year (physiology, neuroscience, anatomy) and applied science in the second and third year. Further exploration of (a) physical therapy students’ epistemological beliefs longitudinally, (b) student understanding of cases as protocols and underlying habits of critical thinking, and (c) students’ understanding of their personal cognitive development will need to occur before any conclusions can be drawn about the relationship of epistemological beliefs to performance on case-based curricula.

**Implications for Clinical Practice**

The findings of this study have several implications for advancing practice in physical therapy that may relate to the successful use of the pedagogical method of case-based learning. This study has demonstrated that GPA, GRE—Verbal, CCTST, and the critical thinking measure of the MSLQ predict critical thinking about cases. It also demonstrated that, for these physical-therapy students, motivation, task value, and epistemological beliefs do not predict critical thinking about cases. GPA, in contrast, predicts both case-based knowledge and critical thinking about cases; that is, students with higher GPAs tend to perform better on case-based knowledge than students with lower GPAs. Students who have difficulty with foundational courses may need assistance and mentoring when they move to the application and analysis of knowledge
in case studies. The finding that GRE—Verbal predicts critical thinking about cases is important to consider in instruction. In a study of 522 physical therapy students, Day (1986) found that that the GRE—Analytical scores accounted for 33% of the variance of final GPA. The GRE—Analytical is described by the Electronic Testing Service (2010):

The analytical writing section measures your critical thinking and analytical writing skills. It assesses your ability to articulate and support complex ideas, analyze an argument, and sustained a focused and coherent discussion. It does not assess specific content knowledge. (p.2).

The two critical thinking questions of the case study ask the student to describe the reasoning process that they used to make their decisions about outcome measures and interventions and to explain how they used best evidence, knowledge, personal experience, and expert opinion of clinicians and instructors to make their choices. Using both the GRE—Verbal as well as GRE—Analytical scores may be useful in identifying students who have difficulty making and describing their decision making process. This information indicates the need for more opportunities for students to present their thought processes in written form as well as verbally.

Although accounting for a smaller proportion of the variance, the critical thinking component of the MSLQ and the CCTST predict critical thinking about cases. An unexpected finding in my study is that the CCTST has an inverse relationship with critical thinking about cases. This finding means that as standardized critical thinking scores rise, performance on critical thinking about cases decreases. This finding is inconsistent with other studies and is likely to be due to chance or to problems in the measure of case-based critical thinking. This latter possibility will be discussed further in limitations of the study.
In this study as well as that of Dutton (2003), motivation, task value, and self-regulation do not predict case-based critical thinking. Contrary to the research of Ertmer et al. (2003) with veterinary students, motivation and self-regulation may not be relevant predictors of outcomes in case-based critical thinking in physical-therapy students.

Also in this study and similar to Dutton (2003), naïve epistemological beliefs do not predict case-based critical thinking, contrary to the research of Dutton (2003) with occupational-therapy students. This finding may be due to the trend of physical therapy towards a “hard” science or the belief of students that cases can be completed with algorithms, heuristics, and protocols as long as the student possesses the correct knowledge. This conclusion needs further exploration but until further research is conducted, several steps can be taken during instruction. Students can be taught that cases are not protocols, rather they require critical thinking to formulate an educated decision. Instructors can use explicit examples to demonstrate where critical thinking is needed in sample case studies and encourage students to explain their answers both verbally and in writing. Students can be educated in the cognitive stages of development, given explicit examples of each level of development, and educated about the difference between expert opinion and best evidence.
APPENDIX
CASE PRESENTATION FORMAT CASE STUDY QUESTIONNAIRE AND SCORING RUBRIC FOR CASES

<table>
<thead>
<tr>
<th>Case Study Format – Student Provided with Video Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement dysfunction video – selected task(s)</td>
</tr>
<tr>
<td>Agreement between clinician and student that task(s) are</td>
</tr>
<tr>
<td>dysfunctional and agreement on underlying key observations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case Study Questionnaire – Part I- Movement Dysfunction Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are your underlying hypotheses for each of the key observations of movement analysis?</td>
</tr>
<tr>
<td>Or in other words, What is the system and the problem within the system that you believe or hypothesize is responsible for each movement problem? See Sample Case for example</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case Study Format – Student Provided with Examination Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client demographic data</td>
</tr>
<tr>
<td>Reason for current hospitalization (HPI)</td>
</tr>
<tr>
<td>Past medical history</td>
</tr>
<tr>
<td>Current medications</td>
</tr>
<tr>
<td>Provided</td>
</tr>
<tr>
<td>Provided</td>
</tr>
<tr>
<td>Provided</td>
</tr>
<tr>
<td>Provided</td>
</tr>
<tr>
<td>Patient or therapist statement of functional problem</td>
</tr>
<tr>
<td>e.g. patient complains of difficulty with sit to stand</td>
</tr>
<tr>
<td>Provided</td>
</tr>
<tr>
<td>Current physical examination</td>
</tr>
<tr>
<td>Mental status, range, strength, tone, synergy</td>
</tr>
<tr>
<td>Functional levels, assist</td>
</tr>
<tr>
<td>Provided</td>
</tr>
<tr>
<td>Provided</td>
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<tr>
<td>Provided</td>
</tr>
<tr>
<td>Goals established by expert clinician</td>
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<tr>
<td>Provided</td>
</tr>
</tbody>
</table>
### Case Study Questionnaire – Part II- Movement Dysfunction Analysis

<table>
<thead>
<tr>
<th>Question</th>
<th>Skill Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Based on (1) patient diagnosis, (2) key movement dysfunctions, (3)</td>
<td>Knowledge</td>
</tr>
<tr>
<td>underlying system involvement, (4) examination findings, and (5)</td>
<td></td>
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<tr>
<td>long and short term goals established by the expert clinician, what</td>
<td></td>
</tr>
<tr>
<td>three standardized outcome measures would you choose to show</td>
<td></td>
</tr>
<tr>
<td>improvement when re-evaluation is done in four weeks?</td>
<td></td>
</tr>
<tr>
<td>3. For these three outcome measures, describe the reasoning process</td>
<td>Critical thinking</td>
</tr>
<tr>
<td>that you used in arriving at these 3 among the many you might</td>
<td></td>
</tr>
<tr>
<td>have selected? In other words, for each of the outcome measures, what</td>
<td></td>
</tr>
<tr>
<td>evidence, information, personal experience, opinions of clinicians,</td>
<td></td>
</tr>
<tr>
<td>teachers, self, and/or peers led you to make these choices?</td>
<td></td>
</tr>
<tr>
<td>4. You have 1 hour daily for one-on-one physical therapy treatment.</td>
<td>Knowledge</td>
</tr>
<tr>
<td>You can also teach the patient, family member, and nursing staff</td>
<td></td>
</tr>
<tr>
<td>exercises and/or tasks that can be practiced outside of therapy time.</td>
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<tr>
<td>Outline your complete intervention for your patient for the next week</td>
<td></td>
</tr>
<tr>
<td>and identify the underlying system(s) being addressed by each of the</td>
<td></td>
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<tr>
<td>interventions. State your rationale for the selection of each</td>
<td></td>
</tr>
<tr>
<td>intervention, describe how you will progress the patient and</td>
<td></td>
</tr>
<tr>
<td>intervention over the next 2 weeks.</td>
<td></td>
</tr>
<tr>
<td>5. What three interventions and the underlying system(s) they addressed</td>
<td>Knowledge</td>
</tr>
<tr>
<td>are CRITICAL to your patient’s success in reaching goals established by</td>
<td></td>
</tr>
<tr>
<td>the expert clinician?</td>
<td></td>
</tr>
<tr>
<td>6. For these three interventions, describe the reasoning process that</td>
<td>Critical thinking</td>
</tr>
<tr>
<td>you used in arriving at these three interventions. That is, what</td>
<td></td>
</tr>
<tr>
<td>evidence, information, personal experience, opinions of clinicians,</td>
<td></td>
</tr>
<tr>
<td>teachers, self, and/or peers led you to make these 3 choices out of</td>
<td></td>
</tr>
<tr>
<td>the many interventions you could have selected?</td>
<td></td>
</tr>
</tbody>
</table>
Cases 1, 4, 7, and 10 will be scored for both knowledge and critical thinking.

Scoring for questions designed to elicit knowledge = a sum across all cases of the correct responses given by a student for each of the knowledge measurement questions as well as a total summation score. Question #1 has multiple components; each component will be scored separately and a subtotal score for this item will be obtained. Correctness of response for all items will be determined by the investigator in conjunction with an expert clinician prior to the administration of the questionnaire. There is no penalty for an incorrect response. The knowledge content is thought to be representative of the curricular content of this course built on previous neurological courses in the curriculum.

The scoring system for responses describing the thinking process used in answering 3 and 6 was developed to focus on the phrases within the student responses to the 4 critical-thinking questions. The phrases will be rated by the investigator to represent one of the following behaviors:

<table>
<thead>
<tr>
<th>Scoring rubric for critical thinking questions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmits facts and truths from an authoritative source.</td>
<td>1</td>
</tr>
<tr>
<td>Accepts uncertainty and ambiguity of knowledge; personal opinions are equally valid.</td>
<td>2</td>
</tr>
<tr>
<td>Recognizes that though uncertainty exists, all opinions are not equal</td>
<td>3</td>
</tr>
<tr>
<td>Independently makes and commits to choices of ideas and action applying the methods and criteria of the discipline in the context of the student’s consciously identified values</td>
<td>4</td>
</tr>
</tbody>
</table>

Each phrase within the student responses describing a selected outcome measure or intervention that can be classified will be assigned a numerical value according to the above scoring system; the sum of the values will be divided by the number of phrases classified yielding a total score that will be used as an indicator of the level of critical thinking behavior exhibited.
SAMPLE CASE

Case Study 1: 72 year male L hemiparesis; 7 days post stroke: Delbert Lukey
Observations: Student is able to watch video along with description below.
Transfer out of bed to wheelchair
We first meet Delbert Lukey when the PTA is assisting him in transferring from the bed to the wheelchair. The bed is rather soft. We see the posterior aspect of the patient. He sits in a rounded posture with a lack of thoracic/trunk extension. His transfer to the wheelchair is a series of small movements with a lack of trunk extension and difficulty maintaining full elbow extension and push off on the left arm. Very little extension of the knees is seen during the transfer. The COM is not moved forward sufficiently to unweight the pelvis. To make the transfer to the wheelchair, the PTA provides moderate assist to bring weight forward and up. Once seated in the wheelchair, his posture remains rounded with forward head. We hear no vocalizations from the patient but he appears to be attending to the directions of the PTA as he places the footrests on the wheelchair.
Propel wheelchair down the hallway
The patient is then asked to propel his wheelchair down the hallway using both legs. He appears to have fairly symmetrical use of his legs. His posture has not changed. It remains rounded with forward head. Very little affect is noted in the patient’s face.
Transfer wheelchair to mat
The therapist asks the patient to transfer to the mat using the same type of transfer as was previously performed at the bedside. The patient shows preference for performing a stand pivot versus a scoot transfer. The therapist notes the discrepancy in task chosen and explains to patient who appears to understand the desired task. With the wheelchair arm removed, the therapist gives directions to the patient. In response to sit tall, there is little change in patient posture. After 3-4 small scoots, he requires a rest. While resting, the therapist talks with the patient. His speech is not very clear, somewhat mumbled, although he has no speech deficits from the stroke. He talks with the therapist about watching his grandson do activities and everything is so easy. He agrees that the hardest part of moving his body is the thinking, then the doing. After the rest, he is ready to finish the transfer. It is noted that the patient is quite tall with long legs and that the mat height is not adjustable. He has difficulty shifting his center of mass forward to unweight and extend legs during the transfer.
Sitting edge of mat
After completing the transfer, the patient is seen sitting. His weight is slightly shifted to the left at the lower pelvis. We see slightly more ER of the LLE than the R. The patient is seen to spontaneously readjust his posture in sitting for a slightly more even weight bearing. He uses his R arm to pull on the mat.
Reach for objects in sitting
The patient is asked to slide his hand (s) one at a time across a half hula hoop which is held in the air in front of the patient at increasingly higher levels. Very little thoracic extension is noted especially as the hoop is brought higher. There are no automatic changes in trunk posture to accommodate the increased height of the hoop making it difficult for the scapula position to accommodate the humeral head. The patient finally demonstrates some humor when the hoop is moved higher. When reaching with the RUE moving R to L he must place the LUE on the mat for stability. The patient again shows some appropriate humor but little facial change is noted or words spoken. When the hoop is raised to a height that requires that the patient lift the UE to approximately 110 degrees of flexion, the patient is unable to move the LUE through the range. The activity is changed from a closed kinetic chain to an open kinetic chain activity where the patient is reaching for bean bags. The task is manipulated so the patient either must keep the trunk stable or the trunk mobile. Different heights of the bags require more or less cervical and thoracic extension and more or less lateral weight shift. The patient demonstrates near normal scapulohumeral rhythm and speed of reaching with the RUE up to 150 degrees. The LUE movement is less smooth with less excursion of the scapula.
Sit to stand to walker (24)
The patient is given specific directions to perform sit to stand from the nonadjustable mat with emphasis on using the quads to push to erect. On the first attempt of sit to stand, there is rounded posture and the patient is unable to shift his COM forward enough to come to stand. The therapist may be blocking his forward translation with her body. On the second attempt propulsive force and center of mass forward movement are sufficient to come to stand. Subsequent gait with rolling walker shows rounded posture, flexed hips and flexed knees. Steps are small and shuffling, it looks as if gravity is “pulling” this patient to the floor.

Hedman, Hanke, Rogers (1996)

**Analysis (we will practice this in class) per Hedman’s model**

<table>
<thead>
<tr>
<th>Initial conditions</th>
<th>Preparation</th>
<th>Initiation</th>
<th>Execution</th>
<th>Termination</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posture</td>
<td>Stimulus ID</td>
<td>Timing</td>
<td>Amplitude</td>
<td>Timing</td>
<td>Outcome achieved?</td>
</tr>
<tr>
<td>Ability to interact with environment</td>
<td>Response Selection</td>
<td>Direction</td>
<td>Direction</td>
<td>Stability</td>
<td></td>
</tr>
<tr>
<td>Internal set</td>
<td>Response programming</td>
<td>Smoothness</td>
<td>Smoothness</td>
<td>Accuracy</td>
<td></td>
</tr>
<tr>
<td>Environmental context</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

The **Key observations** common to transfers, sitting and reaching, and sit to stand are:
1. Inability to attain and hold/sustain upright posture in sit and stand
2. Delayed initiation of movement
3. Slow movement
4. Effortful movement/fatigue
5. Reduced postural control static and dynamic
6. Environmental context – length of body related to height of furniture
7. Reduced ability to recruit mm for propulsive movement
8. Inability to move COM over BOS for efficient, less effortful, and successful movement
9. Selection of alternate (less effortful) strategies
Case Study Questionnaire:
1. What are your underlying hypotheses for each of the key observations of movement analysis?

Or in other words,
1. What is the system and the problem within the system that you believe or hypothesize is responsible for each movement problem? (Knowledge)
   a. Inability to attain and hold/sustain posture in sit and stand
      i. Cardiopulmonary fatigue (cardiopulmonary)
      ii. Muscle tightness and opposing muscle weakness (functional posture and muscle amplitude)
      iii. Postural permanent structural changes (bone, contractures)
   b. Delayed initiation of movement
      i. Reduced muscle fiber numbers and recruitment (muscle amplitude, timing)
      ii. Fear of speed (momentum) (ability to interact with environment, speed, cognitive)
   c. Slow movement
      i. Fatigue (cardiopulmonary and muscle)
      ii. Reduced muscle fibers, reduced type II fibers
      iii. Fear
      iv. Slow cognitive processing e.g. think, then do; movements no longer automatic
      v. Patient requires time for response selection; perhaps old automatic pattern no longer functional or effective
      vi. Lack of motivation (affect)
   d. Effortful movement/fatigue
      i. Weakness due to stroke, hospitalization, age
   e. Reduced postural control static and dynamic
      i. Tightness of flexor muscle and weakness of opposing extensors
      ii. Poor core strength and tonic musculature
   f. Environmental context – length of body related to height of furniture
      i. Pt. at disadvantage with body length, height of bed, w/c, mat
      ii. Lack of muscle reserve to create momentum
   g. reduced ability to recruit mm for propulsive movement
   h. inability to move COM over BOS for efficient, less effortful, and successful movement
      i. poor posture requires extreme forward flexion to get COM forward
   i. Selection of alternate (less effortful) strategies
      i. Pt. has tried some strategies (e.g. squat pivot) without success, immediately moves to more successful strategy (long legs)
Once student is finished, can click on “examination findings.”

**Examination findings:** Students now have access to the actual examination performed by the PT, OT, and other health care professionals associated with this patient’s care. Once they have read over the examination findings, which include objective data such as patient history, home status, strength, range of motion, flexibility, sensory testing, speech workup, and psych workup, they will then answer the following questions.

### Examination findings:

- **Dx:** R CVA middle cerebral artery; unremarkable hospital course
- **HPI:** 72 yr. WM Hx of hypertension x 10 years; meds lotensin.
- **Statistics:** 5'9", 200#.
- **Social:** Retired schoolteacher, junior high history and social studies; married, wife Helen age 68 generally healthy-arthritic knees, able to care for spouse. Involved in church group, likes to play cards, socialize with friends from school, frequently volunteer at school functions, pt. very popular with students. Occasionally does substitute teaching. Does not smoke, occasional mixed drink social events. Pets: 1 small rat terrier. Son and two grandchildren ages 18 and 20 live closeby, willing to assist.
- **Home:** single floor house, one step from garage, 2 access steps front with rail on R. Bathroom large enough to accommodate walker, adaptations for shower and commode.
- **Status prior to admission:** ambulated independently community distances, drove independently; occasional fatigue when shopping greater than 1 hour, normally took “sit” breaks
- **Skin integrity:** intact
- **Comprehension:** intact
- **Expression/speech:** intact
- **Memory:** no deficits with STM or LTM
- **Perceptual/visual:** no deficits, glasses for reading.
- **Sensation:** Intact to LT/PP and proprioception all 4 extremities
- **PROM:** Intact all 4 extremities. Trunk – slight inability to maintain neutral APT easily, tendency for PPT sit and stand.
- **Tone:** normal
- **Flexibility:** tight hamstrings (50), psoas (10/Thomas test) bilaterally, tight latissimus bilaterally with 170 degrees shoulder flexion.
- **Strength:** RUE 4/5, LUE 3+/5
- **RLE 4/5, LLE 4-5**
- **Endurance:** fatigues easily, propels w/c 200’ with BLE perceived exertion 8/10.
- **Ambulates with rolling walker 50’ x 2 with PE 8/10, requires 2-3 min. rest.**

**Goals to be achieved in 4 weeks:** Patient will…

1. **Ambulate 100’ with straight cane and 500’ with rolling walker on level surface independently with perceived exertion of 4/10.**
2. **Transfer independently from surfaces including regular height chair, soft bed, toilet, and car seat.**
3. **Demonstrate good core stability and neutral anterior pelvic tilt in standing and sitting activities for periods of 10 minutes.**
4. **Ascend/descend 4 steps with single point cane independently without loss of balance.**
2. Based on (1) patient diagnosis, (2) key movement dysfunctions, (3) underlying system involvement, (4) examination findings, and (5) long and short term goals established by the expert clinician, what three standardized outcome measures would you choose to show improvement when re-evaluation is done in four weeks?  

3. For these three outcome measures, describe the reasoning process that you used in arriving at these 3 among the many you might have selected? In other words, for each of the outcome measures, what evidence, information, personal experience, opinions of clinicians, teachers, self, and/or peers led you to make these choices? 

4. You have 1 hour daily for one-on-one physical therapy treatment. You can also teach the patient, family member, and nursing staff exercises and/or tasks that can be practiced outside of therapy time. Outline your complete intervention for your patient for the next week and identify the underlying system(s) being addressed by each of the interventions. State your rationale for the selection of each intervention. For each intervention, describe how you will progress the patient and intervention over the next 2 weeks.  

5. What three interventions and the underlying system(s) they addressed are CRITICAL to your patient’s success in reaching goals established by the expert clinician?  

6. For these three interventions, describe the reasoning process that you used in arriving at these three interventions. That is, what evidence, information, personal experience, opinions of clinicians, teachers, self, and/or peers led you to make these 3 choices out of the many interventions you could have selected?
LIST OF REFERENCES


BIOGRAPHICAL SKETCH

Gloria T. Miller was born in Schenectady, New York. She received a BS degree in physical therapy from Russell Sage College in Troy, New York in 1978. She received an MA degree in exercise physiology from the University of Central Florida in 1990. In 1994 she received a MHS in physical therapy from the University of Florida. Since 1994, she has held the position of instructor on the physical therapy faculty at the University of Florida. She has served as both the Academic Coordinator of Clinical Education as well as the Curriculum Coordinator. She was accepted to the doctoral program in educational psychology in the Fall of 1997, and attained doctoral candidacy in January of 2002. While pursuing her doctoral studies, she has taught full time in the physical therapy curriculum for the University of Florida, where she has focused her attention on methods to increase critical thinking with physical therapy students. Upon her graduation, she plans to remain on faculty at the University of Florida, where she plans to continue her research on facilitation of critical thinking using case-based learning.