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The purpose of this research was to compare the effects of problem based learning (PBL) and traditional lecture instruction (TI) courses on critical thinking, knowledge and application of strength and conditioning throughout a semester long collegiate undergraduate course. Twenty undergraduate exercise and sport science students enrolled in either a TI course (n=12) or a PBL course (n=8).

The results revealed no statistically significant difference for critical thinking development using the California Critical Thinking Skills Test (CCTST). Both PBL and TI resulted in improvement on National Strength and Conditioning Association Certified Strength and Conditioning Specialist (NSCA-CSCS) certification practice exam knowledge questions pretest to posttest as well as for the pretest to posttest NSCA-CSCS certification practice exam application questions.

Student course evaluations revealed student perceptions of PBL in which students found textbook usage, the use of PBL problems, and communication of strength and conditioning concepts with the group as the most beneficial PBL course components to learning strength and conditioning with peers as teachers as the least beneficial. PBL students also noted feelings of frustration, culture shock, and lack of time in learning course material. All PBL students were graduating seniors with no prior PBL experience. The instructor recorded observed critical thinking, application of knowledge, and positive and negative comments and class interactions in field notes. Students did not improve

critical thinking, knowledge, and application in strength conditioning better with PBL than TI. It is important to note that PBL scores were not statistically less than TI suggesting that PBL was an equally effective pedagogical method. Findings from the field notes suggest critical thinking and applying knowledge was observed during PBL classroom discussion and instructor interactions with individual students. Students' perceptions revealed students did learn to become more independent learners and problem solvers.

COMPARSION OF PROBLEM BASED LEARNING AND TRADTIONAL LECTURE

INSTRUCTION ON CRITICAL THINKING, KNOWLEDGE, AND APPLICATION

OF STRENGTH AND CONDITIONING

by

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APPROVAL PAGE

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

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CHAPTER I

INTRODUCTION

Graduates of undergraduate Exercise Science curricula pursue employment in a variety of settings ranging from hospitals, fitness centers, health clinics, community centers, universities to research centers (Ives 2007). Hence, one goal of exercise science education is to prepare competent graduates to successfully make the transition from classroom setting into professional practice. Descriptions of professional practice have historically focused on technical and specialized skills and applied knowledge (Williams 2000). More frequently professionals are confronted with problems during the workday that require immediate and problem-specific resources to solve (Doig 1994). Employers seek graduates who are highly knowledgeable, skilled problem solvers, team players, and lifelong learners (Hmelo and Evenson 2000). In order to prepare students for entry into professional practice, educators must create learning environments that engage students in ways that help them develop the necessary context expertise as well as problem solving, collaboration, and lifelong learning skills (Dunlap 2005).

Unfortunately, traditional undergraduate exercise science courses using lecture-based instruction are often content driven, emphasizing abstract concepts over concrete examples and application. Little attention is given to learning problem solving, collaboration, and lifelong learning skills (Barrows 1983). Furthermore, faculty often have little pedagogical training and revert to previous learning experiences, simply stated "teaching as we were taught" (Duch, Groh et al. 2001). Traditionally, lecture has been the choice method of instruction because it is seen as the most efficient and convenient method of instruction to offer the most information in the shortest time. Faculty may be unaware that it is reported that only 5-15% of presented content is learned in lecture based courses (Doig 1994). Furthermore, there is often little concern for the students' capacity to absorb, understand, retain, and apply the information in subsequent clinical situations (Barrows 1983). If students cannot retain or apply information given by lecture than the goal of professional preparation is not being met. In retrospect, lecture-only courses may not be the most effective method of professional education.

The Information Age has seen enormous changes in communication, education, information access, and technology aspects of our lives (Duch, Groh et al. 2001). As information becomes more easily accessible and continues to grow, so does the amount of information presented in a course. In accordance with Del Bueno (2005), it has been demonstrated in nursing students who met academic entry requirements and passed state licensing examinations could not identify and/or problem solve patient care when faced in real-life situations (Del Bueno 2005). Focus of teaching content regardless of increasing volume was suggested as a possible cause.

In order to most efficiently deliver material to students in a lecture course, the instructor typically researches all relevant sources to condense the content (Doig 1994). Within this process the instructor learns how to decipher through sources to determine which ones are credible and most pertinent. However the students often may not have this same ability. Professionals must use credible sources to help find solutions when faced with a problem. The professional must determine the level of credibility, what information is needed, and apply the information found to the context of the problem in order to use these sources. Thus, researching and analyzing sources of information is an important step in the problem solving process.

Information–heavy presentation within a lecture likely results in students cramming to simply memorize information in order to pass examinations. Such instructional methods may not result in long-term knowledge retention (Beers 2005). Long-term knowledge is acquired through activation of prior knowledge, discussion, application, and reflection. Cognitive psychology principles suggest that prior knowledge is the key in determining what additional knowledge can be learned (Norman and Schmidt 1992). Instructional methods must allow the activation of prior knowledge in order to process and garner new knowledge. One method to activate prior knowledge may be small-group discussion. During small-group discussion, students have the opportunity to elaborate on the knowledge at the time of learning (Norman and Schmidt 1992). Furthermore, presenting a situation or an opportunity to learn within a specific context will foster group discussion and ultimately long-term knowledge and effective problem solving skills.

Problem solving has been referred to as the ability to apply appropriate metacognitive and reasoning strategies (Hmelo-Silver 2004). In the traditional classroom setting students often are exposed to problem solving application lectures in a contextual situation; yet for a student to truly learn to perform problem solving skills, he or she must be given the opportunity to actively do so. Instructors continue to teach basic science principles, using examples of application, with the implied hope that these principles will be utilized to solve clinical problems (Norman and Schmidt 1992). Even if students are given the opportunity to develop problem solving skills, appropriate and timely feedback are needed for success. Feedback such as reflecting on the learning experience may help learners understand the relationship between learning and the problem solving process. Reflection helps students relate new to prior knowledge, mindfully abstract knowledge, and understand how learning and problem solving skills are reapplied (Hmelo-Silver 2004).

During the problem-solving process, the professional must analyze the problem using prior knowledge activation to determine what is known and unknown and seek a variety of sources to assist in finding the unknown information. The professional synthesizes a solution through critical thinking and reflects upon the experience through self-evaluation once all the pertinent information is collected and critiqued. In critical thinking, a person gives reasoned consideration to evidence, context, theories, methods, and criteria in order to form a purposeful judgment and simultaneously monitors, corrects, and improves the process through meta-cognitive self-regulation (Facione

1994). Critical thinking experts define critical thinking as the process of purposeful, self-regulatory, judgment; an interactive, reflective, reasoning process (Facione 1994). For example, The National League of Nursing has affirmed that professionalism requires thoughtful decision making founded on the ability to make purposeful, reflective judgments which involve analysis, interpretation, inference, evaluation and explanation i.e., critical thinking (Facione 1994).

Statement of the Problem

In the field of Exercise and Sport Science, Certified Strength and Conditioning Specialists (CSCSs) are professionals who apply scientific knowledge to train athletes for the primary goal of improving athletic performance (Commission 2007). The CSCS professional conducts sport-specific testing sessions, designs and implements safe and effective strength training and conditioning programs and provides guidance regarding nutrition and injury prevention (Commission 2007). According to the National Strength & Conditioning Association Certification Commission (NSCA-CC), the Certified Strength & Conditioning Specialist (CSCS) examination questions are written at cognitive levels which reflect the job-related tasks of the strength and conditioning professional (Commission 2007). The NSCA-CC defines three cognitive levels as recall, application, and analysis. Recall requires only the identification of isolated bits of information (Commission 2007). Application requires the interpretation or manipulation of limited concepts where the outcome varies relative to the situation. Analysis requires integration and synthesis of a variety of concepts to solve or evaluate a specific problem

(Commission 2007). Although recall is important, application and analysis are complex cognitive skills applied to critical thinking, not rote memorization. The NSCA-CC definitions of application and analysis include additional higher order cognitive thinking based on Bloom's Taxonomy (Bloom 1956) such as synthesis and evaluation. Because the strength and conditioning professional uses higher order cognitive skills to critically think when designing sport-specific strength and conditioning programs, education of these professionals must prepare students for knowledge retention as well as critically thinking ability using a higher order thinking of strength and conditioning.

To best prepare students for the strength and conditioning profession, educators must find the most effective instructional method for teaching students how to design strength training and conditioning programs. In order to properly design a program the student will need to learn critical thinking skills of application and analysis. Because traditional lecture instruction (TI) has been shown to be less effective than other teaching methods in practical application and critical thinking skills (Nii 1996; Dalton 1999; Tiwari 2006), a solution might be Problem-Based Learning (PBL). PBL is an active learning instructional method that uses "real world" problems to facilitate instruction so students can develop critical thinking and problem solving skills while gaining new knowledge. As an active learning method, students work through problems in small collaborative groups emphasizing the application of knowledge and the development of higher order thinking. PBL allows students to become active learners because learning is placed in the context of real-world problems and requires students to become responsible for their own learning, i.e. self-directed learning (Spencer 1999; Hmelo-Silver 2004). PBL in the education of health professionals was first established in North America at McMaster University in 1969 due to the increasing frustration of the inability of medical students to apply knowledge learned in previous years (Barrows 1980). It has also been used in the fields of health professionals such as nurses, chiropractors, physical therapists, athletic trainers, and pharmacists, as well as basic science courses (Rangachari 1991; Amos and White 1998; Doucet 1998; Saarinen-Rahiika, Binkley et al. 1998; Segers, Dochy et al. 1999; Last 2001; Teshima 2001; Prince 2003; Hwang and Kim 2006). Because of the use of PBL in educating these health professionals, this instructional method may be also used to educate future strength and conditioning professionals. However, we were unable to locate any studies that have investigated the use of PBL in the education of strength and conditioning professionals.

Today, more than 21,000 professionals including strength and conditioning coaches, athletic trainers, physical therapists, personal trainers, physicians, chiropractors, researchers and educators are CSCS certified (Commission 2007). This credential encourages increasing levels of competence among practitioners and raises the quality of strength training and conditioning programs provided by those who are CSCS certified. Additionally, the CSCS is the only strength training and conditioning certification to be nationally accredited by the National Commission for Certifying Agencies (NCCA) since 1993 (Commission 2007). The credentials associated with the CSCS and the many professionals from varying specializations holding this certification supports its importance and ever-increasing recognition in the field of Exercise and Sport Science. As its recognition continues to grow, graduating students will need to possess this certification for employment within the strength and conditioning field.

Specifically, the purpose of this research was to compare how PBL versus traditional lecture instruction (TI) impact critical thinking, knowledge and application of strength and conditioning throughout a semester long collegiate undergraduate course.

Objective and Hypotheses

Specific Aim One - Compare the outcome of PBL and TI semester long courses on Strength and Conditioning on knowledge of strength and conditioning course material.

Hypothesis One – The PBL course will result in greater knowledge of strength and conditioning course material as assessed by the mean between the pretest and posttest using the recall questions of the National Strength and Conditioning Association Certified Strength and Conditioning Specialist Practice Exam on these topics.

Rationale – This study investigated the feasibility of PBL students performing better than TI students on knowledge questions. Previous studies have demonstrated that PBL students scored significantly higher than TI on multiple-choice examinations (Doucet 1998; Hwang and Kim 2005).

Specific Aim Two- Compare the outcome of PBL and TI semester long courses on Strength and Conditioning on the application of strength and conditioning course material.

Hypothesis Two – The PBL course will result in an increased ability to apply knowledge of strength and conditioning course material as assessed by the mean difference between the pretest and posttest using the application and analysis questions of the National Strength and Conditioning Association Certified Strength and Conditioning Specialist Practice Exam on these topics.

Rationale – This study investigated the feasibility of PBL students performing better than TI students on application questions. Previous studies suggested PBL students scored higher than TI students on application questions (Antepohl and Herzig 1999; Doucet 1998; Murphy 2006).

Specific Aim Three - Compare the outcome of PBL and TI semester long courses on Strength and Conditioning on students' critical thinking skills.

Hypothesis Three – The PBL course will result in increased critical thinking skills compared to traditional lecture instruction course as assessed by the mean difference between the pretest and posttest of the California Critical Thinking Skills Test (CCTST).

Rationale - Pretest and posttest designs are suggested when assessing students and programs to measure critical thinking change or development over time (Facione 1991). Nursing studies have suggested that PBL is effective in improving critical thinking scores (Amos and White 1998).

Operational Definitions

1. Problem Based Learning (PBL) is operationally defined as a student centered instructional method using the presentation of real-life situational problems to a

tutorial group in order to solve the problem, the group follows a modified Seven Jump Sequence PBL process (Spencer 1999; Barrows 1986).

2. Traditional Lecture Instruction (TI) is operationally defined as an instructor centered instructional method by means of lecture with power point presentations, video presentations and laboratory work.
3. Critical Thinking improvement is operationally defined as the overall mean difference between the mean pretest and posttest scores of the California Critical Thinking Skills Test.
4. Application of knowledge is operationally defined as the overall mean difference between the mean pretest and posttest scores of the application and analysis questions on the National Strength & Conditioning Association (NSCA) Certified Strength and Conditioning Specialist (CSCS) Certification Practice Exam.
5. Knowledge is operationally defined as the overall mean difference between the mean pretest and posttest scores of the recall questions on the National Strength & Conditioning Association (NSCA) Certified Strength and Conditioning Specialist (CSCS) Certification Practice Exam.

Limitations

1. The level of previous knowledge of each participant may be different.
2. The level of previous practical application in program design of each participant may be different.

3. The level of previous written and oral communication skills, research skills, and initial critical thinking skills of each participant may be different.
4. Any prior experience with PBL of each participant.

Delimitations

The following delimitations will be made for the purpose of this study:

1. This study will be delimited to undergraduate exercise and sport science major students who have completed previous course work in exercise physiology, biomechanics, and exercise instruction.
2. This study will be delimited to two, fifteen-week undergraduate three-credit hour courses in strength and conditioning.
3. The same instructor will teach both course sections in the same classroom during the same time of the day.

CHAPTER II

REVIEW OF LITERATURE

The following review of Problem Based Learning (PBL) research provides the foundation for this inquiry of teaching methods. To meet the goals of this research the literature search has been limited to university courses using PBL in health professional education. This chapter will describe PBL, specific formats, and characteristics as well as review the literature pertaining to critical thinking, knowledge and application in comparison with traditional lecture instruction (TI).

PBL Overview and Description

PBL is an active learning instructional method that uses real-life problems to facilitate student learning. PBL teaches students to identify what they know and what they need to know to find the information they need, analyze and communicate the findings to others (Williams 2000). PBL has been implemented as an entire curriculum, a course, or subset within a traditional course. It is used in disciplines of the medical and health professions, the basic sciences, as well as settings to include high school, undergraduate and graduate university programs, and continuing education.

This diversity in PBL implementation presents challenges in interpreting and performing PBL research. Educators have modified PBL to address the needs of the specific student populations, disciplines, and settings resulting in an inconsistency for comparison. Furthermore, the definition of PBL is varied and elusive (Barrows 1986; Norman and Schmidt 1992; Albanese and Mitchell 1993). These challenges also create obstacles when measuring ambiguous learning outcomes such as critical thinking and application of knowledge (Rangachari 1991; Nii 1996; Maudsley 1999; Hwang and Kim 2006). Although interpretation of PBL research faces many challenges, the purpose, learning goals, and process are common to most PBL studies.

Purpose

PBL is an active learning process focusing on content within a contextual situation in which students must work independently and collaboratively within a group structure. The purpose of PBL is three-fold: learn basic knowledge or content, develop critical thinking skills to rationalize how to apply the basic knowledge to the context, and apply the knowledge to the situation (Barrows 1986). Rather than rote memorization of facts (lower ordered thinking), the contextual situation, or problem, compels students to identify and learn the content to formulate a solution, higher ordered thinking (Duch et al 2001).

History

McMaster medical school in Ontario, Canada in the late 1960s, established the first completely problem based medical curriculum, with Maastricht University in the Netherlands following in 1974 (Spencer 1999). It has been suggested that the rationale for the introduction of PBL occurred in medical education to alleviate problems within the curriculum such as students using irrelevant information, inability to integrate concepts and make appropriate use of prior knowledge, and acquiring lifelong learning skills (Barrows 1980).

Such problems may have occurred due to the primary use of TI methods such as the lecture. A lecture is defined as a period of more or less uninterrupted talk from a teacher and occurs in an environment where information is delivered to a group of students (Bligh 1998; Tiwari 2006). The instructor has a prepared set of notes and can deliver the same lectures year after year while the students passively learn the information presented (Rangachari 1991). Lectures, while to some extent essential, are limited in addressing the increasing involvedness of practical application in which independent critical thinking skills are required (Nii 1996). These limitations arising from the use of lectures have resulted in educators seeking other instructional methods such as PBL to instruct critical thinking and application.

PBL Process Formats

PBL is focused on small groups with a facilitator and follows a particular sequence of problem solving steps. Once a problem is presented to the student group, the students begin working towards a solution. Barrows initially developed a PBL taxonomy in which PBL methods were categorized based on effectiveness in learning objectives (Barrows 1986). Four educational goals were identified through the use of PBL: structuring of knowledge for use in clinical contexts, developing effective problem-solving skills and self-directed learning skills, and motivating students to learn. (Barrows

1986) The design and format of the specific PBL curriculum determines the level at which each educational goal is achieved.

Although six PBL formats have been identified, there are variations within each format: lecture-based cases, case-based lectures, case method, modified case-based, problem based, and closed loop problem-based (Barrows 1986). Using lecture-based cases requires a case study to be presented to students prior to the given lecture. Unfortunately, this method only presents information and does not foster any of these educational goals. In case-based lectures a lecture is presented prior to the case study. Students have the opportunity to analyze the case using prior knowledge. However, students use only the information given in the lecture to analyze the case, which may limit self-directed learning. In a case method format students are given a completed case to review for subsequent in-class discussion. No lecture is presented; consequently some self-directed learning must occur prior to class for students to understand concepts. Because the students receive a completed case, the opportunity for students to analyze, synthesize, and apply information to the case does not occur. Thus, critical thinking and higher ordered thinking skills are limited. An extension of this method is the modified case method in which small tutorial groups are utilized as opposed to a large number of students. Although students may be more motivated to contribute to group learning, the same limitations exist as with the case method (Barrows 1986).

In problem based and closed loop problem-based formats students are presented with an ill-structured, real-life professional problem. Students begin by using prior knowledge to determine what they know and do not know, concepts that need further explanation or understanding, what issues are relevant, and possible hypotheses. The group finalizes this step by determining which learning objectives to research and what resources to use for the gathering of information. Next, students perform independent research through self-directed learning in which students take the initiative for their own learning: diagnosing needs, formulating goals, identifying resources, implementing appropriate activities, and evaluating outcomes (Spencer 1999). More specifically, each student will research the learning issues independently by examining and collecting information from resources such as refereed journals, text books, books, professional organization websites, strength and conditioning coaches, and appropriate databases, i.e., PubMed. Finally, the group convenes to discuss and evaluate individual findings, establishes an understanding of the learning objectives, revise and formulate new hypotheses, and synthesize a solution. The only difference between problem based and closed-loop problem based is the closed-loop problem based adds a reflective step at the end. After students complete the self-directed learning portion within the PBL process, the last step requires the students to evaluate their information resources, the relevancy of the information found, prior knowledge, and critical thinking skills (Barrows 1986). Discussion of the problem solving process is as important and as relevant to the discussion as the problem solution. This reflective step further addresses the educational goals by requiring students to go beyond the acquisition and discussion of new knowledge in a way that allows them to see its value and to actively evaluate their prior knowledge and problem solving skills (Barrows 1986). Thus, the closed-loop problem based format has been reported to be the most effective in the development of all four educational goals among the six PBL formats (Barrows 1986).

Similar to Barrows PBL format, the Maastricht "Seven-Jump" Sequence developed by Maastricht University dissects PBL into seven steps (Spencer 1999). The steps are as follows:

1. Clarify and agree on working definitions and any unclear understanding of concepts.
2. Define the problem using their terminology.
3. Analyze the problem and brainstorm ideas.
4. Arrange the ideas into possible explanations or hypotheses.
5. Generate and prioritize learning objectives.
6. Research the learning objectives.
7. Present the research to the group, synthesize explanations, and apply new information to develop a solution.

An additional reflection step should be placed after the solution is developed to simulate the Barrow closed-loop PBL model (1986). Once completed, this process begins again with a new problem.

PBL in a health sciences librarianship course was described by Dimitroff et. al. (1998). Students identified and defined the problem based on the ill-structured scenario provided, identified the information they needed to address the problem, acquired the needed knowledge, synthesized it, and applied it in the development of a solution. Dimitroff PBL steps were as follows: recognition of a problem with significant academic or operational implications, initial formulation of the problem, description of the problem situation, identification of solutions for analysis and testing, and evaluation of solutions to the problem. Comparatively, Rangachari (1991) explained a PBL design within an undergraduate course in pharmacology. Using a small group format, this procedure attempted to test the students on hypothesis generation, the design of experimental tests, and their ability to reassess, synthesize, and assimilate new information. Rangachari discussed the PBL process as the steps in which issues are raised, identified, and refined into learning objectives and the required information is research, analyzed, incorporated, and shared. Furthermore, the success of this PBL process required students to critically evaluate their own performance and their peers, i.e., reflection. In addition to the PBL process, content refers to "what" is learned and corresponds to the content of the course. It is important to realize that what is learned effectively stems from how it is learned (Rangachari 1991). The characteristics of the PBL process are similar between these studies regardless of the discipline or setting PBL occurs.

Implementation of PBL Curricula

As previously stated, PBL has been implemented in a wide variety of settings and disciplines. In addition, factors involved with PBL implementation such as the PBL process, the number of students per group, interaction time, the role of the facilitator, and the problem can create challenges when deciding how to best implement PBL. Below is a review of the literature addressing these factors.

Usage of Groups in PBL

PBL methods often use tutorial groups in the problem solving process. Giving students the opportunity to work in a group prepares them for the professional world by learning how to lead, facilitate, record, compromise, cooperate, discuss, prioritize, organize, plan, research, make decisions, negotiate, and resolve conflict (Nilson 2003). For example, a strength and conditioning coach will work in groups with sport coaches, athletic trainers, athletes, dieticians, athletic directors, and other professionals to work toward meeting the goals of the athletes. Groups provide a supportive environment for students to discuss the problem and possible strategies to reach a solution. By listening to multiple ideas and evaluating the different approaches, students develop an understanding that there is more than one approach to a solution. The success of a group relies on factors such as roles and expectations of group members, the number of students per group, the time given for face-to-face interaction, and the facilitator. At the beginning of the problem solving process, the group members should collectively establish roles and expectations of each member and the group. Amos and White (1998) had each student group develop "Rules of Trust" to guide the group interactions. The number of group members is of importance to the success of the group. A minimum of four members per group has been suggested to be best for the problem solving process (Nilson 2003). PBL studies of have reported varied group sizes from four to nine members per group (Delafuente 1994; Amos and White 1998; Doucet 1998; Antepohl and Herzig 1999;

Bovee 2000; Hwang and Kim 2006). It is still unknown as to the optimal number of students per group for PBL.

Time Demands of PBL

The amount of face-to-face time given for group interaction varies among studies of the problem solving process. Studies comparing PBL and TI have documented the amount of time for weekly group meetings and TI. The amount of time has varied between studies from one day per week for three hours to two days per week for six hours and three days per week for three hours (Rangachari 1991; Delafuente 1994; Amos and White 1998; Doucet 1998; Antepohl and Herzig 1999; Tiwari 2006). However in the Dimitroff (1998) study, students met once every other week giving little time for face-to-face discussion and instructor feedback causing a challenge in the success and progress of the problem solving process. Even though studies have varied in interaction time between students and facilitator, having too little time can be a limiting factor for the PBL process. Unfortunately, no specific amount of time has been shown to be the most advantageous for PBL (Dimitroff 1998).

Facilitator's Role in PBL

As PBL is student centered rather than instructor centered, the instructor acts as a facilitator or tutor for the group (Hmelo-Silver 2004). The facilitator is solely present to guide and facilitate student critical thinking by asking questions that require students to elaborate, justify, and provide rationale for their decisions. If the group is working toward an incorrect path of thought or is having difficulties, the facilitator may help clarify or redirect the path of thought. In addition, the facilitator may provide "what if" scenarios to challenge students understanding of the learning objective (Brahler, Quitadamo et al. 2002). Thus, the facilitator acts as a guide for critical thinking.

Types of Problems Used in PBL

Lastly, PBL incorporates ill-structured, complex, and realistic problems that facilitate learning. Problems may require students to decide what assumptions are needed and why, what information is relevant, and what steps or procedures are required in order to solve the problem (Duch, Groh et al. 2001). Not all the information given in the problem needs to be relevant to a solution, as is the case of a real-world situation, i.e., ill-structure, and not all information needed for a solution will be given to the student immediately (Duch, Groh et al. 2001). For this reason many PBL problems are designed with multiple stages to be given to the group one at a time as they work through the problem (Duch, Groh et al. 2001). Students first encounter problems as a means to enhance motivation, reactivate prior knowledge, and trigger self-directed learning skills in a process of explaining, understanding, and solving the problem (Schmidt 1983). Thus, it is imperative that the problem should match the students' previously acquired level of knowledge, motivate students to pursue further study, suitable for analysis and application, and achieve the learning objective (Des Marchais 1999; Duch, Groh et al. 2001). The students face the problems just as they would in real-life clinical situations with the path to the solution unknown (Heinrichs 2002). In 1999, a Delphi study by Des Marchais constructed and evaluated criteria of PBL problems. Findings determined an effective PBL problem should stimulate analysis, assure self-directed learning, use previous knowledge, propose a realistic context, lead to learning objectives, stimulate discussion and be prototypical cases. These commonalities may act as a guide or blueprint for instructors initiating PBL. Differences occur within these commonalities, which may attribute to disparities associated with PBL research.

Effectiveness of PBL on Learning Outcomes

In addition to simply mentioning the numerous disciplines and settings utilizing PBL as an instructional method and curriculum, researchers have further investigated learning outcomes of PBL in comparison to TI. Measured outcomes have included critical thinking, knowledge, motivation, application or clinical competence, student and faculty attitudes, assessment tools, graduate performance, costs, etc (Norman and Schmidt 1992; Albanese and Mitchell 1993; Vernon and Blake 1993; Nandi, Chan et al. 2000; Dochy, Segers et al. 2003). The learning outcomes specific to the strength and conditioning profession (critical thinking, knowledge, and application of knowledge) will be addressed in the literature review with specific interest given to studies comparing PBL and TI.

Qualitative Assessment of Critical Thinking

Using PBL provides students with the opportunity to be active participants in the learning process and to develop critical thinking skills. It teaches the student how to take vast amounts of information, and develop reasoning skills and critical thinking skills to apply the knowledge to a specific problem (Amos and White 1998). As PBL enhances critical thinking, it results in higher ordered learning that might not require a significantly greater amount of time from the instructor as the learning falls on the responsibility of each student. Critical thinking skills and application were measured on undergraduate Exercise Testing and Prescription students (N=6) using PBL groups (n=3) with an online learning module (OLM) (Brahler, Quitadamo et al. 2002). A modified PBL process to include a one-hour introductory lecture was used and students then worked in groups analyzing patient cases from the OLM, which prompted students to move from lower ordered learning to higher ordered tasks. Similar to the process of designing strength and conditioning programs, designing exercise prescriptions using the OLM process began with reviewing the patient case history, developing a comprehensive pathological and non-pathological problem lists, prioritizing, reorganizing, and analyzing these problems, developing an exercise prescription plan, and providing rationale for the plan. Moreover, student groups determined which group had the most effective exercise prescription and discussed, justified, and modified the plan during a critical reflective class discussion (Brahler, Quitadamo et al. 2002). This process was thought to allow students to conceptualize and critically reflect on formulating their own prescription plans at each stage of development (Brahler, Quitadamo et al. 2002). Throughout the PBL process critical thinking was measured qualitatively using the Garrison (1992) five-stage problem solving process. As the groups worked, the instructor would evaluate individual student critical thinking skills and application skills based on observation. Unfortunately, Brahler and Quitadamo did not report findings due to the low number of students. However, this study is an example of using PBL in an attempt to enhance critical thinking and application in an undergraduate exercise prescription course.

The effects of PBL instruction were similarly measured in twenty-four nursing students (N=24) into groups of nine (Amos and White 1998). Using a qualitative analysis of self-assessed student course evaluations, seven learning outcomes were measured to include critical thinking, learning how to learn, creativity in learning, the link to community, teamwork, research skills and personal growth. Of the learning outcomes, critical thinking was listed as the most self reported outcome of the PBL instruction. Students were additionally asked to qualitatively compare the PBL experience and previous TI. Results indicated students found PBL more enjoyable, gave a complete picture of material rather than recall for examinations, was more reality-oriented, and educated the learner to the responsibilities of researching and presenting (Amos and White 1998). One important note is that competencies of course objectives were measured by nursing care plans, multiple choice examinations, student papers and presentations. However, these findings were not reported. Although Amos and White asked students to compare their PBL experience with TI, neither study used a control group to compare results. Studies using qualitative methods are appropriate for measuring critical thinking, but the qualitative method may not allow for comparison in knowledge measurement outcomes.

Quantitative Assessment of Critical Thinking Using the CCTST

The California Critical Thinking Skills Test (CCTST) measures critical thinking skills in college students by testing the ability to analyze, evaluate, infer, and inductively and deductively reason when faced with a problem. The CCTST consists of 34 items, each with four response options, one of which is correct. Each correct answer is assigned to 1 point; as a result, scores can range from 0 to 34 with higher scores reflecting stronger critical thinking skills (Facione 1991). After four experiments including 1,000 college students to determine if the CCTST was able to measure the growth in critical thinking skills, an overall mean score was measured at 16.24 (Facione 1991). The CCTST reports six scores: an overall score and five subscale scores. These subscales are analysis, inference, evaluation, and inductive and deductive reasoning (Bowles 2000).

Construct validity for the CCTST was developed from the outcomes of the American Philosophical Association (APA) Delphi Report (Facione 1994). Findings also reported the CCTST to be a strong indicator for college GPA, SAT verbal and SAT math scores (Facione 1991). Assessment of the reliability of the CCTST using the Kuder Richardson-20 reliability test found an internal consistency reliability of pretest and posttest ranges from 0.68 to 0.70. The results of a test found to be reliable will fall between 0.65 to 0.75 on the Kuder Richardson-20 reliability test. Therefore, the CCTST was found to be a reliable test to measure critical thinking (Bowles 2000).

Pretest and posttest designs are suggested when assessing students and programs to measure critical thinking change or development over time (Facione 1991). Research in health care professions may benefit from using the CCTST as it requires the ability to make decisions based on cognitive foundations.

Quantitative Assessment of Critical Thinking Disposition Using the CCTDI

Similar to the CCTST, the California Critical Thinking Disposition Inventory (CCTDI) was the first critical thinking disposition test which was developed to measure aspects or characteristics of a good critical thinker (Facione 1994). The Delphi research project on critical thinking by the American Philosophical Association identified seven dispositions of critical thinking inquisitiveness, systematicity, analyticity, cognitive maturity, truth-seeking, open-mindedness, and critical thinking self-confidence (Facione 1994). This 75-item instrument is used to measure critical thinking disposition in primarily undergraduate college students. The CCTDI reports eight scores: a score on each of the seven sub scales and an overall score. A score of 30 or below indicates consistent weakness in relation to the given disposition; a score of 40 indicates an average disposition, and scores above 50 indicates a strong indicator for critical thinking disposition (Facione 1994). The Delphi report also found a high significant correlation with the CCTST ($r = 0.66$) (Facione 1994).

Quantitative Assessment of Critical Thinking

Quantitative analysis would lend itself to comparison of knowledge and application tests between PBL and TI. The effects of PBL and lecture on critical thinking were quantitatively assessed among 79 nursing students randomly assigned to a PBL nursing course (n=40) or lecture nursing course (n=39) (Tiwari 2006). Both courses were taught in two consecutive semesters i.e., one academic year. The PBL process modeled Barrows (1986) and incorporated groups of 10, meeting 3 to 6 hours per week, while the lecture instruction met 2 to 3 hours per week. Over a three-year period, critical thinking skills were quantitatively measured at four time points: prior to the courses, immediately following the courses, one year, and two years later. The California Critical Thinking Deposition Inventory (CCTDI) results indicated there was no significant difference in critical thinking disposition between the PBL and lecture groups prior to the course; however, there was a significant difference in critical thinking between the groups among all post measurements. These results indicate that PBL improves the development of critical thinking skills among nursing students greater than lecture.

A quasi-experimental study measured the effects of PBL and TI on self-regulated learning to include self-assessed motivation and learning strategies, such as critical thinking (Sungur and Tekkaya 2006). Students in a high school biology course were assigned to two groups, PBL (n=30) and TI (n=31). Barrows (1986) PBL process was adopted to teach human respiratory system and excretory system. Motivation and learning strategies were measured pretest and posttest using the Motivation Strategies for Learning Questionnaire (MSLQ). Results indicated there was no significant difference between groups in the pre-test for motivation and learning strategies. Initially, both groups were found similar to each other with respect motivation and learning strategies. However, there was a significant difference on the posttest between groups for collective learning strategies. In addition, a univariate ANOVA found a significant difference for critical thinking with PBL scoring higher than TI. These results imply that PBL is a better method for instruction to teach critical thinking as a learning outcome.

Assessment Between Levels of Students

Nursing studies have utilized the CCTST to determine the predictability of national board examination passing rates, clinical competence, and comparison to the California Critical Thinking Disposition Inventory CCTDI.

Critical thinking dispositions and critical thinking skills were compared among nursing students enrolled in associate (n=137), baccalaureate (n=102) and RN-to-BSN (n=66) programs (Shin, Jung et al. 2006). Results of the CCTDI and the CCTST tests revealed a strong relationship between the two tests. Additionally, there was a significant difference in CCTST scores between nursing programs with the BSN students scoring the highest in total and all subscales.

A similar study compared critical thinking skills of sophomore (n = 156) and senior nursing students (n = 85) in a baccalaureate program using the CCTST and CCTDI (McCarthy, Schuster et al. 1999). Results indicated senior nursing students scored significantly higher than sophomore students in both the CCTST and CCTDI. Similar to the Shin (2006) study, a significant correlation was found between the CCTST and CCTDI scores signifying that students with good critical thinking skills have a supportive personality trait for critical thinking.

The positive relationship between strong critical thinking skills and its adjacent characteristics has also been supported by research that compared critical thinking skills to critical thinking dispositions of year one (n = 38), year two (n = 53), year three (n = 57), year four (n = 80) baccalaureate nursing students (Profetto-McGrath 2003) Using a cross-sectional design, the CCTST and CCTDI were administered at one point of time, one semester, to all four cohorts. Even though the year four CCTST mean scores were greater than year one, no significant difference was found in the CCTST between all four years. Similarly, no significant difference for the CCTDI was found among the four years. However, the results indicated a significant relationship between CCTST and CCTDI which agrees with the results of Shin (2006) and McCarthy et. al. (1999). An interesting note is 38% scored above 20 on the CCTST, identifying a high level of critical thinking skills among the students with only 2.6% scoring below 10. According to the authors, the lack of statistical significant difference among the years in the CCTST may be associated with cognitive development. Most students remained in the earlier dualistic and multiplicity stages of cognitive development indicating a possible relationship between critical thinking skills and cognitive development. These studies collectively show a strong relationship between critical thinking skills and a disposition toward critical thinking. In addition, the student classification, or possibly the increased length of time in an education program, or even the educational program may affect the degree of critical thinking skills and disposition.

Positive Relationship between Critical Thinking and Clinical Skill Ability

Nursing studies measuring critical thinking skills and clinical competence or clinical judgment skills utilizing the CCTST have mixed results. A positive relationship was found between CCTST and the Clinical Decision Making in Nursing Scale (CDMNS) scores among nursing students (N = 65) from two BSN schools (Bowles 2000). Furthermore, results revealed that of the CCTST subscales only inductive reasoning and inference were significant predictors of clinical judgment. Correspondingly, critical thinking was assessed using the CCTST and results were compared to the National Council Licensure examination for Registered Nurses (NCLEX-RN) among baccalaureate nursing students (N = 218) (Giddens and Gloeckner 2005). The CCTST was administered to students at the beginning of the nursing program and the last semester, i.e., a pretest and posttest design. Students who passed the NCLEX-RN examination had a significantly higher pretest or pre-entry CCTST score than those who failed the examination. Therefore, those who passed the examination entered into the nursing program with better critical thinking skills. Likewise, the pass group had a statistically significant higher mean score of the posttest or exit CCTST. In comparing the pretest and posttest scores of the CCTST, a significant difference was found only in the deductive reasoning subscale. Total CCTST scores were not statistically significant in predicting NCLEX-RN performance. Results from this study imply a relationship between critical thinking and NCLEX-RN performance. When using a standardized test to measure clinical competence, these studies have shown a positive relationship between critical thinking skills and passing scores on these standardized tests.

No Relationship between Critical Thinking and Clinical Skill Ability

Not all studies have shown positive results with the CCTST. In a comparison of senior BSN students (N = 143) CCTST scores and a standardized clinical competence, CCTST mean scores were measured at 16.76 above the standard mean of 15.89 (May, Edell et al. 1999). A Pearson product-moment correlation showed no statistical significance between the CCTST scores and clinical competence among the senior BSN students. Possible rationales for these outcomes may be due to the validity of the clinical competence evaluation tool, which was measured subjectively using a Likert scale using three separate types of evaluators: the faculty, student, and preceptor.

A pretest and posttest CCTST was administered to BSN students (N = 70) and found the KR-20 alpha statistics reliability scores ranged from 0.21 to 0.51 unlike the normative range of 0.68 to 0.70 (Leppa 1997). In addition, total mean CCTST scores decreased from pretest to posttest. Leppa suggests the reason for these results may be due to the type of student population in the nursing program. These students were non-traditional, adult students returning college after working as registered nurses (RNs) in the field. Many of these students had reported previous negative experiences in academics resulting in low academic confidence. Therefore, the type of student population may be deciding factor when selecting a critical thinking skills test. Perhaps traditional college students in good academic standing are a better type of student population when testing for critical thinking skills. These students have continued their education making for an easier transition into higher education. Also, their academic success reinforces their efforts and encourages them to maintain the academic standing.

An additional factor, which may influence the results of the CCTST scores, is the amount of time between a pretest and posttest. Over four weeks, the effects of PBL on critical thinking skills were assessed on seventeen athletic training students (McGee 2003). No significant differences were found which might be attributed to the short length in time.

Although studies in nursing and athletic training have shown varying outcomes using the CCTST, it has not been used to measure critical thinking skills of students in strength and conditioning.

Knowledge and Application Ability in PBL

Assessing learning of knowledge and application ability within PBL curricula still remain largely disparate areas of PBL research. Numerous literature reviews have examined studies on the effects of PBL on knowledge and knowledge application in comparison to TI using methods such as multiple-choice questions, national certifications or national board examinations, case studies, essays, etc (Albanese and Mitchell 1993; Vernon and Blake 1993; Nandi, Chan et al. 2000; Dochy, Segers et al. 2003). Assessing students' abilities to apply knowledge using problem solving is the focus of the literature. Therefore, test items need to require examinees to apply knowledge to commonly occurring and important problem-solving situations (Segers, Dochy et al. 1999). The general perception has been that traditional students perform better on a standardized examination of basic science tests while PBL students perform better on clinical examinations. For example, studies examining the effects of PBL and TI on the National Board of Medical Examination Part I (NBME I) found TI students scored higher than PBL students (Nandi, Chan et al. 2000). Although PBL students may gain less knowledge than traditional students, it is reported they may retain more of the acquired knowledge over time (Dochy, Segers et al. 2003; Beers and Bowden 2005). Furthermore, PBL better prepared medical students for tests of clinical knowledge and performance such as the National Board of Medical Examination Part II (NBME II) (Nandi, Chan et al. 2000). Multiple-choice examinations have historically focused on the student's ability to memorize facts. If written examinations, such as the CSCS examination, are structured in the context of solving a problem and requiring synthesis of information and prioritization of options, it would provide opportunities for knowledge application (Heinrichs 2002). Thus, it is necessary to review the research on the effects of PBL on knowledge and knowledge application as learning outcomes.

PBL Versus TI Outcomes

In a study comparing the effectiveness of PBL and lecture on knowledge and assessment tools in pharmacology course (N=123) students were randomly selected into two sections (Antepohl and Herzig 1999). PBL students were divided into groups of six to nine with two tutors per group. The PBL process was a modified Maastricht Seven Jump sequence, which included two hours of PBL and one hour of lecture per week. The lecture groups met for three hours per week. Knowledge and application were assessed using pre and post examinations that included 20 multiple-choice questions and 10 short essay questions. Results comparing pre test to posttest showed no significant difference in knowledge and application between groups. More specifically, no significant difference was found between groups on multiple-choice questions. However, the PBL group scored higher than the lecture group on the essay questions. Furthermore, there was no significant difference between the multiple-choice questions and the essay questions within the PBL group. However, there were significantly lower scores on short essay questions than multiple-choice questions within the lecture group. This study provides some indication that PBL does not inhibit students learning content or knowledge. Interestingly, the authors recognized that the multiple-choice questions asked lower ordered thinking whereas the short essay questions asked higher ordered thinking. Therefore, the difference of knowledge assessment may not be in the type of questions but the different levels of knowledge in question (Antepohl and Herzig 1999).

Correspondingly, PBL and lecture-based learning were compared in an adult health, nursing course (Hwang and Kim 2005). Both the PBL group (n=35) in groups of seven and lecture group (n = 36) were tested prior to and after the course on respiratory and cardiac nursing using a 32-item test. Questions were selected from the guidebooks of the Korean National Examination for Registered Nurses. In identifying a baseline comparison between the two groups, pre-test results indicated no significant difference between groups resulting in the same level of knowledge and application for both groups. After the course, a posttest found the PBL group had a significantly higher test score than the lecture group. These results indicate that PBL may be a better instructional method for knowledge and application.

PBL (n = 15) and TI (n = 31) were compared on long-term knowledge retention in an adult health, nursing course (Beers and Bowden 2005) Students were tested on diabetic knowledge using a ten question multiple-choice examination immediately following the presentation and one year later. In addition, the Health Education Systems Inc. (HESI) Medical Surgical Nursing Exit Examination was administered to both groups one year following. Findings identified no significant difference in overall HESI examination scores between groups. Nevertheless, there was a significant difference on the endocrine section of the HESI examination in which PBL scored higher than TI. As for the ten-question diabetic knowledge test, PBL scores were higher in the posttest given one year after the course demonstrating the positive effects of PBL on long-term retention.

A similar study compared Medical Technology certification scores from the American Society of Clinical Pathologists (ACSP) examination on PBL group (n = 52) and TI (n = 10) on a six-week clerkship course (Teshima 2001). Course content included phlebotomy, patient relations, routine hematology, urinalysis, and microbiologic specimen processing. Test scores denoted a significant difference in the urinalysis category favoring the PBL groups; yet no significant difference was found in the total mean scores and all other categories. These findings are similar to Beers (2005). Possible rationales for no significant difference in overall scores and significant difference in a specific content area may be due to the instruction of that specific content in class.

Knowledge and critical thinking skills were measured in continuing medical education on headache diagnosis and management in PBL (n = 38) and lecture (n= 49) groups (Doucet 1998). The PBL groups were divided into five groups of seven to eight physicians while the lecture groups divided into to four groups. Knowledge of headache, migraine, chronic daily headache and medication-induced headache was assessed using a 40 multiple-choice question pretest and posttest. The Key Features Problems (KFP) examination was used to measure critical thinking skills of graduating medical students three months after the program. The 'key feature' is defined as a critical step in the resolution of a problem. In medical education, key features are those steps that are most likely to lead to errors in the resolution of a problem in which they target specific points of a problem that are difficult to identify and manage in a practice situation (Doucet 1998). Reports confirm the PBL group performed significantly higher than the lecture group on the knowledge posttest, yet there was no difference between groups on the pretest. Additionally, mean KFP scores were also significantly higher for the PBL group. These studies confirmed that PBL is positively effective on clinical examinations that measure knowledge, and application of knowledge or clinical competency. Collectively, PBL has evidence to suggest that it is a more effective method when teaching for long-term retention than TI.

It is also necessary to report that a number of studies have demonstrated no outcome differences between PBL and TI. A study of chiropractic students assigned to either a PBL course (n=54) in groups of four to six or a traditional course (n=50), measured higher ordered thinking using a multiple-choice examination (Bovee 2000). A 25 multiple-choice examination was administered to all students on spinal evaluation. Test questions were designed to measure evaluation, application, and synthesis of knowledge and were similar to the National Board of Chiropractic Examiners (NBCE). Findings concluded there was no significant difference on scores between PBL and traditional courses.

An objective test was administered to PBL (n = 36) and lecture (n = 18) groups in an adult nursing course (Beers 2005). All students were given a pretest of ten question multiple-choice questions measuring basic sciences related to diabetes and a posttest of ten different questions multiple-choice questions measuring the planning, implementation, and evaluation of nursing care for diabetics. Results denote no significant difference in pretest and post test scores between groups. Despite the fact that the outcomes of this study did not show a difference in effect of teaching method on objective test scores, the pretest and posttest neglected to assess similar concepts and levels of knowledge. Although these studies do not show a significant difference between PBL and TI, it can be noted that PBL did not cause students to perform lower on multiple-choice examinations.

Conclusion

After reviewing the literature on PBL and TI methods in health profession education, researchers have reported varying conclusions regarding the effects on critical thinking skills, knowledge and application. According to Brahler and Quitadamo (2002), professionals in exercise science are often responsible for evaluating and synthesizing the physiological and non-physiological factors to develop exercise prescriptions, which includes program design in strength and conditioning. Unfortunately, no studies have investigated the use of PBL and TI for teaching strength and conditioning material.

CHAPTER III

METHODOLOGY

Design

The purpose of this research was to compare how Problem Based Learning (PBL) versus traditional lecture instruction (TI) impacts critical thinking, knowledge and application of strength and conditioning throughout a semester long collegiate undergraduate course. The course was designed to prepare students for the CSCS examination and to work in the strength and conditioning field. The approach compared the effectiveness of each instructional method on improving students' critical thinking, knowledge and ability to apply knowledge.

Participants

Undergraduate Exercise and Sport Science students were randomly assigned when they voluntarily registered for the course into one of two sections of the strength and conditioning course: one section used PBL and the second section used TI. In keeping with principles of effective group work, the maximum number of students allowed in the PBL section was ten (n=10). The maximum number of students allowed in the TI section was initially ten (n=10). However, twelve students enrolled and completed the TI section (n=12) and ten students enrolled in PBL and two students dropped the PBL course (n=8). Because course objectives were specific to strength and conditioning and were associated with higher ordered skills, prerequisites included coursework in exercise physiology, biomechanics, and exercise instruction. These courses set a foundation of prior knowledge for the student to build upon in learning strength and conditioning course material. An individual other than the course instructor obtained written informed consent as approved by the UNCG Institutional Review Board. The instructor was unaware of who consented until after grades were submitted.

Instrumentation

Participation was voluntary and the instructor/researcher was not informed of who agreed to participate. All students completed the needed measurement tools as part of the course requirements. Grade point averages (GPAs) and prerequisite course grades were requested at the first day of class along with a demographic questionnaire (Appendix A) requesting information from each student on group work and PBL experience, certifications, relative practical and work experience, length of time, and reasons for taking the course. Two instruments were used: the California Critical Thinking Skills Test (CCTST) and the Certified Strength and Conditioning Specialist (CSCS) practice examination.

A pretest and posttest CCTST assessed students' critical thinking change or development over time (Facione 1991). The pretest was administered during the first week of class and the posttest during the last week of class.

The National Strength & Conditioning Association (NSCA) Certified Strength & Conditioning Specialist (CSCS) examination questions were written at cognitive levels which reflect the job-related tasks of the strength and conditioning professional (Commission 2007). The NSCA-CSCS practice examinations, volume one, two, and three are commonly used by students in preparation for the CSCS examination. The CSCS Exam Content Description Booklet explains and identifies recall, application, and analysis questions. Recall questions measure knowledge while application and analysis questions measure application of knowledge. The NSCA Certification Commission identified and categorized practice examination questions within the program design and testing and evaluation section in each volume. Furthermore, the NSCA-CC classifies questions by program design and testing and evaluation learning objectives within the CSCS Examination Practical/Applied Condensed Content Outline. A total of thirty questions were selected from the forty-one questions on program design and testing and evaluation in all practice examination volumes. Questions were selected by the researcher and based on the ten student learning objectives (SLOs) stated in the procedures section and the course text. Fifteen recall questions measured knowledge and fifteen application and analysis questions measured application of knowledge on program design and testing and evaluation. Questions were omitted due to duplication in the volumes, did not coincide with the ten student learning outcomes or focused on prior knowledge of prerequisite course material. See Table 1 for questions selected from the CSCS practice examination volumes one, two, and three.

Table 1. Selected CSCS practice examination questions.

Program Design SLOs	Question	Test Volume	Chapter	Knowledge	Application
1	62	1	17, 18	X	
	64	2	18	X	
	48	3	19		X
2	42	1	18	X	
	55	1	18	X	
	61	1	18		X
	42	2	18	X	
3	48	1	18		X
	54	2	18		X
4	56	1	18	X	
	48	2	18	X	
	49	3	18		X
5	63	1	18		X
	50	2	18		X
	42	3	22	X	
6	53	1	18	X	
	58	2	21		X
7	63	3	18		X
8	64	1	22	X	
	56	2	22		X
	45	3	22	X	

Testing and Evaluation SLOs	Question	Test Volume	Chapter	Knowledge	Application
9	52	1	14	X	
	54	1	15	X	
	41	2	15	X	
	47	2	14	X	
	44	3	14		X
	56	3	14		X
10	63	2	15		X
	51	3	15		X
	62	3	15		X

Written approval was granted by the NSCA-CC to utilize the NSCA-CSCS practice examination questions and the CSCS Exam Content Description Booklet (Appendix B). Similar to the CCTST, the NSCA-CSCS practice examination measured the change in knowledge and application of knowledge through a pretest and posttest design and was administered the first and last week of class.

Procedures

ESS 395 Strength and Conditioning was an experimental course offered by the Department of Exercise and Sport Science at UNCG for the Spring 2008 semester. Two sections were offered: one section was taught on Monday, Wednesday, and Friday from 8am to 8:50am and the other section was taught on Tuesday and Thursday from 8am to 9:15am. Both sections were taught in the Health and Human Performance Building Room 347 and instructed by the same instructor. Course content and student learning objectives specific to program design and testing and evaluation adopted by the NSCA CSCS examination are shown below.

1. Design training programs that maximize performance by prescribing various training methods and modes based on the uninjured athlete's training goals and current training status.
2. Design training programs that maximize performance and muscle balance by selecting exercises based on the uninjured athlete's training goals and current training status.

3. Design training programs that maximize performance by applying the principles of exercise order based on the uninjured athlete's training goals and current training status.
4. Design training programs that maximize performance by determining and prescribing appropriate loads/resistance based on the uninjured athlete's training goals and current training status.
5. Design training programs that maximize performance by determining and prescribing appropriate volumes (defined as reps x sets) based on the uninjured athlete's training goals and current training status.
6. Design training programs that maximize performance by determining and prescribing appropriate work/duration and rest periods, recovery methods and training frequencies based on the uninjured athlete's training goals and current training status.
7. Design training programs that maximize performance by determining and prescribing appropriate exercise progression based on the uninjured athlete's training goals and current training status.
8. Design training programs that maximize performance by utilizing the principles of periodization.
9. Select and administer appropriate test based upon the unique aspects of a sport, sport position and training status.
10. Evaluate and identify the significance of testing results.

Essentials of Strength Training and Conditioning 2nd Edition (Baechle and Earle 2000) was the required course text and *Training for Speed, Agility, and Quickness 2nd Edition* (Brown and Ferrigno 2005) was the recommended text by the instructor. A copy of each course section's syllabus and schedule are found in Appendix C. TI was taught in section one, Monday, Wednesday, and Friday class. PBL was taught in section two, Tuesday and Thursday class.

TI Instruction

TI included lecture with power point presentations, DVD video presentations, class discussions, and laboratory work. A CD-ROM accompanying the instructor text was used for the power point presentations for Chapter 14: Principles of Test Selection and Administration, Chapter 15: Administration, Scoring, and Interpretation of Selected Tests, Chapter 17: Resistance Training and Spotting Techniques, Chapter 18: Resistance Training, Chapter 19: Plyometric Training, Chapter 20: Speed, Agility and Speed-Endurance Development, Chapter 21: Aerobic Endurance Exercise Training, Chapter 22: Training Variation and Periodization, and Chapter 25: Developing Policies and Procedures Manual. TI instruction was designed as though it was completely instructor centered. Modifications to the instruction were made if the instructor felt it was necessary or if students requested.

<u>Assignments</u>

The CCTST and the NSCA-CSCS practice examination were required course assignments. Additional learning assessments include online multiple-choice quizzes and one semester project in which students designed a comprehensive strength and conditioning program. The university general course evaluation was administered to students at the end of the course.

PBL Instruction

Over the fifteen-week semester, two PBL problems were presented. Each problem was a three-stage problem in which each stage was given to the students one at a time (Appendix D). The three-stage problem began with needs analysis, followed by test interpretation, and last was program design. The blueprint of each problem was created to mimic the process a strength and conditioning professional adheres to when designing a program for athletic performance and injury prevention. Each PBL problem module consisted of the PBL orientation session, tutorial group sessions, out-of-class self-directed study, a group presentation session, and a reflection session. These sessions did not contain any lectures and the instructor served only as a guide.

<u>PBL Initiation</u>

An introduction workshop to PBL was conducted at the class session following the second week of class. Students learned the purpose and rationale of PBL and how PBL differs from TI (McGee 2003). Following this introduction, an icebreaker exercise was conducted for students to get to know each other, to facilitate group cohesiveness and communication. The instructor used a sample PBL problem to facilitate and guide the students through the practice session. The sample PBL problem incorporated a general fitness case study in which students were presented with the medical history, physical activity readiness questionnaire, lifestyle questionnaire, and goal inventory of a personal training client. The purpose of using a general fitness case study for a PBL practice trial was to familiarize students with the PBL process by using prior knowledge (Appendix E).

In addition, students learned how to perform a literature search and critique the literature via a tutorial. Students had the opportunity to discuss any previous experiences with PBL and group work as well as any anxieties or concerns during the practice trial and after the first PBL module. A class discussion of group guidelines and roles were established at the next class session.

Tutorial Group

Setting and enforcing group rules at the beginning of the course encouraged students to take ownership of their effective performance as a group. A written set of standards and expectations, discussed by the group, helped to establish norms and group behaviors (Duch, Groh et al. 2001). The instructor assisted in the establishment of these rules because the group was new to PBL. Students agreed upon the following rules: be prepared and have designated assignments on time, be an active participant, no social loafing, use group time wisely, notify designated contact person if unable to be present, no arguing, keep an open mind, show for respect for everyone's role, and ensure everyone is able to give input. Consequences for bad behavior or breaking a rule was discussed and determined by the group. Adding consequences to the group rules held individual group members accountable. Another way to promote individual accountability and to lower barriers to group work was to establish individual roles within the group (Duch, Groh et al. 2001). Strategies included formulating a role for each student and rotating the roles after every problem. Role rotation discouraged students from sticking to roles that seem easy to the student and given them additional experience in those role which may be more challenging (Duch, Groh et al. 2001). Assigned roles adopted by Duch et al (2001) include the following:

1. Discussion Leader: Keeps the group on track; maintains full participation.
2. Recorder: Records assignments, strategies, unresolved issues, convenes group outside of class.
3. Reporter: Reports during whole-class discussion.
4. Writer: Writes final draft of assignment (Nilson 2003).
5. Accuracy Coach: Checks group understanding and facilitates the evaluation of resources.

Students selected their top three role preferences. The instructor used these preferences to determine the role of each student. Students were allowed to use a "divide and conquer strategy" if it is perceived that the individual work can be combined for the final presentation with minimal group interaction (Duch, Groh et al. 2001). One way to increase group cohesiveness was the presenter role, one that presented the PBL problem final group presentation. The role distribution began as: four presenters, two writers, one discussion leader, one recorder, one reporter, and one accuracy coach. Role options were modified when the group went from ten members to eight members. The reporter and recorder roles were combined. The accuracy coach was eliminated due to its ineffectiveness. Students worked together when checking for accuracy. The role distribution was modified to: one discussion leader, two recorders/reporters, two writers, and three presenters.

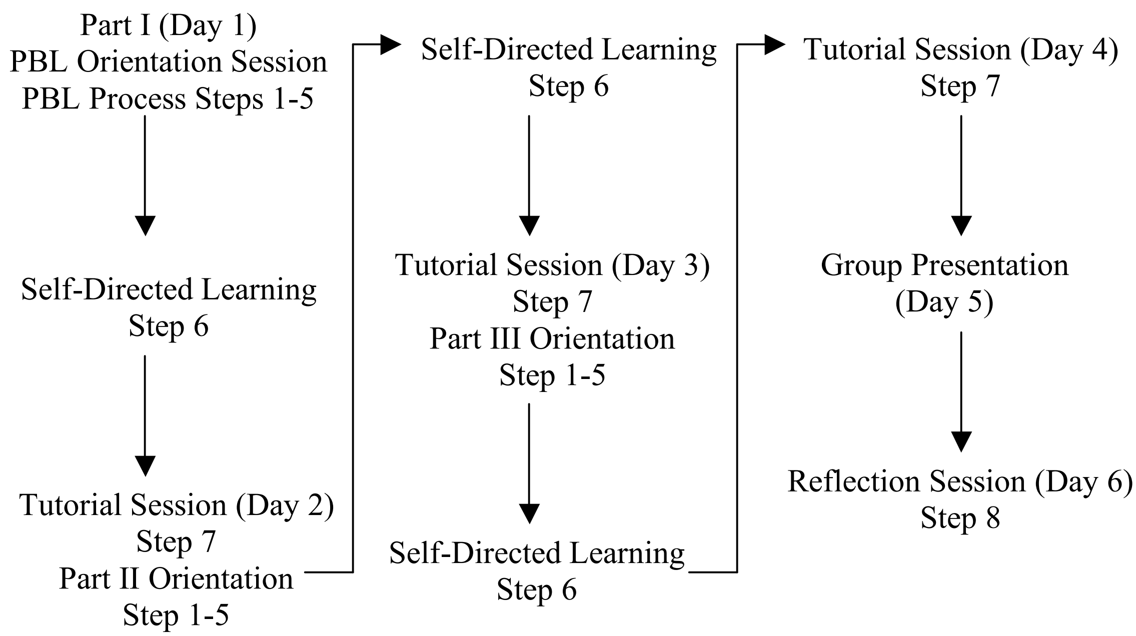
PBL Format

The PBL module followed a modified Maastricht "Seven Jump" Sequence and Barrow's closed loop problem based format (Barrows 1986 and Spencer 1999). This modified format included the seven steps of the Maastricht "Seven Jump" Sequence and the eighth step was the reflection class derived from the closed loop problem based format.

1. Clarified and agreed on working definitions and any unclear understanding of concepts.
2. Defined the problem using their terminology.
3. Analyzed the problem and brainstorm ideas.
4. Arranged the ideas into possible explanations or hypotheses.
5. Generated and prioritize learning objectives.
6. Researched the learning objectives.
7. Presented the research to the group, synthesized explanations, and applied new information to develop a solution.
8. Reflection, evaluation, and review of student learning objectives

This reflection class allowed time for students to reflect on the PBL process and problem. Verbal and written feedback on individual and group work was given using a peer evaluation form. The group developed remedies for possible problems such as time management by using an online discussion board and posting all notes and articles online. Figure I depicts the PBL process using the modified Maastricht "Seven Jump" Sequence and Barrow's closed loop problem based format for one PBL problem. PBL process steps 1-7 were repeated for each stage of the problem. The group presentation and reflection sessions occurred once all three stages were completed.

Figure I. PBL Module. (3-4 week process)



<u>Assignments</u>

The CCTST and CSCS examination pretest and posttest were course assignments. Each PBL module had two assignments: individual student papers and the group paper and presentation. Individual papers were due after each stage of the problem and once the entire PBL module was completed. The group paper and presentation were only due after each PBL module was completed. Each student assessed his or her peers using a peer evaluation adopted by Amos and White (1998) at the end of each PBL module (Appendix F). The university general course evaluation was administered to students at the end of the course. In addition, students completed a self-assessed PBL course evaluation adopted by Duch et al (1999) at the end of the course.

Data Analysis

Descriptive statistics for demographic data such as grade point average, course prerequisite grades, age, gender, and student classification was calculated to describe the student population and determine any significant pre-existing differences between the two groups. In addition, descriptive statistics were calculated for group work and PBL experience, certifications, relative practical and work experience, length of time, and reasons for taking the course. Descriptive statistics for each dependent variable was reported to include pretest and posttest CCTST scores, CSCS practice examination knowledge questions, and CSCS practice examination application questions for each group. CCTST overall and subscale scores were collected by CAPSCORE Inc. of Insight Assessment. CSCS knowledge scores were determined by the correct number of answers out of fifteen total knowledge questions. The CSCS application scores were determined similar to the CSCS knowledge scores.

Two (group) x 2 (time) analyses of variance with repeated measures compared the PBL group to the TI group in the dependent variables of critical thinking development, CSCS knowledge, and CSCS application. The alpha level was set a priori at $P<0.05$ and Tukey's Post hoc testing was used to test the omnibus F value. The researcher acknowledged the low N value by the low powered study due to the low number of participants needed by the PBL model.

Descriptive statistics were calculated for the PBL course evaluation. A strongly agree to strongly disagree scale, a course grading scale from excellent to poor, and open ended questions were used for the PBL course evaluation. The university general course evaluation was also submitted to both courses. SPSS software (version 15.0 and 16.0) was used for all statistical analyses. The instructor recorded field notes for both courses after each class.

CHAPTER IV

RESULTS

This study compared the effects of Problem Based Learning (PBL) and traditional lecture instruction (TI) on critical thinking, knowledge and application of strength and conditioning throughout a semester long collegiate undergraduate course. This chapter is an overview of the statistical analyses, descriptive data results of each hypothesis and course evaluation results.

Participant Descriptive Data

Twenty-two students enrolled in ESS 395 Strength and Conditioning in the spring 2008 semester. Twelve students enrolled and completed a TI section. Ten students initially enrolled in the PBL section with eight students completing the PBL section. Data reflects the twenty students who completed the course. Descriptive data for age, GPA and prerequisite grades are presented in Table 2. Prerequisite grade values were coded in SPSS as A (8), A- (7), B+ (6), B (5), B- (4), etc.

Table 2. Group descriptive data for age, GPA, and prerequisite grades.

Group	Age (SD)	GPA (SD)	ESS 375 (SD)	ESS 376 (SD)	ESS 379 (SD)
TI n=12	22* (1.04)yr	2.9 (.39)	B- 4 (1.8)	B- 4 (1.8)	A-7 (2.1)
PBL n=8	25* (.48)yr	2.75 (.48)	B- 4 (1.3)	B- 4 (2.4)	B+ 6 (1.8)

Note: p = .000

The TI group had a slightly higher mean GPA (2.9) than the PBL group (2.75). PBL group (25) had a higher mean for age than the TI group (22). A t-test was computed to determine any significant differences among group by age, GPA, and each prerequisite grade (Appendix H). A t-test for age indicated a significant difference between groups ($F_{(1, 18)}$=19.019, p=.000). Two PBL students were non-traditional adult students. No significant difference was found for GPA between groups ($F_{(1, 18)}$=1.206, p=.287). No significant differences were found for any of the prerequisite grades, ESS 375 ($F_{(1, 16)}$=1.882, p=.189), ESS 376 ($F_{(1, 16)}$=.746, p=.400), and ESS 379 $F_{(1, 14)}$=.006, p=.939) Table 3 presents descriptive data for gender, major, class, and ethnicity.

Table 3. Group descriptive data for gender, major, class, and ethnicity.

Group	Gender		Major		Class		Ethnicity	
TI n=12	M	6	Fitness Leadership	7	Senior	12	White, Caucasian	8
	F	6	Sports Medicine	4			Black, African American	4
			Aquatic Leadership	1				
PBL n=8	M	3	Fitness Leadership	8	Senior	8	White, Caucasian	4
	F	5					Black, African American	3
							Hispanic, Latino	1

M: Male, F: Female

All students were graduating seniors. One third of the TI group was Sports Medicine majors while all PBL students were Fitness Leadership majors. Tables 4, 5, and 6 present the self-reported questionnaire descriptive data for primary reasons for course enrollment, group work experience, PBL experience, certifications, and practical experience and length of time.

Table 4. Self reported questionnaire descriptive data for reasons of course enrollment and previous experience in teaching methods.

	Group	
	TI	PBL
Needed a Capstone Course	2(17%)	1(13%)
Interest in Strength and Conditioning	5(42%)	5(63%)
CSCS prep course	5(42%)	2(25%)
Group Work Experience	12(100%)	7(88%)
PBL Experience	12(100%)	0

It is apparent that students either were interested in strength and conditioning or enrolled to prepare for the CSCS examination. Results indicate all TI students have previous PBL experience and no PBL students have previous PBL experience. Table 5 presents self-reported certification data.

Table 5. Self reported certifications of enrolled students.

	Group	
	TI	PBL
CPR	11(92%)	4(50%)
First Aid	10(83%)	3(38%)
Group Fitness Instructor	1(8%)	1(13%)
Personal Trainer	0(0%)	1(13%)*
Lifeguard	3(25%)	0(0%)
Emergency Medical Technician	0(0%)	1(13%)
Certified Pool Operator and Water Safety Instructor	1(8%)	0(0%)

*An in-house training, not a nationally accredited personal trainer certification.

CPR certification was the highest reported certification for both groups followed by First Aid. Furthermore, CPR was reported more frequently in the TI group than the PBL group. The results indicate no student held a nationally accredited personal trainer certification. Table 6 displays self-reported practical experience and the length of time per experience.

Table 6. Self reported practical experience and time.

Experience	TI	Length of Time (yr)	PBL	Length of Time (yr)
Coach	4(33%)	1.6(2.6)	3(38%)	0.5(1.4)
Fitness Floor Supervisor	4(33%)	0.5(0.9)	2(25%)	0.25(0.5)
Group Fitness Instructor	1(8%)	0.1(0.4)	1(13%)	1.1(3.2)
Personal Trainer	0	0	3(38%)	0.63(1.1)
Other Experience		0.2(0.6)		0.4(1.1)
Orthopedic Technician	1(8%)		0	
EMS Fitness Advisor	0		1(10%)	
Cardiac Rehab	1(8%)		0	
Athletic Training Internship	0		1(10%)	
Camp Counselor	0		1(10%)	

Coach and fitness floor supervisor were the highest reported for practical experience among the TI group. Similarly, coaching was the highest reported for the PBL group along with personal trainer. Even though, only one student in the PBL group reported a personal trainer certification.

Knowledge

The findings of this study rejected the hypothesis that PBL course completion will result in greater knowledge of strength and conditioning course material than TI as assessed by the mean between the pretest and posttest using the recall questions of the NSCA-CSCS Practice Exam on these topics. The descriptive results for the knowledge questions are reported in Table 7. The correct number of answers out of fifteen questions determined each test score. A repeated measures ANOVA indicated no significant difference between groups ($F_{(1, 18)}$=.407, p=.532) with an effect size of .02. No significant difference was found for group x time interaction ($F_{(1,18)}$=.107, p=.747). However, a significant main effect for time was found ($F_{(1, 18)}$=24.179, p=.000) with an increase in knowledge scores from pre to post testing (Appendix G).

Table 7. Knowledge mean scores (out of 15 possible).

Group	Pretest (SD)	Posttest (SD)
TI	5.42 (1.68)	7.17 (1.27)
PBL	5.63 (1.51)	7.63 (1.1)
Combined Groups	5.5 (1.57)	7.35 (1.18)*

*Significant from pretest, p=.000.

Application

The findings of this study rejected the hypothesis that the PBL course will result in an increased ability to apply knowledge of strength and conditioning course material as assessed by the mean difference between the pretest and posttest using the application and analysis questions of the NSCA-CSCS Practice Exam on these topics. The descriptive results for the application questions are reported in Table 8. The correct number of answers out of fifteen questions determined each test score. A repeated measures ANOVA indicated no significant difference between groups ($F_{(1, 18)}$=.944, p=.344) with an effect size of .05. No significant difference was found for group x time interaction ($F_{(1,18)}$=1.493, p=.238). However, a significant main effect for time was found ($F_{(1, 18)}$=24.369, p=.000) with an increase in application scores from pre to post testing (Appendix G).

Table 8. Application mean scores (out of 15 possible).

Group	Pretest (SD)	Posttest (SD)
TI	7.33 (2.1)	8.92 (1.51)
PBL	6.13 (2.17)	8.75 (1.28)
Combined Groups	6.85 (2.16)	8.85 (1.39)*

*Significant from pretest, p=.000.

Critical Thinking

The findings of this study rejected the hypothesis that the PBL course will result in increased critical thinking skills compared to the TI course as assessed by the mean difference between the pretest and posttest of the California Critical Thinking Skills Test (CCTST). The descriptive results for the CCTST are reported in Table 9. A repeated measures ANOVA indicated no significant differences between groups ($F_{(1, 18)}=.101$, $p=.754$) with an effect size of .06. Furthermore, no significant main effect for time ($F_{(1, 18)}=.064$, $p=.803$) and group x time interaction ($F_{(1,18)}=.101$, $p=.754$) were found (Appendix G). Results indicate critical thinking skills did not increase in PBL in comparison to TI. In addition, critical thinking skills did not significantly increase over time regardless of group.

Table 9. CCTST mean scores.

Group	Pretest (SD)	Posttest (SD)
TI	15.42 (4.78)	15.42 (4.52)
PBL	15.88 (3.83)	16.25 (5.7)
Total	15.6 (4.32)	15.75 (4.9)

Field Notes

See Appendix H for instructor field notes for observations and notable issues.

Field notes were not transcribed for qualitative analysis.

PBL Self-Assessment Evaluation

The PBL course evaluation was a self-assessment questionnaire, which was divided into five sections, the benefits of PBL course components on learning, problem solving and critical thinking skill improvement, student learning objectives' ability, overall course rating, and open-ended questions. Tables 10-13 describe students' perceptions of the PBL course.

Table 10. (n=8) Mean scores on student perceived benefits of PBL components.

"Indicate the extent to which you agree that these course components were beneficial to your learning of Strength and Conditioning"	Mean (SD)
The use of problems	4.25(0.46)
Working in groups	3.50(0.93)
Completing assignments related to PBL problems	3.63(0.52)
Communicating about *strength and conditioning* with your group	4(0.76)
Peers as teachers.	2.63(0.74)
Whole class discussions, question and answer sessions, or oral reports from groups	3(0.93)
Facilitation by the instructor	3.75(0.71)
The textbook.	4.5(0.76)
Using electronic resources, primarily the Internet, to find information.	3.75(0.71)
Library resources, other than electronic ones.	2.63(0.92)
Use of computers as an investigative tool in the laboratory.	3(0.76)

Note: Results are based on a five-point scale of 5(strongly agree) to 1 (strongly disagree).

Table 11. (n=8) Mean scores on student perceptions of PBL skill improvement.

"Indicate the extent to which you agree that this course has helped you to improve your skill in the following areas."	Mean (SD)
Communicating literature and/or laboratory research results.	4.13(0.35)
Participating in discussions.	4(0.76)
Writing about *strength and conditioning*.	4(0.53)
Working productively with a team.	3.88(0.35)
Finding relevant information.	4.25(0.46)
Analyzing and synthesizing information.	4(0.53)
Use of computers for information retrieval and data analysis.	4(0.53)

Note: Results are based on a five-point scale of 5(strongly agree) to 1 (strongly disagree).

Table 12. (n=8) Mean scores of student perceptions of learning objectives of PBL section.

"Indicate the extent to which you agree with the following statements. I am able to:"	Mean (SD)
Design training programs by prescribing various training methods and modes.	3.38(0.92)
Design training programs by selecting exercises.	3.75(0.89)
Design training programs by applying the principles of exercise order.	3.5(1.07)
Design training programs by determining and prescribing appropriate loads/resistance.	3.25(0.89)
Design training programs by determining and prescribing appropriate volumes.	3.38(0.92)
Design training programs by determining and prescribing appropriate work/duration and rest periods, recovery methods and training frequencies.	3.63(0.74)
Design training programs by determining and prescribing appropriate exercise progression.	3.75(0.71)
Design training programs by utilizing the principles of periodization.	3.5(0.93)
Select and administer appropriate test.	3.88(0.64)
Evaluate and identify the significance of testing results.	3.88(0.64)

Note: Results are based on a five-point scale of 5(strongly agree) to 1 (strongly disagree).

Table 13. (n=8) Mean scores of student perceptions of instructor, course, and peer group.

Rating	Mean (SD)
Instructor	4.25(0.46)
Course	2.88(0.64)
Peer Group	3.63(0.74)

Note: Results are based on a scale of 5(excellent) to 1(very poor).

Qualitative themes derived from the open-ended questions were developed and coded through interpretation of student feedback of the PBL course (Appendix J). Statements were sorted by common subject matter to develop the themes. Below are the *questions* with the respective responses.

-Please indicate how many PBL courses you have taken prior to this one.

All students responded never had taken a PBL course.

-What problem (used this semester in this course) did you like most? Why?

Four students stated the PBL football problem was liked the most due to "most familiar," "most productive", "enjoyed" the experience, and "we had previous PBL experience" from the first PBL problem. Four students stated the PBL basketball problem was liked the most due to "most familiar" and three students stated, "sufficient time spent" on the problem.

-What aspects of the course contributed most to your learning, and why?

Five students stated research and self-directed study contributed most to learning. Other common comments were explaining information to others, class discussion, reading to find answers, and writing papers.

-Do you feel more comfortable now with the problem-based learning format than at the start of the semester? Would you take another PBL course? Why or why not?

Five students stated they were more comfortable with PBL. Three students would take another PBL course because it adds a practical learning experience and if it is paired with TI. Five students stated not to take another PBL course. One of the five students did mention they would take another PBL course if it were paired with TI. Reasons for not taking another PBL course included feeling "overwhelmed", group was not productive, group work affected my grade, and "people have different grade expectations which can hurt your grade." Two students stated they prefer "information given to me."

-In what ways do you think your group worked well?

Five students stated group discussions, three students stated self-directed study, and three students stated assigning tasks contributed to the group work.

-What changes in the way your group worked could have improved your learning?

Three students stated students needed to be more prepared for class. Other comments included "more peer teaching," "incorporate grades with doing your part of the work," more effective discussions, learning how to synthesize information, "not spending too much time on one problem," and "nothing" needed to improve group work.

-What special issues, concerns, or questions would you want addressed in the planning of this course for the future?

Four students suggested offering a course with TI for the first half followed by

PBL for the second half. Other suggestions included online discussion board throughout the entire semester, instructor as discussion leader, eliminating the group grade, and more frequent feedback.

University Course Evaluations of PBL and TI Sections

The university general course evaluation was administered via online to the TI and PBL courses. Results are displayed in Table 14 using a frequency distribution from strongly agree to strongly disagree. Students were given a section to comment on their respective course. Five PBL students and four TI students completed the university course evaluation.

Table 14. PBL and TI university student course evaluation results.

Evaluation Item	PBL (Percent Answered)		TI (Percent Answered)	
The course requirements were clear.	Strongly Agree Agree	20% 80%	Strongly Agree Agree Disagree	25% 25% 50%
The instructor set high expectations for your learning.	Strongly Agree Agree	60% 40%	Strongly Agree Agree	25% 75%
Your knowledge and skills increased due to taking this course.	Strongly Agree Agree Disagree	20% 60% 20%	Strongly Agree Agree Disagree	25% 25% 50%
The evaluation criteria were clear.	Strongly Agree Agree	20% 80%	Agree Disagree	25% 75%
The instructor was organized and well prepared.	Strongly Agree Agree	20% 80%	Agree	100%
The instructor demonstrated thorough knowledge of the subject matter.	Strongly Agree Agree	80% 20%	Strongly Agree Agree	25% 75%
The instructor provided frequent and prompt feedback.	Strongly Agree Agree	20% 80%	Agree Disagree	25% 75%
The instructor demonstrated respect for diverse talents and ways of learning.	Strongly Agree Agree	20% 80%	Agree Disagree	75% 25%
The instructor encouraged you to be actively involved in learning experiences.	Strongly Agree Agree	80% 20%	Agree Disagree	75% 25%
The instructor encouraged student-faculty communication, in and out of the classroom.	Strongly Agree Agree	20% 80%	Agree Disagree	75% 25%
You would recommend this course to other students.	Strongly Agree Agree Disagree	20% 40% 40%	Agree Disagree Strongly Disagree	25% 50% 25%
You would like to take another course with this instructor.	Strongly Agree Agree Disagree	20% 40% 40%	Agree Disagree Strongly Disagree	25% 50% 25%

Only three PBL students responded to the comment section of the evaluation. Below are the PBL course comments.

- *"I wish this course would have been with less writing since it was not a writing intense course. I would have liked to learn the materials first before working the case studies first then just jumping in with the case studies/PBL problems. I feel I would have been less stressed that way since I would have been more prepared." "This type of learning is probably all right with some individuals but it is not for me. The instructor was pleasant and seemed excited about the opportunity to teach the course but I do not feel that my knowledge has grown that much more using PBL style learning. Again maybe the class needed to be partially book learning and then a couple of PBL's that way the student feels a little more prepared. I do appreciate Heather's help and guidance with PBL."*
- *"This course was good but needs some tweaking. Although the PBL is an asset to practical application, this course could have used some lecture added. There is a lot of information that can be taken from the class. A good combination of the two class types would be more beneficial."*
- *"I wish I would have known that it was basically a writing intensive course because I took it for the knowledge and to help my GPA, but since I'm not an awesome writer I think its going to hurt rather than help."*

Only two TI students responded to the comment section of the evaluation.

- *"I thought that I would have learned something new taking this class but I didn't. I know there was another section and I heard that they did a lot of work. All we did was take quizzes and listen to her read over her power points. I felt like I wasn't challenged and it was a waste of a class. It seems like the effort for the class was there but nothing came out of it."*
- *"This course was challenging - I really enjoyed it. The only comment I have is that I would have liked to do more hands-on learning. We did do some but I would like to have done more - especially when we discussed Olympic lifting. Otherwise, it was a good course."*

CHAPTER V

DISCUSSION

Overview of the Study

This inquiry evaluated the effect of Problem Based Learning (PBL) and traditional lecture instruction (TI) on knowledge, application of knowledge and critical thinking skills in strength and conditioning. Students' and the instructor's perceptions of PBL and TI were explored as well. This section will first discuss the results of knowledge, application, and critical thinking, then discuss perceptions of PBL, and finally provide implications for future studies and professional practice.

Knowledge

Results of this study indicated no significant difference in knowledge increases between PBL students and TI students on the pretest and posttest CSCS Practice Exam knowledge questions (Table 7). These findings concur with nursing, pathology, pharmacology, and chiropractic studies comparing PBL and TI on knowledge in which PBL did not cause students to perform differently than TI in these studies (Antepohl and Herzig 1999; Beers and Bowden 2005; Bovee 2000; Teshima 2001). Conversely, a nursing study demonstrated that PBL students scored significantly higher than TI students on selected questions from the guidebook of the Korean National Examination for Registered Nurses (Hwang and Kim 2005). This study also reported no significant difference in students' attitude toward learning; however, motivation to learn was significantly higher in the PBL group. This study suggested that learning independence through the PBL method contributed to a higher motivation to learn with PBL than TI (Hwang and Kim 2005). These findings when compared to the current investigation may suggest that students from an Asian culture may respond differently to instructional methods than U.S. students based on cultural expectations of student behavior in education. Similarly, a continuing medical education course for physicians comparing PBL and TI on headache diagnosis and management found that the PBL group performed significantly higher than the TI group on the knowledge posttest and critical thinking skills (Doucet 1998). These participants were practicing physicians who had completed medical school and their residency verifying success in an academic setting. A possible cause for previous findings of increased student performance in PBL environments may be the cultural influences on educational expectations of the students and the type of student population as shown in the latter study with practicing physicians. (i.e., age, academic career, and maturity).

One potential reason for the current finding of no differences in knowledge acquisition between PBL and TI groups may be due to the fact that none of the PBL students had previous PBL experience. Students new to PBL spend a great deal of time learning how to learn by reading information that may not be related to the problem, which creates a slow and inefficient learning process (Doig 1994). The transition to PBL may result in learning less content initially. Further, students faced a challenge of limited library resources. The library no longer offered some of the relevant journals needed to research content for solving problems during the middle of the semester. Students were less prepared for class because they had difficulties finding needed information. This challenge stalled the PBL process resulting in less content covered throughout the course. The instructor's intent was to complete four PBL problems; however, only two PBL problems were completed due to the slow progress. Completing only two of the four PBL problems likely have affected the results because less content was reviewed. Although the course was designed to complete the four PBL problems, equal improvements in knowledge scores occurred as indicated by effect size. However, it should be noted that PBL did not cause students to perform lower on the CSCS Practice Exam knowledge questions when compared to TI.

Application

Results of this study demonstrate that PBL students did not significantly increase their ability to apply knowledge on the CSCS Practice Exam application questions in comparison to TI students (Table 8). Although the course was designed to complete the four PBL problems, equal improvements in application scores occurred as indicated by effect size. These findings are in contrast with previous PBL research on application of knowledge (Doucet 1998; Antepohl and Herzig 1999; Murphy 2006). Results from a continuing medical education course comparing PBL and TI indicated PBL students scored significantly higher than the TI on "key features problems," an examination used to measure steps of applying of knowledge to solve a medical problem (Doucet 1998). A pharmacology course that compared PBL and TI found PBL students scored significantly higher than TI students on the application essay questions (Antepohl and Herzig 1999). Further, a previous study comparing PBL and TI in an exercise physiology course on application of knowledge and retention found application of knowledge scores from open-ended exam questions were significantly higher in the PBL group than TI at the end of the course and one year later (Murphy 2006). Furthermore, no significant differences were found for GPA and prerequisite grades on the senior level PBL and TI students. (Murphy 2006) However, the PBL course used was a PBL hybrid that incorporated PBL with web-based discussions, lectures, and laboratory exercises. Potential reasons for the outcome of this study to differ from previous research may be due to the use of multiple-choice questions versus essay or open-ended questions. The research seems to support the fact that increases in knowledge of application is best assessed in PBL curricula via essay type questions.

Critical Thinking

Critical thinking skills did not significantly increase in PBL in comparison to TI (Table 9). Similar results of no increases in critical thinking occurred in a previous PBL study measuring critical thinking skills in athletic training students during a pharmacology instructional module (McGee 2003). A contributing factor to the lack of significant findings in the previous study may be the short duration of time, four weeks, allotted for critical thinking development. A study in nursing measuring critical thinking development found a non-significant decrease in CCTST scores (Leppa 1997). This study suggested the reason for findings might be due to the type of student population tested. These students were non-traditional students who reported having previous negative academic experiences resulting in low academic confidence. Therefore, the type of student population may be a deciding factor when selecting an appropriate critical thinking skills test.

Conversely, a nursing study measuring the effects of PBL and TI on critical thinking using the CCTDI found that PBL improved critical thinking greater than TI (Tiwari 2006). This study used the CCTDI, not the CCTST, to measure critical thinking disposition that makes direct comparison to the current study difficult. As mentioned earlier, cultural expectations of student behavior may have also affected the results as this study was completed in an Asian society. Other critical thinking studies used the CCTST were cross-sectional analyses of nursing students of varying classification, such as Registered Nurse (RN) and Baccalaureate of Science in Nursing (BSN) and sophomore students and senior students (MCCarthy et. al. 1999 and Shin 2006). The CCTST was administered only one time among groups. No pretest or posttest was given, thus these studies' findings did not measure critical thinking development.

One reason for the lack of increased critical thinking performance in the PBL groups may have been due to each courses' pretest scores, TI (15.42) and PBL (15.88), which are in close proximity to the CCTST Delphi study mean (16.24). The TI group mean pretest score of 15.42 and posttest score of 15.42 demonstrated no change in critical thinking. The PBL students achieved a mean pretest score of 15.88 and posttest score of 16.25, which is very similar to the CCTST Delphi study reported mean of 16.24 (Facione 1991). A ceiling effect often limits the ability of the highest performing students to achieve adequate gains upon instructional methods (Albanese 2000). Similarly, a study comparing critical thinking skills among classifications of baccalaureate nursing students found 38% of all students scored above 20 on the CCTST, identifying a pre-existing high level of critical thinking skills which may have contributed to the lack of significant findings within the study (Profetto-McGrath 2003). If a ceiling effect occurred, the lower performing students must make large gains in scores due to the inability of the higher scorers to improve creating an unrealistic request (Albanese 2000). The potential for the higher pre-test scorers to respond to PBL is limited by the fact that they cannot increase in posttest scores much higher (Albanese 2000).

Student Perceptions of PBL

PBL students were given the opportunity to evaluate the course using an evaluation form adopted by Duch, et. al. (1999) as well as a generic university general course evaluation. TI students evaluated the course using only the generic university general course evaluation. The Duch et. al. (1999) form evaluated specific PBL components that are reported to be a more meaningful evaluation tool for refining a PBL course and exploring the student experience.

Perceived Benefits of PBL

Students determined the textbook, the use of PBL problems, and communicating strength and conditioning concepts with the group as the most beneficial course components to learning strength and conditioning (Table 10). PBL compelled students to utilize the text and communicate their findings to their classmates in order to complete each learning issue. Requiring students to read the text and communicate the information orally and in writing may assist students' preparation for the CSCS exam and professional practice. Open-ended questions revealed researching and self-directed study as the factors that most contributed to learning along with explaining information to peers, class discussion, and writing papers as other contributing factor of learning. Similar findings were reported in an exercise physiology study comparing PBL to TI in which PBL students stated in support of PBL, "reading journal articles helped me learn more about the material in the book" (Alessio 2004). It may be possible that PBL assisted with reading and writing comprehension based on students' perceptions.

The least beneficial course components as assessed by students were library resources and peers as teachers. Challenges occurred using the library to locate relevant articles, which hindered the group's progress toward completing the PBL problem. As noted in the instructor's field notes, students struggled as discussion leaders, which may be due to the ambiguity of never previously facilitating discussion as well as several personal issues. One discussion leader worked as an EMT in the evenings and sometimes would attend class late or not at all. In addition, this student was an adult student who tended to be condescending toward his peers as noted in the peer evaluations. This attitude may have affected how his peers responded and their motivation. The problem solving progress declined due to the discussion leader's repeated lateness or absence and the library resource limitations. The instructor made the decision to act as the discussion leader in certain class meetings in order to expedite the process. Students made comments to the instructor that they were thankful the instructor acted as the discussion leader.

Perceived PBL Skill Improvement

Students believed they most improved on locating relevant information and communicating literature and research results (Table 11). Interestingly, all skills were rated high for improvement by taking the PBL course. Team productivity scored the lowest even though students met outside of class and held blackboard discussions. Not meeting group member expectations, poor communication and a lack of group contribution may be possible causes for this low rating. Students suggest "more peer teaching" and "incorporating grades with doing your part of the work," learning how to synthesize information, and "not spending too much time on one problem" as ways to improve group dynamics.

Grades were given for peer evaluations. Each student only viewed the combined scores and feedback. Students generally scored their peers higher than what the instructor would have scored. Each student gave written constructive feedback; yet, it did not reflect the peer evaluation score. Numerical scores were higher than the written constructive feedback suggested. Potential reasons for the differing results may be the fear of peer likeability. Students stated they did not want their peers upset with them.

Perceived Student Learning Outcomes

Student perceived learning outcomes indicated that they were better able to select and administer appropriate tests, evaluate and identify the significance of testing results, and design training programs by selecting exercises, determining and prescribing appropriate exercise progressions (Table 12). These results may be due to the structure of the PBL problems, time spent on the PBL problem relevant to the student learning objective, and more information or more accessible information than the other student learning objectives. Each PBL problem was structured as a progressive disclosure case in which the needs analysis of the athlete and sport was presented first; test and results interpretation next and last was program design. The majority of classroom time was spent on the first two parts of each problem as students were getting familiarized with the PBL process. Similar findings were revealed in a PBL qualitative nursing study in which students requested longer time to be spent on the PBL scenarios because they felt "there was not enough time to learn everything; the large volume of knowledge that needed to be learnt was time-consuming (Biley 1999). Course field notes show that these suggestions did not change even as students become more familiar with the PBL process.

Limited time and information on program design may have affected students' ability to feel confident and knowledgeable in the program design student learning objectives. Lack of research and resources on program design causes a restriction on literature searches specific to strength and conditioning (Cissik, Hedrick et al. 2008). There is slightly greater degree of information available on ideal volumes and intensity for training speed, agility, core, mobility, and combining various types of training modes for training programs. However, research on program design has not kept pace with the strength and conditioning practice due to the inherent limitations imposed by where the majority of the strength and conditioning research is conducted (i.e., universities) and the unwillingness of coaches and athletes to participate in training studies (Cissik, Hedrick et al. 2008).

University Course Evaluations

University course student evaluations for both the TI and PBL courses differed mostly in the clarity of course requirements, evaluation criteria, and course recommendations (Table 14). All PBL respondents felt the course requirements were clear whereas half TI respondents disagreed. Similar findings are reported for the evaluation criteria. Seventy-five percent of the TI respondents would not recommend this course whereas 60% of the PBL respondents would recommend this course to other students. Potential causes for these findings may be the verbal and written explanation of the course requirements and evaluation methods. Instructor observations show that TI students were more concerned about test scores on CCTST and the CSCS preparation exam than the PBL students. TI students asked questions on the posttest scores and how it related to the final course grade as observed by the instructor. Also, TI students expressed a dislike for the TI as mentioned in the field notes. All other evaluation components showed general agreement between the two courses. A limitation of using a general university course evaluation is the feedback is not as meaningful as needed for the instructor to make course adjustments. The PBL course evaluation adopted by Duch et. al. (1999) offered more detailed information for the instructor to improve the course.

Professional Application Considerations

Findings from this study may be a resource for educators deciding on appropriate instructional methods for strength and conditioning. The following are specific concerns of incorporating PBL, instructor perceptions, student perceptions, and recommendations for inclusion of PBL into the curriculum.

Transition from TI to PBL

None of the PBL students in this study had self-reportedly taken a prior PBL course nor had any previous experience with PBL. Expecting students who have been cultivated and amassed by TI over their entire undergraduate career and possibly their primary and secondary education to suddenly be comfortable and excel in a different type of educational environment seems to be overly optimistic (Albanese 2000). In addition, the students in this study were graduating seniors. These students are psychologically oriented toward moving on to the professional career and often give less than their best effort (Facione 1997). It is possible that a non-graduating student population may have given better results.

Culture Shock

Student perceptions from this study agreed with previous findings in which students felt anxiety, confusion, and lack direction when transitioning from TI to PBL (Walton and Matthews 1989; Biley 1999; Alessio 2004). This initial response may be linked to working outside of a "comfort zone" where traditional roles include the instructor responsible for teaching a lecture and the students process the information (Alessio 2004). These roles change in PBL and the student is responsible for developing his or her own plan of direction, a shift in the comfort zone occurs, and tension develops (Alessio 2004).

Breaking Old Habits

Previous work has indicated how overwhelming students' motivation was to do no more than acquire knowledge by conforming to their TI study patterns (Biley 1999). Results of this study also indicated some students preferred to be "given the information". Students, who are familiar with learning tasks assigned to them by an instructor and gaining knowledge primarily from lecture then repeating that material on tests, may have major adjustment to make when they introduced to PBL (Doig 1994).

The transition from TI to PBL may create another tension in the breadth and depth of learning. TI covers a breath of information at the surface leaving students to acquire a superficial knowledge. On the other hand, PBL offers a deeper understanding of less content; yet provides tools to learn additional content independently. Students may feel frustrated because they assimilate learning with covering "large volumes of knowledge" in a short amount of time (Biley 1999).

Time

Students in a PBL course, who have been habituated to TI, may become less efficient learners until they become familiar with the new learning method (Walton and Matthews 1989). Current findings indicated students reported PBL as “time consuming” and “overwhelming”. Field notes denoted students were not prepared for class and requested extensions for deadliness numerous times. Reduced efficiencies in early PBL stages likely occurred due to students learning a new pedagogical method (i.e. the PBL process), learning “how to learn” such as learning self-directed study skills, and dealing with the frustration of applying TI study habits to PBL.

The adjustment from TI to PBL may take from three months to nine months for students to build confidence and to learn the process (Doig 1994). PBL may continue to be a frustrating experience for students who have excelled in TI and who have trouble with the ambiguity of PBL. However, students who succeed in PBL may have not done so in a TI. PBL offers another pedagological tool for instructors to reach students of varying learning skills. Students become more efficient and comfortable with the PBL process as they become better skilled researchers, discover their own process for self-directed study and scrutinize their understanding (Doig 1994).

Instructor perceptions of PBL

Transitional effects may occur in faculty with the shift from an instructor-centered environment (TI) to a student centered environment (PBL). A sense of losing control and/or relief may affect the faculty as the students are given more responsibility for their own learning and the faculty is relieved of some responsibilities (Doig 1994). A perceived lack of structure and inexperience with PBL may lead to anxiety initially for an instructor (Bernstein, Tipping et al. 1995). Faculty may use time differently in PBL than TI. PBL problem development and grading papers was less time consuming than developing lectures, as experienced by the researcher. PBL offered the flexibility to counsel students who were not progressing well by reducing class preparation time. Students met with the researcher outside of class for assistance and the instructor added feedback to discussion boards. Previous faculty comments found the interaction between themselves and students to be more collegial, fun, easy, engaging, and relaxed in prior PBL studies (Bernstein, Tipping et al. 1995). The instructor spent time during class listening to group discussion, giving feedback, or redirecting students when gone off course as noted in the field notes. Instructor observations noted students using articles and text to gather information and discuss their findings with other students to fill gaps of missing information needed to complete the problem. Comparable comments were made by the instructor/researcher in an exercise physiology study comparing PBL and TI in which the instructor stated, *"As I listened to group discussions, I noted that students were asking each other questions that reflected deep learning and abstract thinking"* (Alessio 2004). The researcher also observed *"students using resources other than the required text, to search for answers and information and confirm statements made by group members"* (Alessio 2004). Faculty must learn and employ good facilitation skills that promote group interaction and conflict resolution skills for PBL to be successful, as would the development of good lectures be required for TI to be successful (Doig 1994).

It is important to note the instructor's bias towards teaching PBL over TI. A learning environment that is enjoyable for both instructor and students may affect learning or engagement in the material. The potential lack of enthusiasm from the instructor may have influenced the students and vice versa resulting in a less enjoyable learning environment in the TI course.

Students' Suggestions

PBL students recommended a course that offered both PBL and TI. Some student feedback mentioned to begin the course with TI than shift to PBL at the middle of the semester. Possible reasons for these suggestions could derive from the lack of prior PBL experience and the students' familiarity with a curriculum that is predominately TI. Previous studies have shown similar requests of students suggesting either a combination of PBL and TI or exposure to TI then subsequently phasing in PBL (Bernstein, Tipping et al. 1995). Student feedback implied that PBL was superior in terms of retention and reinforcement of information, was more interesting, stimulating, enjoyable learning method, enhanced interpersonal skills and learned how to learn rather than memorizing facts (Bernstein, Tipping et al. 1995). An exercise physiology study comparing PBL and TI found 95% of students were favorable toward PBL (Murphy 2006). Student remarks indicated that "not only does the incorporation of PBL help to add to my learning, I feel like without it I am being cheated" and PBL made the material "more relevant and meaningful" and "PBL was effective and an interesting way to learn course material"

(Murphy 2006).

Incorporating PBL into the curriculum

Students may feel less overwhelmed if introduced to PBL and other active learning methods earlier and throughout the curriculum. Educators may experience less reluctance to changing learning methods when students are exposed to a variety of instructional methods throughout the entire curriculum. A gradual introduction of PBL at the beginning of the curriculum will benefit both students and faculty because students will be exposed to understanding how to learn, be better self-directed learners, and be more efficient with time spent on course material. Adding PBL in small increments to a TI course early in the curriculum may alleviate the frustration and culture shock from the students and the instructor during a PBL only course. Advanced level courses such as professional courses or practical applied courses will benefit from using PBL by students mimicking professionals working through real-world situations. PBL has the advantage of learning in the context in which learning is subsequently to be applied (Walton and Matthews 1989). The instructor will then have the opportunity to observe students' ability to recall prior knowledge and apply it in these courses. The instructor and students can fill any knowledge gaps or missing links to application in courses prior to students graduating. If a goal of education is to prepare professionals, then adopting PBL may assist students in acquiring a set of professional skills such as critical thinking, problem solving, self-directed learning, collaboration, active listening (Walton and Matthews 1989). PBL offers instructors a method to equip students with the skills to fill content gaps once they are working professionally and to handle the process dependent situation they will surely encounter (Doig 1994).

Limitations

This study was limited to 22 undergraduate exercise and sport science students who were graduating seniors that had taken exercise physiology, biomechanics, and exercise instruction. Only two PBL students were non-certified personal trainers with less than one-year experience in practical application in program design. The majority of students had only the standard cardiopulmonary resuscitation (CPR) and first aid certification. PBL students in this study did not have any prior experience with PBL. Perhaps previous PBL experience and/or other instructional methods beyond TI would cause students less anxiety and frustration.

Through adoptions of Barrow's closed loop PBL format of one group of eight to ten students, it may have limited this study statistically because of the low N. The instructor observations were a valuable commodity when analyzing the group dynamics and learning in the PBL course. Although field notes of the instructor's observations were collected, they were not transcribed. A qualitative research design component may give a much better understanding to student and instructor responses to PBL.

Recommendations for Future Research

Further investigations on PBL are needed to determine its effect on knowledge, application, and critical thinking within the strength and conditioning field. This study should be considered as an initial attempt in determining the effectiveness of PBL in strength and conditioning education.

Rate of Learning

A new research endeavor may be to determine the effect of PBL on the rate of learning. This rate of learning can be thought of as once students become competent with the PBL process, how quickly can they acquire new knowledge, apply that knowledge, and think critically about professional problems. Previous studies have discussed the benefit of PBL on cognitive development, contextual learning, and knowledge retention (Albanese and Mitchell 1993; Norman and Schmidt 1992; Walton and Matthews 1989). No studies examining the rate of learning were found. PBL may aim to speed up the learning process as it is a way of enabling students to learn and critically think more efficiently than they can do in TI of largely rote learning (Walton and Matthews 1989).

Knowledge Retention

This study was held over the course of one semester i.e. fifteen weeks. The impact of teaching PBL throughout a curriculum may be more profound than that of one semester course. However, a course can offer more controlled environment to examine specific effects of PBL (Albanese and Mitchell 1993). Its downfall is time and the time for students to learn the process. A time period longer than fifteen weeks may provide a better environment to draw conclusions as to the effectiveness of PBL. Although the PBL students did not significantly gain more knowledge than TI students, studies have reported PBL students retain knowledge over time (Dochy, Segers et al. 2003; Beers and

Bowden 2005). Subsequent retention is increased even though learning the PBL method may initially reduce the amount that students learn (Norman and Schmidt 1992). Future research may measure knowledge retention on PBL and TI in strength and conditioning.

Learning Styles

This study did not examine the effects of each instructional method on learning styles. None of the research reported in this investigation analyzed PBL or TI on learning styles. A future inquiry may find new evidence supporting PBL and learning styles on strength and conditioning education.

Conflicting Results

Researchers must take account the natural environment PBL is practiced and draw attention to the difficulties incurred when trying to control uncontrollable factors and design methods (Norman and Schmidt 2000). The statistical findings of this study conflicted with field notes taken by the instructor. The instructor felt as thought she observed learning and critical thinking in the PBL course. This inconsistency has been noted in previous research, in which the researcher stated, *"student perceptions of their learning did not correspond with my observations of in-class learning activities, nor did they predict test performance"* (Alessio 2004). Furthermore, the researcher stated, *"despite student objections about the lack of learning they felt was occurring with PBL methods, I perceived that student discussion and knowledge acquisition was happening*" (Alessio 2004). Qualitative methods may be a better selection for measurement when assessing PBL due to its naturalistic setting. Studies have utilized qualitative methods such as observation and open-ended questions when evaluating PBL (Amos and White 1998; Braher and Quitadamo 2002). It is possible that the research design for this study may not have been the most appropriate approach to assess desired outcomes.

Conclusion

The intent of an instructor is to impart an appreciation of method rather than to memorize the facts, for method is remembered when facts have been forgotten or when there are too few or no facts (Walton and Matthews 1989). Educators must create learning environments that engage students to develop professional skills in conjunction with knowledge to become a successful strength and conditioning professional. Pedagogical changes are warranted for learning strength and conditioning in an evolving information age. TI has historically been the instructional method of choice. However, it may not be the most effective instructional method in developing professional skills such as critical thinking, problem solving, and knowledge acquisition. The aim of this research was to compare the effects of PBL and TI on knowledge of strength and conditioning, application of strength and conditioning, and critical thinking. The results indicated PBL students did not learn more or improve their critical thinking more than TI. Even though there was less content delivered by PBL, equal improvements of scores occurred. Field notes may have facilitated a better understanding in which critical thinking and knowledge application were observed during PBL classroom discussion and instructor interactions with individual students. Students' perceptions revealed PBL students did learn to become independent learners and problem solvers.

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APPENDIX A

Student Demographic Questionnaire

ESS 395
Spring 2008
Student Profile

Name: ___________________________

Major/Concentration: ________________________________

What is the reason you are taking this course?
____
____
____

Have you had any previous experiences with group work?

Circle: Yes No

Have you had any previous experience with Problem Based Learning?

Circle: Yes No

List all current and prior certifications.

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

List a relevant work experience or practical experience in strength and conditioning, sports medicine, and/or fitness.

Position/Place of Employment or Experience	Length (months/yrs)
1. ___________________________________	_____________
2. ___________________________________	_____________
3. ___________________________________	_____________
4. ___________________________________	_____________

Appendix B

Approval Letter from the

National Strength & Conditioning Association Certification Commission

"NSCA-CC Commission" <commission@nsca-cc.org>	To	"'Heather Louise Sanderson HLSANDER'" <hlsander@uncg.edu>
	cc	
08/08/07 09:08 AM	Subject	RE: CSCS Practice Exam Material Permission

Heather: Thank you for your interest in using the Certified Strength and Conditioning Specialist (CSCS) Exam Content Description Manual and the three volume CSCS Practice Exam set as a measurement tool for your dissertation on "The Effects of Problem-Based Learning on Knowledge and Application of Strength and Conditioning."

The NSCA Certification Commission grants you permission to use these items provided you reference them in the table(s) and footnote(s) (if any) in the body of the dissertation and in the reference list AND if you agree to provide the NSCA Certification Commission with a completed copy of your dissertation.

Please let me know if you have any questions or need further information.

Janet Owens

Associate Executive Director of Operations

NSCA Certification Commission

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Appendix C

ESS 395 Syllabi and Schedules

The University of North Carolina at Greensboro
Department of Exercise and Sport Science
Spring 2008 Syllabus

Course Number:	ESS 395
Course Title:	Strength and Conditioning
Credit:	3:3
Course Days/Times:	Monday, Wednesday, Friday, 8am-8:50am

Prerequisites: ESS 375, 376, 379, or permission of the instructor

For Whom Planned: Open to all Exercise and Sport Science majors and others satisfying prerequisites.

Instructor Information:
Heather Sanderson
Office: 406 SRC
Office Hours: By appointment only
Phone: 334-5924
Email: hlsander@uncg.edu
(I check email several times per day-email is the fastest way to have questions answered).

Course Description:
The goal of this course is to teach students how to design sport-specific strength and conditioning programs that will aid in injury prevention as well as performance enhancement. The development of these programs is achieved through the periodized manipulation of acute training variables.

Required Text:
Baechle TR & Earle RW. (2000). Essentials of Strength Training and Conditioning, (Second Edition). Champaign, IL: Human Kinetics.

Recommended Text:
Brown, L & Ferrigno, VA. (2005). Training for Speed, Agility, and Quickness, (Second Edition). Champaign, IL: Human Kinetics.

Assigned readings: Additional readings may be assigned. Readings will be available in the Reserve Room at Jackson Library and/or online on Blackboard.

Student Learning Outcomes:

After successful completion of this course, the student will be able to:

1. Design training programs that maximize performance by prescribing various training methods and modes based on the uninjured athlete's training goals and current training status.
2. Design training programs that maximize performance and muscle balance by selecting exercises based on the uninjured athlete's training goals and current training status.
3. Design training programs that maximize performance by applying the principles of exercise order based on the uninjured athlete's training goals and current training status.
4. Design training programs that maximize performance by determining and prescribing appropriate loads/resistance based on the uninjured athlete's training goals and current training status.
5. Design training programs that maximize performance by determining and prescribing appropriate volumes (defined as reps x sets) based on the uninjured athlete's training goals and current training status.
6. Design training programs that maximize performance by determining and prescribing appropriate work/duration and rest periods, recovery methods and training frequencies based on the uninjured athlete's training goals and current training status.
7. Design training programs that maximize performance by determining and prescribing appropriate exercise progression based on the uninjured athlete's training goals and current training status.
8. Design training programs that maximize performance by utilizing the principles of periodization.
9. Select and administer appropriate test based upon the unique aspects of a sport, sport position and training status.
10. Evaluate and identify the significance of testing results.

Evaluation Methods and Guidelines for Assignments:

Exams, 4@100 points each	400 points
Semester project (Paper and Presentation)	200 points
10 Online MC quizzes	100 points
Total	700 points

Percentage Earned	**Letter Grade**
90-100%	A
80-89.99%	B
70-79.99%	C

60-69.99%	D
< 60%	F

I **DO NOT CURVE** the grades that are earned during exams, quizzes or individual assignments. Depending on the final distributions of scores, however, I *may* chose to use a plus/minus to reward those students who are especially close to the next higher letter grade (e.g., 78.5% may be either a C+ or B-). I will not *use* the plus/minus scale to lower your grade (e.g., 70.1% will be a C, not a C- or D+).

Exam and Quiz Format:
Exams and quizzes will consist of multiple choice, case study or real-life problem questions. There will be two content-based exams and two critical thinking exams. Each exam will be given at the beginning and end of the semester. There will be a minimum of 7 - 10 quizzes during the semester. If more than 10 quizzes are given, only your best 10 quiz scores will count toward your final course grade. Most of these will be given on blackboard. However, quizzes may be given in class and may be either announced or unannounced **AND MAY NOT BE MADE UP**.

Semester Project:
All assignments must be typed. Assignments will be graded on completeness of content as well as neatness and format. It is important to have a clean and clear document. The assignment should be well organized as well as easy to read.

Students will design a comprehensive sport-specific strength and conditioning program. Specific instructions on the content of the semester project will be discussed, and information will be posted on Blackboard.

Academic Honor Code and Student Conduct Policies:
Each student is required to document that he or she has abided by the Academic Integrity Policy on all work submitted for the course. A copy of the policy may be found in the UNCG Undergraduate Bulletin or on the web at http://www.uncg.edu/adv/policies.html#honor. The student code of contact will also be enforced in this class. This document may be found at http://studentconduct.uncg.edu/policy/code/

Attendance Policy:
Missing more than 3 unexcused class meetings will result in a 5 percentage point grade reduction in your semester grade (this is your overall semester grade). If you are tardy, you will lose 2.5 percentage points off your final grade.
No make-up work will be given; no extra credit will be given.

Tentative Course Schedule

Week	Topic	Reading Material
1	Exam 1 and 2 Overview	
2	Purpose, Goals, Philosophy Review of FITT; sport specificity; sport skills (SAQP)	Chapter 25, Article Readings
3	Testing and Evaluation	Chapter 14 and 15
4	Testing and Evaluation	Chapter 14 and 15
5	Resistance Training	Chapter 17 and 18
6	Resistance Training	Chapter 17 and 18
7	Plyometric Training	Chapter 19
8	Speed Agility, and Quickness	Chapter 20
9	SPRING BREAK-no class	
10	Speed Agility, and Quickness	Chapter 20
11	Endurance Training	Chapter 21
12	Periodization Models	Chapter 22
13	Periodization Models	Chapter 22
14	Semester Project Presentations	
15	Exam 3 and 4	

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Prerequisites: ESS 375, 376, 379, or permission of the instructor

For Whom Planned: Open to all Exercise and Sport Science majors and others satisfying prerequisites.

Instructor Information:
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Brown, L & Ferrigno, VA. (2005). Training for Speed, Agility, and Quickness, (Second Edition). Champaign, IL: Human Kinetics.

Assigned readings: Additional readings will be required. Each student will be responsible to search the literature in order to find the appropriate reading material.

Student Learning Outcomes:
After successful completion of this course, the student will be able to:

1. Design training programs that maximize performance by prescribing various training methods and modes based on the uninjured athlete's training goals and current training status.
2. Design training programs that maximize performance and muscle balance by selecting exercises based on the uninjured athlete's training goals and current training status.
3. Design training programs that maximize performance by applying the principles of exercise order based on the uninjured athlete's training goals and current training status.
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6. Design training programs that maximize performance by determining and prescribing appropriate work/duration and rest periods, recovery methods and training frequencies based on the uninjured athlete's training goals and current training status.
7. Design training programs that maximize performance by determining and prescribing appropriate exercise progression based on the uninjured athlete's training goals and current training status.
8. Design training programs that maximize performance by utilizing the principles of periodization.
9. Select and administer appropriate test based upon the unique aspects of a sport, sport position and training status.
10. Evaluate and identify the significance of testing results.

Evaluation Methods and Guidelines for Assignments:

Exams, 4@100 points each	400 points
Group Essay, 4 @ 40 points each	160 points
Group Presentation, 4 @ 40 points each	160 points
Peer Evaluation, 4 @ 20 points each	80 points
Individual PBL Essays, 4 @ 50points each	200 points
Total	**1000 points**

Percentage Earned	Letter Grade
90-100%	A
80-89.99%	B
70-79.99%	C
60-69.99%	D
< 60%	F

I **DO NOT CURVE** the grades that are earned during exams, quizzes or individual assignments. Depending on the final distributions of scores, however, I *may* chose to use a plus/minus to reward those students who are especially close to the next higher letter grade (e.g., 78.5% may be either a C+ or B-). I will not *use* the plus/minus scale to lower your grade (e.g., 70.1% will be a C, not a C- or D+).

Exam Format:
Exams will consist of multiple choice, case study or real-life problem questions. There will be two content-based exams and two critical thinking exams. Each exam will be given at the beginning and end of the semester.

Problem Based Learning:
Problem based learning (PBL) is an active learning instructional method that uses "real world" problems to facilitate instruction. Students work through problems in a small collaborative group in and outside of class emphasizing the application of knowledge and the development of higher order thinking.

PBL Problem Module
At least four PBL problems will be presented allowing for three to four weeks per problem. There will be 3 parts per problem and each part will be presented once the previous part has been completed. Each PBL problem module will consist of the PBL orientation session, three to four tutorial group sessions, out-of-class self-directed study, a group presentation session, and a reflection session. These sessions will not contain any lectures and the instructor will serve only as a guide to assist you in your learning. Each PBL module will follow the group problem solving steps below:

1. Clarify and agree on working definitions and any unclear understanding of concepts.
2. Define the problem using your own terminology.
3. Analyze the problem and brainstorm ideas.
4. Arrange the ideas into possible explanations or hypotheses.
5. Generate and prioritize learning objectives.
6. Research the learning objectives.
7. Present the research to the group, synthesize explanations, and apply new information to develop a solution.
8. Reflection, evaluation, and review of student learning objectives

Group Function
This class will function as one group working independently during and outside of class throughout the entire semester. The collective resources and effort of the group will be used to problem solve. In order for the group to function well, the group will discuss and agree upon a set of guidelines or ground rules. Consequences will be defined as well. Assigned roles will be given to each student and rotated after each PBL module.

1. Discussion Leader: Keeps the group on track; maintains full participation.
2. Recorder: Records assignments, strategies, unresolved issues, convenes group outside of class.
3. Reporter: Reports during whole-class discussion.
4. Writer: Writes final draft of assignment.
5. Accuracy Coach: Checks group understanding and facilitates the evaluation of resources.
6. Presenter: Presents the PBL problem final group presentation.

Peer Evaluation
A portion of your grade will depend on the performance of your group and your performance in the group. That portion of your grade is dependent upon your attendance, participation, contribution, preparation, and quality of work. You will evaluate yourself and the other members of your groups after each problem is completed. How your peers evaluate you can influence your grade.

Assignments
All assignments must be typed. Assignments will be graded on completeness of content as well as neatness and format. It is important to have a clean and clear document. The assignment should be well organized as well as easy to read.

Each PBL module will have one individual essay and one group essay and presentation to be completed at the end of each module. Specific instructions on the content of each essay and presentation will be discussed, and information will be posted on Blackboard.

Each student is required to perform a literature search and bring a typed paper of findings to report to the group at specific assigned dates.

Academic Honor Code and Student Conduct Policies:
Each student is required to document that he or she has abided by the Academic Integrity Policy on all work submitted for the course. A copy of the policy may be found in the UNCG Undergraduate Bulletin or on the web at http://www.uncg.edu/adv/policies.html#honor. The student code of contact will also be enforced in this class. This document may be found at http://studentconduct.uncg.edu/policy/code/

Attendance Policy:
The success of this course is dependent upon each student's effort toward the group learning. Participation in class discussion and group work is essential to learning. The entire class is expected to engage in active listening, reading, and critical thinking. Therefore **missing more than 3 unexcused class meetings will result in a 5 percentage point grade reduction in your semester grade (this is your overall semester grade)**. If you are tardy, you will lose 2.5 percentage points off your final grade.

No make-up work will be given; no extra credit will be given.

Tentative Course Schedule

Week	PBL Module
1	Exam 1 and 2 Overview
2	Set Group Rules and Roles Sample PBL Module
3	PBL Module 1-Part 1
4	Part 2 and 3
5	Group Presentation Individual and Group Paper Due Reflection Session
6	PBL Module 2-Part 1
7	Part 2 and 3
8	Group Presentation Individual and Group Paper Due Reflection Session
9	SPRING BREAK – no class
10	PBL Module 3-Part 1
11	Part 2 and 3
12	Group Presentation Individual and Group Paper Due Reflection Session
13	PBL Module 4-Part 1
14	Part 2 and 3
15	Group Presentation Individual and Group Paper Due Reflection Session
Finals Week	Exam 3 and 4

Appendix D

PBL Problems

ESS 395

PBL Problem Module 1

Part I: Needs Analysis (20 points)

Problem: You are the strength and conditioning coach for a NCAA Division II athletic program. The head women's basketball coach asks you to help develop an incoming freshman small forward (3 guard), Jane. The coach has no other forwards to start and will need Jane to be the starting forward. She will not arrive on campus until July due to housing.

Jane's Profile:
Gender: Female
Age: 18
Height: 5'8"
Weight: 140lbs.
Athletic Status: Division II college basketball forward

Learning Issues:

Test Selection, Sequence, and Administration

1. Analyze the sport, the player position, and the athlete to include athletic parameters, sport and metabolic specificity, current training status, current training cycle, medical history, age, race, and gender.
2. Identify and apply the factors used in test selection, such as environment, equipment needed and availability, validity and reliability.
3. Identify and apply the factors in good test administration.
4. Match the type of test and specific tests for sport-specific/position-specific assessments.

ESS 395
PBL Problem Module 1

Part II: Test Interpretation (10 points)

Problem: You have evaluated the sport, Jane's profile, and all necessary tests. Jane's test results are below. How does she compare to the normative values? Based on these results, what are your goals for Jane and how will you prepare her for the next training cycle? Give a rationale for your decision.

Jane's test results:
1 RM Bench Press – 88 pounds
1 RM Squat – 145 pounds
SEMO Agility Test – 9.1 seconds
Vertical Jump – 16.8 inches
1.5 Mile Run – 13:58 minutes: seconds
Body Fat % - 24%

Learning Issues:

Test Interpretation

1. Describe the statistics used to interpret test results.
2. Analyze the test results by comparing to normative values for the specific population by sport, position, gender, age, and/or sport population.
3. Determine what training factors need improvement.
4. Briefly describe how to approach developing a plan for improvement.

ESS 395
PBL Problem Module 1

Part III: Program Design (20 points)

Problem: Design a program for Jane based on your findings. Take into consideration the sport coach's needs and the time of year i.e. training cycle.

Learning Issues:

1. Describe the steps to assess individual athlete's performance.
    a. Analysis of sport, position, and the athlete's profile.
    b. Outcomes and analysis of test results.
2. Determine limitations of strength, aerobic, and anaerobic performance based on age and sex.
3. Identify the training cycle and give a rationale for why this program meets the training cycle goals and specificity.
    a. Describe the breakdown of the basketball macrocycle include length of each mesocycle.
    b. Discuss the type of periodization plan and the rationale.
4. Design an individual program which includes:
    a. Chart a four-week cycle and include a detailed first week microcycle.
        i. Give a detailed FIVR for all athletic parameters needed, including specific exercises, progressions of exercise, volume, load, rest periods, etc.
        ii. Explain how this program will improve specific athletic parameters as well as how this program will prepare the athlete for the next phase or cycle.

ESS 395
PBL Problem Module 2
Part 1 (15 points)

Problem: You have been hired as the football strength and conditioning coach for a NCAA Division I athletic program. It is mid-May. During your first initial meeting with the head football coach, he explains how his program has always competed for a national championship each year. He expects his athletes to be well prepared for the season. He tells you that last year the team's weakness fell on the cornerbacks. They were getting beat by the wide outs. Attached is the last week of the current training program developed by the previous strength and conditioning coach.

Profile: Starting Football defensive cornerback
Gender: Male
Age: 21
Height: 70"
Weight: 186
Athletic Status: Senior, Division I

Learning Issues:

1. Analyze the sport, the player position, and the athlete to include athletic parameters, sport and metabolic specificity, and current training status.
2. Analyze the following program include goals, FIVR, benefits and limitations.
3. Match specific tests for sport and position, determine the test order, and include a sample test battery.

ESS 395
PBL Problem Module 2

Part II: Test Interpretation (15 points)

Problem: You have evaluated Division I football, the cornerback's profile, and all necessary tests. Test results are below. How does the cornerback compare to the normative values? Based on these results, what are the goals for this athlete? After meeting with the coach and reviewing the off season program, you decide to focus on muscular power, speed, agility, and quickness. Explain the fundamentals for training SAQP. Give a rationale for your decision.

<u>Monday Tests</u>
BW: 186lbs
Vertical Jump: 26in
Bench Press: 295lbs
40yd sprint: 4.3s

<u>Tuesday Tests</u>
Broad Jump: 64in
T-Test: 10.5

Learning Issues:

Test Interpretation and Training Variables
1. Describe the test results.
2. Determine if this test battery is correct along with test order and appropriate test selection.
3. Compare results to normative values for the specific sport population and position.
4. Determine what training factors need improvement.
5. Identify special types of aerobic training and the purpose of each.
6. Describe the theoretical and physiological basis and application of speed, agility, quickness and plyometric training methods.
7. Explain the proper techniques when executing speed, agility, and plyometrics.
8. Identify training variables for speed, agility, quickness, and plyometric training.
9. Identify safety considerations for plyometric training especially for a football player.

ESS 395
PBL Problem Module 2

Part III: Program Design (10 points)

Problem: After watching game tapes and talking with the coach, you find the cornerback is getting beat off the snap and when cutting to the inside. Develop a program for first-step quickness, increase acceleration, change of direction, and back pedal speed.

Learning Issues:

1. Identify the training cycle and give a rationale for why this program meets the training cycle goals and specificity.
    b. Describe the breakdown of the football macrocycle include length of each mesocycle.
    c. Describe how the training schedule should shift as a function of the training season.
    d. Discuss the type of periodization plan and the rationale for each (if needed):
        i. Strength/Power
        ii. Speed
        iii. Agility/Quickness (Reactive Ability)
        iv. Plyometrics

2. Design an individual program which includes:
    e. Chart the mesocycle and include a detailed last week microcycle.
        i. Give a detailed FIVR for:
            1. Strength/Power
            2. Speed
            3. Agility/Quickness
            4. Plyometrics
        ii. Include specific exercises/drills, progressions, volume, load, and work:rest ratio.
        iii. Explain the purpose of the exercises/drills as it relates to the sport/position, and specifically the training goals.

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Appendix E

Practice PBL Problem

ESS 395-2
Case Study

A client has registered for 15 personal training sessions with you. Her paperwork is attached. She would like to meet with you next week to begin training. Your goal is to design an exercise program to meet the needs and goals of the client. Develop a month long program showing a periodized progression and include a detailed 1-week microcycle. Justify your rationale for all your decisions.

Part 1: Client screening and select appropriate assessments.

1. Review her medical history, ERSQ, goal inventory, and lifestyle evaluation.
2. What factors do you consider when screening her?
3. Are there any factors that may inhibit or bring caution to her training?
4. What questions do you ask during her consultation?
5. What tests did you select and why?
6. What instructions do you give to your client for testing?
7. Determine the order of tests and give a rationale.

Part 2: Test Interpretation

The following tests were selected and scored:
Height: 5’3”
Weight: 168lbs
RHR: 92
RBP: 122/88
3-site skinfold (Suprailiac, Tricep, Thigh): 34.2%
8-site Girth measurements:

Chest	40.5in	Bicep	11.75in
Forearm	9.75in	Waist	36in
Abdominal	38.5in	Hips	42.5in
Thigh	25in	Calf	15in

Curl up: 50rep
Push up: 3rep
Sit-n-reach: 17.5in
Step test: 156bpm

1. How does she compare to normative data?
2. What are her areas of strength and needed improvement?
3. How would you proceed?

Part 3: Program Design

1. Develop a month long program showing a periodized progression and include a detailed 1-week microcycle include FITT for all fitness components.
2. Describe 1 training session, what do you discuss with your client, discuss the order of the exercises and each fitness component.

Appendix F

Peer Evaluation

PBL Peer Evaluation

Upon completion of each PBL Module, each member of the group is to evaluate one another. Using a separate evaluative form for each group member, please rate his/her performance as a group member using the scale provided. Thank you.

Student Name: ________________________________Date:_____________________

	Lowest-----------------Highest			
1. Quality of Work (work is timely, current, creative, organized)	1	2	3	4
2. Content/Process (demonstrates self-directed and balanced learning via written work, oral presentations and group responsibility)	1	2	3	4
3. Application to Practice (discusses and applies leaning to other situations and/or future problems)	1	2	3	4
4. Follows Rules of Trust (follows group rules)	1	2	3	4

1. Be prepared and have designated assignments on time.
2. Be an active participant, no Social Loafing
3. Use group time wisely.
4. Notify designated contact person if unable to be present.
5. No arguing, keep an open mind.
6. Show for respect for everyone's role.
7. Ensure everyone is able to give input.

5. Group Participation (actively participates in activities, critiques and questions)	1	2	3	4

Total Possible Points: 20
Total Score: ____________

6. Comments (please provide if any of the above criteria is rated a 3 or below)

Adapted and used with permission of Dr. Mary Jo White and Dr. Libby Amos, University of Texas Health Science Center, Houston Texas.

Appendix G

SPSS Tables

Group Statistics

	Section	N	Mean	Std. Deviation	Std. Error Mean
GPA	Traditional Instruction	12	2.9017	.39247	.11330
	PBL	8	2.7500	.48471	.17137
Age	Traditional Instruction	12	22.0000	1.04447	.30151
	PBL	8	25.1250	5.51459	1.94970

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Upper	Lower
GPA	Equal variances assumed	1.206	.287	.772	18	.450	.15167	.19658	-.26134	.56468
	Equal variances not assumed			.738	12.889	.474	.15167	.20544	-.29254	.59587
Age	Equal variances assumed	19.019	.000	-1.937	18	.069	-3.12500	1.61329	-6.51441	.26441
	Equal variances not assumed			-1.584	7.336	.155	-3.12500	1.97288	-7.74713	1.49713

Group Statistics

	section	N	Mean	Std. Deviation	Std. Error Mean
ESS375	1.00	11	4.0909	1.81409	.54697
	2.00	7	4.0000	1.29099	.48795
ESS376	1.00	11	4.3636	1.80404	.54394
	2.00	7	3.7143	2.36039	.89214
ESS379	1.00	9	6.7778	2.10819	.70273
	2.00	7	6.1429	1.77281	.67006

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
ESS375	Equal variances assumed	1.882	.189	.115	16	.910	.09091	.79178	-1.58759	1.76941
	Equal variances not assumed			.124	15.689	.903	.09091	.73299	-1.46546	1.64728
ESS376	Equal variances assumed	.746	.400	.661	16	.518	.64935	.98179	-1.43195	2.73065
	Equal variances not assumed			.621	10.425	.548	.64935	1.04489	-1.66598	2.96469
ESS379	Equal variances assumed	.006	.939	.639	14	.533	.63492	.99352	-1.49596	2.76581
	Equal variances not			.654	13.871	.524	.63492	.97098	-1.44944	2.71928

CCTST

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	CCTST1
2	CCTST2

Between-Subjects Factors

		Value Label	N
Section	1	Traditional Instruction	12
	2	PBL	8

Descriptive Statistics

	Section	Mean	Std. Deviation	N
CCTST1	Traditional Instruction	15.4167	4.77605	12
	PBL	15.8750	3.83359	8
	Total	15.6000	4.32131	20
CCTST2	Traditional Instruction	15.4167	4.52183	12
	PBL	16.2500	5.70088	8
	Total	15.7500	4.89764	20

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
time	Sphericity Assumed	.338	1	.338	.064	.803
	Greenhouse-Geisser	.338	1.000	.338	.064	.803
	Huynh-Feldt	.338	1.000	.338	.064	.803
	Lower-bound	.338	1.000	.338	.064	.803
time * Section	Sphericity Assumed	.337	1	.337	.064	.803
	Greenhouse-Geisser	.337	1.000	.337	.064	.803
	Huynh-Feldt	.337	1.000	.337	.064	.803
	Lower-bound	.337	1.000	.337	.064	.803
Error(time)	Sphericity Assumed	94.938	18	5.274		
	Greenhouse-Geisser	94.938	18.000	5.274		
	Huynh-Feldt	94.938	18.000	5.274		
	Lower-bound	94.938	18.000	5.274		

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	9513.004	1	9513.004	240.744	.000
Section	4.004	1	4.004	.101	.754
Error	711.271	18	39.515		

KNOWLEDGE

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	K1
2	K2

Between-Subjects Factors

		Value Label	N
Section	1	Traditional Instruction	12
	2	PBL	8

Descriptive Statistics

	Section	Mean	Std. Deviation	N
K1	Traditional Instruction	5.4167	1.67649	12
	PBL	5.6250	1.50594	8
	Total	5.5000	1.57280	20
K2	Traditional Instruction	7.1667	1.26730	12
	PBL	7.6250	1.06066	8
	Total	7.3500	1.18210	20

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
time	Sphericity Assumed	33.750	1	33.750	24.179	.000
	Greenhouse-Geisser	33.750	1.000	33.750	24.179	.000
	Huynh-Feldt	33.750	1.000	33.750	24.179	.000
	Lower-bound	33.750	1.000	33.750	24.179	.000
time * Section	Sphericity Assumed	.150	1	.150	.107	.747
	Greenhouse-Geisser	.150	1.000	.150	.107	.747
	Huynh-Feldt	.150	1.000	.150	.107	.747
	Lower-bound	.150	1.000	.150	.107	.747
Error(time)	Sphericity Assumed	25.125	18	1.396		
	Greenhouse-Geisser	25.125	18.000	1.396		
	Huynh-Feldt	25.125	18.000	1.396		
	Lower-bound	25.125	18.000	1.396		

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1601.667	1	1601.667	610.697	.000
Section	1.067	1	1.067	.407	.532
Error	47.208	18	2.623		

APPLICATION

Within-Subjects Factors

Measure:MEASURE_1

time	Dependent Variable
1	AP1
2	AP2

Between-Subjects Factors

		Value Label	N
Section	1	Traditional Instruction	12
	2	PBL	8

Descriptive Statistics

	Section	Mean	Std. Deviation	N
AP1	Traditional Instruction	7.3333	2.10339	12
	PBL	6.1250	2.16712	8
	Total	6.8500	2.15883	20
AP2	Traditional Instruction	8.9167	1.50504	12
	PBL	8.7500	1.28174	8
	Total	8.8500	1.38697	20

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
time	Sphericity Assumed	42.504	1	42.504	24.369	.000
	Greenhouse-Geisser	42.504	1.000	42.504	24.369	.000
	Huynh-Feldt	42.504	1.000	42.504	24.369	.000
	Lower-bound	42.504	1.000	42.504	24.369	.000
time * Section	Sphericity Assumed	2.604	1	2.604	1.493	.238
	Greenhouse-Geisser	2.604	1.000	2.604	1.493	.238
	Huynh-Feldt	2.604	1.000	2.604	1.493	.238
	Lower-bound	2.604	1.000	2.604	1.493	.238
Error(time)	Sphericity Assumed	31.396	18	1.744		
	Greenhouse-Geisser	31.396	18.000	1.744		
	Huynh-Feldt	31.396	18.000	1.744		
	Lower-bound	31.396	18.000	1.744		

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	2325.038	1	2325.038	483.474	.000
Section	4.538	1	4.538	.944	.344
Error	86.563	18	4.809		

Appendix H

Field Notes

Spring 2008
ESS 395 Course Notes
Section 1 and 2

Monday, January 14 and Tuesday, January 15: Present syllabus and discussed course expectations.

Wednesday, January 15: Presented Chapter 25 lecture, The Strength and Conditioning Professional.

Thursday, January 16-Snow day: Classes delayed until 1pm

Tuesday, Jan 22: Two students late for CCTST exam; one did not show. She took the test the next day with the section 1 group. 3 students were not present during informed consent. Need to get their consent at some point.

Wed. Jan 23: One student had taken the CCTST the week prior on a written format. The section 2 student took the exam with the group.

Thurs. Jan 24: Asked for students' feedback on the CCTST. They said it was different and hard to take on the computer. They did not like having to scroll up and down to read questions and select answers. One student said she felt the answer she would have given was not an option. The CSCS pre test was administered.

Fri. Jan. 25: Student feedback from CCTST, one student said "he doesn't think like that". He likes simple things. CSCS pretest was given.

Mon. Jan. 28: Chapter 14 lecture, Test Selection and Order

Tues. Jan 29: Had students rank their top 3 choices for group roles and turn it in to me. Stand and deliver activity was very successful. It required students to open up about group work, communication, and interpretations. Moved into practice trial for PBL. Used a case study, handed students the client's paperwork. I used a general fitness client case study. I asked students who wanted to be the discussion leader, recorder, and reporter. One student said she wanted to be the DL but had ADD. I told her it would be good for her b/c it would help her focus. The group read the opening case study statement and the DL delegated selected questions to 2-3 students within the group (creating sub-committees). The DL kept asking if everyone was on track and decided to stop once all the groups were finished. She asked the students with questions 1-3 to go first. The students gave their answer, recorders wrote, and students asked questions to confirm their answer. No one disagreed. This continued with all groups. I did notice that the students lack an understanding of how to read screening forms, they forgot baseline information such as what is the current level of fitness, they did poorly when selecting and ordering appropriate assessments such as taking into consideration the client's current level of fitness of 60 minutes of walking per week. The group wanted to perform a 1RM squat and a 1.5 mile run (no other tests were discussed). They disagreed on which should be first. Throughout this process, they used no resources to only one text. Only 1-2 students actually opened up their book. I had to interject once they ran off course with the tests selection and order. Throughout the process, I sat back and wrote notes of missing or incorrect information and challenging areas. Once I interjected, I had the group revert back to the first question and talk about what was missing or I asked questions to get them to think about what would be a better choice. I also had to help them learn how to read and analyze a client's lifestyle evaluation. Some of the group members said they would tell their client what to eat prior to testing. I handed out an article on RD vs PT and the scope of practice at the next class.

Wed. Jan 30: Mark Williams visit.

Thurs. Jan 31: Mark Williams visit.

I wanted to have a current practicing S&C coach present his background, philosophy, current trends, and advise to students who are considering this field. He mentioned to me after class how he was astounded how many of our students are not physically active. Students did not understand the importance of UG grades to enter graduate school for S&C. Mark mentioned how it is very difficult to become a college coach without a MS. He was fortunate with his experience and networking.

Fri. Feb 1: Finished chapter 14 lecture. Asked students for feedback from Mark's visit. One student said he felt Mark was too honest. He did not want to know about the financial sacrifices and the long hours of a strength and conditioning coach. Administered online quiz 1.

Mon. Feb 4: Chapter 15 lecture-Test Interpretation. Students asked to be more active in class. They wanted to try the sport-specific tests and practice Olympic lifts. They were expressing their dislike for the instructional method (TI).

Tues. Feb 5: No class; instructor sick

Wed. Feb 6: No class; instructor sick

Thurs. Feb. 7: Presented PBL problem 1 part 1 to class. Handed out assigned group roles and responsibilities to group. The students began answering each question in their own terms. They questioned each other on the meaning of specific terms. They had a tough time making decisions on the direction of their thoughts. They tended to worry about topics that were yet to come, such as designing a program. I had to redirect the group to focus on the original question. They decided to assign each group member to research certain topics and return to the next class with their newly found information.

Fri. Feb 8: Cont. Chapter 15 lecture

Mon. Feb 11: Chapter 17 lecture-Exercise Techniques

Tues. Feb 12: Students could not make decisions. Sarah was discussion leader because Martin had a family emergency. Answered questions superficially. The depth of information was lacking. Some students were prepared and even brought articles. Some typed their findings. Other wrote briefly on a scratch sheet of paper. The students seem to feel they completed each question. Announced individual papers due on Thursday. The reporter sent me her notes to post on black board.

Wed. Feb 13: Watched USAW video. I told the class to take notes because their quiz would have questions on any videos I post. No one took notes.

Thurs. Feb 14: No class: Snow delay until 10am. I extended the paper due time to 5pm that day. Some students were thankful; others wanted a further extension. Students did not seem confident in their ability to successfully write a paper. They wanted me to give a definite page limit and some felt I was not specific enough in the PBL part 1 questions. I felt their frustrations and uncertainty was good in the sense that they need to do a better job as a group by researching deeper into the literature and making decisions.

(Thoughts after grading the papers: poor writing! No grammar checks or spelling. Students lacked the depth and completion of the problem. They used references inappropriately as they would directly quote from the reference opposed to paraphrasing, applying the reference information to the problem, and citing. I also noticed how there were different answers to questions that as a group they had come to a consensus with the answers. It seems as if they interpreted the group discussion differently.)

Friday. Feb 15: Presented a video "Athlete Body in Balance" which discussing functional testing and training for mobility, stability, and flexibility of athletes. Some students took notes. I posted an online quiz.

Monday. Feb 18. Chapter 18 (anaerobic training lecture) part 1

Tuesday, Feb 19: Returned part 1 papers. Asked students how they felt about the papers." Some thoughts were: did not feel they were prepared or had enough information, felt rushed, did not know how to write the paper, did not feel the recorder's notes were as thorough as needed. I told the class that I took into consideration that this was their first time writing a paper using the PBL process. I also informed them to think about how to better prepare for the paper by working on the breadth and depth of knowledge as a group. They need to keep in mind that the group work and self-directed study days will easily help with the individual papers. We returned to the problem and began working on part 2. Martin had returned as discussion leader. He struggles with getting the group to work together. I think Erin did a better job with inclusion as discussion leader. She assigned parts of the problem to smaller groups of 2-3. This model worked well. Martin tries by asking questions however not all are responsive. They returned to the DII article for insight on statistics and normative values. Brittany got online to research additional articles for normative data. However, there were only articles on anthropometric measures not athletic parameters. Some of the students did not know what standard deviation or the bell curve meant. Other students tried to explain it; however, I still felt some uncertainty by those students asking. Martin assigned parts for each group member to research and bring their information on Thursday.

Wed. Feb 20: Chapter 18 continued.

Thursday, Feb. 21: The group struggled on the last section of part 2 which asked how would they approach training based on the results of the tests. They tend to go too in depth in when it asks them to briefly describe. They go on a "tangent" in one direction. When this occurs, I have to interject to refocus them. When the end of class arrived, I announced part 2 paper due on Tuesday. Students asked for an example paper. There is some hesitation on writing a paper. One student made a comment that she is happy to graduate this semester so she will not have to write papers. I informed her that at a job papers are called reports. Students asked more questions about the paper.

Friday. Feb 22: Watched Advanced Strength Training video on HIT and High Volume Training. Students actually took notes on video. I announced an online quiz.

Monday, Feb. 25: Plyometric Training Lecture. No class discussion other than one student asking about plyometric training for a staggered start position versus a squat start position for swimmers. I had one student demonstrate a normal vertical jump than a vertical jump with a delayed amortization phase. This visual may help the students understand the Phase II of the stretch-strengthening cycle during plyometrics.

Tuesday, Feb 26: Students submitted their Part II individual papers. I decided to have the reporter record class notes to give the recorder a break. She has been working diligently on note taking, which has limited her participation in class discussion. Part 3 problem, program design, was presented. The discussion leader wanted to revise some of the selected tests to add tests for anaerobic capacity and sprinting. The group decided on adding line drills; however, the discussion leader had a difficult time facilitating the discussion and having the group to come to a consensus. I had to interject the discussion and explain why we (S&C coaches) choose to use certain tests at certain times of the macrocycle. Once I explained it, they seemed to get a grasp on the concept. Furthermore, I explained to the group that the PBL problem is a real-world problem which means it is not allows a "text book example". Real life situations do not present themselves that simple.

Wednesday, Feb 28: Plyometric Lab: Class met in SRC to perform jumps and hop drills. Students struggled with basic drill techniques.

Thursday, Feb 29: The discussion leader was absent. I decided to lead the group discussion. It became apparent to me by reading the students' faces that they were frustrated with the facilitation of the discussion leader during the previous class. Also, the students verbally expressed their worries that part 3 seemed overwhelming. During this class, I had the students break up into smaller groups of 2 and 3 and assigned each group a portion of the problem. The students seemed to like this format because the problem seemed doable when dividing it among everyone. I gave the students homework to research off-season programs for women's basketball and periodization models.

Friday, March 1: Plyometric Lab 2: Students performed box drills and depth jumps. One student stopped participating after the warm up.

Monday, March 4: Watched Plyometric Training Video.

Tuesday, March 5: I asked students to present their findings from their research. Students were not prepared. Some forgot to bring their articles, others had not printed the articles, and some students did not perform their homework. I informed the students that we only have one more class day to complete our part 3 before the individual papers were due and coming to class unprepared only makes writing their papers more difficult. I had the students return to their small group to finalize their decisions. After giving them 30 minutes together, I brought the entire class back and had each group present their findings. We found each group had different findings that did not agree with each other. The students began working together to challenge each decision and determine what is the best course of action. When had five minutes left and I informed the students to continue to work on their own and research metabolic training for off-season basketball for next class.

Wednesday, March 6: Chapter 20, Speed Lecture.

Thursday, March 7: Again a disappointing class with students attending unprepared. Students asked to have the individual paper due date extended. I felt that with spring break students would have adequate time to complete their work. I explained to the students the importance of coming to class prepared with research ready to share and I would not extend the deadline because I do not want to enable this poor behavior. The students decided to work on the problem over the break by using an online discussion board. They also decided to meet outside of class prior to the Tuesday after spring break. We returned to work on the problem. I had the groups write on the board the microcycle and mesocycles they developed. The microcycle group decided to simply copy and paste a program from an article they found. I noticed problems with exercise selection and order with the article. I discussed poor group decision to simply copy and paste information from an article. One student said "what is wrong with using the article when you told us to use articles to complete our work". I replied by explaining to the class we still need to critique articles.

Friday, March 8: Watched Agility and Speed Video.

Monday, March 17: Finished Agility and Speed Video. Continued Chapter 20 lecture on agility.

Tuesday, March 18: Individual Papers Due. I announced Group Presentation due on Thursday and group paper due the following Tuesday. Used class time for the presenters and writers to finalize decisions on RT and conditioning programs. Class did not finish the conditioning portion of the problem. One student did ask how to train an athlete using a %RM load for an exercise that we did not test, such as lat pull down. I agreed with the challenge between textbook and reality. I explained what coaches do for athletes to find their load. He showed frustration with developing a program when it is not black and white or a step-by-step plan. I explained the text shows guidelines; however, the guidelines only give direction. You still have to use trial and error and experience when prescribing exercise.

Wed. March 19: Finished Chapter 20 lecture.

Thursday, March 20: Robert and Tonora presented the group presentation. They were not thorough nor did they take the feedback that was given on Tuesday's class in regards to exercise order, selection. Afterward, the students completed their peer evaluations.

Friday, March 21: No class; Spring Holiday.

Monday, March 24: Agility Lab. Had students work on resisted sprints with bands and partners, agility ladders, lock outs with the stability ball, star drill with cones and weave drills with bags. Students are not conditioned and have poor body mechanics.

Tuesday, March 25: Group paper due. Begin PBL Problem 2. Only half the class was present (4 students). Since the group discussion leader was not present, I lead the group.

A student did asked who would lead the discussion. I said I would. They replied with good. This makes me wonder if in some instances a student should not be a discussion leader and the instructor should facilitate. Not sure yet. We began working on the football program. A few students were not familiar with football. Therefore, another student who played football taught the class football defensive positions, wide receiver route patterns, cornerback starting position, and athletic parameters. He also discussed the cornerback's strategy for defending the WR. It was nice to see a student who is less vocal in the group discussion teach the class. He explained it well. The students began researching for articles and discussing their thoughts of sport analysis such as anaerobic vs. aerobic conditioning. They referred to the text for rest vs. work ratio in football and determined it was more anaerobic. At the end of class, I assigned homework for the students to research football.

Wednesday, March 26: Reviewed quiz 5, agility and speed. Many students had problems with this quiz. Began lecturing chapter 21, aerobic training. This chapter should be a review since it is discussed in ESS 379. However, students are not familiar with exercise pace, which is typically used for an athlete's training intensity level. One of the students in the class is an endurance athlete at UNCG. We were able to ask him questions to help explain some training topics for those unfamiliar with endurance training.

Thursday, March 27: Asked students to present their findings. Students had trouble because the Library had no access to journals in strength and conditioning. I also was unable to access S&C journals through the library. This poses a huge problem for our class. However, I have found that some students will only research articles in one journal. They do not take extra steps to search the database of literature search engines. I found a number of articles in class and posted on bboard. They discussed test selection and the student who taught football on Tuesday had to review his presentation because a number of students who were not present did not understand football as well. As we began reviewing the football program the problem presented, one student said he felt it "looked good" and did not see a reason to analyze the program. The problem did ask the students to analyze the program and determine any limitations. So we had to recap. I announced their papers were due on Tuesday. Since we did not complete the problem in class, I developed a discussion board for the students to work outside of class.

Friday, March 28: Continued the aerobic training chapter lecture.

Monday, March 31: Aerobic Training Lab.

Tuesday, April 1: The discussion board was successful. Students posted their findings and discussed the best course of action for test selection and protocols. They also discussed the current program review. We begin PBL Problem Part 2 in class. Students were unsure of how to interpret tests since the book does not have the chosen tests' results. They discussed the problem's test selection and order and decided there are more appropriate tests for a DI cornerback. Their struggle and frustration was good for them to learn that answers are not always easy to find and coaches do not allows use the best tests. Papers Due.

Wednesday, April 2: No Class: NIRSA National Conference

Thursday, April 3: No Class: NIRSA National Conference

Friday, April 4: No Class: NIRSA National Conference

Monday, April 7: Chapter 23: Periodization Lecture. Notified students of their semester projects due. Two students will present per day. Student drew for presentation dates.

Tuesday, April 8: The group was divided into three smaller groups. Two groups moved to the computer lab to search the literature while one group remained in the classroom and used the text. I moved continuously from the lab to the classroom assisting the students. I posted some SAPQ lectures and articles on blackboard to assist. This problem may be the most difficult because the students have not been familiarized with SAPQ training variable and designing programs.

Wednesday, April 9: Chapter 23: Periodization Lecture continued.

Thursday, April 10: Each group presented their findings. We worked together as a class to determine if the findings were correct for this situation and if we need further, more depth, information. We completed learning issues 1-7. Students were then divided into to two small groups to work on learning issue 8 and 9 respectively.

Friday, April 11: Peaking in Competition lecture.

Monday, April 14: Semester Project Presentations. The first student was unprepared. He incorporated sport practice drills and pick up games into his program. Training variables only included frequency, intensity/volume, and exercise selection (which was a bodybuilder's workout). No olympic lifts, preparatory lifts, skill transfer lifts, or rest periods were discussed. No plyometrics, speed or agility drills. His sessions were too long (almost 2 hours). His in-season program did not include peaking nor did he discuss whether his program was linear or nonlinear. The next student was very similar in which the program focused only on RT with some SAPQ; however, she did not discuss the training variables for SAPQ, such as frequency, distance/duration/ or # of contacts, progression of drills, and work:rest ratio. Both students did not discuss warmup, flexibility exercises, and core training.

Tuesday, April 15: Students returned to their respective smaller groups to share findings and determine the best decision. I observed each group and found both groups were not prepared and they spent most of the time reading and writing information from the text. Again, we did not complete the entire problem because students were unprepared. We spent class time on work that should have been completed during self-directed study. One student did complete the work and seemed bored and frustrated because he had already finished the problem. This portion of the problem was most challenging for the group because we discussed training variables for SAPQ. SAPQ is fairly new to students and without a thorough discussion I feel the quality of work may suffer.

Wednesday, April 16: Semester Project Presentations. Students are incorporating sport practice drills or pick up games into their training. NCAA compliance regulations were discussed during Chapter 25 lecture along with the job duties of the S&C coach and working with sport coaches. Same issues occurred with Monday's presentations on program design. Students are waiting until the last minute to begin their paper and presentations. They are feeling overwhelmed. Some students have emailed me to review their papers this week. Only one student emailed me in March to review her paper.

Thursday, April 17: Individual Papers, PBL 2-Part 2 due. Begin working on Part 3. Students showed signs of lack of motivation. They were not eager to begin a new problem and needed persistence and direction on attempting the learning issues. The class again divided into two sections and started working on the 1st part of problem 3. Some students were not familiar with football, nor a football season. One student used the internet to search for a football season and a training macrocycle. Another student researched in the text. I took the moment to help students understand the difference between DI-A football or now called, the Bowl Championship Series, and DI-AA, Championship Series. The students needed to understand that in a DI-A program during the season a month of no games may pass from the conference championship game to a bowl game. This concept was important for this problem because the athlete was in a Big 6 conference school i.e., DI-A program. Students were given homework to investigate football preseason programs.

Friday, April 18: Student Presentations

Monday, April 21: Student Presentations

Tuesday, April 22: Students were unprepared for class. Some had articles that I posted on blackboard; however, they had not read those articles. We had to back track and review the 1st learning issues. Students were not processing as quickly to begin working on the program. Therefore, they had to work on it individually out of class. I opened a discussion board and the only comments posted were how they felt unprepared and they would perform poorly on this paper.

Wednesday, April 23: Student Presentations

Thursday, April 24: Individual Papers, PBL 2-Part 3 due. Administered CSCS posttest.

Friday, April 25: Student Presentations. Interestingly, students who are current or old college athletes, or who are coaching high school athletes are performing better on presentations. They are applying the course principles and seem to grasp a better understanding of S&C.

Monday: April 28: We had our last presentation. Announced to class the posttests.

Tuesday, April 29: Group Presentation. Students completed peer evaluations and PBL course evaluations.

Wednesday, April 30: Administered CSCS posttest.

Thursday, May 1: Administered CCTST posttest.

Friday, May 2: Administered CSCS posttest.

(Bloom 1956; Neufeld and Barrows 1974; Barrows 1980; Barrows 1983; Barrows 1986; Neufeld, Woodward et al. 1989; Norman and Schmidt 1992; Albanese and Mitchell 1993; Vernon and Blake 1993; Creedy and Hand 1994; Facione, Facione et al. 1994; Facione 1994; Barr and Tagg 1995; Savery and Duffy 1995; Lieux 1996; Foley, Polson et al. 1997; Segers 1997; Amos and White 1998; Birgegard and Lindquist 1998; Antepohl and Herzig 1999; Bompa 1999; Fink 1999; Rankin 1999; Segers, Dochy et al. 1999; Albanese 2000; Association 2000; Evenson and Hmelo 2000; Hmelo and Evenson 2000; Norman and Schmidt 2000; Williams 2000; Duch, Groh et al. 2001; Teshima 2001; Roche 2002; Smits, Verbeck et al. 2002; Sundblad, Sigrell et al. 2002; Willis, Jones et al. 2002; Dochy, Segers et al. 2003; McGee 2003; McLoda 2003; Hmelo-Silver 2004; Norton 2004; Savin-Baden and Wilkie 2004; Beers 2005; Beers and Bowden 2005; Su, Osisek et al. 2005; Van Gekder 2005; Ehrenberg 2006; Hwang and Kim 2006; Roselli and Brophy 2006; McLoughlin and Darvill 2007)