2003

The effect of scaffolding movement challenges on students' task-related thoughts and performance

Paul Bernard Rukavina
Louisiana State University and Agricultural and Mechanical College

THE EFFECT OF SCAFFOLDING MOVEMENT CHALLENGES ON STUDENTS' TASK-RELATED THOUGHTS AND PERFORMANCE

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Kinesiology

by
Paul Rukavina
B.S., University of Wisconsin-River Falls, 1996
M.S., Arizona State University, 1998
December, 2003

ACKNOWLEDGEMENTS

I express my gratitude to Dr. Amelia Lee for her guidance throughout my program of study. Dr. Lee has served as my major professor and as the chair of my dissertation committee. I have always admired her vision for the department of Kinesiology, Physical Education, and myself and her ability to lead people (especially myself) in fruitful directions. I would also like to thank Drs. Melinda Solmon, Richard Magill, Dennis Landin, Robert Mathews for serving on my committees and sharing their time with me. More specifically, I would like to thank Dr. Solmon for showing me how to apply statistic knowledge to research studies and spending time with me at conferences. Also, thanks to Dr. Magill, Dr. Landin, and Dr. Li Li for allowing me to participate in their seminars, for answering all my questions and being great role models. Thanks to Dr. Mathews for helping me with independent studies and participating as my minor professor in psychology. Thanks to Dr. DiStefano to opening my eyes to construct validation. I appreciate all their knowledge and insight they have shared with me over my stay.

Thanks to the staff of the Department of Kinesiology and the staff of the Graduate school who helped me during my course of study. Thanks to Stephen Graham who coded my many videotapes.

Finally, to my family, Mom, Dad, and my brother Marc who have inspired and provided support throughout my doctorate level work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The purpose of the study was to examine the influence of teaching approaches on thoughts and practice behaviors of students, and how those thoughts and behaviors affect transfer of learning. First, a self-report instrument for assessment of cognitive processes that meditate motor skill outcomes was validated. The cognitive processes included prior knowledge usage, self-efficacy, critical thinking and attention-concentration. University students who had taken a physical activity class (N=409) completed the questionnaires. Three out of the initial four subscales were confirmed as fitting the data. Attention-concentration was dropped probably because it was an element of critical thinking.

In a university golf activity class, students were assigned into three groups for instruction to learn a golf-pitching task: guided discovery (scaffolded movement challenges using task cards to learn movement concepts), model group (students were presented concepts and shown a correct model) and a control group (received no information except the initial basic instruction the other two groups also received). Instruction lasted six days. Skill performance scores, form scores and self-report cognitive measures (cognitive processes questionnaire and strategies students used to be successful) were recorded.

Results indicated that it was the lower-skilled students were responsible for improvements over time. Students used different strategies depending upon the instruction they received. Students in the trial and error used attentional strategies, those in the correct model reported that it was the technique related to posture and grip that helped and the guided discovery group clearly concentrated on applying concepts to be successful. However, no differences in transfer were evident. It is possible that guided discovery students did not have enough time to translate their understanding into outcomes.

The results of the study provide evidence to support a mediating process perspective framework for understanding the links between teacher and student variables, and student variables and outcomes. Researchers should continue to design studies to explain how different instructional conditions and students variables elicit different cognitions and strategy use from students. In the future, it is important to investigate when and under what conditions certain behaviors and thoughts are elicited by the instructional approach will lead to more successful performance on skill and transfer tests.

CHAPTER 1: INTRODUCTION

A major goal of research on teaching in physical education is to understand and enhance teacher effects and student learning. During the last half of the 20th century, the level of research has been significant, establishing general principles of effective teaching behavior for teachers to apply in various situations. For example, providing students clear information about the skill and task to be learned or scaffolding practice at appropriate difficulty for individual students are principles that have been drawn from the research literature (Rink, 1996). At the same time research has provided us with a greater understanding of the complexities of teaching and learning. Initially, pedagogical research assumed a direct relationship between what the teacher does and the level of performance students achieved in motor skills. More recently pedagogical research supports the role of the teacher as a facilitator and the student as an active participant in the learning process, as well as considering the context in which learning occurs.

Mediational Processes Perspective

Mediational processes perspective is a conceptual framework for organizing investigations related to the mediating effects of students' thoughts and behaviors on instruction. Mediating student variables can be conceptualized as entry characteristics, cognitive processes students employ as they learn, and the actions that result from those thoughts (Solmon & Lee, 1996). Entry characteristics include the students' initial skill and knowledge, as well as all prior experiences they bring to the learning environment. Within the learning environment, students employ learning strategies or cognitions that affect the level of engagement. In turn, other cognitions related to the confidence level of students may prolong cognitive engagement and lead to higher quality practice behavior. Acknowledgement of the capability or role the student can take in learning changes the conception of the teaching-learning process. Teachers do not directly influence achievement; instead, they design and orchestrate the learning environment to influence students' learning processes and behavior, and ultimately this impacts student outcomes (Lee & Solmon, 1992).

A large amount of research has been conducted on a range of student thoughts and behaviors (e.g., successful practice or critical thinking,) but little information is available to explain how teacher actions and ways they design the learning environment will evoke student variables. The framework used by a teacher to select and deliver content, as well as organize the students' experiences, is called a teaching approach (Graham, Holt/Hale, & Parker, 1998; Nicholls, 1986; Rink, 1998; Rukavina, 2002). The various approaches available are situated along a continuum depending upon the nature of the problem to be solved and the learning processes students will use to solve problems (Mosston & Ashworth, 1994). Teachers who provide students with direct information and solutions to problems can expect them to replicate the demonstrations provided during skill practice, and answer questions with memorized facts. On the other hand, teachers may choose to present problems or movement activities that require students to "go beyond the information provided" and discover a concept or produce their own solution. The notion of a continuum of teaching approaches is consistent with the mediational processes perspective and assumes that teachers can structure problems for students to solve by evoking particular thought processes.

Very little research has investigated the link between student mediating variables and the skill outcomes produced. One of the NASPE (1995) standards is for students to be proficient in a few movement forms but competent in several. Given the nature of mediational processes, it is important to determine which variables lead to different types of outcomes. One prominent outcome many teachers strive to accomplish is to help students transfer motor skills learned in one situation to other environments in their daily lives. It is well established that students learn best when they are able to connect new knowledge with prior knowledge to develop a conceptual understanding of the content. One important question to be answered is how can teachers facilitate this process of knowledge construction?

Further investigation of the link between teaching approaches and student thoughts and behaviors, and the link between student variables and particular student outcomes is critical to the understanding and development of appropriate interventions for teachers. Mediational processes perspective provides an excellent framework to guide research and add to this knowledge base.

Experiments

This two-part study examined how different teaching approaches evoke student thoughts and behaviors, which in turn are hypothesized to differentially affect transfer of motor learning. The first phase of the study involved construct validation of an instrument to assess students' cognitive processes. Initially, questions from several different instruments were pooled together to assess 4 different factors: prior knowledge, critical thinking, self-efficacy, and attention-concentration. Four hundred nine questionnaires were distributed to students who were enrolled in a physical activity or had previously taken activity classes. An exploratory analysis was used to identify the factor structure. Subsequently, a confirmatory analysis was used to examine the fit between the data and the model. For both analyses, results are discussed in terms of the match to theory.

The second phase of the study involved the comparison of three different approaches used to teach the golf pitch: A reproductive approach, a constructive approach, and a discovery approach (or control group). Fifty-four university-aged students served as participants. The reproductive approach consisted of providing verbal instructions of motor concepts whereas the productive approach involved scaffolding movement activities with task cards and having students go beyond the information provided to obtain a deeper understanding of the concepts. Scaffolding is an instructional technique that allows students to work at a level beyond their initial capability allowing them to concentrate on tasks that are in their range of competence (Wood, Bruner, & Ross, 1976).

According to the mediational processes perspective, instructional approaches should evoke particular thoughts and behaviors, which in turn, affect student outcomes. In the study, behavior measures of successful and appropriate practice along with cognitive processes were assessed at different entry skill levels. It was expected that cognitions and practice variables should vary according to entry skill and the teaching approach. For the link between cognitive processes and outcomes, it was hypothesized that students' use of critical thinking to understand the concepts at a deeper level promotes transfer of learning when students are presented with a golf pitch of different distance and height.

CHAPTER 2: INSTRUMENT DEVELOPMENT

Introduction

In the past, researchers attempted to understand effective teaching through examining the relationship between teaching behaviors (process) and student achievement (product). Measurements included quantifying overt teacher behaviors and measuring student performance with standardized motor skill tests. However, a process-product model, which primarily emphasized teaching behaviors, lacked the complexity essential to describe the multifaceted process of teaching and learning (Marx & Winne, 1987). In attempting to expand or incorporate variables of student learning processes, a mediating process paradigm emerged as a viable framework. Rather than teachers directly influencing achievement, teachers design and orchestrate the learning environment, influencing students learning processes and behavior, and ultimately impacting student outcomes (Lee & Solmon, 1992).

The shift to a mediational processes perspective incorporates the belief that teaching may be better understood through investigating how students are engaged during instructional episodes. In initial mediating research, investigators relied upon overt measures of mediating variables such as time-utilization or numbers of practice trials (Silverman, 1991). Doyle (1977) criticized the over reliance of observable measures and recommended investigation of internal or cognitive processes. Cognitive processes may be defined as cognitions or student thoughts that affect learning, including their motivations, perceptions, expectations, beliefs, levels of attention, and use of strategies (Wittrock, 1986). Understanding how mediating process variables impact learning will facilitate teachers' development of effective instructional approaches to enhance student learning of motor skills.

Studying student cognitive processes requires self-report assessment devises to detect changes in unobservable mental operations. Self-report measures are assessment devices where researchers ask students about their thinking or their beliefs. Examples of these devices may be summed rating scales (i.e., likert scales) or stimulated recall interviews. Although self-report measures have the potential to introduce problems such as subjects basing their responses on a prior theories (Nisbett & Wilson, 1977), researchers who carefully collect data using appropriate procedures can provide reliable, valid and important information (Ericsson & Simon, 1980; Howard, 1981; Lee & Solmon, 1992; Locke & Jensen, 1974). Further, evidence from educational studies using self-report measures to assess students' cognitive processes concluded self-report instruments can be more accurate predictors of student outcomes than time on task measures (Peterson & Swing, 1982; Peterson, Swing, Stark, & Waas, 1984).

In the study of teaching and learning in physical education, assessment of mediating variables on learning outcomes is in process. Investigations of student learning processes have suggested that students are aware and can report their cognition. Using instruments such as questionnaires (Hebert, Landin, & Solmon, 2000; Solmon & Boone, 1993; Solmon & Lee, 1996; Solmon & Lee, 1997) and stimulated recall interviews (Lee, Landin, & Carter, 1992) students as young as 4th grade were able to describe details about their cognitive processes allowing researchers to yield important findings concerning how they learned from instruction.

While researchers have discovered and investigated how student mediating processes can produce particular learning outcomes, little is known about the teaching approaches that will evoke particular mediating learning processes. Teaching approaches are conceptualized along a continuum from reproductive approaches to constructive approaches based upon the learning processes students exhibit (Mosston & Ashworth, 1994). Students in a reproductive approach try to reproduce information or the solution provided by the teacher whereas students in a constructive approach go beyond the information provided to construct their own meanings (e.g., use critical thinking, attention-concentration or use of prior experience).

The purpose of this study was to develop a context-specific instrument to assess cognitive processes evoked from different teaching approaches of motor skills in university physical activity classes and provide initial evidence of reliability and validity. Other scales have been devised for use with elementary age students (Solmon & Lee, 1997; Solmon & Boone, 1993). University students have more prior experience than younger children, can think abstractly, and can report more precisely their problem solving efforts. Further, the scales available were developed from a goal theory perspective and had subscales explicitly related to motivation constructs (Solmon & Lee, 1997; Solmon & Boone, 1993). The instrument developed in this study had subscales related to critical thinking or the use of prior experience that is often associated with constructive teaching approaches.

To develop an instrument to assess cognitive processes during motor skill learning, the recent literature on construct validation was reviewed. Benson (1998) conceptualizes 3 stages involved in construct validation: substantive, structural and external. In the substantive stage, constructs are defined both theoretically and empirically (i.e., description of the observed variables and how they are measured). In the structural stage, researchers check how observed variables covary with each other and how they covary with the structure of the construct's theoretical domain. Finally, researchers check how the constructs of interest covary according to predicted ways with other constructs. This article addressed the first two stages of construct validation.

Cognitive Processes

The complex array of student thoughts and behaviors evoked by instruction may be conceptualized into three broad categories: entry characteristics, cognitive processes students employ as they learn, and the actions that result from those thoughts (Solmon & Lee, 1997). The substantive phase of this study included investigation of the theory underlying each of four cognitive processes that might be used during motor skill instruction: attention-concentration, critical thinking, prior experience and self-efficacy. Attention-concentration refers to the conscious or nonconscious engagement in cognitive or motor activities (Magill, 2001). Example items include "I concentrate when I practice skills" or "my mind wanders while I practice skills." What students attend to is affected by the entry characteristics students bring to the learning environment. Entry characteristics include notions about the subject matter, perceptions of their own competence, initial skill, prior knowledge and experience (Solmon & Lee, 1997). Students use entry characteristics as a framework from which they perceive class events and interact uniquely within the learning environment. What students attend to determines what information gets processed and ultimately affects student motor and cognitive performance (Lee & Solmon, 1992).

McBride (1991) explored various critical thinking definitions from different educational theorists (e.g., Lipman, 1988; Paul, 1987; Beyer, 1987) and used these to devise a description and explanation appropriate for physical education. Critical thinking in motor skill learning refers to logical thought processes students use to figure out a motor problem. More specifically, critical thinking is defined as "reflective thinking that is used to make reasonable and defensible decisions about movement tasks or challenges" (McBride, 1991). Reflective thinking refers to students' ability to draw upon their prior experience and to draw upon their general and specific knowledge base. Reasonable denotes that critical thinking involves logical thought process while the word defensible implies that students should be held accountable for the decisions they make about movement and thinking.

McBride (1991) has also created a schema or a conceptual framework to hypothesize the sequence and components of critical thinking in physical education. Each component represents a set of behaviors or thought processes that students use from receiving information from the teacher to responding with solutions to problems. The component processes in the model are as follows: cognitive organizing, cognitive action, cognitive outcomes and psychomotor outcomes. In the beginning phase, students attend to information from the teacher and focus on the problem to solve. When students actively accept the goal of the task, they experience a state referred to as cognitive dissonance. On the other hand, students who passively accept information from the teacher enter cognitive acquiescence. After receiving the problem to be solved, students organize and assess the information to establish a hypothesis.

In McBride's third and fourth components of the schema, students practice and test the hypothesis developed during cognitive organization. An example item of the critical thinking dimension includes "I form hypotheses (movement plans) and test them during practice." Responses during practice may be expressed cognitively (i.e., cognitive outcomes) or presented in form of a motor response (i.e., psychomotor outcomes) depending on the nature of the problem to be solved. Based on students' success with the response, they may receive a new problem to solve from the teacher or generate a new hypothesis for more attempts on the existing problem. Students analyze and reflect back on their performance drawing conclusions on how they did. An example item is "I check my performance during practice and draw conclusions on how successful I am" or "I compare and contrast my performance from one practice attempt to the next". Throughout the process of understanding and solving the motor problem, students' metacognition orchestrates and monitors their cognitions and motor responses.

Another cognitive process that students may use during practice is use of prior experience. Items representing the category include "I try to relate the skill I am learning to other skills I already know" or "I have little need to use my prior experience to help me do better during practice". Typically, when students receive little information from the teacher on how to solve the action and movement problem, they are forced to use their prior experience to help them solve the problem (Rukavina, Lee, Solmon, & Hill, 2001). A major part of productive or movement education teaching approaches involves providing problems that require students to use their prior knowledge to help find a solution to the problem. Also, in a study comparing expert and novice teachers, expert teachers framed new problems and asked questions relevant to what students learned in a past unit (Chen & Rovegno, 2000). In other words, with each new problem students solved a link to past learning was evident.

Last, self-efficacy is a student's confidence or belief in executing a task to produce a desired outcome. Example items of self-efficacy include "I feel like I will do terrible no matter how hard I try" or "I am confident I will be able to do well when I practice skills". Bandura (1977, 1986) hypothesizes that student success will increase students' confidence while failure leads to frustration or lower efficacy. High self-efficacy students are posited to have higher motivation and will choose to participate, exert more effort and persist longer than students with lower self-efficacy. Students with high self-efficacy can focus their attention on a problem and extend more effort whereas students who perceive difficulties may feel stress and tend to divert attention from possible solutions.

The four constructs in this study are related since all are student thoughts hypothesized to mediate the relationship between instruction and students' skill outcomes. In other words, teachers structure the learning environment to evoke student thoughts and behaviors that will ultimately impact skill outcomes. Critical thinking, attention-concentration, and prior experience are expected to be positively correlated because each construct is cognitive in nature and is hypothesized to be evoked during productive teaching approaches. Also, it is hypothesized that students' beliefs that they are competent will promote future cognitive engagement in a task and use of learning strategies (Paris & Okra, 1986; Schunk, 1985; Thomas, Iventosch, & Rohwer, 1987).

Method

Participants

Four hundred nine university-aged students who were currently enrolled in or had previously taken an activity class where specific motor skills were learned (e.g., tennis) completed the questionnaire. Students were required to have motor skill learning experience because the goal of study was to assess cognitive processes evoked from motor skill instruction.

Instrument Development

Items selected for the questionnaire were derived through a series of steps. Initial items were gathered from questionnaires used in previous studies (Hebert, Landin, & Solmon, 2000; Solmon & Boone, 1993; Solmon & Lee, 1997), from the Learning and Study Strategies Inventory (Weinstein, Palmer, & Shulte, 1987), and several items were generated to fit the specific variables of interest. The pool of possible items for each factor was 10 questions to allow data analyses to ascertain which questions fit together best for this population of subjects. The wording of some items was modified to fit university-aged students, adjusted for clarity of meaning or revised to counterbalance (positive or negatively weighed) other items in the same category. Previous wording was modified because some items referred to elementary physical education class and included phrases such as “classmates”, “PE lesson” or “PE class”. Counterbalancing was performed to facilitate comprehension, encourage students to read items carefully, and reduce the likelihood of producing social desirable responses causing method effects (Solmon & Lee, 1997).

The questionnaire used a 5-point likert scale asking students to respond to questions ranging from “Not at All True of Me” (1) to “Very Much True of Me” (5). The items were randomly ordered with subsequent adjustments made so that no more than two consecutive items were in the same direction or from the same hypothesized factor. An analysis of the relationship of test content to the constructs in the study was performed. The questionnaire was shown to eight graduate students and professors in a Kinesiology Department to verify that each question matched the factor it was intended to measure. As a result of the evaluation, some questions were deleted and others reworded for clarity. The final version of the questionnaire consisted of 40 questions (i.e., variables) thought to measure 4 factors.

Procedure

The instrument was administered to participants during their regularly scheduled university classes. To each class of participants, the investigator explained that the purpose of the study was to develop a physical activity questionnaire to be used for further research on learning motor skills. Participants were assured that there were no right or wrong answers and that their answers would be confidential. Students were instructed on how to interpret the Likert scale and encouraged to read carefully each item before marking their answers on the scantron. Also, students were instructed to ask questions if there were any items that needed further clarification.

Scantrons were checked for completeness when students finished and those with conspicuous patterns were omitted.

Results

Data Analysis

Overview of Data Analysis. A 4-phrase approach, using SAS (V8) statistical computing software, was performed for structural stage of construct validation. In the data screening phase, descriptive statistics such as mean, standard deviation, skewness and kurtosis were performed on each item to check for violation of normality (N=409). Next, each item was assessed for its correlation with other items within each factor. Items were omitted that could improve the item-total coefficient correlation. Items were omitted until the Coefficient Alpha value could not be improved through removing items from the scale. The data were split into development and validation samples after performing item analysis procedures. An exploratory factor analysis (EFA) was run with the development sample (N=199), and a confirmatory factor analysis (CFA) was run with the validation (N=210). An EFA was used to identify underlying dimensions (Gorsuch, 1983). The solution or factor structure from the EFA formed the initial measurement model for the CFA. Lastly, a confirmatory analysis was used to assess how well the data fit the hypothesized model.

Data Screening. A univariate data analysis of the observed variables was performed including checks of mean, standard deviation, skewness and kurtosis. Initially, all negative items were transformed. After the absolute value was taken, kurtosis ranged between .02 and 2.97, and skewness ranged between .09 and 1.79 (see table 1). Kurtosis refers to the extent that the distribution of responses deviates from normal curve because curve is peaked or flat. For kurtosis, two particular variables (the values are 2.97 and 2.54) were slightly higher than the others.

Table 1. Descriptive statistics of variables for cognitive processes questionnaire instrument development

Variable	Mean	STD	Variance	Skewness	Kurtosis
1	4.02	0.88	0.78	-0.74	0.23
2	3.86	1.06	1.13	-0.76	-0.03
3	3.95	0.95	0.90	-0.92	0.75
4	3.81	1.05	1.10	-0.74	-0.01
5	3.80	1.00	1.01	-0.73	0.20
6	3.89	0.96	0.92	-0.90	0.73
7	4.11	0.89	0.79	-1.22	1.95
8	3.64	1.06	1.12	-0.60	-0.28
9	3.87	0.94	0.89	-0.85	0.85
10	3.47	1.03	1.06	-0.57	-0.08
11	4.00	0.90	0.81	-0.86	0.61
12	3.92	0.93	0.86	-0.95	0.86
13	4.44	0.88	0.78	-1.79	2.97
14	3.67	1.04	1.08	-0.49	-0.32
15	3.66	0.97	0.94	-0.58	0.07
16	3.55	1.09	1.18	-0.52	-0.31
17	4.22	0.91	0.83	-1.32	1.76
18	3.65	1.01	1.02	-0.51	-0.16
19	3.44	1.09	1.18	-0.46	-0.33
20	3.65	1.00	1.01	-0.48	-0.27
21	3.93	0.97	0.94	-0.99	0.95
22	3.53	1.00	1.01	-0.69	0.08
23	3.28	1.03	1.05	-0.24	-0.53
24	3.75	0.89	0.80	-0.74	0.62
25	4.17	1.01	1.02	-1.42	1.76
26	3.60	1.06	1.11	-0.55	-0.27
27	3.40	1.03	1.05	-0.32	-0.37
28	3.34	0.98	0.96	-0.29	-0.31
29	3.96	0.92	0.84	-0.91	0.88
30	3.79	1.02	1.04	-0.69	-0.02
31	3.63	1.04	1.09	-0.40	-0.53
32	2.84	1.22	1.48	0.09	-0.95
33	3.57	1.04	1.08	-0.64	-0.08
34	3.70	0.99	0.98	-0.70	0.07
35	4.35	1.07	1.15	-1.81	2.54
36	3.36	1.18	1.40	-0.32	-0.83
37	3.91	0.98	0.96	-0.82	0.36
38	4.04	0.92	0.84	-1.01	1.01
39	3.62	0.98	0.96	-0.61	0.15
40	4.20	0.94	0.87	-1.34	1.79

Both variables were related to the frustration aspect of the self-efficacy construct. Variable 35 was " I feel like I will do terrible no matter how hard I try", and variable 13 was "Practicing skills is too hard so I feel like giving up". Analysis of all the descriptive statistics suggests that the central tendency of the distribution items were slightly negative skewed but had sufficient variability. All items were retained for further item analysis.

Item Analysis. After the descriptive statistics were analyzed, an item analysis was performed on each hypothesized subscale to eliminate any questions that did not correlate well with the other items on each scale. Items 1, 5, 10, 12, 13, 15, 22, 23, 28, and 31 were dropped because they had a low item-total correlation. Items were retained if they correlated well with the other items in the subscale. All 4 final subscales were deemed reliable because the Cronbach Alpha coefficients were greater than .7 (Nunnally, 1978). The final coefficient alpha reliability estimates (Cronbach, 1951) for the remaining items are located in table 2.

Table 2. List of remaining items and Cronbach Alpha coefficients for each construct

Construct	**Cronbach Alpha Coefficient**	**Hypothesized Items**
Self-Efficacy	.89	7, 9, 17, 21, 25, 29, 35, 38, 40
Critical Thinking	.82	4, 8, 16, 20, 24, 34
Attention-Concentration	.80	3, 6, 11, 19, 27, 33, 37
Prior Experience	.82	2, 14, 18, 26, 30, 32, 36, 39

Exploratory Analysis. After item evaluations, an exploratory analysis was used to identify the set of underlying factors that explain the correlations among the measured items (Floyd & Widaman, 1995). The principal factor method was employed to extract factors that accounted for the highest possible squared correlations (i.e., communality estimates) among items and maximized the amount of variance accounted for by each factor. The extraction was followed by a promax rotation to allow oblique, or correlated, factors. Items that received a factor loading of .40 or greater on a particular factor, and less than .40 on the other factors, indicated a meaningful factor loading (Gorsuch, 1983). Items were eliminated that loaded on multiple factors because more than one factor accounted for the variance of the observed items. Items used in the exploratory analysis are reported in table 2.

On the first run of the analysis, 6 factors were suggested by the scree plot and rotated factor pattern. Items that loaded on multiple factors were eliminated. These items included hypothesized attention-concentration related items 3, 6, 11 and 19 (e.g., it is easy for me to concentrate while I practice skills), and items 33 and 37 (e.g., I monitor my performance during practice) that loaded on the critical thinking factor. The content of 33 and 37 were congruent with metacognition component of critical thinking theory or students' monitoring and orchestration of thoughts and actions so the items were retained. Item 27 (My center of attention is on my practice not other things happening in the room) was removed because it loaded as a 1-item (specific) factor. After omitting these items, the pattern of the factor loadings suggested only three meaningful factors (see table 3). The variance explained by each factor was 7.2 for self-efficacy, 2.514 for critical thinking and 1.72 for prior experience use suggesting the factors accounted for meaningful amount of the variance in the data.

An oblique rotation after extraction of the factors allowed individual factors to correlate amongst each other. The relation between self-efficacy and critical thinking was .35, between self-efficacy and prior experience usage was .38 and between prior experience and critical thinking was .31. Six items for prior experience, 7 items for self-efficacy, and 8 items for critical thinking were kept for the initial measurement model.

Overview of Confirmatory Factor Analysis. A confirmatory factor analysis, using SAS systems PROC CALIS procedures (SAS Institute Inc., 1989) was used to confirm the factor structure (Hatcher, 1994). All analyses used the maximum likelihood method of estimation, and each analysis was performed on a variance-covariance matrix constructed from the item-level data. The purpose of the confirmatory factor analysis was to test and refine the hypothesized measurement model.

Table 3. Rotated factor pattern and final communality estimates from exploratory analysis of cognitive processes questionnaire items and corresponding factor loadings from the obliquely rotated factor pattern matrix (std reg coefs), decimals omitted (N=199).

Questions	Self-Efficacy	Critical Thinking	Prior Experience	h^2
17. I feel bad because tasks are too hard	65			50
21. I am confident I will be able to do well when I practice skills	72			55
25. Everything I try while practicing doesn't seem to help me get better	75			56
29. I feel confident because I feel like I am improving	73			67
31. When I practice skills, I get frustrated	68			45
35. I feel like I will do terrible no matter how hard I try	80			65
38. I have beliefs in my ability to do good when I practice skills	71			61
40. I feel I can do well when I practice skills	77			65
14. I compare and contrast my performance from one practice attempt to the next		58		38
18. I analyze my practice attempts as to what I did wrong or right		62		49
26. When I practice, I try to find a reason for my errors		58		40
32. I form hypotheses (movement plans) and test them during practice		82		60
36 I rarely form hypotheses about the best way to move when I practice		62		39
39. I check my performance during practice and draw conclusions on how successful I am		68		60
33. I monitor my performance during practice		62		49
37. I rarely monitor what I do during practice		51		47
8. While practicing, I usually don't think about my past experience			65	44
12. I have little need to use my prior experience to help me do better during practice			72	49
16. While practicing this task, I try to find relationships between the skill I am learning and the skills I can already do			49	49
20. I try to relate the skill I am learning to other skills I already know			54	54
24. I didn't need to relate information about other skills to help me learn skills			77	59
34. I rarely relate what I am doing to my prior experience with other skills			57	44

A measurement model is the relationships between latent variables and indicator variables**.** If the model accounts for the observed relationships in the data, the model then provides a good fit to the data.

Assessment of the Measurement Model. Several indicators were consulted in decisions to retain or omit items in the model. Each item was tested against a null hypothesis that the factor loading was equal to zero. A factor loading is equivalent to a path coefficient from a latent factor to an item. Obtaining a t-value greater than 1.96 indicates a significant contribution of the item to the theoretical definition of the construct. Also, a distribution of normal residuals that is centered on zero, is symmetrical and contains no or few large residuals over the absolute value of 2 indicates a good fit to the data (Hatcher, 1994). Having many large residuals indicates either the item is assigned to the wrong factor or the item is multidimensional (Anderson & Gerbing, 1988). Another index to assess paths between items and factors is the Lagrange multiplier test. The test shows the item-factor estimations that if freed would lead to the largest reduction in the chi-square statistic (Schumacker & Lomax, 1996). Items may be reassigned, cross-loaded or deleted resulting in a change in chi-square.

Several goodness-of-fit indices were used in combination to assess model fit, model comparison, model parsimony and alternative fit (Lomax & Schumacker, 1996). Model fit indices indicate whether the hypothesized model fits the data covariances. Model fit criteria included chi-square (χ^2), goodness-of-fit (GFI), and adjusted goodness-of-fit (AGFI). Chi-Square statistic is a test of the null hypothesis that the covariance matrix fits the model's structure. A nonsignficant p-value indicates a good fit. The GFI index represents how much variance/covariance the hypothesized model accounts for. A value of greater than .9 is an accepted criterion (Lomax & Schumacker, 1996).

Model comparison indices indicate if the hypothesized model provides a better fit to the data than an independent model or a model with no structure known not to fit the data. In other words, the null model or a model known not to fit to the data is used as the comparison. Model comparison or relative fit criteria included normed fit index (NFI) and comparative fit index (CFI). Higher values represent the degree to which the model represents an improvement in the fit of the data compared to that of the null or independent model. Acceptable values are ones that produce a criterion greater than .9.

Model parsimony indices indicate if the hypothesized model is as parsimonious as other models. Parsimony refers to the number of estimated coefficients that is needed to achieve an adequate level of fit (Schumacker & Lomax, 1996). In essence, a fully estimated model is compared with an under estimated or independent model. Model parsimony indices include the ratio of chi-square to its degree of freedom (χ^2/df). If the model analyzed is a parsimonious model, the chi-square value equals the degrees of freedom. When chi-square/df values become lower than 2, the model may be accepted (Hatcher, 1994).

The last category of fit indices is alternative fit or Root mean error square of approximation (RMSEA). RMSEA is an indication of model-data fit per df or is an analysis of the residuals between the hypothesized model and the data. Values less than .08 represent models with good fit to the data and less than .05 are optimal.

In the graphical development of the final measurement model, Bentler's (1989) rules of identifying variables were used. The squares represent the indicator variables and ovals represent factors. The letter F represents factor variables and the letter V represents indicator variables. Each factor is connected with a curved, two head arrow indicating that each construct is allowed to covary with each other construct (see figure 1).

Initial Measurement Model. Using the chi-square value as a goodness of fit index, the model was statistically significant, χ^2 (186, n=209) =400.2151, p =.0001 (see table 4). However, in practice, the chi-square statistic is quite sensitive to sample size and departures from multivariate normality and often results in rejection of well fitting models (James, Mulaik, & Brett, 1982; Joreskog & Sorbom, 1989). Other goodness of fit statistics was systematically evaluated. The chisquare/df statistic was greater than 2, the RMSEA was greater than .07, the NFI, NNFI, CFI and CFI(Agfi) were less than .9. Assessment of goodness of fit indices suggested that model be revised to obtain a better fit.

The Revised Measurement Model. Unsatisfactory goodness of fit indices, the pattern of large normalized residuals, non-significant parameter significance tests, and Lagrange multiplier tests provided evidence that several indicators were multi-dimensional variables or did not fit the construct they were thought to measure. An item is multi-dimensional when more than one factor is influencing responses to the items. Nine variables (12, 18, 25, 29, 31, 34, 36, 37, 38) were systematically eliminated from the model through consulting modification indices and theory. After each variable was eliminated, the model was re-estimated and modification indices were again consulted until the goodness of fit indices were acceptable.

For self-efficacy, two of the items represented high self-efficacy (e.g., I feel confident because I am improving) and the other two items represented low self-efficacy (e.g., When I practice, I get frustrated) were eliminated. For usage of prior experience, two eliminated items represented negative wording (e.g., I analyze my practice attempts as to what I did wrong or right). Critical thinking factor eliminated items included one positive item relating to forming hypotheses (I rarely form hypotheses about the best way to move when I practice), analyzing practice attempts (I analyze my practice attempts as to what I did wrong or right) and a negative item relating to monitoring performance (I rarely monitor what I do during practice). Omitting items did not change the theoretical makeup of the construct; other items represented alternate wordings for those parts of the theory.

The fit indices for the revised measurement model are different than the initial measurement model (see table 4). This table shows that the revised measurement model displayed values greater than .9 on the non-normed-fit index (NNFI), normed fit index (NFI), adjusted goodness of fit (AGFI), and the comparative fit index (CFI), indicative of an acceptable fit (Schumacker & Lomax, 1996) whereas the initial measurement model fit indices did not. The Root mean square error of approximation (RMSEA) of the initial measurement model was .0744 whereas the revised model was near .05 indicating a reasonable fit.

Table 4. Goodness of fit, model comparison and parsimony indices for the cognitive factors questionnaire (initial and revised measurement model)

Goodness of fit [a] Indices	Initial Measurement Model	Revised Measurement Model	Category of the Goodness of Fit Indices [b]
χ^2	400.1251 (p=.0001)	96.3284 (p=.0034)	1
df	186	62	
χ^2/df	2.151	1.553	3
RMSEA	.0744	.0516	4
C.I. for RMSEA[1]	(.0644-.0844)	(.0300-.0710)	
NFI	.7961	.8988	2
NNFI	.8621	.9506	2
CFI	.8778	.9607	2
GFI (AGFI)	.8060	.9072	1

Note [a]: χ^2= Chi-square; RMSEA = Root mean square error of approximation; NFI a =normed-fit index; NNFI = non-normed fit index; CFI = comparative fit index; GFI (AGFI) = Adjusted goodness of fit

Note [b]: For categories 1=overall fit, 2= model comparison, 3 = model comparison, 4 = alternate fit

In addition, the revised model does not display any non-significant factor loadings and only a small number of normalized residuals greater than 2.0 were left. Standardized factor loadings for the indicator variables presented in table 5 ranged from .49 to .86. The t-scores obtained for the coefficients in table 5 ranged from 6.96 to 13.46, indicating that all factor loadings were significant ($p < .001$) and the items are measuring what they are intending to measure.

Table 5 also provides the reliabilities of the indicators (the square of the factor loadings), along with composite reliability for each construct. Composite reliability is a measure of internal consistency comparable to the coefficient alpha (Fornell & Larcker, 1981).

Table 5. Properties of the final measurement model

Construct and Indicators	Standardized Loading	t [a]	Reliability
Self-Efficacy (F1)			.76 [b]
V17	.49	6.96	.24
V21	.86	13.46	.74
V35	.59	8.62	.35
V40	.72	10.90	.52
Critical Thinking (F2)			.79 [b]
V14	.65	9.67	.42
V26	.62	9.17	.39
V32	.55	7.86	.30
V33	.72	11.18	.52
V39	.75	11.61	.56
Prior Experience (F4)			.76 [b]
V8	.52	7.45	.27
V16	.78	12.40	.61
V20	.82	13.22	.67
V24	.53	7.60	.28

[a] All t tests were significant at $p < .001$
[b] Denotes composite reliability

All three scales demonstrated acceptable levels of composite reliability, with coefficients in excess of .70. A coefficient over .70 indicates that the items that constitute each scale are highly correlated with one another (Hatcher, 1994).

In the confirmatory analysis, all factors were allowed to covary with each other. The relationship between self-efficacy and critical thinking was .46, and the relationship between self-efficacy and prior experience usage was .51. The moderate correlations between self-efficacy and the other two constructs possibly suggest that students who are cognitively engaged may have high confidence in their beliefs in the ability to perform skills. The correlation between critical thinking and prior experience usage was .79 suggesting that these items may be measuring the same construct or perhaps prior experience usage may be an element of critical thinking.

Combined, these findings generally support the initial reliability and validity evidence of the constructs and their indicators. The revised measurement model was therefore retained as the study's final measurement model (see table 6).

Discussion

The purpose this study was to describe the construction of an instrument for assessing students mediating cognitive processes in physical education. In terms of the stages of construct validation, the focus was on the first two stages to theoretically define the constructs and then test to determine if each individual item measures the construct it was purported to measure.

The hypothesis relating self-efficacy and cognitive engagement was supported. Moderate relations between self-efficacy and critical thinking (.46) and between self-efficacy and the use of prior experience (.51) were reported. In education experiments, students who had high self-

Table 6. Final measurement model variables

Self-efficacy subscale

-- I feel bad because tasks are too hard
-- I am confident I will be able to do well when I practice skills
-- I feel like I will do terrible no matter how hard I try
-- I feel I can do well when I practice skills

Critical thinking subscale

-- I compare and contrast my performance from one practice attempt to the next
-- When I practice, I try to find a reason for my errors
-- I form hypotheses (movement plans) and test them during practice
-- I check my performance during practice and draw conclusions on how successful I am
-- I monitor my performance during practice

Prior experience

-- While practicing, I usually don't think about my past experience
--While practicing this task, I try to find relationships between the skill I am learning and the skills I can already do
-- I try to relate the skill I am learning to other skills I already know
-- I didn't need to relate information about other skills to help me learn skills

---

efficacy were cognitively engaged longer in the task and used learning strategies more frequently than those with low self-efficacy (Paris & Okra, 1986; Schunk, 1985; Thomas, Iventosch, & Rohwer, 1987). In this study, it appears that students who have high self-confidence in their ability to perform the skills will be more cognitively engaged during practice. The results from this study provide a rationale for future study on the relationships between self-efficacy and the use of learning strategies and critical thinking during motor skill practice.

High relations (.79) found between usage of prior experience and critical thinking was consistent with the hypotheses that these factors are highly cognitive in nature. A possible reason for the high correlation could be that prior experience usage is a sub-component of the critical thinking process. As a part of McBride's (1991) definition of critical thinking, he includes the idea of "reflection" or referring back to their general and specific prior experience in his definition. Also, constructivist-oriented teaching approaches commonly organize learning experiences relevant to student prior knowledge to make learning more meaningful to them (Chen & Rovegno, 2000). Thus, referring back to prior knowledge may be a critical component when students are discovering solutions in learning motor skill tasks.

In the exploratory analysis, the attention-concentration factor was omitted from the analysis. In the initial item analysis, attention-concentration subscale reliability achieved a Cronbach Alpha estimate of .80. However, this estimate was considered tentative because large numbers of items in a scale tend to inflate coefficients and exploratory and confirmatory factor analyses were not run. When the constructs were analyzed together using an exploratory analysis, a four-factor solution was denied. A large number of items that were theorized to relate to the attention-concentration scale loaded on multiple or other constructs. Also, several negatively worded items from different constructs loaded on one factor. This communality was probably due to a method effect where students interpreted some negatively worded questions differently then the construct they were intended to measure.

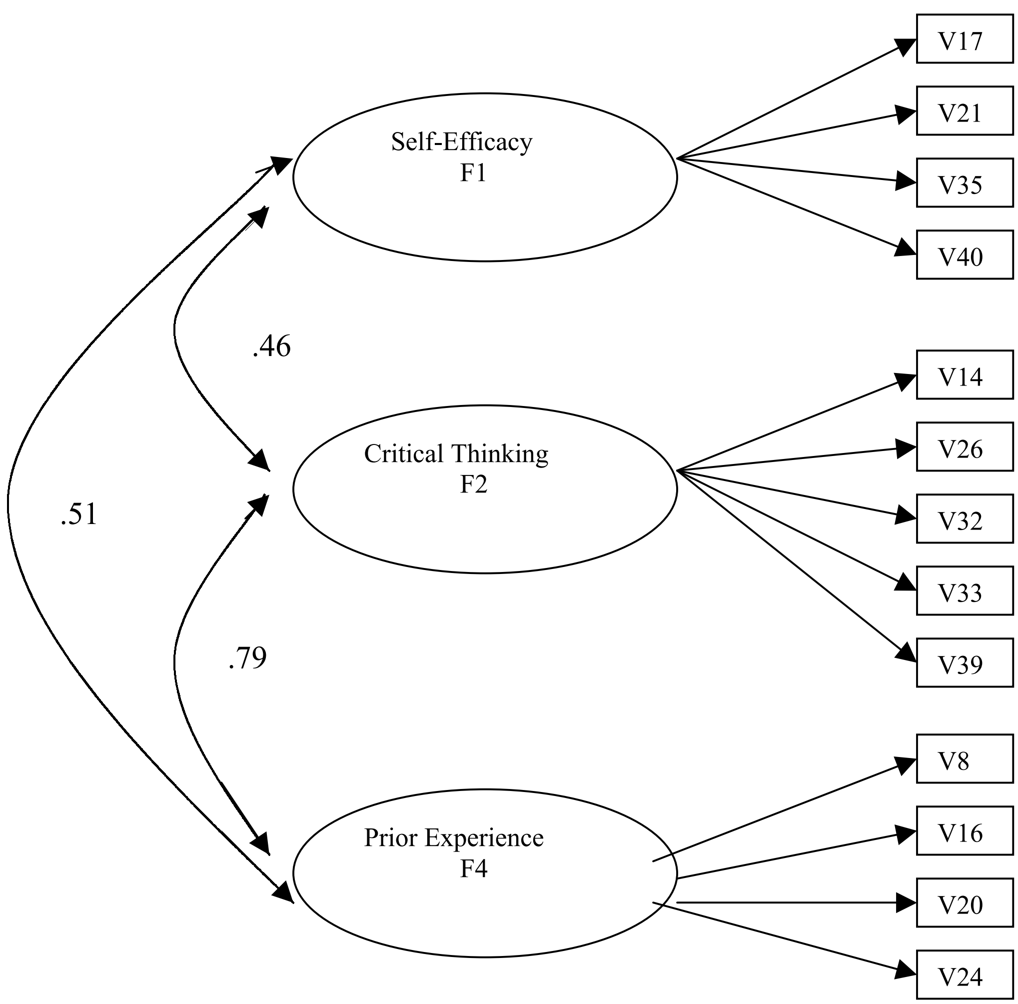
Based on the pattern of loadings, it is possible that attention-concentration is also a sub-component in critical thinking. The two items that loaded on the critical thinking factor referred to monitoring performance during practice. Theoretically, McBride's (1991) critical thinking schema has two possible aspects where attention-concentration is involved. The first step of the schema involves focusing on the problem to be solved. Also, McBride theorizes that throughout the critical thinking process, students are using metacognition to monitor their thinking, cognitive outcomes and movement outcomes. The content of the two items is congruent with the metacognition element; thus, the items were allowed to load on the critical thinking factor.

Limitations

Constructing a student thoughts instrument was a first step in studying the interrelationships among student thoughts. A limitation of the study is the need to test alternative and competing models. The goal of this study was to confirm a measurement model with the focus of developing the individual dimensions of the constructs. Future studies may include the development of a structural model with inter-relationships tested as mediation paths or grouped together under second order factors. Even though obtaining simple structure is a goal, items between subscales may be cross-loaded. For example, it is possible that some items from prior experience may be cross-loaded to both prior experience and critical thinking latent factors.

Another limitation is the need for cross-validation of the model using an independent sample. If the model fails to cross-validate, it is possible that the model may be different for other populations (e.g., geographic region, skill, age). The results of the study should only generalize to university-aged students who have motor skill learning experience in a physical activity class from a southern university and not to elementary or high school students. Last, social desirability is always a potential problem in research involving questionnaires, even though every effort was made to provide an environment where students would respond without influence from peers or the teacher.

In summary, this study produced a context-specific, valid and reliable instrument to assess self-efficacy, usage of prior experience, and critical thinking factors. The results from this study suggest that critical thinking may have several cognitive processes as subscale components. Thus, further study should include devising a critical thinking scale designed specifically for motor skill practice. Devising the scale should involve the external stage of construct validation, which in this context is the investigation of the interrelationships among critical thinking subscales as well as other thought processes that impact motor skill practice. Also, the impact of self-efficacy on students' cognitive engagement is an important topic. This would involve classifying students into self-efficacy levels for a particular task and then comparing the cognitive engagement for the groups.



Note: V= Variable, F= Factor

Figure 1. Graphical display of final measurement model

CHAPTER 3: EXPERIMENT

Introduction

Research from the domain of teacher cognition and the mediational processes perspective supports conceptions of students as active participants and teachers as facilitators of the learning processes. Rather than teachers directly influencing achievement, teachers design and orchestrate the learning environment influencing students' learning processes and behavior, which in turn, impact student outcomes (Lee & Solmon, 1992). The mediational processes perspective provides an excellent framework for investigating links between instruction and student thoughts and behaviors, and also, the investigation of the impact of thoughts and behaviors on motor skill outcomes.

Students' Thoughts and Behaviors

Thoughts and behaviors of students that mediate teachers' instruction can be conceptualized into three broad categories: entry characteristics, cognitive processes employed during learning, and the actions resulting from those thoughts (Solmon & Lee, 1996). Students bring entry characteristics with them to class. These characteristics include perceptions of their own competence, notions about the subject matter, initial skill levels, knowledge, and prior experience (Solmon & Lee, 1996). Students' entry characteristics act as a mental framework through which they perceive class events and interact uniquely within the learning environment. Students actively filter what information to process and how much is processed interpreting teachers' instruction in unique ways (Lee & Solmon, 1992).

Students also determine which, if any learning strategies or metacognition to use during instruction and subsequent practice (Solmon & Lee, 1996). Learning strategies are procedures employed to enhance acquisition and retention of information or skills (Wittrock, 1986). Cognitive processes shown to positively impact practice sessions include the ability to detect and correct errors (Solmon & Lee, 1996), connecting prior experience with present information (Rukavina, Lee, Solmon & Hill, 2001), engaging in cognitive effort (Lee, Swinnen, & Serrien, 1994), and thinking critically and using metacognition (Ennis, 1991; McBride, 1991). Critical thinking is "reflective thinking that is used to make reasonable and defensible decisions about movement tasks or challenges" (McBride, 1991, p. 115). Metacognition refers to the cognitive processes that are involved in the management, orchestration and reflection of thinking and use of learning strategies (Mayer & Wittrock, 1996; McBride, 1991).

Student engagement or the quality of practice is the best predictor of achievement or motor skill gains (Ashy, Lee, & Landin, 1988; Buck, Harrison, & Bryce, 1991; Silverman, 1990, 1993). In other words, students who complete more appropriate and/or successful practice trials demonstrate superior skill learning. Successful practice is the students' ability to consistently achieve the action goal, and appropriate practice is the students' ability to use proper form (Hebert, Landin, & Solmon, 2000) or apply technique based upon particular concepts. All students in the same learning environment, however, do not have the same experiences. Students vary in the quality and number of practice trials (e.g., Silverman, 1993; Solmon & Lee, 1996) and this variability of performance appears to be influenced from two interacting factors: student ability and task difficulty. Lower-skilled students typically have lower success rates and perform fewer appropriate practice trials than their higher-skilled peers (e.g., Buck, Harrison, & Bryce, 1990; Grant, Ballard, & Glynn, 1990). Student practice, when task difficulty exceeds students' skill level practice, is typically unsuccessful and inappropriate (e.g., Rikard, 1992; Silverman, 1985a, 1985b, 1993).

Self-efficacy— a student's belief or confidence in executing a task to produce a desired outcome—is a common cognitive mechanism associated with learning motor skills. Many studies report a rise in self-efficacy with practice (e.g., Harrison, Fellingham, Buck, & Pellett, 2002) and when practice is scaffolded (i.e., stepwise practice sessions) it is especially advantageous for lower-skilled students (Hebert, Landin, & Solmon, 2000). However, it is important to note that self-efficacy has not been causally linked with learning but rather has effected other mediating student variables like performance on previous trials or prior experience (Feltz, 1992). For example, results from education studies reveal that students with high self-efficacy will continue to practice, are more likely to be engaged cognitively in the task, and will use more learning strategies (Paris & Okra, 1986; Schunk, 1985; Thomas, Iventosch, & Rohwer, 1987). However, when task difficulty exceeds students' level of entry characteristics, it is hypothesized that students' efficacy will decline, ultimately discouraging them from being cognitively engaged.

Constructive vs Reproductive Teaching Approaches

In general, two different types of teaching approaches exist depending on the nature of the problem to be solved. Teachers can use either a "reproductive" approach, where they provide students with a solution to the problem, or a "constructive" approach, where students are required to discover solutions on their own (Mosston & Ashworth, 1994).

A commonly used reproductive teaching approach is to provide students information about a task with a "correct" model. Research shows that a skilled demonstration aides learning (Magill, 2001; McCullagh, 1993). Two different theories support how students try to behaviorally reproduce a model's performance: Bandura's cognitive mediation theory and the theory of direct perception. In Bandura's cognitive mediation theory, cognition mediates the link between perception and action (Magill, 2001; Scully & Newell, 1985). Evidence suggests that students' use the invariant coordination relationships between body parts (Magill 2001; Scully & Newell, 1985; Schoendfelder-Zohdi, 1992; Whiting, 1988) and with repeated exposure to a model, students develop a cognitive representation of those relationships (Carroll & Bandura, 1990).

Teachers can also provide students with task information through direct verbal instruction (Magill, 2001). Verbal information serves to focus learners' attention on critical aspects or timing among inter-relations of body parts of a model (Magill, 2001; Masser, 1993). In some tasks, such as juggling or a soccer kick-up, verbal instruction may be redundant to information provided by the model (Davis, 2003; Rukavina, Lee, Solmon, & Hill, 2002). Thus, any verbal instructions used should provide information that learners might not easily retain from watching the model. Regardless of how information is presented, when provided with large amounts of information, students will select strategies to aid in replicating responses and adopt a movement pattern similar to that portrayed by the information (Rukavina, Lee, Solmon, & Hill; 2002).

In contrast to a reproductive approach, teachers can structure the learning environment to require students to construct their own solutions to the problem. One constructive approach is discovery learning, whereby teachers provide students with only the action goal of the task. Students employ a trial and error strategy, learning from mistakes until a successful technique is discovered (Rukavina, Lee, Solmon & Hill, 2001; Singer & Pease, 1978). Without any information provided from the teacher, students typically refer to their prior knowledge and experience during practice (Rukavina, Lee, Solmon, & Hill, 2001). It is hypothesized that the errors in performance help students to become more familiar with the interworkings of the task, aiding in the transfer of learning to a new situation. Edwards and Lee (1985), using a laboratory task, found that students who experienced errors were more successful in transfer than those receiving a solution. Other studies show a slower rate of learning for students in a discovery group but no differences in transfer compared to those in a group receiving information from a "correct" model (Toole & Arink, 1985; Rukavina, Lee, Solmon, & Hill, 2002; Rukavina, Lee, & Solmon, 2001; Singer and Pease, 1978). Motor learning researchers, on the other hand, provide evidence that for some tasks, like a ski simulator (e.g., Vereijken & Whiting, 1990; Wulf & Weigelt, 1997), providing no instruction may be as effective or more so than instruction.

Teachers can also scaffold the environment to guide students in their discovery of the task and accomplishment of the objectives. Guided discovery is where teachers constrain the movement task by focusing students' attention on exploring various movement problems (Graham, Holt/Hale, & Parker, 1998) rather than asking students to solve the action goal on their own. In other words, certain student movement qualities can be refined when the teacher generates questions to help students identify, analyze, and critique movement problems (Ennis, 1991). Mosston and Ashworth (1994) postulate that constructive styles stimulate students to go beyond teacher instruction to discover different movement alternatives or single correct concepts. Students who engage in problem-solving to obtain concepts of particular movement qualities are hypothesized to have greater motor skill transfer than those who are provided a solution to the problem (Toole & Arink, 1982).

Using a convergent discovery approach, teachers can guide students toward achieving particular movement patterns through problem-solving or use of critical thinking processes. McBride (1991) hypothesizes that critical thinking is a process of carefully orchestrated cognitive operations and not a series of trial and error attempts. Critical thinking has also been hypothesized to occur through a metacognitive-controlled process involving cognitive dissonance, cognitive organization, cognitive action, and cognitive and psychomotor outcomes (Mayer & Wittrock, 1996; McBride, 1991). When presented with a problem, students experience cognitive dissonance that motivates them to try to solve the problem. Initially, students identify the nature and key elements of the problem. For example, a student tries to pitch a golf ball from the ruff and onto the green but fails to get the ball off the ground. The student identifies several problems (e.g., my grip is wrong) that may help solve the action goal. It is at this point that a teacher can help the student by proposing questions or aiding in designing the problems to consider and solve.

In the next step, students take information from instruction and past practice trials to refine responses, make judgments or formulate hypotheses. Students generate cognitive and/or psychomotor outcomes to test their hypotheses. Using metacognition to monitor critical thinking, students keep in mind the problem to be solved, select appropriate particular thinking processes, and monitor the operations carried out.

Physical education researchers have compiled evidence to support the notion that particular student variables can facilitate learning, but there is little knowledge available to explain how instruction can be designed to most effectively evoke those variables. Likewise, researchers have devoted a limited amount of effort to identifying thoughts and behaviors that lead to particular learning outcomes.

The purpose of this study was to examine the influence of reproductive versus constructive teaching approaches on the thoughts and practice behaviors of students with varying entry ability. Also, the study focused on how those thoughts and behaviors affect transfer of learning. It is expected that students' cognitions and practice variables will vary with entry skill and teaching approach. It is also hypothesized that guiding discovery will facilitate students' use of critical thinking, allowing them to gain a deeper understanding of the content. In addition, students with higher entry-level skill should perform better and have higher levels of self-efficacy.

Method

Participants

Participants included 54 undergraduate university students enrolled in four sections of beginning golf. Informed consent, previous sport and physical education experiences and demographics were obtained prior to start of the study. Three research assistants with golf experience were selected from each of the four sections to serve as teachers for the classes. The selected teachers participated in a training session prior to the start of the study.

The teachers had various levels of prior golf experience. The experienced golfers were assigned to the guided discovery condition because a conceptual understanding of golf was needed to successfully explain the movement challenges. These teachers ranged in experience from a 14 handicapped player with some teaching experience to a 3 year recreational player with one year high school golf. Prior golf experience was not a necessity for the other two conditions; the teachers only needed the ability to transition students and read the script and play the video. These teachers ranged in golf experience from a 13 year player who had played at various levels of commitment and competition to a person who had under one year experience.

Task

The golf pitching task was used in this study. In the game of golf, the role of the pitch is to project a golf ball lying a short distance from a green onto the green near the hole. A pitch is different than a chip. The objective of chipping is to project a ball with a low trajectory expecting the ball to roll a fair distance after it hits the ground. The objective of the pitch is to have a higher trajectory minimizing the amount that the ball rolls once it hits the ground. A golf pitching task was selected because a) students need a biomechanically efficient movement pattern to be successful, b) outcome scores are easily assessable, c) students can achieve the basic movement pattern in a relatively short period of time, d) understanding movement concepts helps perform the skill and e) a transfer test is easily designed based on the concepts learned during instruction.

The task involved pitching a golf ball onto a concentric ring target painted on an outdoor lawn surface (Wulf, Lauterbach, & Toole, 1999). The distance from the pitching location to the center of the target was 15 m. The goal was to project the ball using a pitching wedge (golf club) with enough trajectory or arch to go over a 1 m barrier and land in the center of the target. Where the ball rolls was of no consequence because the score was derived from where the ball hit the turf. At the end of the experiment, students performed a transfer task. The transfer test required students to pitch from a distance of 20 m from the target and hit the ball over a 2 m barrier. The distance was 5 m longer than the practice distance and 1 meter higher than the height of the practice barrier.

Videotape Models

A male golfer skilled in the golf pitch served as the correct model. He was videotaped from behind and from the side while pitching a golf ball to a target. For the rear view, the camera was placed directly behind the golfer who was facing the target. Students received information about the flight of the ball in relation to the swing mechanics from watching this view. For the side view, the camera was perpendicular to the target line showing the anterior side of the body. The side angle provided students with information on form and swing mechanics.

Task Presentation Groups

Students were randomly assigned to one of three different task communication conditions (discovery-control, model and guided discovery). Each group participated in a sequence of events during an instructional period (see table 7). All students on the first day were gathered together and provided basic instruction on the action goal, grip, stance, and posture before receiving their respective treatment. On subsequent days, basic instruction was reiterated to ensure that students were aware of these characteristics.

All students received basic instructions on the action goal, grip, stance, and posture. The action goal was to project a ball using a pitching wedge over a barrier onto the center of the target. The difference between a chip and a pitch was explained to give students an idea of the type of shot that was required. An open stance with a 10-12 inch distance between student's feet was recommended, and a "C" posture (flexion of knees and waist) was encouraged using the cues "butt out, chest out and head up". From this position, the arms hang down naturally about a "fist and a thumb" distance apart from the body.

Table 7. Sequence of events during instructional periods for each task presentation group

Time	**Model**	**Guided Discovery**	**Discovery**
5 min	Preview script of the day for teacher	Preview script of the day for teacher	Preview script of the day for teacher
10 min	Provide time for putting instruction or practice	Provide time for putting instruction or practice	Provide time for putting instruction or practice
3 min	Provide basic instruction for golf pitch	Provide basic instruction for golf pitch	Provide basic instruction for golf pitch
3 min	Show video and read the concept of the day for students	Explain the challenge for the day	Provide golf facts
7 min	Provide practice time for students	Provide practice time and present the task sheet to students	Provide practice time for students
9 min	Record 10 shots for each student in group rotation	Record 10 shots for each student in group rotation	Record 10 shots for each student in group rotation

The student should “choke-down” on the club using an overlapping grip while opening the clubface. Students were instructed to swing back and through.

Students in the discovery-control learning condition received basic instruction and viewed the correct model. After the first day, the discovery group was provided no information except verbal reiteration of the basic instruction. Discovery students did not see the correct model again. During the time other groups received the treatment, these students were read golf facts unrelated to swing mechanics. Students were encouraged to use trial and error to solve the action and movement goals.

Students in the guided discovery group were assigned movement problems to explore. A series of movement problems were designed to facilitate learning performance concepts about the basic pitch shot: maintaining stance, pendulum swing, early wrist action, ball placement, openness of clubface, varying height of the backswing and greater sensitivity and less jerk (see table 8). Concepts derived by students should aid in transferring performance to a different distance and projection height. The movement challenges were sequenced in the order of criticalness or importance. For example, the first concept, staying in the stance throughout the swing should improve students' ability to make contact with the ball. On the other hand, other concepts like "opening the clubface" or "varying the height of the backswing" allow students to adjust the loft of the ball or the distance of the shot.

Each problem required students to perform particular swing dynamics and use critical thinking to arrive at a movement concept. Initially, the teachers explained the swing dynamics and students were asked to notice how those dynamics impacted the swing of the club, the contact with the ball and the flight of the ball. In other words, the attention of students was “externally directed” to the club and the ball.

Table 8. Definitions of movement concepts used in the treatment

Concepts	Definition of Concepts
Maintaining Stance	Stance is maintained by keeping your lower body still and eyes on ball till contact
Pendulum Swing	The club is swung like a pendulum enabling the loft of the club to propel the ball into the air
Early Wrist Action	Starting the swing with the wrist bend places the loft of the club in position to project ball higher into the air
Ball Placement	Placing the ball forward in the stance increases the loft of the ball
Openness of clubface	Opening the clubface "towards the sky" increases the loft of the ball
Varying height of backswing	Distance of ball projection is varied by increasing the height of the backswing
Greater sensitivity/ less jerk	For short pitches, letting the club do all the work (not using muscle force during the swing or placing extra tension on the grip)

After students understood the problem, they were instructed to make a prediction or hypothesis about the concept or the results of the swing dynamics. Teachers "checked for understanding" by having one student repeat to the group the movement challenge before allowing students to practice.

After students finished their exploration, the teacher called them together to explain the task card assignment designed to help students engage in problem solving related to the movement concepts. Teachers handed out the task cards and instructed students to pick one of two concepts. One concept was correct with the other one incorrect but represented a viable alternative. After all students indicated that they had selected an alternative, the teacher read the correct answer out loud. If their choice was incorrect or there seemed to be a lack of understanding, students were instructed to return to the problem on a later day (during their practice time at the end of the class) and rethink the problem based on the new information learned. Teachers discouraged any social interaction or cooperation among students during the group meeting and each student practiced individually.

Students in the model and verbal instructions condition watched the correct model on video and listened to movement concepts described by the teacher. The students in these groups received the same task-relevant information as students in the guided discovery. The difference between treatment groups was that the teacher of the model group verbally read the concepts to the students and showed a videotape of the correct model whereas students in the guided discovery group read the concepts on their task cards after they tried to solve the movement challenge. Also, the guided discovery teachers read the concept alternatives out loud while the students were deciding which was correct.

Experimental Design and Procedure

A randomized block design was employed with session as the block, skill level as the moderating variable and condition (discovery, model and guided discovery) as the treatment. Prior to the study, teachers were selected from each of the 4 sections and assigned to 1 of the 3 teaching approaches. Based on the pitching skill pretest, students were assigned to a condition during each section so entry skill level was equal among conditions.

The experiment lasted approximately 2 weeks and included set-up and teacher training, thought processes and skill measurements, and instruction (see table 9). The university golf sections met every day of the week at the same time. On the first day of the experiment students signed consent forms, filled out prior experience forms and teachers were selected. Students were instructed to bring a pitching wedge to class and use that club throughout the study. The next day the teachers participated in a training session on experimental protocol. The third day, students took a 20 trial pretest on the apparatus that was used throughout the study for daily testing and posttests.

Table 9. Sequence of daily events throughout experiment

Day	Events
1	Recruitment of students first day of enrollment – Initial forms
2	Train teachers – Run though scripts, practice teaching, and practice scoring
3	Pre-test – 15 m pitch (1 m barrier)
4	Instruction – Maintaining stance concept – Strategies questionnaire
5	Instruction – Pendulum swing concept
6	Instruction – Early wrist action concept
7	Instruction – Ball placement and openness of clubface concepts
8	Instruction – Vary height of backswing Concept – Strategies questionnaire
9	Instruction – Greater sensitivity/ less jerk concept – Cognitive processes questionnaire
10	Posttests – Retention 15 m pitch, transfer 20 m pitch (2 meter barrier)
11	Make-ups – Retention and transfer posttests

The golf class was divided into two parts: putting and the pitching experiment. Everyday before the experiment started, students practiced putting before pitching instruction started. When it was time to start the experiment, all students in each section received a 1-3 minute basic instruction (posture and grip). Next, students were divided into groups to individually receive the treatment. After receiving instruction, individuals practiced for 5-7 minutes before the first three students were called over to practice in front of the video camera. Students were instructed to practice their best movement form after the initial 5-10 minute practice time.

On the fourth and eighth day of the experiment students completed an open-ended strategies questionnaire and on the last day of instruction, students completed a closed-ended cognitive processes questionnaire. The last days of the experiment students performed the retention and transfer tests. Attrition was anticipated so attendance in 4 of the 6 instructional periods and completion of the learning tests and questionnaires was required for inclusion.

On the last days of the experiment, students warmed-up with ten trials and performed a 20 trial retention test in front of the videocamera. Upon completion of the retention test, students took a break and then were rotated back in front of the camera to perform a 20 trial transfer test. The transfer test required students to pitch from a distance of 20 m from the target and hit the ball over a 2 m barrier. The distance is 5 m longer than the retention test and 1 meter higher than the height of the other barrier. Due to logistical problems (e.g., student absences or students needing to leave for their next class), some students did not receive their transfer and retention tests on the same day. All trials were scored by the teacher and coded for form.

Fidelity to the teaching script was sought. Prior to the study, the teachers reviewed instructional guidelines and the lesson plans. In an educational session, the investigators discussed each lesson individually and instructors practiced providing instruction and transitioning from area to area. Lack of teaching experience was not an issue because the majority of the teachers' actions and verbalizations were scripted for them to follow. The only skill the teachers needed was the ability to clarify movement challenges after a question or tell students what they needed to do next. All teachers were able to perform their specific duties. Each day before the instruction, teachers practiced their teaching assignment for the research team. The research team observed the teachers during the study to ensure that scripts were followed. Also, providing the correct model via videotape and having each teacher read from the same script helped minimize variation in instruction.

Form Measures and Coding Procedures

Before beginning coding of student performance, an instrument was developed to code students' ability to apply the concepts presented by teachers or developed by students during the lessons. A research team knowledgeable on golf form assessment was assembled. Members of the team agreed upon categories that matched the concepts and a 0-2 scoring system. If students met the criteria or could apply the concept in movement they received 2 points. If students had some understanding and could partially apply the concept, they received a 1. A zero represented no ability to apply the concept.

A training tape was needed to provide instruction for a research assistant. To accomplish this, students from a LSU university golf class were videotaped while practicing the golf pitch and the research team coded trials using the 5 categories. The same tape was used as the training video for a research assistant. An assistant was recruited and instructed on how to code the practice trials. After the training, the research assistant coded several sets of 20 trials from the training video until he consistently achieved greater than 80% agreement with the research team. Inter-rater agreement was established every 400 trials to control for observer drift. After every reliability session, the disagreements between the research team and the research assistant were discussed. When the agreement fell below 80%, the assistant would code another 20 trials and agreement was reassessed. The research assistant fluctuated between 72% to 91% assessment for observer drift.

Form, Skill Performance and Cognitive Measures

Skill Performance Scores. Skill performance scores were a measure of students' ability to successfully hit the target. The first 20 trials performed in front of the videocamera served as a pretest to categorize subjects as low-, medium- or higher-skill. At the end of each instructional day, students rotated so that they could practice 10 shots in front of the videocamera while the teachers recorded their skill performance scores. Skill performance scores during acquisition were a measure of successful practice. On the last day of the experiment, students performed retention and transfer tests. The radius of the middle circle was 45 cm with each additional ring increasing the radius by 1 m (1.45 m, 2.25 m, 3.45 m, and 4.45 m). Five points were awarded if the ball hits the center of target, 4 points for the second ring, 3 points for the third ring, 2 points for the fourth ring and 1 point if the ball hits inside the outside ring. If the ball hits the line, the higher point was given.

Form Scores. Form scores are a measure of appropriate practice or students' ability to apply concepts during performance. Students' ability to apply the concepts was assessed by coding videotapes of each attempt recorded as a skill performance score. The checklist for form assessment was based on application of the concepts taught during treatment. For each category, students were assigned points between 0 and 2. If students met the criteria of a category or could apply the concept in movement they received 2 points. If the student had some understanding and could partially apply the concept, they received a 1 or they received a zero demonstrating little or no understanding. Points were tallied and summed across categories for each trial performed. "Height of the backswing" or "openness of the clubface" concepts were not assessed because it was too difficult to code.

Strategy Use. After the second and fifth practice sessions, students were asked to describe in writing the strategies they used to be successful in their practice. A recording form with one question was designed to collect data on the learning strategies students used. The question was "what strategies did you use to be successful". The open-ended questionnaire was given before the closed-ended questionnaire on student thoughts.

Student Thoughts. On the last day of the unit (i.e., sixth day of practice), assessments of students' thoughts during practice (critical thinking, use of prior experience, and self-efficacy) were collected using a likert-format questionnaire. The students were asked to respond to questions ranging from "Not at All True of Me" (1) to "Very Much True of Me" (5) (see Chapter 1- Instrument Development). Wording of some questions was slightly changed to be applicable to golf pitching. For example, the word "skill" was replaced with "golf pitching".

Results

Using Silverman and Solmon (1998) as a guide for determining the unit of analysis in field research, the treatment was applied to the class, measurements were taken at the level of the student and skill level was used as a moderating or categorical variable. Students were assigned lower-, medium- or higher-skilled based on the pretest skill performance scores. Some analyses employed a random-block design using section as a block. Section is the time of day students attended class. There were 4 sections. All ANOVA and chi-square analyses were performed using SAS statistics software (V8). Proc Mixed was used for all ANOVA analyses.

Reliability

Skill Performance Score Reliability. Evidence of reliability of the task was determined using a repeated measure analysis of the higher-skilled students' pretest skill performance scores. A 20 (trial) ANOVA with repeated measures revealed a non-significant trial effect [$F(19,285)=$

1.40, p= .1259] with a CS covariance structure. Lack of change across trials indicates test score reliability.

Form and Skill Performance Scores

Daily Practice Scores. Daily practice was analyzed according to students' ability to apply concepts and their success at hitting the target. A 3 (treatment) x 3 (skill) x 6 (day) ANOVA with repeated measures on the last factor was used to analyze skill performance scores and another ANOVA with the same design for form scores. Both analyses included section as a block.

For skill performance scores, the skill main effect was significant [$F(2,245) = 5.16$, $p = .0064$]. Follow-up tests reveal differences between higher (M=1.81, SD=.21) and lower- (M=1.0477, SD= 0.21) skill levels with medium-skilled (M=1.31, SD=.45) scoring in between higher- and lower-skilled but not significantly different. Also, the treatment by day interaction [$F(10, 245)=2.09$, $p=.0258$] was significant. These findings are shown graphically in Figure 2.

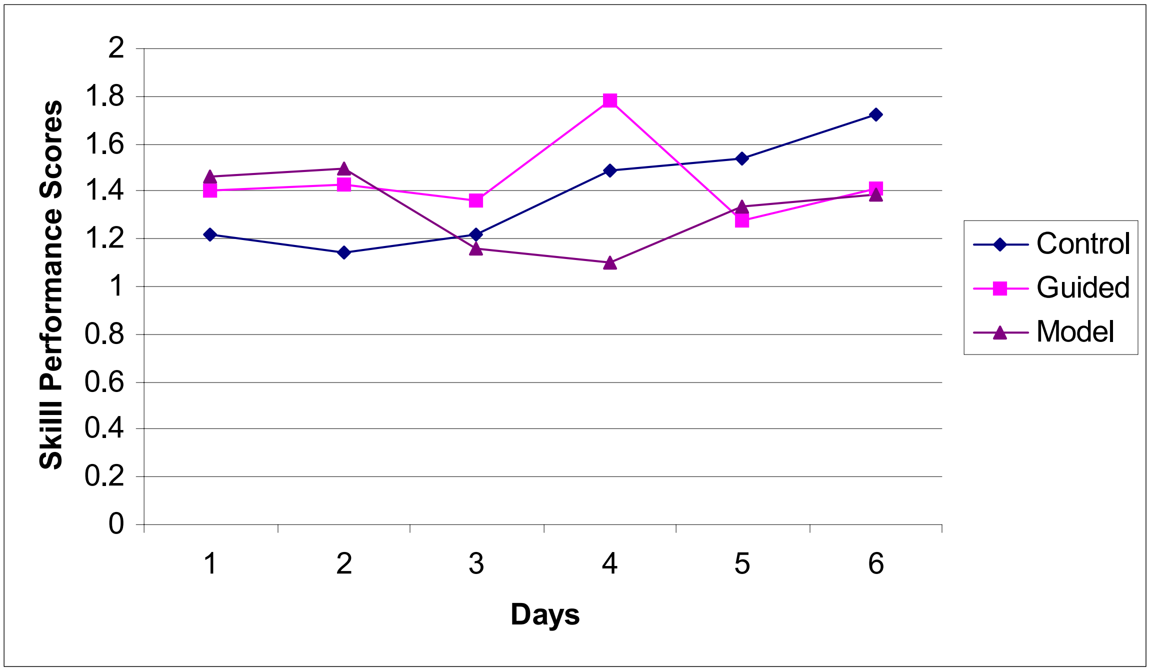


Figure 2. Treatment by day interaction for skill performance scores during acquisition.

Other effects that were not significant were the treatment main effect [F(2,245)=.15, p=0.8646], day main effect [F(5, 245)=1.20, p=0.3108], treatment by skill interaction [F(4,245)=1.12, p=0.3490], skill by day interaction [F(10, 245)=.63, p=0.7912], and treatment by skill by day interaction [F(20,245)=.82, p=0.6874].

For form scores, the day main effect (D1, M=5.55, SD= .37, D2, M= 5.91, SD=.37, D3, M=5.96, SD= .37, D4, M=5.47, SD=.37, D5, M=6.24, SD=.37, D6, M=6.66, SD=.38) was significant [F(5, 237)= 9.04, p<.0001]. Also, the treatment by day interaction F(10, 237)= 2.79, p=.0028 (see figure 3) was significant. As shown the scores of the model group dropped significantly on the 4th day. A skill by day interaction F(10, 237)=2.11, p=.0247 (see figure 4) was also significant. An inspection of the form scores across days suggests that lower-skilled students were less able to apply the concepts initially, and their performance over time was more variable. By day 6, however, their form scores were similar to the other two groups.

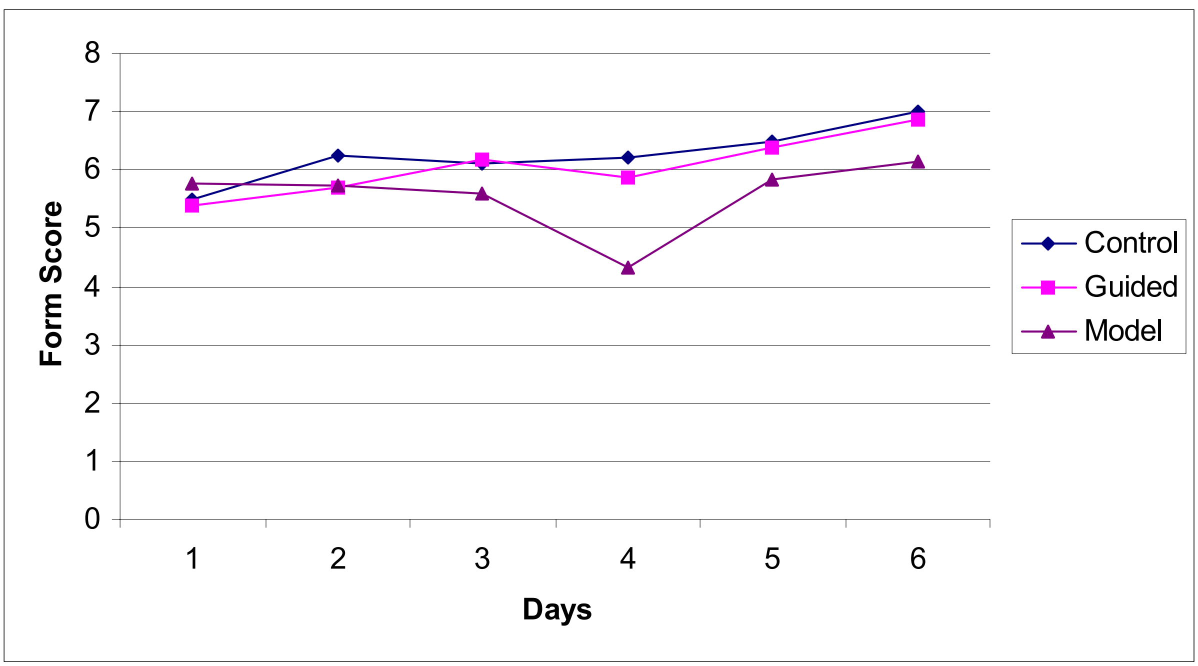


Figure 3. Treatment by day interaction for form scores

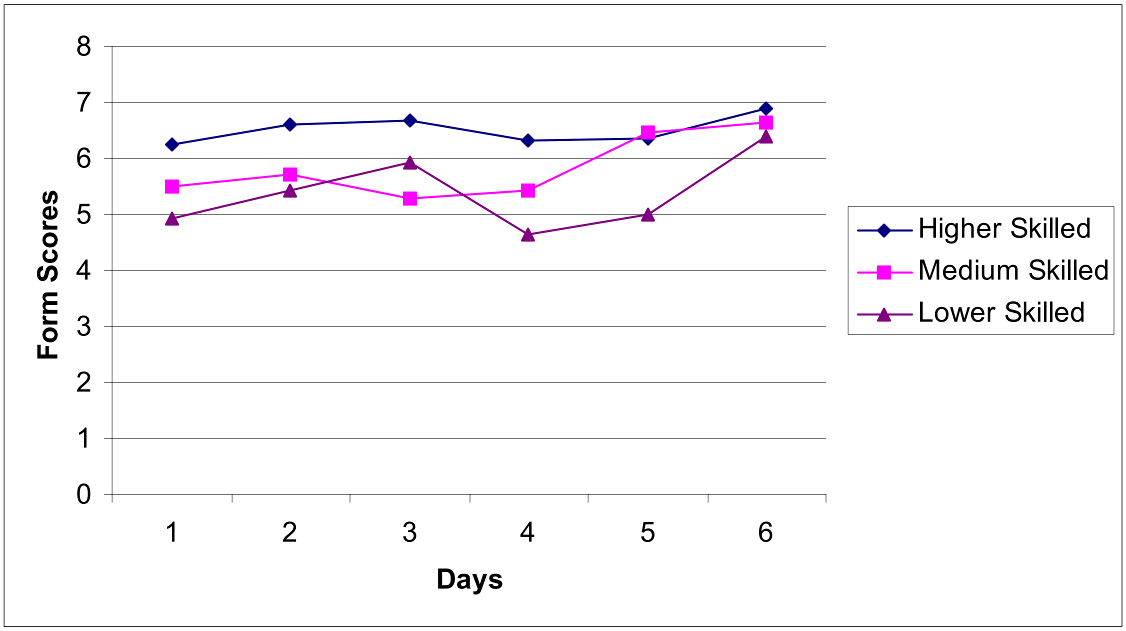


Figure 4. Skill by day interaction for form scores during acquisition

The other effects for form scores that were not significant were the treatment main effect [F(2,237)=.59, p= 0.5567], skill main effect[F(2,237)=1.00, p=.3702], treatment by skill [F(4,237)=.41, p=.8012], and treatment by skill by day [F(20, 237)=1.24, p=.2222].

Pretest-Retention Test. Learning can be inferred when students significantly increase their performance from pretest to retention either for skill performance measures or appropriate scores (i.e., form). A 3 (skill) x 3 (treatment) x 2 (pre-post trial block) ANOVA with repeated measures on the last factor for skill performance scores was computed. The design included section as a block with a CS covariance structure modeling. A trial block effect [F(1,85) = 4.83, p =.0306], skill effect [F(2, 95) = 20.04, p <.0001] and skill by trial block interaction were significant [F(2, 85) = 5.55, p =.0054]. Effects for the treatment effect [F(2,85) = .52, p=.5948], treatment by skill interaction [F(4,85) =.55, p=.7030], treatment by trial block [F(2,85)=1.23, p=.2977] and treatment by skill by trial block interaction [F(4,83)=.38, p =.8226] were not significant.

The skill by trial block interaction suggests that students of different initial skill performed differently from pre to post test (see figure 5). Follow-up tests reveal that for the pretest the higher-skilled (M = 2.18, SD=.21) group was superior to the medium-skilled (M= 1.10, SD=.20), which in turn, was superior to the lower-skilled (M= .41, SD=.21). For post-tests, the higher-skilled group (M=1.90, SD=.21) was superior to the lower-skilled (M=1.29, SD=.21) with the medium-skilled (M=1.46, SD=.20) scoring in between not different than either. From pretest to retention, lower-skilled improved while the others had no significant differences across trial blocks.

For form scores, the trial block effect was significant F(1,83) = 6.77, p =.011 (pretest M=5.33, SD=. 48, post-test M=6.38, SD=.48). A trial block effect suggests that all students, regardless of skill level or treatment, improved in their ability to apply the concepts presented in the treatment from pretest to posttest. There were no other significant differences for form scores.

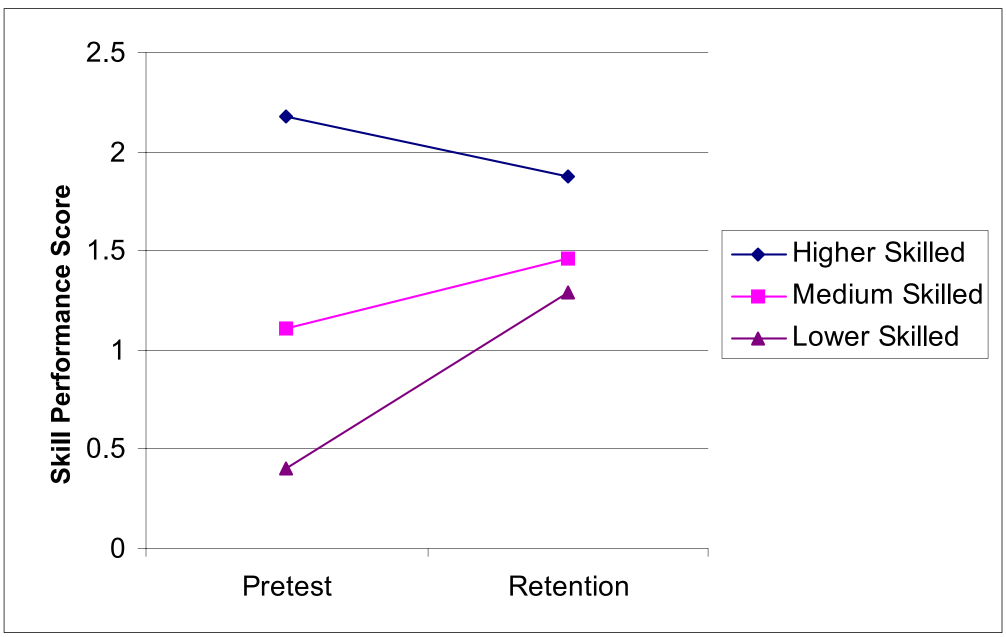


Figure 5.Skill performance score from pre- to post-test (skill by trial block effect)

Transfer. For transfer, a 3 (treatment) x 3 (skill) ANOVA with section as block was used to analyze both skill performance and form scores. The treatment main effect [F(2, 6)= .63, p= .5624], skill main effect [F(2, 36) = 1.27, p= .2924], and treatment by skill [F(4, 36) = .40, p= .8046] were not significant for skill performance scores. For form scores, the treatment main effect [F (2, 39) = 1.13, p= .3325], skill main effect [F (2, 39) = 1.33, p= .2774], and treatment by skill [F (4, 39) = 1.21, p= .3219] was not significant.

Cognitive Measures

Student thoughts. Student scores for each of the student thoughts (critical thinking, self-efficacy, prior experience) were obtained by averaging the likert scale scores of the items within each subscale. A 3 (treatment) x 3 (skill) ANOVA with section as block for each of the three dependent variables revealed a treatment by skill interaction [F(4, 35) = 3.38, p =.0193] for the critical thinking subscale (see figure 6). Follow-up tests revealed that the higher-skilled control group students (M=3.93, SD=.32) scored greater than the medium-skilled group (M=3.57, SD=.27) with the lower-skilled (M=2.84, SD=.28) not different than either group. For the model group, the higher-skilled (M=3.89, SD=.32) were different than lower-skilled (M=2.88, SD=.30) with the medium-skilled (M=3.46, SD=.29) not different than the other groups. For guided discovery, no other significant differences were computed. The treatment main effect [F(2, 6)=.57, p=.5930] or the skill main effect [F(2, 35)=1.39, .2632] were not significant for the critical thinking subscale.

No other significant differences were revealed for either self-efficacy or prior experience subscales. Main effects for self-efficacy [F(2, 6)= .16, p = .8530], skill [F(2, 35) =.42, p= .6634], and the self-efficacy by skill interaction were not significant [F(4, 35) =.52, p=.7238]. Likewise, the main effects for prior experience [F(2, 6)= .29, p=.7569], skill [F(2, 35)=.12, p=.8855], and prior experience by skill interaction [F (4, 35)=1.81, p= .1490] were not significant.

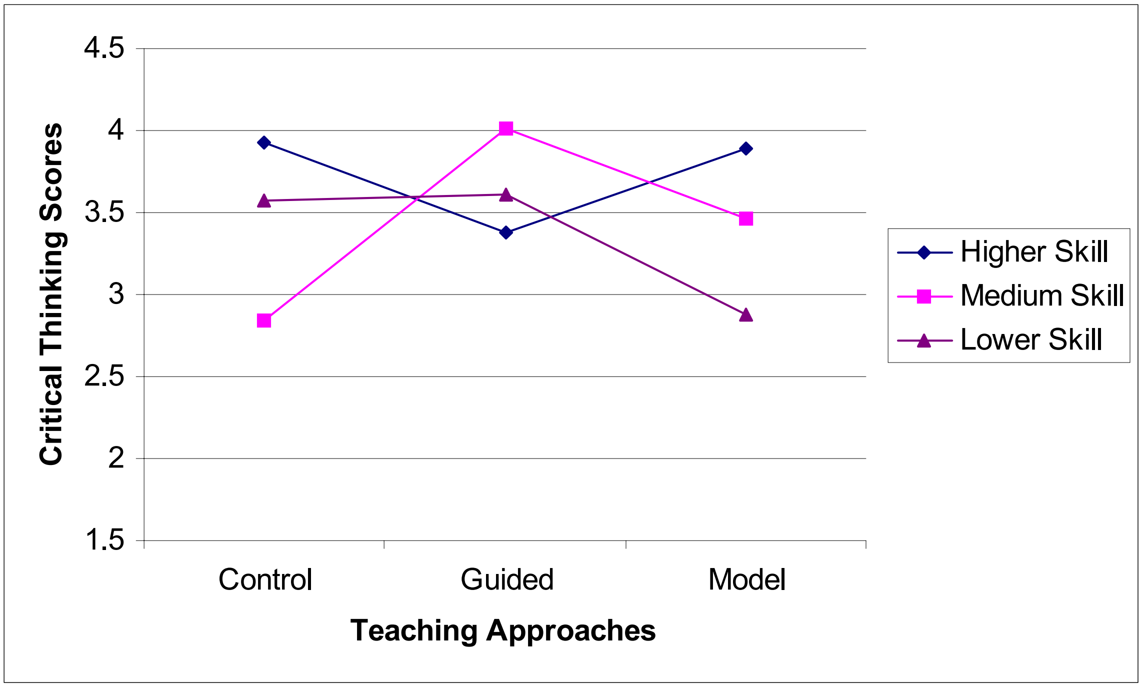


Figure 6. Treatment by skill interaction for critical thinking scores

Strategies. An inductive procedure was used to analyze the open-ended strategies questionnaire responses. First, student responses to the strategies questionnaire were word processed to a master list in no particular organization. The unit of analysis for coding was defined as any statement describing a strategy used to be successful during practice of the golf pitch. The categories for coding emerged by organizing the statements into various groupings. The groupings were eventually collapsed into 5 categories with a definition or theme defining each category. Subsequently, each unit (response) was coded into one of the categories.

To establish inter-rater agreement for assignment of units to qualitative categories, a second coder coded 10% of the written responses. Inter-rater agreement was .89 between the two raters. Upon competition of the coding, a frequency count for each instructional group was tallied and chi square analyses were performed to determine if the response frequency pattern varied according to treatment group, and skill level within each treatment group.

Chi-Square Analysis. Chi-square analyses were conducted on the strategy statements by treatment. Responses were collapsed across days. Based on students' responses to the strategies open-ended questionnaire, five categories were used in the analysis: Technique-posture and grip, technique, swing mechanics, degree of effort or success, stress management and focus and concepts/critical thinking (see table 10 for definitions). The frequency count of student responses by treatment is presented in table 11. The chi-square analysis, treatment by category, revealed that the distribution of student responses [χ^2 (8, 20.9840, p =.0072] varied according to the treatment they received.

Table 10. Definitions of categories for open-ended questionnaire.

Categories	Definitions	Examples
Technique-Posture and grip (**TP**)	Student talks about a specific posture or grip technique or about technique in general.	Bend knees, back straight, keep my head down, kept eye on the ball
Technique-swing mechanics (**TS**)	Student talks about using body parts during the swing or use of force during the swing	Use wrist bend, try to control my arms, tried to swing smooth
Degree of effort or success (**SA**)	Student perceives their performance as successful or unsuccessful or comments on their effort	I wasn't successful at all, I suck, I was getting good loft and ball checking well, I tried hard,
Stress management and focus (**MS**)	Anything referring to focusing on a target during performance or statements referring to stress management	I relaxed, I concentrated, tried not to get too frustrated when I mess up, taking my time
Concept/critical thinking (**CS**)	Talked about a concept that would improve outcome or refers to a concept in general or critical thinking (or trial and error) that would lead to understanding a concept	Left clubface open, I put the ball further in my stance, I used loft of the club

Comparison of the observed and expected frequencies for the control group suggests that students made more references than expected (according to the chi square distribution) on focusing on the target or stress management and more references on effort or success. The data suggests that a large number of students in the control group used "trying to relax" or "focusing on the target" as a strategies to improve their performance. Also, students had a large number of comments reporting how unsuccessful they were with certain circumstances based on their trial and error.

Comparison of the observed and expected frequencies suggests that the model group made fewer references than expected to concepts/critical thinking and more references than expected to posture and grip. It was apparent that a large number of students in the model group focused on improving their posture and grip technique and less on the concepts that were read to them.

Table 11. Frequency count by treatment for day 2 of student responses to open ended questionnaire (expected chi-square values in parenthesis)

Treatment Group	Concept	Stress Management and focus	Degree of Effort or success	Technique Posture & grip	Technique Swing Mechanics	Totals
Control	24 (27.3)	17 (14.0)	20 (14.8)	21 (24.1)	13 (14.8)	95
Model	18 (25.3)	11 (13)	13 (13.7)	33 (22.3)	13 (13.7)	88
Guided Discovery	34 (23.3)	11 (12.0)	8 (12.6)	13 (20.6)	15 (12.6)	81
Totals	76	39	41	67	41	264

Comparison of the observed and expected frequencies suggests that the guided discovery group made more references than expected in concepts/critical thinking and swing mechanics and fewer than expected in posture and grip and comments on effort or success. Guided discovery students were focused on solving the movement problems to understand the concepts of swing mechanics and less focused on the posture and grip.

Discussion

The results clearly show that the lower-skilled group was responsible for the improvements over time. The lower-skilled students improved significantly from pre to posttest for skill performance scores whereas medium and higher-skilled students did not. Similarly, for the form scores, during practice it was the lower-skilled students who made the greatest gain over time, even though their performance was more variable. It is typical for lower-skilled students to experience greater performance gains then those students in later stages of learning (Magill, 2001). Students in the first stage of learning usually make larger errors and when those errors are corrected result in large improvements in performance. On the other hand, students that progress to later stages makes smaller errors yielding littler improvements when corrected. From a pedagogical perspective, it is clear that the beginning or novice students were more influenced by the instruction and practice. It should be pointed out that the instruction was focused at a beginning level and offered few challenges for the advanced golfers.

Students' thoughts and behaviors were different for each of the instructional conditions. Students that received only basic instruction received limited amounts of information forcing them to use trial and error to obtain any information to help them improve. These students used attentional strategies such as "focusing on the target" and "trying to relax" to be successful. In contrast, students in the model group learned by watching a correct model and listening to movement concepts. The objective of providing students movement concepts was to expose them to principles that would help them pitch the ball higher and allow them to control for distance. However, a smaller than expected proportion of students reported success in using the concepts presented to them and instead, they indicated that it was the technique related to aspects of posture and grip that helped. It is possible that students did not understand how to apply the concepts or found that receiving visual information from the model on posture was more easily obtained and thus more useful.

Lastly, other students were guided through movement challenges as a means to understand movement concepts. This scaffolding process was a framework that assisted students in learning by placing more emphasis on critical thinking. Students were challenged to choose between alternatives and consider either possibility. Students in this group needed to solve a problem by exploring different movements and figuring out the concept that was associated with that movement challenge. They were expected to formulate a hypothesis on how the movement would turn out, compare and contrast their results with what they expected, and select the correct concept from two viable alternatives. These students made few references to posture and grip but instead reported that particular concepts learned from participating in the movement activities helped them be successful. It is possible that the emphasis on scaffolding helped students understand the concepts well enough to use the new possibilities in their performance. Guided discovery students did not comment on their lack of success or effort maybe because they were focused on performing the movement challenges and had a clear understanding of different alternatives to try.

The hypothesis that guided discovery group would employ critical thinking frequently was supported. Students reported that were frequently cognitively engaged or used critical thinking during the scaffolded instruction and practice. Students of initial skill level did not differ in their frequency of critical thinking usage; however, the frequency of usage within the other two groups did. Higher-skilled students were significantly different from medium-skilled in the discovery group and from the lower-skilled in the model group. These results suggest that different instructional conditions may be more cognitively engaging for different initial skill levels. Instructional conditions where students receive correct detailed information or receive only the action goal may be more cognitively engaging for higher-skilled students as opposed to learning basic concepts though guided discovery. In contrast, the lower-skilled may benefit more from practicing basic posture and grip or guided through movement challenges before being presented with verbal information or a correct model. These results are consistent with a developmental perspective that students and teachers should not be comparing students' skill performance with an advanced or "mature" model in the initial phases of learning a skill (NASPE, 1999).

The results of the study did not support the hypothesis that students in a guided discovery environment would experience greater transfer because they were more frequently engaged in critical thinking. It was hypothesized that learning concepts through critical thinking would help students understand the concepts, which in turn, would translate to improved performance. It is possible that all groups were engaged in some form of critical thinking and what they learned was used to improve their performance on the transfer test. On the other hand, perhaps the guided discovery students did have a greater understanding of the concepts but did not have enough practice time to incorporate the concepts into their performance.

The controversy surrounding the amount of practice time needed for transfer for students taught with a guided discovery or movement approach has been discussed by other researchers.

Toole and Arink (1982) experienced no differences in transfer with first graders. They taught mechanical principles of movement with the majority of instruction in a problem-solving format with the other group receiving the same content except taught in a command/demonstration approach. Students received one 30-minute class and one 20-minute class per week for 20 weeks. On the other hand, McRell (1971), in an unpublished thesis, found that after 3 years, fourth and fifth graders who were taught with a movement education approach were significantly better on throwing and running than those who were taught with the traditional approach. Although these studies have methodological problems, this brings up the issue of how much time or how many practice trials will significantly show better transfer results if at all. The real results of scaffolded learning might not be evident for many years.

Another possibility for the lack of transfer for the guided discovery group may be the frequency of critical thinking. Although the guided discovery group did report frequently critical thinking during instruction, their frequency level did not exceed the frequency of the other two groups. Several possibilities exist to explain why students did not report using critical thinking more frequently than other groups. It is possible that this was the first time some of these students had experienced a physical activity class where they were required to think critically, and they spent the entire experiment time getting accustomed to a new style of teaching. Another possibility was that students did not have the propensity to critically think. Other researchers (e.g., McBride, 1997; Cleland & Pearse, 1995; McCarthy & Schrag, 1990) have encountered resistance from students who had not been exposed to critical thinking and were not familiar with learning that way. Student may have traditional conceptions of learning (i.e., teachers fill students with knowledge) and would "go through the motions" during the activities without exploring the opportunities available to them.

Another possibility for lack of differences between groups may have been that for critical thinking in movement activities to be effective, social interaction is needed. Some theorists define learning through critical thinking as having two different components: individual active knowledge construction and processes of encultralization and social interaction (Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994). In this study, teachers facilitated critical thinking by guiding student thought using movement activities on task cards. It is possible that social interaction and shared discourse would further promote students' understanding of the concepts and hold students accountable for their meaning constructions. To facilitate learning the teacher could help students elaborate on their initial responses to problems and guide the sharing of ideas from their exploration about the movement tasks to an increased level of performance. In this study, students may have chosen the correct alternative, but were not able to defend their reasoning on how they got the correct answer. Also, teachers might have the option of both constraining tasks more, or adding correct content when students have trouble figuring out the problem. Teachers in this study only facilitated students' discovery through guiding them with the task cards, which is an incomplete scaffolding approach but a good beginning.

Movement activities with task cards may be analogous to what beginning teachers typically do when trying to teach with a discovery approach. Novice teachers tend to overgeneralize the contrast between discovery and traditional approaches thinking that the exploratory methods do not involve telling students what to do (Rovegno, 1992, 1993, 1998). Rovegno (1998) found that when trying to learn how to teach with movement approaches, teachers typically provide students the tasks or problems and do not follow-up on their critical thinking by asking further questions, providing them correct content or placing further constraints on the task. In other words, students were not provided closure on the problems and were not taken to a higher level of understanding. The teachers in the present study were trained in the treatment but were unable to scaffold student learning or increase student understanding beyond what was provided in the written material.

At the end of six days of instruction, no differences were evident among any of the instructional conditions as a function of skill performance or form. In other words, the discovery condition or the group that only received basic instruction did as well as those groups that had received further instruction. These results suggest that for some tasks, students who know the action goal can benefit from an organized environment without direct instruction from the teacher. These results are consistent with motor learning studies with ski simulators (e.g., Vereijken & Whiting, 1990; Wulf & Weigelt, 1997) that found that providing just the action goal was just as good or better than providing instruction.

In this study, the hypothesis that higher-skilled students would report higher levels of self-efficacy was not supported. There were no differences among skill groups for level of self-efficacy at the end of practice. Looking at open-ended questionnaire responses, some students did report their frustrations (e.g., control group students' trial and error reporting) but no patterns among skill levels or treatment were found. These results are contrary to Hebert, Landin and Solmon (2000) whose findings supported Bandura's (1977) hypotheses that success leads to greater perceptions of competence and failure leads to lower levels. These researchers found that students with higher skill levels also reported high self-efficacy beliefs. In the present study, all students regardless of skill level improved during the instructional time. This could explain the lack of difference in perceptions of competence that was measured at the end of the unit.

Students' frequency of referring back to prior experience was not different among instructional approaches. One typical part of teaching approaches that facilitates problem solving is when students use their prior experience to help solve the problems. It is possible that students depend primarily on prior experience to solve the problem when no information is provided. Rukavina, Lee, Solmon and Hill (2001) reported that when compared to students viewing a model, those who received only the action goal indicated more frequent use of their prior experiences to solve the movement problem. On the other hand, another possibility might be that the frequency of referring to prior experience depends on the type of task being learned. Rukavina, Lee, Solmon and Hill (2001) asked students to project a soccer ball over a barrier and they modified kicking patterns that were familiar to them. The golf pitch is a specific skill and it is possible that students had no previously learned movement patterns learned from the past to modify or adapt.

In summary, the results of this study provide evidence to support a mediating perspective framework for understanding the links between teacher and student variables. Teachers using different instructional formats in the study elicited different strategy usages from students. In the future, researchers should continue to design studies to explain how different instructional conditions and student variables elicit specific mediating thoughts and behaviors. For example, in this study, entry skill level had an effect on the amounts of critical thinking reported by students. Also, it is important to investigate when and under what conditions certain behaviors and thoughts elicited by an instructional approach will lead to more successful performance on skill and transfer tests. A large number of pedagogical studies assess only behavior or student perceptions about their experiences with no reference to motor performance. While research in a real world context is important and leads to higher external validity, assessment of daily performance and learning justifies the need to have a higher level of control. Both types of research contribute to the pedagogical knowledge base.

REFERENCES

Anderson, J. C. & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*, 411-423.

Ashy, M. H., Lee, A. M., & Landin, D. K. (1988). Relationship of practice using correct technique to achievement in a motor skill. *Journal of Teaching in Physical Education, 7*, 115-120.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review,* 84, 191-215.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Benson, J. (1998). Developing a strong program of construct validation: A test anxiety example. *Educational Measurement: Issues and Practices, Spring,* 10-17.

Bentler, P. M. (1989) EQS structural equations program. Los Angeles: BMDP Statistical Software.

Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness-of-fit in the analysis of covariance structures. *Psychological Bulletin, 88*, 588-606.

Beyer, B. (1987). *Practical strategies for the teaching of thinking*. Boston: Allyn & Bacon.

Buck, M., Harrison, J.M., & Bryce, G. R. (1991). An analysis of learning trials and their relationship to achievement in volleyball. *Journal of Teaching in Physical Education, 10*, 134-152.

Carroll, W. R., & Bandura, A. (1990). Representational guidance of action production in observational learning: A causal analysis. *Journal of Motor Behavior, 22,* 85-97.

Chen, W. & Rovegno, I. (2000). Examination of expert and novice teachers' constructivist-oriented teaching practices using a movement approach to elementary physical education. *Research Quarterly for Exercise and Sport, 71*, 357-372.

Cleland, F., & Pearse, C. (1995). Critical thinking in elementary physical education - Reflections on a yearlong study. *Journal of Physical Education, Recreation and Dance, 66(6)*, 31-38.

Cobb, P. (1994). Where is the Mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher, 23(7)*, 13-20.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*, 297-334.

Davis, J. A. (2003, April). *Effects of gender and verbal cues on the cognition and performance of a motor task*. Paper presented at the meeting of the American Alliance of Health, Physical Education, Recreation and Dance, Philadelphia, PA.

Doyle, W. (1977). Paradigms for research on teacher effectiveness. *Review of Research in Education, 5*, 163-198.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23(7),* 5-12.

Edwards, R. V., & Lee, A. M. (1985). The relationship of cognitive style and instructional strategy to learning and transfer of motor skills. *Research Quarterly, 56*, 286-290.

Ennis, C. D. (1991). Discrete thinking skills in two teachers' physical education classes. *The Elementary School Journal, 91*, 473-487.

Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological Review, 87*, 215-251.

Floyd, F. J., & Widaman, K. F. (1995). Factor analysis in the development and refinement of clinical assessment instruments. Psychological Assessments, 7, 286-299.

Fornell , C. & Lacker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*, 39-50.

Gorsuch, R. L. (1983). *Factor analysis* (2nd ed.), Hillsdale, NJ: Lawrence Erlbaum Associates.

Graham, G., Holt/Hale, S. A., & Parker, M. (1998). *Children moving. A reflective approach to teaching physical education*. Mountain View, Ca: Mayfield Publishing Company.

Grant, B. C., Ballard, K. D., & Glynn, T. L. (1990). Teacher feedback intervention, motor-on-task behavior, and successful task performance. *Journal of Teaching in Physical Education,9, 123-139.*

Harrison, J. M., Fellingham, G. W., Buck, M. M., & Pellett, T. L. (1995). Effects of practice and command styles on rate of change in volleyball performance and self-efficacy of high-, medium-, and low-skilled learners. *Journal of Teaching in Physical Education, 14*, 328-339.

Hatcher, L. (1994). *A step-by-step approach to using the SAS System for factor analysis and structural equation modeling*. Cary, NC: SAS Institute Inc.

Hebert, E. P., Landin, D., & Solmon, M. A. (2000). The impact of task progressions on students' practice quality and task-related thoughts. *Journal of Teaching in Physical Education, 19, 338-354.*

Howard, G. S. (1981). On Validity. *Evaluation Review, 5,* 567-576.

James, L. R., Mulaik, S. A., & Brett, J. M. (1982). *Causal analysis*. Beverly Hills: Sage.

Joreskog K. G. & Sorbom D. (1989). *LISREL 7: A guide to the program and applications*, 2nd edition. Chicago: SPSS Inc.

Lee, A. M., Landin, D. K., & Carter, J. A. (1992). Student thoughts during tennis instruction. *Journal of Teaching in Physical Education, 11*, 256-267.

Lee, A. M., & Solmon, M. A. (1992). Cognitive conceptions of teaching and learning motor skills. *Quest, 44*, 57-71.

Lee, T. D., Swinnen, S. P., & Serrien, D. J. (1994). Cognitive effort and motor learning. *Quest, 46*, 328-344.

Lipman, M. (1988). Critical thinking- What can it be? *Educational Leadership, 46(1)*, 38-43.

Locke, L. F., & Jensen, M. K. (1974). Thought sampling: A study of student attention through self-report. *The Research Quarterly, 45*, 263-275.

Magill, R. A. (2001). *Motor learning: Concepts and applications* (6th ed.). Dubuque, IA: Brown and Benchmark.

Marx, R. W., & Winne, P. H. (1987). The best tools teachers have—their students' thinking. In C. C. Berliner & B. V. Rosenshine (Eds.) *Talks to teachers* (pp. 267-304). New York: Random House.

Masser, L. (1993). The effect of refinement on student achievement in a fundamental motor skill in grades k through 6. Journal of Teaching in Physical Education, 6, 174-182.

Mayer, R. E., & Wittrock, M. C. (1996). Problem-solving transfer. In D.C. Berliner & R.C. Calfee, (Eds.) *Handbook of educational psychology* (pp. 926-944). New York: Simon & Schuster Macmillan.

McBride, R. E. (1991). Critical thinking-An overview with implications for physical education. *Journal of Teaching in Physical Education, 11*, 112-125.

McBride,R. (1997). You can lead a horse to water, but…Structuring for critical thinking may not guarantee that students will like it. Paper presented at the annual meeting of the American Alliance for Health, Physical Education, Recreation & Dance, St. Louis, MO, March 20-24.

McCarthy, C. & Schrag, F. (1990). Departmental and school leadership in promoting higher-order thinking skills. *Journal of Curriculum Studies, 22*, 529-543.

McCullagh, P. (1993). Modeling: learning, developmental, and social psychological considerations. In R.N. Singer, M. Murphey, and L.K. Tennant (Eds.), *Handbook of research on sport psychology* (pp. 106-126). New York: Macmillan.

McRell, E. R. (1971). *A comparison of a movement education program, a traditional physical education program, and a program without physical education using selected movement patterns*. Unpublished master's thesis, Western Illinois University, Macomb.

Mosston, M., & Ashworth, S. (1994). *Teaching in physical education* (4th ed.). New York: Macmillan.

National Association for Sport and Physical Education (1995). *NASPE: Moving into the future: National standards for physical education—a guide to content and assessment*, St. Louis: Mosby.

National Association for Sport and Physical Education (1999*). Looking at physical education from a developmental perspective: A guide to teaching.*

Nichols, B. (1986). *Moving and learning, the elementary school physical education experience*. St. Louis, MO: Mosby.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we know: Verbal reports on mental process. *Psychological Review, 84*, 231-259.

Nunnally, J. (1978). *Psychometric theory*. New York: McGraw-Hill.

Paul, R. W. (1987). Dialogical thinking: Critical thought essential to the acquisition of rational knowledge and passion. In J. B. Barron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 127-148). New York: W. H. Freeman.

Paris, S. G., & Oka, E. R. (1986). Children's reading strategies, metacognition, and motivation. *Developmental Review, 6*, 25-56.

Peterson, P. L., & Swing, S. R. (1982). Beyond time on task; Students' reports of their thought processes during classroom instruction. *Elementary School Journal, 82*, 481-491.

Peterson, P. L., & Swing, S. R., & Waas, G. A. (1984). Students' cognitions and time on task during mathematics instruction. *American Educational Research Journal, 21*, 487-515.

Rikard, G. L. (1992). The relationship of teachers' task refinement and feedback to students' practice success. *Journal of Teaching in Physical Education, 11*, 349-357.

Rink, J. E. (1996). Effective instruction in physical education. In S. J. Silverman & C. D. Ennis (Eds.), *Student learning in physical education: Applying research to enhance instruction* (pp. 171-198). Champaign, IL: Human Kinetics.

Rink, J. E. (1998). Teaching physical education for learning (3rd. ed.). Boston, MA: McGraw-Hill.

Rovegno, I. (1992). Learning a new curricular approach: Mechanisms of knowledge acquisition in preservice teachers. *Teaching and Teacher Education, 8*, 253-264.

Rovegno, I. (1993). The development of curricular knowledge: A case of problematic pedagogical knowledge during advance knowledge acquisition. *Research Quarterly for Exercise and Sport, 64*, 56-68.

Rovegno, I. (1998). The development of in-service teachers' knowledge of a constructivist approach to physical education: Teaching beyond activities. *Research Quarterly for Exercise and Sport, 69*, 147-162.

Rukavina, P. B., Lee, A. M., & Solmon, M. A. (2002). Mediational Processes Perspective: Providing scaffolding environments for problem-solving. Unpublished Manuscript.

Rukavina, P. B., Lee, A. M., Solmon, M. A, & Hill, K. (2001, April*). Cognitive processes in direct and indirect task communication strategies*. Paper presented at the meeting of the American Education Research Association-Research on Learning and Instruction in Physical Education, Seattle, WA.

Rukavina, P.B., Lee, A. M., Solmon, M. A. & Hill, K. (2002, Mar). *Comparing the efficacy of task communication strategies to promote learning.* Paper presented at the meeting of the American Alliance of Health, Physical Education, Recreation and Dance, San Diego, CA.

SAS Institute Inc. (1989). *SAS/STAT users guide*, version 6, fourth edition, volume 1. Cary, NC: SAS Institute Inc.

Schmidt, R. A., & Lee, T. D. (1998*). Motor control and learning: A behavioral emphasis* (3rd ed.). Champaign, IL: Human Kinetics.

Schoenfelder-Zodhi, B. G. (1992). *Investigating the information nature of a modeled visual demonstration*. Unpublished Doctoral Dissertation, Louisiana State University, Baton Rouge.

Schumacker, R. E., Lomax, R. G. (1996). *A beginners guide to structural equation modeling*. Mahway, New Jersey: Lawrence Erlbaum Assocatiates.

Scully D. M., & Newell, K. M. (1985). Observational learning and the acquisition of motor skills: Toward a visual perception perspective. *Journal of Human Movement Studies, 11*, 169-186.

Schunk, D. H. (1985). Self-efficacy and classroom learning. *Psychology in Schools, 22*, 208-223.

Silverman, S. (1985a). Relationship of engagement and practice trials to student achievement. *Journal of Teaching in Physical Education,5, 13-21.*

Silverman, S. (1985b). Student characteristics mediating engagement-outcome relationships in physical education, *Research Quarterly for Exercise and Sport,* 56, 66-72.

Silverman, S. J. (1991). Research on teaching in physical education, *Research Quarterly for Exercise and Sport,* 62, 352-364.

Silverman, S. J. (1990). Linear and curvilinear relationships between student practice and achievement in physical education. *Teaching and Teacher Education, 6*, 305-314.

Silverman, S. J. (1993). Student characteristics, practice, and achievement in physical education. *Journal of Educational Research, 87*, 54-61.

Silverman, S. & Solmon, M. (1998). The unit of analysis in field research: Issues and approaches to design and data analysis. *Journal of Teaching in Physical Education, 17*, 270-284.

Singer, R. N., & Pease, D. (1978). Effect of guided vs. discovery learning strategies on initial motor task learning, transfer, and retention. *Research Quarterly, 49*, 206-217.

Solmon, M. A., & Boone, J. (1993). The impact of student goal orientation in physical education classes. *Research Quarterly for Exercise and Sport, 64*, 418-424.

Solmon, M. A., & Lee, A. M. (1996). Entry characteristics, practice variables, and cognition: Student mediation of instruction. *Journal of Teaching in Physical Education, 15*, 136-150.

Solmon, M. A., & Lee, A. M. (1997). Development of an instrument to assess cognitive processes in physical education classes. *Research Quarterly for Exercise and Sport, 68*, 152-160.

Thomas, J. W., Iventosch, L, & Rohwer Jr., W. D. (1987). Relationships among student characteristics, study activities, and achievement as a function of course characteristics. *Contemporary Educational Psychology, 12*, 344-364.

Toole, T., & Arink, E. A. (1982). Movement education: Its effect on motor skill performance. *Research Quarterly for Exercise and Sport, 53*, 156-162.

Vereijken, B., & Whiting, H. T. A. (1990). In defense of discovery learning. *Canadian Journal of Sport Science, 15*, 99-106.

Weinstein, C. E., Palmer, D. R., & Schulte, A. C. (1987). *Learning and study strategies inventory*. Clearwater, FL: H & H Publishing.

Whiting, H. T. A. (1988). Imitation and learning of complex cyclical actions. In O.G. Meijer and K. Roth (Eds.), *Complex motor behavior: 'The' motor-action controversy* (pp. 381-401). Amsterdam: North-Holland.

Wittrock, M. C. (1986). Students' thought processes. In M.C. Wittrock, (Ed.), *Handbook of research on teaching* (3^{rd} ed., pp. 297-314). New York: Macmillan.

Wood, D. J., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*, 89-100.

Wulf, G., Lauterbach, B., & Toole, T. (1999). The learning advantages of an external focus of attention in golf. *Research Quarterly for Exercise and Sport, 70*, 120-126.

Wulf, G. & Weigelt, C. (1997). Instructions about physical principles in learning a complex motor skill: To tell or not to tell… *Research Quarterly for Exercise and Sport, 68*, 362-367.

APPENDIX A – DATA TABLES

Instrument Development Results, Means and Standard Deviations for Form and Skill Performance, ANOVA Results, Frequency Counts and Chi-Square Results for Strategies Questionnaire

Table A-1. Intercorrelations Among All Variables - Cognitive Processes Questionnaire Instrument Development

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	t19	t20	t21	t22	t23	t24	t25	t26	t27	t28	t29	t30	t31	t32	t33	t34	t35	t36	t37	t38	t39	t40
t1	1.00																																							
t2	-.03	1.00																																						
t3	.21	.26	1.00																																					
t4	.07	.29	.38	1.00																																				
t5	.19	.27	.45	.32	1.00																																			
t6	.18	.29	.75	.43	.43	1.00																																		
t7	.32	.24	.46	.30	.54	.50	1.00																																	
t8	.05	.19	.18	.41	.16	.20	.21	1.00																																
t9	.32	.20	.48	.33	.54	.53	.68	.19	1.00																															
t10	-.19	.22	-.10	.04	-.09	-.04	-.09	.20	-.13	1.00																														
t11	.20	.34	.58	.43	.40	.61	.46	.27	.48	.02	1.00																													
t12	.03	.19	.16	.31	.10	.14	.11	.38	.12	.37	.24	1.00																												
t13	.24	.13	.30	.17	.31	.33	.40	.19	.35	-.04	.41	.12	1.00																											
t14	.04	.31	.25	.31	.26	.25	.22	.26	.19	.12	.38	.21	.18	1.00																										
t15	.17	.04	.15	.10	.07	.16	.14	.22	.14	-.05	.17	.10	.20	.03	1.00																									
t16	.11	.29	.26	.47	.27	.29	.29	.33	.32	.01	.35	.23	.22	.37	.13	1.00																								
t17	.26	.13	.31	.25	.33	.35	.40	.18	.38	-.06	.31	.14	.51	.08	.28	.33	1.00																							
t18	-.02	.49	.20	.34	.15	.21	.14	.27	.18	.20	.37	.30	.17	.46	.11	.46	.17	1.00																						
t19	.19	.12	.27	.12	.13	.32	.12	.05	.14	.03	.30	.08	.23	.15	.33	.18	.35	.21	1.00																					
t20	.15	.29	.31	.50	.27	.31	.34	.40	.39	.00	.38	.36	.17	.38	.14	.62	.23	.48	.15	1.00																				
t21	.27	.15	.40	.29	.44	.37	.50	.19	.55	-.09	.42	.06	.42	.19	.15	.33	.44	.25	.22	.36	1.00																			
t22	.05	.22	.16	.22	.14	.21	.15	.33	.13	.12	.20	.28	.10	.06	.29	.18	.28	.21	.37	.20	.18	1.00																		
t23	.03	.19	.24	.15	.18	.23	.14	.07	.15	.03	.35	.03	.13	.28	.04	.14	.07	.22	.24	.12	.25	.15	1.00																	
t24	.09	.18	.14	.24	.10	.12	.12	.37	.13	.19	.24	.46	.21	.13	.11	.35	.19	.23	.10	.44	.19	.30	-.00	1.00																
t25	.23	.15	.23	.21	.33	.26	.32	.24	.31	.01	.29	.13	.42	.09	.25	.28	.44	.25	.31	.24	.48	.27	.09	.24	1.00															
t26	-.01	.49	.23	.31	.18	.25	.16	.22	.20	.18	.37	.23	.20	.37	.07	.33	.18	.50	.19	.32	.21	.20	.24	.24	.19	1.00														
t27	.09	.32	.39	.34	.31	.39	.30	.14	.32	.02	.47	.10	.26	.28	.16	.36	.34	.30	.41	.29	.38	.22	.43	.12	.26	.36	1.00													
t28	-.12	.07	-.06	-.00	-.14	-.07	-.09	.04	-.11	.31	-.00	.22	-.01	.00	.01	-.08	.02	.07	.02	.01	-.11	.18	-.04	.22	.03	.11	-.00	1.00												
t29	.29	.24	.39	.38	.45	.40	.48	.24	.50	-.06	.47	.17	.40	.32	.08	.40	.39	.30	.18	.40	.55	.11	.22	.20	.50	.33	.40	-.10	1.00											
t30	.18	.37	.34	.38	.37	.35	.38	.25	.41	-.01	.46	.20	.28	.40	.13	.43	.26	.40	.19	.47	.45	.27	.29	.26	.34	.39	.37	.00	.56	1.00										
t31	.46	-.07	.25	.18	.18	.30	.29	.11	.32	-.20	.18	-.06	.27	-.01	.19	.19	.38	-.02	.27	.14	.30	.11	-.04	.14	.33	-.01	.14	-.13	.34	.15	1.00									
t32	.06	.26	.07	.24	.11	.10	.06	.16	.11	.05	.12	.08	-.06	.36	-.05	.25	-.00	.31	.17	.30	.12	.08	.14	.07	.01	.33	.22	-.05	.18	.27	-.06	1.00								
t33	.08	.38	.27	.35	.25	.30	.25	.25	.27	.04	.36	.14	.18	.39	.19	.36	.15	.41	.18	.37	.31	.23	.23	.18	.30	.41	.36	.08	.37	.42	.08	.33	1.00							
t34	.12	.26	.19	.35	.18	.20	.16	.37	.19	.12	.24	.39	.11	.27	.15	.44	.27	.37	.16	.45	.22	.26	.04	.44	.27	.27	.21	.07	.30	.30	.19	.16	.30	1.00						
t35	.23	.15	.33	.22	.33	.30	.37	.17	.37	-.08	.31	.15	.41	.10	.17	.26	.44	.15	.24	.23	.50	.25	.05	.23	.55	.23	.22	.04	.51	.35	.34	-0.00	.25	.30	1.00					
t36	-.00	.23	.01	.19	.18	.09	.13	.20	.12	.15	.12	.14	.09	.27	.06	.29	.12	.28	.14	.33	.23	.17	.09	.17	.15	.26	.22	.02	.21	.25	-.02	.50	.32	.32	.19	1.00				
t37	.11	.32	.22	.32	.26	.30	.26	.24	.25	.12	.31	.25	.22	.32	.17	.39	.26	.34	.25	.36	.27	.25	.08	.24	.32	.34	.31	.10	.42	.38	.16	.26	.48	.32	.38	.43	1.00			
t38	.26	.30	.38	.33	.38	.38	.51	.19	.48	-.04	.43	.12	.35	.29	.16	.36	.37	.33	.18	.35	.50	.14	.14	.16	.43	.31	.34	-.13	.58	.47	.34	.13	.39	.25	.51	.19	.36	1.00		
t39	.59	.41	.25	.35	.26	.29	.24	.22	.25	.05	.41	.22	.21	.40	.17	.42	.23	.49	.21	.41	.29	.28	.27	.25	.31	.43	.40	.03	.40	.46	.08	.37	.57	.35	.26	.35	.51	.40	1.00	
t40	.23	.23	.39	.31	.40	.43	.51	.17	.52	-.10	.44	.11	.38	.24	.09	.32	.35	.26	.11	.35	.60	.04	.17	.15	.42	.25	.38	-.05	.58	.44	.26	.08	.35	.21	.53	.15	.32	.66	.36	1.00
M	4.02	3.86	3.95	3.81	3.80	3.89	4.11	3.64	3.87	3.47	4.0	3.92	4.44	3.67	3.66	3.55	4.22	3.65	3.44	3.65	3.93	3.53	3.28	3.75	4.17	3.60	3.40	3.34	3.96	3.79	3.63	2.84	3.57	3.70	4.35	3.36	3.91	4.04	3.62	4.20
Sd	0.88	1.06	0.95	1.05	1.00	0.96	0.89	1.06	0.94	1.03	0.9	0.93	0.88	1.04	0.97	1.09	0.91	1.01	1.09	1.00	0.97	1.00	1.03	0.89	1.01	1.06	1.03	0.98	0.92	1.02	1.04	1.22	1.04	0.99	1.07	1.18	0.98	0.92	0.98	0.94

Table A-2. Information Needed to Compute Composite Reliability

Construct and Indicators	Standardized Loading	Indicator Reliability [a]	Error Variance [b]
Self-Efficacy (F1)			
V17	.49	.24	.76
V21	.86	.74	.26
V35	.59	.35	.65
V40	.72	.52	.48
Problem Solving (F2)			
V14	.65	.42	.58
V26	.62	.39	.61
V32	.55	.30	.70
V33	.72	.52	.48
V39	.74	.56	.44
Prior Experience (F4)			
V8	.52	.27	.73
V16	.78	.61	.39
V20	.82	.67	.33
V24	.53	.28	.72

[a] Calculated as the square of the standardized factor loading.

[b] Calculated as 1 minus the indicator reliability

Table A-3. Descriptive Statistics for Trials 11-20 of Higher Skilled Subjects

Trial	Mean	Std Dev	Minimum	Maximum
1	1.69	1.78	0	5
2	1.75	1.57	0	4
3	1.56	1.55	0	4
4	1.81	1.42	0	4
5	1.81	1.60	0	5
6	2.63	1.63	0	5
7	2.75	1.34	0	4
8	2.69	1.54	0	5
9	2.31	1.89	0	5
10	2.38	1.45	0	5
11	2.81	1.38	0	4
12	2.81	1.68	0	5
13	2.56	1.67	0	4
14	2.13	1.67	0	4
15	1.25	1.73	0	5
16	2.63	1.41	0	4
17	2.56	1.79	0	5
18	2.00	1.83	0	5
19	1.94	2.05	0	5
20	2.38	1.78	0	5

Note: There were 16 high skilled students. Trials represent that last 20 trials of the pretest data.

Table A-4. ANOVA Results for Acquisition-Skill Performance Scores

Effect		DF	DF	F -value	p-value
Treatment main effect	(A)	2	245	0.15	0.8646
Skill main effect	(B)	2	245	5.16	0.0064
Day main effect	(C)	5	245	1.20	0.3108
A x B		4	245	1.12	0.3490
A x C		10	245	2.09	0.0258
B x C		10	245	0.63	0.7912
A x B x C		20	245	0.82	0.6874

Table A-5. Least Square Means and Std. Deviations for Acquisition-Skill Performance Scores

		Mean	Standard Deviation
Treatment Main Effect			
Control	(1)	1.3878	0.1986
Guided Discovery	(2)	1.4459	0.2014
Correct	(3)	1.3241	0.2048
Skill Main Effect			
Higher-skilled	(A)	1.8056	0.2104
Medium-skilled	(B)	1.3045	0.1960
Lower-skilled	(C)	1.0477	0.2076
Day Main Effect			
Day 1		1.3579	0.1705
Day 2		1.3595	0.1715
Day 3		1.2452	0.1726
Day 4		1.4567	0.1719
Day 5		1.3872	0.1703
Day 6		1.5091	0.1736
Treatment by Day Interaction			
1	1	1.2169	0.2308
1	2	1.1398	0.2308
1	3	1.2231	0.2374
1	4	1.4865	0.2308
1	5	1.5365	0.2330
1	6	1.7237	0.2463
2	1	1.4013	0.2379
2	2	1.4388	0.2350
2	3	1.3556	0.2350
2	4	1.7835	0.2441
2	5	1.2841	0.2350
2	6	1.4119	0.2371
3	1	1.4553	0.2389

		Mean	Standard Deviation
Treatment by Day Interaction continued			
3	2	1.5000	0.2488
3	3	1.1569	0.2489
3	4	1.1000	0.2419
3	5	1.3409	0.2389
3	6	1.3916	0.2447
Skill by Day Interaction			
A	1	1.9446	0.2489
A	2	1.8663	0.2500
A	3	1.5595	0.2541
A	4	1.7737	0.2460
A	5	1.8226	0.2460
A	6	1.8668	0.2501
B	1	1.0986	0.2262
B	2	1.2962	0.2293
B	3	1.2083	0.2313
B	4	1.4154	0.2314
B	5	1.3022	0.2283
B	6	1.5062	0.2411
C	1	1.0303	0.2402
C	2	0.9162	0.2433
C	3	0.9679	0.2430
C	4	1.1808	0.2472
C	5	1.0367	0.2402
C	6	1.1543	0.2450
Treatment by Skill Interaction			
1	A	2.0298	0.3223
1	B	1.2908	0.2849
1	C	0.8427	0.2861
2	A	1.8356	0.3075
2	B	1.1156	0.2820
2	C	1.3864	0.3248
3	A	1.5513	0.3224
3	B	1.5071	0.3033
3	C	0.9140	0.3047

Treatment by Skill by Day Interaction

			Mean	Standard Deviation
1	A	2	1.8960	0.3941
1	A	3	1.8091	0.4170
1	A	4	2.0360	0.3941
1	A	5	2.0160	0.3941
1	A	6	2.3654	0.4166
1	B	1	0.7070	0.3421
1	B	2	0.9928	0.3421
1	B	3	1.2583	0.3549
1	B	4	1.4499	0.3421
1	B	5	1.5201	0.3546
1	B	6	1.8168	0.3966
1	C	1	0.8877	0.3450
1	C	2	0.5306	0.3450
1	C	3	0.6020	0.3450
1	C	4	0.9734	0.3450
1	C	5	1.0734	0.3450
1	C	6	0.9889	0.3573
2	A	1	1.7323	0.3880
2	A	2	1.9163	0.3712
2	A	3	1.7497	0.3712
2	A	4	2.2997	0.3712
2	A	5	1.6663	0.3712
2	A	6	1.6497	0.3712
2	B	1	1.2243	0.3408
2	B	2	1.0529	0.3408
2	B	3	1.0100	0.3408
2	B	4	1.2485	0.3705
2	B	5	1.0386	0.3408
2	B	6	1.1189	0.3534
2	C	1	1.2473	0.3967
2	C	2	1.3473	0.3967
2	C	3	1.3073	0.3967
2	C	4	1.8024	0.4192
2	C	5	1.1473	0.3967
2	C	6	1.4673	0.3967
3	A	1	2.0454	0.3942
3	A	2	1.7864	0.4167

Treatment by Skill by Day Interaction Continued

			Mean	Standard Deviation
3	A	3	1.1197	0.4167
3	A	4	0.9854	0.3942
3	A	5	1.7854	0.3942
3	A	6	1.5854	0.3942
3	B	1	1.3646	0.3668
3	B	2	1.8428	0.3835
3	B	3	1.3566	0.3833
3	B	4	1.5479	0.3668
3	B	5	1.3479	0.3668
3	B	6	1.5828	0.3835
3	C	1	0.9561	0.3676
3	C	2	0.8707	0.3845
3	C	3	0.9944	0.3838
3	C	4	0.7667	0.3842
3	C	5	0.8894	0.3676
3	C	6	1.0067	0.3842

Table A-6. Least Square Means and Standard Deviations for Acquisition-Form Scores

	Mean	Standard Deviation
Skill Main Effect		
1	6.5139	0.5462
2	5.8382	0.4971
3	5.5458	0.5310
Treatment Main Effect		
1	6.2666	0.5086
2	6.0683	0.5193
3	5.5631	0.5293
Day Main Effect		
1	5.5527	0.3704
2	5.9116	0.3735
3	5.9597	0.3739
4	5.4681	0.3725
5	6.2411	0.3711
6	6.6628	0.3775

Table A-7. Least Square Means and Standard Deviations for Acquisition-Form Scores

		Mean	Standard Deviation
Skill by Treatment Interaction			
1	1	6.2424	0.5941
1	2	6.6011	0.5957
1	3	6.6681	0.6012
1	4	6.3099	0.5904
1	5	6.3465	0.5904
1	6	6.9155	0.6013
2	1	5.4873	0.5352
2	2	5.7008	0.5393
2	3	5.2744	0.5450
2	4	5.4387	0.5423
2	5	6.4683	0.5409
2	6	6.6600	0.5591
3	1	4.9284	0.5715
3	2	5.4328	0.5842
3	3	5.9366	0.5752
3	4	4.6558	0.5809
3	5	5.9085	0.5745
3	6	6.4131	0.5837
Treatment by Day Interaction			
1	1	5.4893	0.5491
1	2	6.2635	0.5520
1	3	6.1163	0.5578
1	4	6.2141	0.5491
1	5	6.5009	0.5548
1	6	7.0152	0.5699
2	1	5.3955	0.5645
2	2	5.7171	0.5667
2	3	6.1714	0.5635
2	4	5.8807	0.5731
2	5	6.3969	0.5635
2	6	6.8483	0.5733
3	1	5.7733	0.5718
3	2	5.7541	0.5850

		Mean	Standard Deviation
3	3	5.5914	0.5850
3	4	4.3096	0.5757
3	5	5.8255	0.5718
3	6	6.1250	0.5850

Table A-8. ANOVA Results for Acquisition-Form Scores

Effect	DF	DF	F -value	p-value
Treatment Main Effect (A)	2	237	0.59	0.5567
Skill Main Effect (B)	2	237	1.00	0.3702
Day Main Effect (C)	5	237	9.04	<.0001
A x C	10	237	2.79	0.0028
B x C	10	237	2.11	0.0247
A x B	4	237	0.41	0.8012
A x B x C	20	237	1.24	0.2222

Table A-9. Least Square Means and Standard Deviations for Pre-Test and Retention Test-Skill Performance Scores

		Mean	Standard Deviation
Trial Block Main Effect			
Pretest (A)		1.2234	0.1275
Posttest (B)		1.5329	0.1275
Skill Main Effect			
Higher (1)		2.0378	0.1356
Medium (2)		1.2684	0.1250
Lower (3)		0.8283	0.1314
Treatment Main Effect			
Control (1)		1.29	0.1610
Guided Discovery (2)		1.47	0.1644
Model (3)		1.41	0.1644
Skill by Trial block Interaction			
1	A	2.1800	0.2131
1	B	1.8788	0.2131
2	A	1.1073	0.2005
2	B	1.4633	0.2005
3	A	0.4058	0.2074
3	B	1.2932	0.2074
Treatment by Trial Block Interaction			
1	A	1.2735	.20
1	B	1.3106	.20
2	A	1.1761	.21
2	B	1.7567	.21
3	A	1.2435	.21
3	B	1.5679	.21

			Mean	Standard Deviation
Treatment by Skill Interaction				
1	1		2.0749	0.2543
1	2		1.0842	0.2236
1	3		0.7171	0.2304
2	1		2.1315	0.2446
2	2		1.2820	0.2397
2	3		0.9858	0.2572
3	1		1.8818	0.2545
3	2		1.4896	0.2398
3	3		0.8457	0.2407
Treatment by Skill by Trial Block Interaction				
1	1	A	2.3799	0.3434
1	1	B	1.7699	0.3434
1	2	A	0.9628	0.2967
1	2	B	1.2057	0.2967
1	3	A	0.4778	0.3018
1	3	B	0.9563	0.3018
2	1	A	2.0232	0.3228
2	1	B	2.2398	0.3228
2	2	A	1.1195	0.3191
2	2	B	1.4445	0.3191
2	3	A	0.3858	0.3456
2	3	B	1.5858	0.3456
3	1	A	2.1368	0.3436
3	1	B	1.6268	0.3191
3	2	B	1.7396	0.3191
3	3	A	0.3540	0.3198
3	3	B	1.3374	0.3198

Table A-10. ANOVA Table For Pre-Test and Retention Test- Skill Performance Scores

Effect	DF	DF	F -value	p-value
Treatment Main Effect (A)	2	85	0.52	.5948
Trial Block Main Effect (B)	1	85	4.83	.0306
Skill Main Effect (C)	2	85	20.04	<.0001
A x B	2	85	1.23	.2977
A x C	4	85	.55	.7030
B x C	2	85	5.55	.0054
A x B x C	2	95	38.41	<.0001

Table A-11. Least Square Means and Standard Deviations for Pre-Post Tests-Form Scores

Effect		Mean	Standard Deviation
Skill Main Effect			
Higher-Skilled (1)		6.41	.54
Medium-Skilled (2)		5.73	.52
Lower-Skilled (3)		5.41	.53
Trial Block Main Effect			
Pretest (A)		5.33	.48
Retention (B)		6.38	.48
Treatment Main Effect			
Control (1)		6.27	.52
Guided Discovery (2)		5.81	.52
Model (3)		5.45	.52
Skill by Trial Block Interaction			
1 x A		6.00	.65
1 x B		6.83	.65
2 x A		5.20	.63
2 x B		6.27	.63
3 x A		4.78	.64
3 x B		6.04	.64
Skill by Treatment Interaction			
1	1	7.9241	.7585
1	2	5.3712	.7213
1	3	5.5270	.6894
2	1	6.2803	.7376
2	2	5.6472	.7218
2	3	5.4932	.7680
3	1	5.0427	.7594
3	2	6.1855	.7206
3	3	5.2138	.7235

Effect			Mean	Standard Deviation
Treatment by Trial Block				
1	A		5.9261	0.6243
1	B		6.6221	0.6243
2	A		5.0655	0.6332
2	B		6.5483	0.6332
3	A		4.9859	0.6332
3	B		5.9754	0.6332
Treatment by Skill by Trial Block				
1	1	1	7.7391	0.9994
1	1	2	8.1091	0.9994
1	2	1	4.9587	0.9345
1	2	2	5.7837	0.9345
1	3	1	5.0806	0.8819
1	3	2	5.9734	0.8819
2	1	1	5.7928	0.9471
2	1	2	6.7678	0.9471
2	2	1	4.4806	0.9349
2	2	2	6.8139	0.9349
2	3	1	4.9232	1.0066
2	3	2	6.0632	1.0066
3	1	1	4.4627	1.0001
3	1	2	5.6227	1.0001
3	2	1	6.1521	0.9340
3	2	2	6.2188	0.9340
3	3	1	4.3430	0.9361
3	3	2	6.0846	0.9361

Table A-12. ANOVA Results for Pre-Test and Retention Test- Form Scores

Effect	DF	DF	F -value	p-value
Skill Main Effect (A)	2	83	1.81	0.1705
Trial Block Main Effect (B)	1	83	6.77	0.0110
Treatment Main Effect (C)	2	83	1.29	0.2808
A x B	2	83	0.93	0.9153
A x C	4	83	2.22	0.0737
B x C	2	83	0.32	0.7264
A x B x C	2	95	0.27	0.7643

Table A-13. ANOVA Results for Skill Performance and Form Scores for the Transfer Test

Effect	DF	DF	F -value	p-value
Skill Performance Scores				
Treatment Main Effect	2	6	.63	.5624
Skill Main Effect	2	36	1.27	.2924
Treatment by Skill	4	36	.40	.8046
Form Scores				
Treatment Main Effect	2	39	1.13	.3325
Skill Main Effect	2	39	1.33	.2774
Treatment by Skill	4	39	1.21	.3219

Table A-14. Least Square Means and Standard Deviations for Transfer Test- Form Scores

Effect	Mean	Standard Deviation
Treatment Main Effect		
Control (A)	6.4190	0.6532
Guided Discovery (B)	6.5947	0.6160
Correct (C)	5.5024	0.6270
Skill Main Effect		
Higher (1)	6.9527	0.6735
Medium (2)	5.7859	0.6057
Lower (3)	5.7775	0.6426
Treatment by Skill Group Interaction		
A x 1	8.7092	1.1804
A x 2	5.4098	0.9843
A x 3	5.1380	0.9939
B x 1	6.7393	0.9969
B x 2	6.5342	0.9109
B x 3	6.5105	1.0653
C x 1	5.4095	1.0574
C x 2	5.4138	0.9844
C x 3	5.6841	0.9860

Table A-15. ANOVA Results for Cognitive Processes Questionnaire Subscales

Effect	DF	DF	F -value	p-value
Critical Thinking Construct				
Treatment	2	6	.57	.5930
Skill	2	35	1.39	.2632
Treatment by Skill	4	35	3.38	.0193
Self-Efficacy Construct				
Treatment	2	6	.16	.8530
Skill	2	35	.42	.6634
Treatment by Skill	4	35	.52	.7238
Prior Experience Construct				
Treatment	2	6	.29	.7569
Skill	2	35	.12	.8855
Treatment by Skill	4	35	1.81	.1490

Table A-16. Least Square Means and Standard Deviations for the Critical Thinking Subscale of the Cognitive Processes Questionnaire

Effect	Mean	Standard Deviation
Treatment Main Effect		
Control (A)	3.4476	0.1778
Guided Discovery (B)	3.6673	0.1849
Correct (C)	3.4093	0.1849
Skill Main Effect		
Higher (1)	3.7360	0.1793
Medium (2)	3.4350	0.1661
Lower (3)	3.3532	0.1717
Treatment by Skill Interaction		
A x 1	3.9328	0.3160
A x 2	2.8392	0.2735
A x 3	3.5709	0.2767
B x 1	3.3815	0.2994
B x 2	4.0083	0.2946
B x 3	3.6120	0.3190
C x 1	3.8937	0.3160
C x 2	3.4575	0.2944
C x 3	2.8767	0.2947

Table A-17. Least Square Means and Standard Deviations for the Self-Efficacy Subscale of the Cognitive Processes Questionnaire

Effect	Mean	Standard Deviation
Treatment Main Effect		
Control (A)	3.8917	0.2756
Guided Discovery (B)	4.0900	0.2841
Correct (C)	3.8927	0.2840
Skill Main Effect		
Higher (1)	4.1322	0.2557
Medium (2)	3.8726	0.2392
Lower (3)	3.8695	0.2471
Treatment by Skill Interaction		
A x 1	4.4199	0.4447
A x 2	3.7123	0.3954
A x 3	3.5429	0.4041
B x 1	4.0894	0.4392
B x 2	4.1121	0.4239
B x 3	4.0684	0.4538
C x 1	3.8872	0.4447
C x 2	3.7935	0.4230
C x 3	3.9973	0.4245

Table A-18. Least Square Means and Standard Deviations for the Prior Experience Subscale of the Cognitive Processes Questionnaire

Effect	Mean	Standard Deviation
Treatment Main Effect		
Control (A)	3.4369	0.2816
Guided Discovery (B)	3.2560	0.2886
Correct (C)	3.1373	0.2885
Skill Main Effect		
Higher (1)	3.3044	0.2495
Medium (2)	3.1953	0.2353
Lower (3)	3.3305	0.2430
Treatment by Skill Interaction		
A x 1	3.8830	0.4229
A x 2	2.8455	0.3834
A x 3	3.5823	0.3935
B x 1	3.2600	0.4292
B x 2	3.1362	0.4090
B x 3	3.3718	0.4346
C x 1	2.7702	0.4229
C x 2	3.6042	0.4075
C x 3	3.0375	0.4100

Table A-19. Frequency Count of Student Responses to Open-Ended Questionnaire by Skill for the Guided Discovery Group

	Day 2					Day 5				
Guided Higher-skilled	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
3					2			1		3
21					1		1		1	
39	2				1					2
43					1					1
46			2					1		1
47					2					
Total	2	0	2	0	7	0	1	1	1	7

	Day 2					Day 5				
Guided Medium-skilled	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
6					1					2
7	2	2							1	
14				1	1				2	
26	3	2	1		1					4
28	1	2	2					2		
33		3			1					
Total	6	9	3	1	4	0	0	2	3	6

	Day 2					Day 5				
Guided Lower-skilled	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
85					1					1
10					1				2	1
11		1		2					2	1
22	1	1			1		2			1
37	2	1				2				1
38					1					1
Total	3	3	0	2	4	2	2	0	4	6

Table A-20. Frequency Count of Student Responses to Open-Ended Questionnaire by Skill for the Correct Group

Correct-Higher Skilled	Day 2					Day 5				
	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
8	2					1		2		1
25	1				1	2				
34	1					3				
44									1	
49			4			1		1		1
Total	4	0	4	0	1	7	0	3	1	2

Correct Medium-Skilled	Day 2					Day 5				
	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
2		1	1		1	2		1		1
9					1	1	2			
12			3						1	
20									3	
24			1	2		1	1		1	
40		1		1			1			1
Total	0	2	5	3	2	4	4	1	5	2

Correct Lower-Skilled	Day 2					Day 5				
	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
1	2					1				2
5	1	1				1	1			
30	4	1				1	1			3
31	2	1							2	2
36										
52	5	2			1	1				3
Total	14	5	0	0	1	4	2	0	2	10

Table A-21. Frequency Count of Student Responses to Open-Ended Questionnaire by Skill for the Control Group

Control Higher-Skilled	Day 2					Day 5				
	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
16										1
27								2		
35			1							1
42		1								1
51	3					2	2			
Total	3	1	1	0	0	2	2	2	0	3

Control Medium-Skilled	Day 2					Day 5				
	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
17				1	1			2		5
19				1	1	2			2	
23				2						
32	1				1	2	1			
45									1	1
48			2		1			2		
54	1	1							2	2
Total	2	1	2	4	4	4	1	4	5	8

Control Lower-Skilled	Day 2					Day 5				
	TP	TS	SA	MS	CS	TP	TS	SA	MS	CS
4					1			1		2
13	2	2			2	3	3			
15	1		2					5	1	
18	2		1	3		1				
41				2					2	
29		3				1		2		1
53					2					1
Total	5	5	3	5	5	5	3	8	3	4

Yellow = focus on the target and aim
Blue = relax and concentrate
Green = frustrated

Table A-22. Frequency Count by Treatment for Day 2 of Student Responses to Open-Ended Questionnaire (Expected Chi-square Values in Parenthesis)

Treatment Group	Concept	Stress Management and focus	Degree of Effort or success	Technique Posture & grip	Technique Swing Mechanics	Totals
DAY 2						
Control	9 (8.9)	9 (4.8)	6 (6.4)	10 (12.5)	7 (8.3)	41
Correct	4 (9.0)	3 (4.8)	9 (6.4)	18 (12.5)	7 (8.3)	41
Guided Discovery	15 (10.1)	3 (5.4)	5 (7.2)	11 (14)	12 (9.3)	46
Totals	28	15	20	39	26	128

Table A-23. Frequency Count by Treatment for day 5 of Student Responses to Open-Ended Questionnaire (Expected Frequencies in Parenthesis)

Treatment Group	Concept	Stress Management And focus	Degree of Effort or success	Technique Posture & grip	Technique Swing Mechanics	Totals
DAY 5						
Control	15 (19.1)	8 (9.5)	14 (8.3)	11 (11.1)	6 (6.0)	54
Correct	14 (16.6)	8 (8.3)	4 (7.23)	15 (9.67)	6 (5.18)	47
Guided Discovery	19 (12.4)	8 (6.2)	3 (5.4)	2 (7.2)	3 (3.9)	35
Totals	48	24	21	28	15	136

Table A-24. Frequency Count by Skill for Day 2 of Student Responses to Open-Ended Questionnaire (Expected Chi-Square Values in Parenthesis)

Skill Group	Concept	Stress Management And focus	Degree of Effort or success	Technique Posture & grip	Technique Swing Mechanics	Totals
DAY 2						
Higher	8 (5.4)	0 (2.9)	7 (3.9)	9 (7.6)	1 (5.1)	25
Medium	10 (10.5)	8 (5.6)	10 (7.5)	8 (14.6)	12 (9.8)	48
Lower	10 (12.0)	7 (6.4)	3 (8.6)	22 (16.8)	13 (11.1)	55
Totals	28	15	20	39	26	128

Table 25. Frequency Count by skill for Day 5 of Student Responses to Open-Ended Questionnaire (Expected Frequencies in parenthesis)

Skill Group	Concept	Stress Management And focus	Degree of Effort or success	Technique Posture & grip	Technique Swing Mechanics	Totals
DAY 5						
Higher	12 (11.3)	2 (5.6)	6 (4.9)	9 (6.6)	3 (3.5)	32
Medium	16 (17.3)	13 (8.6)	47 (7.6)	8 (10.1)	5 (5.4)	49
Lower	20 (19.4)	9 (9.7)	8 (8.5)	11 (11.3)	7 (6.1)	55
Totals	48	24	21	28	15	136

APPENDIX B – SAS STATISTICAL PROGRAMS AND DATA

Skill Performance, Form, and Thought Processes Programs and Data (Acquisition and Learning Tests), Written Responses to Strategies Questionnaire, Chi-Square Programs, and Instrument Development Programs (Item Analysis, Exploratory Factor Analysis, Confirmatory Factor Analysis)

<u>SAS Program for Reliability of Skill Performance Score Data</u>

```
dm "output; clear; log; clear";
options ps=55 ls=78 pageno=1;


data outcome;
input ID teacher $ skill $ gender  $ condition $ a1 a2  a3  a4
a5  a6  a7  a8  a9  a10 a11  a12  a13  a14 a15  a16  a17  a18 a19  a20
;
datalines;

3    5    1    1    2    0    4    2    0    3    0    3    4
     3    3    0    0    4    3    5    0    3    3    0    4
8    9    1    1    3    3    1    0    0    0    4    3    5
     0    2    3    0    4    0    0    1    3    4    5    3
16   1    1    1    1    3    4    0    1    2    3    1    4
     3    3    4    3    0    3    0    0    0    0    0    3
21   6    1    0    2    2    0    3    1    1    2    1    2
     1    1    2    3    2    0    0    3    4    1    0    0
25   10   1    1    3    0    1    0    2    0    3    2    0
     4    0    2    5    0    4    4    1    2    0    0    0
27   2    1    1    1    4    0    3    3    2    5    4    3
     5    3    4    0    4    1    4    3    4    3    2    4
34   11   1    1    3    0    0    3    4    0    0    3    1
     0    0    3    4    0    0    0    3    2    0    5    2
35   3    1    0    1    0    4    3    4    2    4    3    3
     0    1    4    3    2    3    0    3    5    5    3    1
39   8    1    0    2    1    0    0    3    2    4    0    0
     0    4    2    3    1    2    0    4    0    0    0    4
42   4    1    1    1    5    3    0    1    2    4    4    4
     4    2    4    5    1    1    2    4    2    0    1    0
43   8    1    1    2    0    2    3    0    5    0    1    3
     4    1    4    3    4    4    2    4    0    4    3    0
44   12   1    1    3    4    2    1    2    2    2    4    4
     3    3    4    4    3    1    0    4    3    2    4    4
46   8    1    1    2    0    3    0    4    4    3    3    4
     3    5    3    3    4    0    2    4    4    3    0    3
47   8    1    1    2    2    0    0    1    0    4    4    2
     5    3    0    4    4    4    0    3    4    3    5    5
49   12   1    1    3    3    3    4    2    4    1    4    3
     0    4    4    4    4    4    1    3    5    4    0    4
51   1    1    1    1    0    1    3    1    0    3    4    1
     2    3    2    1    4    4    0    2    0    0    3    1
;

proc print data=outcome;
run;
data outcome2;
set outcome;
array a{20} a1-a20;
subject + 1;
do trialbk=1 to 20;
y=a{trialbk};
output;
end;
```

```
drop a1-a20;

*Program to assess reliability of the task using cs covariance modeling;
proc mixed data= outcome2 covtest method=reml;
class ID trialbk;
model y= trialbk;
repeated trialbk/ subject = ID type = cs;
Lsmeans trialbk;
```

SAS Program for Acquisition-Skill Performance Score Data

```
dm "output; clear; log; clear";
options ps=55 ls=78 pageno=1;
title1 "repeated measures data for golf dissertation study";

data outcome;
input ID section $ teacher $ skill $ gender $ trt $ a1 a2  a3  a4
a5  a6  a7  a8  a9  a10 a11  a12  a13  a14 a15  a16  a17  a18
a19  a20 b1 b2  b3  b4 b5  b6  b7  b8  b9  b10 c1 c2  c3  c4 c5  c6  c7  c8
c9  c10
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 f1 f2 f3 f4 f5
f6 f7 f8 f9 f10
g1 g2 g3 g4 g5 g6 g7 g8 g9 g10 h1  h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13
h14 h15 h16 h17 h18 h19 h20
i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 i11 i12 i13 i14 i15 i16 i17 i18 i19 i20;
datalines;

Data outcome2;
set outcome;
z1 = (b1 + b2 + b3 + b4 + b5 + b6 + b7 + b8 + b9 + b10)/10;
z2= (c1 + c2 + c3 + c4 + c5 + c6 + c7 +c8 + c9 + c10)/10;
z3= (d1 + d2 + d3 + d4 + d5 +d6 + d7 + d8 + d9 + d10)/10;
z4 = (e1 + e2 + e3 + e4 + e5 +e6 + e7 + e8 + e9 + e10)/10;
z5 = (f1 + f2 + f3 + f4 + f5 +f6 + f7 + f8 + f9 + f10)/10;
z6 = (g1 + g2 + g3 + g4 + g5 + g6 + g7 + g8 + g9 + g10)/10;
drop a1-a20;
drop b1-b10;
drop c1-c10;
drop d1-d10;
drop e1-e10;
drop f1-f10;
drop g1-g10;
drop h1-h20;
drop i1-i20;

Data outcome3;
set outcome2;
array z{6} z1-z6;
subject + 1;
do trialbk=1 to 6;
y=z{trialbk};
output;
end; drop z1-z6;
run;

title "appropriate practice acquisition";
proc mixed data=outcome3 covtest method = reml;
class trt section skill trialbk ID;
model y = trt skill trialbk trt*trialbk trialbk*skill  trt*skill*trialbk
trt*skill;
random section;
repeated trialbk/ subject = trt*skill type = cs;
lsmeans trt/pdiff adj = tukey;
run;
```

SAS Program for Learning (Pre- to Post-Test)-Skill Performance Score Data

```
dm "output; clear; log; clear";
data outcome;
input ID blk $ clss $ skill $ gender $ trt $ a1 a2  a3  a4
a5  a6  a7  a8  a9  a10 a11  a12  a13  a14 a15  a16  a17  a18
a19  a20 b1 b2  b3  b4 b5  b6  b7  b8  b9  b10 c1 c2  c3  c4 c5  c6  c7  c8
c9  c10
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 f1 f2 f3 f4 f5
f6 f7 f8 f9 f10
g1 g2 g3 g4 g5 g6 g7 g8 g9 g10 h1  h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13
h14 h15 h16 h17 h18 h19 h20
i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 i11 i12 i13 i14 i15 i16 i17 i18 i19 i20;
datalines;


data outcome2;
set outcome;
p1 = (a1 + a2 + a3 + a4 + a5 + a6 + a7 + a8 + a9 + a10 + a11 + a12 + a13 +
a14 + a15 + a16 + a17 + a18 + a19 + a20)/20;
p2 = (h1 + h2 + h3 + h4 + h5 + h6 + h7 + h8 + h9 + h10 + h11 + h12 + h13 +
h14 + h15 + h16 + h17 + h18 + h19 + h20)/20;
run;


* learning-validity test;
data outcome3;
set outcome2;
array p{2} p1-p2;
subject + 1;
do trialbk=1 to 2;
y=p{trialbk};
output;
end;
drop p1-p2;



proc mixed data= outcome3 covtest method=reml;
class blk trt skill trialbk;
model y= trt skill trialbk trt*trialbk skill*trialbk trt*skill*trialbk;
random blk ;
repeated trialbk/ subject = trt*skill type = cs;
lsmeans skill*trialbk/pdiff adj = tukey;
run;
```

SAS Program for Transfer Test - Form Score Data

```
dm "output; clear; log; clear";
options ps=55 ls=78 pageno=1;

data form;
input ID teacher $ skill $ gender $ trt $ bk $ a1 a2  a3  a4
a5  a6  a7  a8  a9  a10 a11  a12  a13  a14 a15  a16  a17  a18
a19  a20 b1 b2  b3  b4 b5  b6  b7  b8  b9  b10 c1 c2  c3  c4 c5  c6  c7  c8
c9  c10
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 f1 f2 f3 f4 f5
f6 f7 f8 f9 f10
g1 g2 g3 g4 g5 g6 g7 g8 g9 g10 h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14
h15 h16 h17 h18 h19 h20
i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 i11 i12 i13 i14 i15 i16 i17 i18 i19 i20;
datalines;

data form6;
set form;
z10 = (i1 + i2 + i3 + i4 + i5 + i6 + i7 + i8 + i9 + i10 + i11 + i12 + i13 +
i14 + i15 + i16 + i17 + i18 + i19 + i20)/20;
drop a1-a20;
drop b1-b10;
drop c1-c10;
drop d1-d10;
drop e1-e10;
drop f1-f10;
drop g1-g10;
drop h1-h20;
drop i1-i20;
run;

*proc mixed anova for transfer test form data;
title "transfer data-concept scores";

class ID trt skill bk;
model z10 = trt skill trt*skill;
random bk bk*trt;
lsmeans trt*Skill/pdiff;
                                     run;
```

<u>Skill Performance Data</u>

1	1	9	3	1	3	1	0	0	0	1	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	1	0	0	2	0	0	0	0	2	0
	3		3	2	0	0	3	3	0	1	0	0	1
	0		0	0	0	0	2	0	0	0	0	0	2
	0		0	2	0	0	0	0	0	2	3	0	0
	3		3	3	0	2	0	2	0	4	3	3	0
	4		3	1	0	2	4	0	2	1	1	4	2
	1		1	0	2	2	5	3	3	0	0	0	0
	5		0	0	0	0	0	0	1	0	0	0	0
	0		4	1	0								
2	1	9	2	0	3	4	0	0	0	0	0	0	2
	3		3	0	2	0	0	0	1	0	3	2	0
	2		3	3	0	0	1	0	0	1	0	.	.
	.		.	.	.	.	.	.	.	0	0	0	0
	2		2	1	0	1	4	1	3	0	2	0	2
	1		1	0	4	0	0	0	0	0	0	0	0
	0		0	.	.	.	.	.	.	.	.	.	.
	1		3	0	0	0	2	0	0	0	2	0	1
	3		1	0	0	4	1	0	0	3	3	0	0
	0		1	4	1	0	1	0	3	0	0	0	0
	1		2	0	0								
3	1	5	1	1	2	0	4	2	0	3	0	3	4
	3		3	0	0	4	3	5	0	3	3	0	4
	0		4	0	0	3	0	0	1	0	1	5	1
	3		0	3	3	4	2	3	2	0	0	3	0
	0		3	4	0	0	0	0	2	3	0	2	2
	0		3	1	3	1	1	0	0	0	0	0	0
	3		1	1	1	0	0	0	0	0	0	3	1
	1		0	0	1	5	1	0	3	4	4	0	0
	3		2	1	0	3	5	0	0	0	0	0	0
	1		1	0	0	1	0	0	0	0	0	2	0
	0		4	1	0								
4	1	1	3	1	1	0	0	0	0	0	0	0	0
	0		1	0	4	0	0	0	3	0	0	0	0
	3		0	0	2	4	4	0	0	0	0	0	0
	0		0	0	0	0	0	0	4	0	0	0	0
	2		2	0	0	0	0	0	1	0	3	0	0
	3		0	0	2	0	4	4	3	4	0	4	4
	4		2	4	4	0	4	3	0	0	0	3	3
	3		4	0	5	0	3	0	4	2	0	3	0
	4		5	0	0	1	3	0	0	0	0	0	0
	2		5	0	0	0	4	3	0	0	5	3	3
	0		3	0	0								
5	1	9	3	1	3	0	0	0	0	0	0	0	0
	1		0	0	0	0	0	0	0	0	0	4	0
	0		4	1	1	1	3	0	1	4	0	0	0
	0		4	0	0	0	0	0	0	0	0	3	2
	0		0	0	1	1	3	0	1	0	3	1	0
	0		0	0	0	1	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	3	0	5	1	3	0	0	0	0
	0		0	0	0	0	0	0	2	2	0	1	0

	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0								
6	1	5	2	0	2	1	0	0	0	0	2	2	0
	3		3	0	0	3	0	1	2	0	0	0	1
	0		0	2	0	0	0	0	0	0	2	4	0
	0		0	0	0	0	0	0	4	0	0	1	2
	3		0	0	0	5	4	0	0	1	0	3	0
	0		3	0	0	4	0	0	0	0	0	0	0
	0		0	4	0	0	0	0	0	0	0	0	0
	5		2	0	2	1	0	3	0	4	0	0	0
	2		4	0	2	0	4	2	3	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0								
7	1	5	2	1	2	0	0	0	0	4	0	3	5
	0		0	3	0	3	2	2	3	0	0	0	0
	3		4	4	4	3	3	0	4	3	0	0	0
	0		0	0	0	0	1	5	4	0	0	3	0
	0		1	0	0	0	0	.	.	.	.	.	.
	.		.	.	.	0	0	3	0	0	0	0	1
	0		0	0	0	3	0	0	0	0	1	0	0
	1		0	5	0	0	0	0	0	3	1	4	0
	0		3	4	0	2	0	3	2	1	0	0	0
	0		3	0	0	0	0	0	0	0	0	4	0
	0		0	4	4								
8	1	9	1	1	3	3	1	0	0	0	4	3	5
	0		2	3	0	4	0	0	1	3	4	5	3
	4		4	3	3	0	3	4	0	3	0	0	2
	1		3	4	4	0	0	2	2	2	1	1	5
	4		1	4	0	3	0	2	0	0	4	5	3
	5		1	0	1	5	1	0	1	0	4	0	0
	0		2	3	1	3	2	3	0	0	0	4	2
	4		2	0	1	0	5	4	4	4	2	4	3
	0		0	0	0	3	4	1	3	0	0	1	5
	0		1	0	5	1	0	0	0	0	0	0	0
	0		0	1	1								
9	1	9	2	1	3	0	1	2	1	0	0	2	2
	1		3	0	0	1	2	1	2	4	0	0	2
	4		1	3	2	3	2	4	4	1	1	2	2
	5		4	4	5	4	4	4	3	3	2	2	4
	3		4	3	5	5	4	2	3	5	0	4	4
	3		4	4	3	1	5	3	1	4	4	3	5
	4		5	4	5	2	3	4	4	5	4	4	3
	4		4	4	2	5	5	5	4	4	4	4	5
	2		5	5	4	4	4	4	4	0	4	0	2
	3		4	4	5	2	3	4	2	3	4	4	5
	5		3	3	5								
10	1	5	3	1	2	0	0	0	0	0	0	4	0
	0		0	0	1	0	0	4	0	0	0	0	0
	0		0	0	3	4	2	0	0	0	0	0	0
	4		0	0	0	0	5	0	0	3	0	0	0
	0		2	0	3	0	0	0	3	0	0	0	2
	0		0	2	0	0	2	0	1	3	0	0	0
	0		1	0	2	0	1	3	0	0	0	0	1
	0		0	0	0	3	1	0	0	1	2	3	0
	2		0	0	0	2	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0								

11	1	5	3	1	2	0	0	0	0	0	0	0	2
	0		0	0	0	2	0	0	0	0	0	0	0
	0		0	0	2	0	1	3	2	0	0	0	0
	0		1	0	0	2	0	3	0	0	0	5	0
	0		0	0	0	0	0	0	0	2	3	0	0
	0		0	0	0	0	0	0	0	0	2	4	0
	0		0	0	0	0	0	0	2	4	0	0	0
	0		0	0	0	2	0	0	0	0	0	0	0
	0		4	0	0	0	2	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		3	1	0								
12	1	9	2	1	3	0	2	1	2	0	0	1	1
	0		0	0	0	3	3	1	0	1	3	0	0
	0		0	0	0	0	0	0	1	0	0	0	0
	3		2	0	3	4	0	0	1	0	0	0	0
	0		0	0	0	0	2	0	0	0	0	3	0
	0		0	0	0	0	1	2	0	4	0	0	0
	0		0	0	0	0	1	0	0	2	0	0	0
	0		0	0	1	0	0	0	0	0	0	0	0
	0		1	0	0	0	0	1	1	0	1	0	0
	4		0	0	0	1	0	0	0	0	0	0	0
	0		0	0	0								
13	1	1	3	0	1	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		3	0	0	0	0	0	0	3	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	1	0	0	0	0	0	0	0	0	0
	0		0	0	0	3	0	0	0	0	0	3	0
	0		0	0	3	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0								
14	1	5	2	0	2	3	0	1	0	1	3	0	0
	0		0	0	0	4	0	0	0	4	0	0	1
	0		4	0	0	3	2	0	0	1	0	0	0
	0		0	0	0	3	0	0	1	3	0	0	0
	0		0	0	0	0	1	0	0	0	3	4	0
	0		3	3	0	0	3	2	0	1	0	0	4
	2		0	0	3	2	0	1	0	0	4	2	0
	2		3	0	0	0	0	0	0	0	4	1	2
	0		0	2	0	0	5	3	0	3	0	0	0
	0		0	0	0	0	0	0	0	0	4	0	3
	4		5	0	0								
15	1	1	3	0	1	0	0	0	0	0	0	0	3
	0		0	0	0	0	0	0	0	0	0	0	2
	0		0	2	2	0	0	3	0	0	0	0	0
	0		0	0	1	0	0	0	0	0	0	1	0
	0		0	0	3	0	0	3	3	4	0	0	0
	0		0	0	0	0	0	0	0	0	3	0	0
	0		0	.	.	.	.	.	.	.	.	.	.
	0		3	0	0	2	1	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	0
	0		0	0	0								
16	1	1	1	1	1	3	4	0	1	2	3	1	4
	3		3	4	3	0	3	0	0	0	0	0	3

	4	1	3	4	2	0	0	2	4	3	3	0
	3	1	1	1	4	5	4	0	0	4	0	2
	1	2	0	0	5	4	2	3	1	2	5	2
	4	4	3	4	0	5	0	2	3	2	2	4
	5	2	0	3	0	4	3	2	3	0	4	3
	4	4	0	2	2	4	2	3	3	4	4	0
	3	2	2	2	2	3	4	2	0	1	0	4
	0	4	3	2	4	1	0	0	1	0	4	0
	4	2	2	5								
17	2	2 2	0	1	0	0	0	0	1	0	1	0
	0	0	0	1	2	3	2	1	2	0	3	3
	0	0	0	0	0	0	0	4	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	2	1	0	1	0	2	0	0	1	0	0
	1	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	3	0	1	0	0	2	2
	0	2	3	0	0	5	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	3	0
	0	2	1	0								
18	1	1 3	0	1	1	1	4	0	0	2	1	0
	0	0	0	0	0	3	0	2	0	0	0	0
	0	0	2	1	0	3	1	0	0	0	0	0
	0	2	1	0	0	2	3	0	0	1	3	0
	0	0	2	1	1	0	1	3	2	3	0	2
	1	3	0	0	0	2	0	1	1	0	3	0
	0	0	1	0	0	0	0	0	0	2	1	2
	0	0	0	2	0	0	1	0	1	0	0	2
	0	0	3	3	2	3	0	0	0	0	0	0
	0	0	0	0	0	0	0	4	0	3	0	1
	0	0	0	0								
19	2	2 2	1	1	2	3	1	2	1	0	4	2
	0	0	0	3	1	2	0	3	1	0	0	0
	0	1	1	0	0	0	0	0	0	0	0	0
	1	2	4	4	2	0	0	0	3	0	1	2
	0	1	2	0	0	0	0	4	5	1	4	2
	0	3	3	4	4	0	1	3	0	0	4	0
	3	2	3	0	5	1	0	0	0	0	0	3
	0	0	2	0	5	3	0	3	0	0	3	3
	1	3	4	0	3	0	0	4	0	0	0	0
	0	0	0	1	2	0	0	0	0	3	0	0
	0	0	0	2								
20	2	10	2	1	3	0	0	0	0	0	0	0
	2	0	0	1	3	3	3	0	1	2	0	0
	2	3	2	2	4	2	3	0	1	0	0	4
	3	2	5	4	2	0	0	5	2	.	.	.
	.	.	.	.	.	.	.	2	0	3	1	4
	1	5	4	0	2	0	0	3	4	4	2	3
	3	0	2	0	0	0	0	0	2	2	3	3
	3	0	0	4	0	2	3	3	0	3	0	0
	1	0	0	0	3	0	0	0	0	0	0	0
	0	1	0	1	0	0	0	0	0	0	0	0
	0	0	0	3	0							
21	2	6 1	0	2	2	0	3	1	1	2	1	2
	1	1	2	3	2	0	0	3	4	1	0	0
	.	.	.	.	.	.	.	.	.	.	0	0
	0	0	0	2	0	0	0	2	3	0	0	4

	0		0	0	3	0	0	0	1	1	0	0	3
	3		5	1	4	0	2	0	3	0	0	0	0
	0		2	0	0	2	1	0	0	2	2	3	1
	0		2	1	4	1	1	3	2	3	4	3	2
	4		4	0	0	1	0	1	0	3	1	0	0
	0		2	2	2	4	0	1	0	2	0	2	0
	3		0	0	2								
22	2	6	3	1	2	2	3	0	0	0	0	0	0
	0		0	0	0	0	0	0	0	0	0	0	2
	0		0	3	1	1	1	1	1	0	3	0	4
	3		0	0	1	2	0	1	3	2	0	3	4
	0		0	2	2	0	2	3	2	3	4	1	2
	2		5	4	5	0	5	4	4	3	0	5	2
	0		4	3	2	4	3	4	3	3	2	2	0
	3		3	4	0	3	4	4	2	4	3	4	3
	3		3	4	1	4	3	4	2	4	4	2	2
	2		1	1	3	0	2	1	0	2	1	0	0
	2		1	0	0								
23	2	2	2	1	1	0	0	0	1	0	4	3	0
	0		2	0	0	0	0	0	0	4	0	1	2
	0		0	1	0	0	0	0	0	0	0	3	0
	0		0	3	0	0	2	0	0	0	0	0	2
	2		0	0	3	0	3	0	0	0	2	0	0
	0		0	3	0	.	.	.	.	.	.	.	.
	.		.	5	4	0	0	3	2	3	4	0	4
	0		0	0	0	0	1	0	3	0	0	0	0
	0		0	3	0	0	0	0	0	1	0	0	0
	0		0	3	3	0	2	0	0	2	0	0	1
	0		2	0	0								
24	2	10		2	1	3	4	2	0	0	1	4	3
	3		2	1	0	3	4	2	3	3	0	0	2
	4		2	3	0	3	2	2	0	0	2	1	0
	1		0	2	1	0	2	0	2	0	0	0	1
	0		1	0	0	1	3	0	2	0	4	0	3
	0		1	1	2	0	2	0	1	1	3	3	0
	1		0	0	4	0	1	3	0	0	3	0	3
	0		1	4	4	3	1	3	1	4	3	4	4
	1		4	3	1	1	2	3	2	3	0	1	3
	3		0	0	3	1	0	0	4	5	2	1	5
	2		0	0	0	0							
25	2	10		1	1	3	0	1	0	2	0	3	2
	0		4	0	2	5	0	4	4	1	2	0	0
	0		4	0	5	0	2	2	3	4	0	3	2
	0		0	4	0	2	4	2	0	0	3	3	1
	0		4	1	0	4	3	1	0	2	0	0	0
	0		3	4	0	0	0	3	3	4	0	0	4
	0		2	4	2	3	0	4	0	0	4	0	0
	1		3	0	4	0	1	0	3	4	2	0	4
	4		0	3	0	4	2	4	0	2	0	1	4
	4		0	4	4	2	0	0	0	4	0	0	3
	0		0	3	0	3							
26	2	6	2	1	2	0	0	0	0	0	2	0	0
	3		4	0	3	4	1	2	2	2	4	0	0
	0		1	3	0	3	2	2	0	0	4	0	0
	0		4	4	3	0	0	3	3	2	0	0	0
	1		1	0	2	0	0	0	0	0	0	1	2
	0		3	2	0	0	2	0	0	0	3	0	2

	3	0	0	2	3	3	0	0	0	3	2	4
	4	4	3	4	2	0	4	1	0	3	0	1
	0	4	2	1	0	1	2	0	3	0	0	2
	0	2	1	0	3	0	5	2	0	3	2	0
	2	0	0	3								
27	2	2 1	1	1	4	0	3	3	2	5	4	3
	5	3	4	0	4	1	4	3	4	3	2	4
	2	4	0	4	4	2	2	5	4	2	5	3
	1	3	4	2	3	4	2	1	.	.	.	.
	.	.	.	.	.	.	3	0	5	3	5	2
	4	0	2	3	3	4	4	3	0	3	0	4
	4	1	3	3	5	3	4	4	3	2	5	0
	3	4	3	1	2	3	2	4	0	0	4	4
	3	1	5	4	4	3	0	4	4	0	0	0
	0	0	0	2	0	2	4	0	3	4	5	4
	0	0	0	0								
28	2	6 2	1	2	0	0	0	2	1	0	2	0
	1	1	2	0	0	1	0	3	0	2	0	3
	0	0	1	0	2	0	0	0	0	0	4	1
	0	0	0	0	4	0	0	3	2	2	0	1
	3	4	0	0	4	0	3	2	0	0	2	2
	0	2	2	3	0	4	2	5	1	4	3	0
	0	4	.	.	.	.	.	.	.	.	.	.
	1	0	0	0	0	4	3	0	4	0	2	3
	0	0	0	0	2	0	0	0	2	0	2	4
	2	0	0	0	2	1	3	3	4	4	0	3
	2	2	0	0								
29	3	3 3	1	1	1	0	1	4	0	0	0	1
	0	1	0	1	0	2	0	0	0	0	1	0
	0	0	0	0	0	0	0	4	0	0	0	0
	0	0	0	4	0	0	0	0	1	0	0	3
	0	1	4	1	0	4	2	0	0	1	2	1
	3	0	3	0	1	0	1	0	0	1	3	0
	1	0	1	0	2	4	0	2	4	0	0	0
	0	0	0	0	4	1	4	0	4	1	3	3
	0	4	2	3	0	1	2	0	1	0	0	0
	0	0	0	0	0	3	0	0	3	1	1	2
	5	0	3	5								
30	3	11	3	0	3	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	3	0	2	0
	0	3	0	0	3	3	0	0	2	0	0	0
	0	0	0	0	0	0	0	0	2	0	0	1
	3	0	0	2	0	0	0	.	.	.	.	.
	.	.	.	.	.	0	0	0	0	1	0	4
	0	0	0	.	.	.	.	.	.	.	.	.
	.	0	0	0	0	0	0	0	0	0	0	0
	0	1	0	4	0	1	4	0	0	0	0	0
	0	1	0	0	0	0	0	0	0	1	0	0
	0	0	0	0	0							
31	3	11	3	1	3	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	1	1	0	0	0
	0	0	0	0	0	2	1	0	0	3	2	4
	0	0	0	0	4	0	0	0	2	0	0	1
	0	0	3	2	0	2	0	0	2	3	2	0
	0	0	0	0	0	1	2	3	0	0	2	0
	0	0	3	0	0	0	1	0	0	1	1	0
	4	0	0	0	0	0	1	0	0	0	2	0

	0	4	4	4	0	0	0	3	0	0	3	0
	2	0	0	4	2	0	0	0	0	1	0	0
	4	1	0	0	0							
32	3	3 2	1	1	0	0	0	0	0	5	0	0
	1	0	0	0	2	0	0	3	3	1	2	0
	1	0	0	0	0	0	0	0	0	0	0	3
	0	2	0	2	0	0	2	0	0	1	4	0
	4	2	0	5	0	1	0	0	0	0	2	0
	0	0	0	3	1	1	0	3	0	0	1	4
	3	3	.	.	.	.	.	.	.	.	.	.
	0	3	4	0	0	0	4	2	4	3	3	2
	2	3	3	3	0	0	0	0	0	0	0	0
	1	0	0	0	2	0	0	3	0	0	0	0
	0	0	0	0								
33	3	7 2	1	2	0	0	3	4	0	0	0	1
	0	0	0	0	4	3	0	0	0	0	3	2
	0	0	4	3	0	0	0	0	1	0	0	0
	1	0	0	4	0	1	0	2	0	0	0	4
	0	0	0	0	0	0	0	0	0	2	0	4
	0	0	3	4	0	4	0	3	0	0	0	2
	0	0	0	1	0	0	1	2	0	1	0	0
	0	0	2	1	0	3	2	0	0	0	3	1
	3	0	0	2	0	4	4	0	0	1	0	0
	2	1	0	0	0	0	0	0	0	0	0	0
	0	0	0	0								
34	3	11	1	1	3	0	0	3	4	0	0	3
	1	0	0	3	4	0	0	0	3	2	0	5
	2	0	0	0	0	1	0	4	0	0	2	0
	0	0	0	0	5	0	0	2	4	0	2	2
	2	0	0	0	0	0	0	0	0	0	0	2
	1	0	0	0	0	0	1	4	0	4	4	2
	0	3	0	0	0	3	0	0	0	0	4	1
	0	0	0	1	0	0	0	0	3	0	0	0
	0	0	0	0	0	0	2	0	0	0	2	1
	0	0	0	0	0	0	0	0	0	0	0	0
	0	1	0	0	1							
35	3	3 1	0	1	0	4	3	4	2	4	3	3
	0	1	4	3	2	3	0	3	5	5	3	1
	2	0	5	0	0	0	0	3	4	0	0	4
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	1
	0	0	0	0	1	0	0	0	0	2	0	0
	0	0	0	0	0	0	0	2	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0								
36	3	11	3	0	3	2	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	2	0	0	2
	0	0	0	4	0	0	0	1	2	0	0	0
	0	0	0	0	0	0	0	0	2	.	.	.
	.	.	.	.	.	.	.	2	0	0	0	0
	0	0	3	2	0	0	4	0	0	0	0	2
	0	0	0	0	3	0	4	0	0	0	0	2
	0	0	0	0	3	3	4	4	2	2	3	0
	0	2	0	0	4	2	3	3	1	0	0	0

	0	0	0	0	0	0	0	0	0	0	1	0
	0	0	0	0	0							
37	3	4 3	0	2	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	3	1	0	0
	3	0	2	2	0	0	0	0	0	0	2	0
	0	0	3	1	1	0	2	0	2	0	3	0
	0	0	0	0	1	2	.	.	.	.	.	.
	.	.	.	.	0	1	0	0	0	0	0	4
	2	0	0	0	0	0	0	0	0	0	4	1
	0	1	2	2	0	0	2	0	0	0	0	0
	3	3	0	0	2	4	2	0	0	0	0	0
	3	4	0	0	0	3	0	0	0	0	0	0
	2	0	0	0								
38	3	7 3	1	2	0	0	1	0	0	0	0	3
	0	0	0	0	0	0	0	0	0	0	0	0
	0	4	4	4	0	0	1	5	0	4	2	3
	0	3	4	4	0	1	3	4	0	3	1	0
	5	4	4	3	0	4	0	4	3	5	0	3
	3	4	4	3	0	0	0	1	0	4	0	0
	0	0	0	2	3	3	4	3	4	2	0	3
	3	2	4	0	4	4	2	3	2	0	1	1
	2	1	5	2	2	4	0	3	0	1	0	2
	0	5	4	3	0	1	1	4	0	3	3	2
	3	0	5	4								
39	4	8 1	0	2	1	0	0	3	2	4	0	0
	0	4	2	3	1	2	0	4	0	0	0	4
	3	1	4	3	4	0	3	3	0	3	1	3
	0	0	0	4	1	0	2	3	2	2	0	3
	1	2	3	4	2	3	4	3	2	3	4	1
	0	4	4	1	1	2	2	2	3	4	3	1
	2	0	0	4	4	1	1	0	2	2	1	3
	5	1	1	3	4	4	0	1	4	3	3	0
	3	0	0	1	0	2	0	2	0	0	0	1
	2	1	1	0	0	0	4	1	3	0	3	0
	0	2	4	1								
40	4	12	2	1	3	0	0	0	3	0	2	1
	2	0	0	4	4	1	4	0	0	2	3	0
	0	0	5	0	0	0	3	0	2	4	0	1
	1	3	2	2	0	0	2	1	0	1	3	2
	2	0	0	0	1	1	1	2	0	4	0	0
	3	0	0	0	0	4	0	1	0	0	0	0
	2	0	0	3	3	0	0	1	0	0	5	0
	4	3	0	4	0	0	2	0	2	0	0	3
	3	0	4	1	2	0	0	5	2	0	3	0
	0	0	1	3	3	1	0	2	1	0	0	0
	0	0	0	0	0							
41	4	4 3	1	1	2	0	0	0	0	0	0	0
	2	0	0	1	0	0	3	0	3	0	0	0
	3	0	0	4	4	4	0	0	0	2	0	0
	4	1	0	0	3	0	0	4	0	0	0	0
	2	1	0	0	0	0	0	0	1	0	2	4
	1	1	2	0	0	2	4	0	0	0	0	4
	1	0	2	0	1	3	0	1	3	0	3	0
	3	0	3	0	0	0	0	0	1	1	0	0
	0	0	0	0	0	0	0	1	1	0	2	0
	0	1	2	0	2	0	0	0	0	0	0	0
	0	3	0	0								

42	4	4	1	1	1	5	3	0	1	2	4	4	4
	4		2	4	5	1	1	2	4	2	0	1	0
	0		0	2	0	4	3	0	0	4	4	5	5
	3		0	0	0	0	0	2	4	0	0	3	0
	3		5	4	4	0	3	0	0	0	4	3	3
	1		3	4	1	1	0	0	2	0	3	3	4
	0		4	4	3	3	4	3	4	4	3	5	0
	4		5	0	5	0	2	1	0	0	3	4	4
	3		4	5	4	5	4	3	4	5	0	2	1
	3		3	2	1	0	0	0	1	0	0	0	0
	2		0	1	0								
43	4	8	1	1	2	0	2	3	0	5	0	1	3
	4		1	4	3	4	4	2	4	0	4	3	0
	1		4	3	1	1	3	0	4	3	4	1	0
	1		5	5	2	4	0	1	4	1	1	4	4
	3		2	4	4	3	2	3	3	2	5	4	3
	4		3	2	4	4	3	1	3	3	5	4	4
	3		0	5	2	4	3	4	4	1	4	3	5
	4		1	1	4	4	4	4	4	4	4	4	4
	4		4	4	1	4	3	1	4	3	0	1	3
	1		1	4	1	3	4	3	4	2	4	3	3
	2		1	3	3								
44	4	12		1	1	3	4	2	1	2	2	2	4
	4		3	3	4	4	3	1	0	4	3	2	4
	4		3	0	4	4	0	0	0	3	0	4	0
	4		0	4	3	3	4	0	3	4	.	.	.
	.		.	.	.	.	.	.	0	0	0	0	0
	0		0	0	0	0	2	1	3	0	0	0	3
	3		2	2	0	2	2	4	0	2	0	0	0
	2		0	0	0	0	0	2	0	0	3	0	0
	3		0	0	0	0	3	0	0	0	3	0	3
	0		0	0	0	0	0	0	0	0	0	0	3
	0		0	0	0	0							
45	4	4	2	1	1	4	1	1	1	0	0	2	4
	3		4	0	3	0	0	1	0	3	0	1	0
	5		3	3	0	3	2	2	4	4	0	2	2
	3		1	5	1	0	0	4	4	.	.	.	.
	.		.	.	.	.	.	4	1	3	4	4	2
	4		4	4	3	3	0	1	4	4	5	3	3
	5		2	3	4	0	5	4	4	5	5	4	5
	0		5	3	3	2	3	3	2	3	4	4	2
	5		3	5	3	1	0	4	5	0	5	3	1
	0		2	0	4	5	4	4	4	3	4	0	1
	2		4	4	2								
46	4	8	1	1	2	0	3	0	4	4	3	3	4
	3		5	3	3	4	0	2	4	4	3	0	3
	2		0	3	4	4	4	1	3	4	2	2	4
	3		2	3	2	4	4	2	4	4	3	2	3
	3		4	2	5	4	4	3	4	4	0	0	4
	2		0	3	3	0	2	3	4	4	5	0	4
	3		3	1	3	2	2	2	2	0	1	0	0
	0		3	3	5	3	5	5	1	3	5	0	3
	0		2	1	4	3	2	4	1	0	2	0	2
	0		0	3	0	0	3	0	0	2	1	0	0
	0		1	0	0								
47	4	8	1	1	2	2	0	0	1	0	4	4	2
	5		3	0	4	4	4	0	3	4	3	5	5

	3	2	0	2	1	2	3	0	3	4	3	2
	0	2	2	5	2	3	5	4	0	0	0	2
	0	3	4	0	0	2	5	0	3	4	4	4
	4	3	3	2	2	2	0	0	1	4	2	4
	2	2	1	3	1	4	4	3	0	3	4	3
	3	4	4	3	4	1	4	1	2	1	4	4
	3	1	5	4	0	4	4	2	2	0	3	4
	4	2	1	0	4	1	0	1	0	3	2	0
	0	3	4	5								
48	4	4 2	1	1	0	2	0	0	0	0	0	0
	0	1	3	3	2	0	1	2	0	4	0	0
	0	0	3	0	2	3	0	0	0	2	0	0
	2	0	2	0	0	1	3	0	2	0	0	0
	0	0	0	2	2	2	0	4	3	2	1	0
	4	0	0	1	0	1	4	0	0	3	1	0
	0	0	.	.	.	.	.	.	.	.	.	.
	2	0	3	0	0	3	2	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	2	0	0	0	0	0	0	0	0	0	0
	0	0	0	0								
49	4	12	1	1	3	3	3	4	2	4	1	4
	3	0	4	4	4	4	4	1	3	5	4	0
	4	3	2	3	3	2	4	3	4	5	4	.
	.	.	.	.	.	.	.	.	.	2	0	0
	0	0	0	0	0	0	0	4	3	4	3	2
	2	0	0	1	0	4	5	3	2	4	4	2
	0	1	0	4	4	2	3	2	4	0	4	4
	3	0	4	5	3	4	2	1	4	4	3	2
	3	3	4	4	4	3	4	4	5	1	3	0
	1	3	3	1	0	3	3	2	3	2	2	4
	4	2	3	5	1							
51	1	1 1	1	1	0	1	3	1	0	3	4	1
	2	3	2	1	4	4	0	2	0	0	3	1
	0	1	0	4	3	3	2	0	4	2	2	3
	0	4	4	0	3	0	2	3	2	2	3	3
	3	3	0	0	5	4	2	3	1	2	2	3
	3	5	3	1	3	5	5	2	3	5	0	2
	3	3	.	.	.	.	.	.	.	.	.	.
	2	0	0	1	0	1	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0
	0	2	0	0	0	0	1	0	0	0	0	0
	0	0	0	0								
53	3	3 3	0	1	0	0	0	0	1	2	0	0
	0	0	0	0	0	0	0	0	0	0	0	1
	0	0	0	0	0	0	4	0	0	0	0	4
	0	0	0	0	0	0	0	0	0	0	2	0
	0	0	1	0	0	1	3	1	1	0	0	0
	0	0	2	0	2	0	0	0	0	0	3	1
	2	0	0	0	2	0	0	0	0	0	0	0
	0	0	0	4	1	1	0	3	0	1	5	2
	2	0	1	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	1	0	0	0	0
	0	0	3	0								
54	3	3 2	0	1	4	1	0	0	0	1	0	3
	3	0	0	1	0	0	0	0	0	4	0	0
	1	0	0	3	0	0	0	0	3	0	0	1
	0	2	2	0	4	0	0	2	0	0	4	0

	0	4	0	1	2	3	3	1	0	5	1	0
	0	3	2	0	3	3	4	3	3	3	0	0
	4	0	.	.	.	.	.	.	.	.	.	.
	0	3	0	0	0	3	0	0	0	0	0	0
	2	0	0	0	0	0	0	2	0	0	0	0
	0	0	0	0	0	0	0	3	0	0	2	0
	0	0	0	4								
55	4	12	3	1	3	0	0	0	0	0	4	0
	0	3	0	3	0	0	0	0	0	0	0	0
	0	4	3	0	0	0	0	0	2	0	0	.
	.	.	.	.	.	.	.	.	.	1	3	3
	2	4	0	1	3	0	3	0	2	0	0	0
	1	4	0	3	4	0	4	0	3	0	4	0
	0	0	4	1	0	3	1	0	4	3	4	0
	0	3	0	0	3	4	0	0	1	0	3	3
	2	3	0	2	3	0	0	3	3	0	0	4
	3	0	1	0	3	0	1	0	0	0	0	1
	2	2	1	3	0							
85	4	8 2	1	2	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.
	0	3	3	0	2	0	2	0	2	4	0	0
	0	3	3	0	1	0	1	5	4	3	0	0
	2	0	1	2	4	4	.	.	.	.	.	.
	.	.	.	.	0	0	1	0	3	4	1	0
	0	0	0	2	4	4	3	3	1	3	1	0
	0	0	0	2	1	0	0	0	2	0	0	0
	0	0	0	0	1	0	0	0	0	0	0	0
	2	0	4	2	4	2	0	0	4	0	0	0
	0	0	0	0								

;

SAS Program for Learning (Pre- to Post-Test)-Form Score Data

```
dm "output; clear; log; clear";
options ps=55 ls=78 pageno=1;

data form;
input ID teacher $ skill $ gender $ trt $ bk $ a1 a2  a3  a4
a5  a6  a7  a8  a9  a10 a11  a12  a13  a14 a15  a16  a17  a18
a19  a20 b1 b2  b3  b4 b5  b6  b7  b8  b9  b10 c1 c2  c3  c4 c5  c6  c7  c8
c9  c10
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 f1 f2 f3 f4 f5
f6 f7 f8 f9 f10
g1 g2 g3 g4 g5 g6 g7 g8 g9 g10 h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14
h15 h16 h17 h18 h19 h20
i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 i11 i12 i13 i14 i15 i16 i17 i18 i19 i20;

datalines;


Data form4;
set form;
t1 = (a1 + a2 + a3 + a4 + a5 + a6 + a7 + a8 + a9 + a10 + a11 + a12 + a13 +
a14 + a15 + a16 + a17 + a18 + a19 + a20)/20;
t2 = (h1 + h2 + h3 + h4 + h5 + h6 + h7 + h8 + h9 + h10 + h11 + h12 + h13 +
h14 + h15 + h16 + h17 + h18 + h19 + h20)/20;
drop a1-a20;
drop b1-b10;
drop c1-c10;
drop d1-d10;
drop e1-e10;
drop f1-f10;
drop g1-g10;
drop h1-h20;
drop i1-i20;
run;

title "validity, comparing pre and post (retention) for form data";
*setting data for comparing learning from pre to post test-univariate data
set;
data form5;
set form4;
array t{2} t1-t2;
subject + 1;
do trialbk=1 to 2;
y=t{trialbk};
output;
end;
drop t1-t2;
run;

*repeated measures anova for pre vs post test form data;

title "pre-post appropriate form data";

proc mixed data= form5 covtest method=reml;
class ID trt skill trialbk bk;
```

```
model y= skill trt trialbk trt*trialbk skill*trt trialbk*skill
trialbk*skill*trt;
random bk;
repeated trialbk/ subject = trt*skill type = cs;
lsmeans skill *trialbk;

run;
```

SAS Program for Acquisition- Form Score Data

```
dm "output; clear; log; clear";
options ps=55 ls=78 pageno=1;

data form;
input ID teacher $ skill $ gender $ trt $ bk $ a1 a2  a3  a4
a5  a6  a7  a8  a9  a10 a11  a12  a13  a14 a15  a16  a17  a18
a19  a20 b1 b2  b3  b4 b5  b6  b7  b8  b9  b10 c1 c2  c3  c4 c5  c6  c7  c8
c9  c10
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 e1 e2 e3 e4 e5 e6 e7 e8 e9 e10 f1 f2 f3 f4 f5
f6 f7 f8 f9 f10
g1 g2 g3 g4 g5 g6 g7 g8 g9 g10 h1 h2 h3 h4 h5 h6 h7 h8 h9 h10 h11 h12 h13 h14
h15 h16 h17 h18 h19 h20
i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 i11 i12 i13 i14 i15 i16 i17 i18 i19 i20;
datalines;

Data form2;
set form;
z1 = (b1 + b2 + b3 + b4 + b5 + b6 + b7 + b8 + b9 + b10)/10;
z2= (c1 + c2 + c3 + c4 + c5 + c6 + c7 +c8 + c9 + c10)/10;
z3= (d1 + d2 + d3 + d4 + d5 +d6 + d7 + d8 + d9 + d10)/10;
z4 = (e1 + e2 + e3 + e4 + e5 +e6 + e7 + e8 + e9 + e10)/10;
z5 = (f1 + f2 + f3 + f4 + f5 +f6 + f7 + f8 + f9 + f10)/10;
z6 = (g1 + g2 + g3 + g4 + g5 + g6 + g7 + g8 + g9 + g10)/10;
drop a1-a20;
drop b1-b10;
drop c1-c10;
drop d1-d10;
drop e1-e10;
drop f1-f10;
drop g1-g10;
drop h1-h20;
drop i1-i20;


Data form3;
set form2;
array z{6} z1-z6;
subject + 1;
do trialbk=1 to 6;
y=z{trialbk};
output;
end; drop z1-z6;


title "appropriate practice acquisition";

class trt bk skill trialbk ID;
model y = trt skill trialbk trt*skill*trialbk trt*skill;
random bk;
repeated trialbk/ subject = trt*skill type = cs;
lsmeans trt*skill*trialbk/pdiff adj = tukey;
```

Form Score Data

1	9	3	1	3	1	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	6	6	6	6	6	6	6	6	6	6	7
	7	8	6	6	6	6	7	6	6	7	7	6
	7	7	7	7	8	7	7	4	4	5	4	5
	4	4	4	4	4	8	8	8	8	8	8	8
	10	9	8	8	7	8	8	7	6	7	7	8
	7	8	7	8	8	7	8	8	7	7	8	8
	7	7	8	7	8	7	9	7	8	8	8	8
	7	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8							
2	9	2	0	3	1	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	5	5	5	5	5	5	5	5	5	5	.
	.	.	.	.	.	.	.	.	.	5	5	5
	5	5	5	5	5	5	5	4	4	4	4	4
	4	4	4	4	4	7	6	5	4	6	6	6
	5	5	6	.	.	.	.	.	.	.	.	.
	.	3	3	4	4	4	4	4	4	4	4	4
	3	3	3	4	3	4	3	4	3	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4							
3	5	1	1	2	1	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	9	10	10
	10	10	9	10	9	9	9	7	7	8	7	8
	9	8	9	9	8	9	9	9	8	9	10	9
	9	9	10	9	9	10	9	10	10	10	10	10
	10	10	10	10	10	10	10	10	10	10	10	10
	10	10	10	10	10	10	10	10	10	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8							
4	1	3	1	1	1	5	5	5	5	4	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	4	4	4	4	4	4	4	4	4	4	4
	4	3	4	4	4	4	4	4	4	5	6	6
	5	6	6	6	6	6	6	4	3	5	3	4
	4	4	4	3	4	6	6	6	6	6	6	6
	6	6	6	6	6	6	7	7	6	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	5	6	6	6	6	6	3	3	3
	3	3	3	2	3	3	3	3	3	3	3	3
	3	3	3	3	3							
5	9	3	1	3	1	5	5	3	3	2	2	2
	2	3	3	3	3	3	3	3	3	3	3	3
	3	7	7	7	8	8	7	7	7	7	7	6
	5	6	6	6	6	6	6	6	6	5	5	5
	5	5	5	5	5	5	5	2	2	2	2	2
	3	2	2	2	2	4	4	5	4	4	4	3
	4	5	4	5	4	4	3	4	2	3	2	3
	4	6	6	5	7	6	6	6	7	7	7	7
	6	6	6	7	6	7	6	6	6	7	7	6

	6	6	5	7	7	6	6	5	6	6	6	6
	6	6	6	6	5							
6	5	2	0	2	1	4	6	6	4	4	4	3
	4	6	4	6	6	4	4	4	4	4	6	6
	4	5	6	6	6	6	6	6	6	6	5	5
	3	4	3	4	2	3	4	4	2	5	5	5
	5	5	5	5	5	5	4	4	4	4	5	3
	3	4	4	3	4	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	3	3	3	3	3	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4							
7	5	2	1	2	1	3	3	2	4	2	2	2
	4	2	2	3	3	3	2	3	1	3	2	2
	1	5	5	5	5	5	5	5	5	5	5	6
	4	6	5	5	7	5	4	5	6	6	5	5
	5	5	6	5	5	3	5	.	.	.	.	.
	.	.	.	.	.	6	6	4	5	5	4	5
	6	5	4	.	.	.	.	.	.	.	.	.
	.	6	6	6	6	4	6	5	5	5	5	5
	5	5	5	5	5	5	5	6	5	4	6	6
	5	6	6	7	6	6	5	6	5	6	6	7
	7	6	6	6	6							
8	9	1	1	3	1	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	8	8	8	8	8	8	8	8	8	8	8
	8	6	7	7	7	7	6	8	6	6	7	7
	7	6	5	5	6	7	6	6	5	5	6	6
	6	5	6	6	5	4	4	4	4	4	4	4
	4	4	4	.	.	.	.	.	.	.	.	.
	.	7	5	8	7	7	7	7	5	7	7	8
	8	8	8	8	8	8	8	8	8	7	7	7
	7	6	7	7	7	7	6	6	6	6	6	5
	6	7	6	7	7							
9	9	2	1	3	1	6	6	7	7	6	6	7
	7	6	7	7	7	6	6	6	6	6	6	6
	7	6	6	6	6	6	6	6	6	6	6	5
	5	5	5	5	5	5	5	5	5	3	3	3
	3	3	3	3	3	3	3	5	5	5	5	5
	5	5	5	5	5	7	7	7	7	6	7	7
	7	7	7	5	5	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5							
10	5	3	1	2	1	5	5	5	5	5	5	5
	5	6	6	5	5	5	5	5	5	5	4	5
	5	6	5	5	5	6	6	5	5	5	5	7
	5	6	5	5	6	6	6	5	6	7	7	7
	6	7	6	7	7	6	7	6	6	6	6	6
	6	6	6	6	6	7	8	7	8	6	8	6
	6	7	8	5	5	5	6	5	6	6	6	5
	6	6	5	6	6	6	6	6	4	6	6	6
	6	7	6	6	6	6	7	7	5	7	6	5
	6	6	5	5	5	5	6	6	6	5	6	6
	6	5	6	6	6							

11	5	3	1	2	1	4	4	3	3	3	3	2
	4	3	3	3	2	3	3	3	3	3	3	2
	2	5	4	3	3	3	4	3	4	3	4	3
	3	3	3	3	3	3	3	3	3	7	7	7
	7	7	7	7	7	7	7	3	4	4	4	3
	4	4	4	4	3	4	4	4	4	4	4	4
	4	4	4	6	6	6	6	5	5	5	6	5
	5	3	2	2	2	2	3	3	3	3	2	3
	3	3	3	3	3	3	3	3	3	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	6	6							
12	9	2	1	3	1	3	3	3	4	3	3	3
	3	3	3	2	2	2	3	4	3	3	4	4
	3	4	3	3	4	3	3	2	3	2	3	1
	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	2	1	1	1	1	1	1	1	1
	1	1	1	1	1	2	4	2	4	2	1	4
	2	2	1	3	1	4	4	2	3	2	4	2
	2	1	2	2	2	2	1	1	1	2	3	2
	2	2	2	1	3	2	2	2	2	2	1	1
	1	1	1	1	1	1	1	2	2	1	1	1
	2	1	1	1	1							
13	1	3	0	1	1	3	4	3	4	3	3	4
	4	4	4	4	3	3	4	4	4	3	3	2
	3	3	3	3	2	2	2	2	2	2	2	2
	1	1	1	1	1	1	1	1	2	5	4	4
	5	4	4	5	5	5	6	4	3	3	3	3
	3	3	2	3	3	4	4	4	4	4	4	4
	4	4	4	6	5	5	5	5	5	5	5	5
	5	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	3	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4							
14	5	2	0	2	1	4	4	3	3	2	3	4
	2	3	1	2	3	1	4	3	4	3	3	4
	5	3	3	3	3	3	3	3	4	3	3	3
	4	3	3	3	3	3	3	4	3	3	3	3
	3	3	3	3	3	3	3	6	5	4	4	5
	6	4	5	5	5	5	4	5	4	4	4	5
	4	4	4	4	5	6	5	5	5	5	5	4
	4	5	5	6	6	6	6	6	4	5	5	5
	5	6	6	7	6	7	7	7	7	4	4	4
	4	4	3	4	3	3	4	4	4	4	4	3
	2	4	4	4	4							
15	1	3	0	1	1	4	5	4	4	3	4	3
	3	2	2	3	3	3	2	2	2	2	3	4
	4	4	5	6	4	4	6	5	6	5	8	5
	4	4	5	6	6	7	6	5	6	7	7	8
	7	7	7	7	6	7	7	7	7	8	5	7
	6	8	7	8	6	6	6	6	6	7	6	6
	7	7	7	.	.	.	.	.	.	.	.	.
	.	5	6	5	5	5	5	5	5	5	5	5
	5	5	6	5	6	5	5	7	6	6	6	7
	5	5	6	6	6	6	6	6	5	6	5	5
	4	6	6	5	6							
16	1	1	1	1	1	10	10	8	8	8	9	9
	9	9	9	9	9	9	9	10	8	9	9	9

	9	10	10	10	10	10	10	10	10	10	10	10
	10	10	10	10	10	10	10	10	9	10	10	10
	10	10	10	10	10	10	10	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	10	9	10	10	10	9	10	10	10
	10	10	10	10	10	10	10	10	10	10	10	10
	10	10	10	10	10	10	10	10	10	9	9	9
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	9							
17	2	2	0	1	2	3	3	2	3	2	2	2
	3	2	3	3	2	3	1	2	2	1	2	2
	2	3	2	2	2	2	1	2	2	2	2	2
	2	2	2	1	2	2	2	3	2	2	2	3
	3	2	3	1	2	2	2	2	2	2	2	2
	2	2	2	2	3	0	1	1	0	1	0	1
	0	0	1	3	4	4	3	3	3	3	2	2
	4	2	3	3	3	2	2	3	2	3	2	2
	2	3	2	2	2	2	2	2	2	2	2	2
	2	2	2	2	2	3	3	2	3	2	2	2
	3	2	3	2	3							
18	1	3	0	1	1	4	4	4	4	4	4	4
	3	3	4	4	4	3	4	4	4	4	4	4
	3	5	4	5	4	4	5	4	5	5	5	5
	5	4	5	5	5	4	5	5	5	5	5	5
	7	7	6	6	6	6	5	6	7	6	6	6
	6	6	7	5	4	8	8	7	7	7	7	7
	7	7	7	9	8	8	8	8	6	8	8	9
	7	5	6	6	5	5	5	4	4	3	4	5
	4	4	4	5	4	5	4	5	4	3	3	3
	3	3	3	2	2	3	3	3	3	3	3	3
	3	3	3	3	3							
19	2	2	1	1	2	7	7	7	7	7	8	8
	7	8	7	7	7	7	7	7	7	7	7	7
	7	9	9	8	8	7	7	7	8	9	9	7
	8	8	8	8	7	8	7	8	8	6	6	5
	5	5	6	5	5	5	5	7	7	7	7	7
	6	6	6	6	6	6	6	6	7	6	6	6
	6	6	6	8	8	7	8	7	8	6	6	8
	8	7	7	7	7	7	7	7	8	7	8	8
	8	8	8	7	6	8	8	8	8	7	8	8
	7	8	7	6	7	7	7	6	8	8	8	8
	8	7	8	7	7							
20	10	2	1	3	2	5	5	5	5	5	6	6
	6	6	6	6	6	6	6	5	6	5	5	6
	5	8	8	8	7	7	6	6	7	7	7	8
	8	8	8	8	8	8	8	8	8	.	.	.
	.	.	.	.	.	.	.	7	6	6	6	6
	5	6	6	6	6	8	7	8	8	9	7	9
	9	9	9	6	8	8	7	8	9	8	9	8
	8	7	7	8	8	8	7	8	7	8	7	7
	7	8	7	7	7	8	8	8	7	5	5	5
	5	6	6	7	7	7	7	6	5	7	7	7
	7	7	7	7	5							
21	6	1	0	2	2	6	5	6	6	6	6	5
	5	5	5	5	5	4	4	3	5	5	5	4
	4	.	.	.	.	.	.	.	.	.	.	6
	4	4	5	5	4	4	4	4	5	5	5	5

	5	5	5	5	5	5	5	5	5	6	6	6
	5	5	5	5	6	6	6	7	7	7	6	6
	6	6	6	4	5	6	6	5	3	5	5	6
	6	5	6	6	6	6	6	6	6	6	6	6
	6	6	6	5	5	6	6	6	5	5	4	4
	5	6	6	6	6	6	6	5	4	6	6	6
	4	6	5	4	5							
22	6	3	1	2	2	3	3	4	3	3	4	4
	4	3	4	4	4	4	4	4	4	3	3	2
	2	3	3	3	3	4	4	3	3	3	3	5
	5	5	5	6	6	6	6	6	6	6	6	5
	6	6	5	5	6	5	6	4	5	5	5	4
	4	4	6	6	5	6	5	5	5	5	5	5
	5	5	5	8	7	8	8	8	8	7	8	8
	7	5	6	6	6	6	6	6	6	5	5	6
	5	6	5	5	5	5	5	5	5	7	7	7
	7	6	7	6	6	7	6	6	7	7	6	6
	6	5	6	6	7							
23	2	2	1	1	2	4	4	4	4	4	4	4
	4	4	4	5	4	4	4	4	4	4	4	4
	4	4	4	4	5	6	5	4	4	5	6	6
	5	5	5	5	5	5	6	4	6	7	6	7
	6	6	7	6	6	6	6	7	7	4	6	7
	8	7	6	6	8	.	.	.	.	.	.	.
	.	.	.	7	6	3	4	6	8	7	8	7
	6	5	5	5	6	4	7	7	5	6	6	4
	6	6	6	7	6	5	5	6	7	6	4	4
	3	5	6	6	5	6	6	5	5	6	5	5
	6	5	6	5	5							
24	10	2	1	3	2	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	9	9	10	9	10	10	10
	10	9	10	10	9	10	10	9	9	9	9	10
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	9	9	9	9	9	9	10	10
	9	9	9	9	9	9	9	9	9	9	8	8
	8	9	9	9	8							
25	10	1	1	3	2	5	5	5	4	4	4	4
	4	4	3	3	3	4	3	4	4	3	3	3
	3	3	4	3	4	3	3	3	4	4	3	4
	5	5	5	4	4	4	5	4	4	4	4	4
	4	4	3	3	3	3	3	3	3	3	3	3
	3	3	3	3	3	5	5	6	4	5	5	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	3	4
	4	3	3	4	4	4	4	3	4	3	3	3
	3	3	3	3	3	3	3	3	3	3	3	3
	3	3	3	3	3							
26	6	2	1	2	2	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	5	5	5	5	5	5	5	5	5	5	8
	10	9	10	10	10	10	10	10	10	8	8	8
	8	8	8	8	8	7	8	6	7	7	7	7
	7	8	8	8	8	9	9	9	9	10	9	9

	9	9	9	9	10	10	10	9	10	10	10	10
	10	10	10	10	10	10	10	10	10	10	10	10
	10	10	10	10	10	10	10	10	10	10	10	9
	10	10	10	10	9	10	9	10	10	10	10	10
	9	10	10	10	10							
27	2	1	1	1	2	7	6	6	6	6	5	6
	5	5	5	6	6	6	6	6	5	5	5	6
	6	5	5	5	5	5	6	6	6	6	6	8
	8	8	8	8	8	8	8	8	8	.	.	.
	.	.	.	.	.	.	.	6	5	6	6	6
	7	7	6	6	6	6	6	6	7	6	6	6
	6	6	6	4	4	4	4	4	4	4	4	4
	4	7	7	7	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	7	8
	7	8	8	8	8	8	8	8	8	8	8	8
	7	8	8	8	8							
28	6	2	1	2	2	5	5	6	6	7	7	5
	5	5	5	5	6	7	6	7	8	6	9	6
	8	8	7	7	8	7	7	8	8	8	8	10
	10	9	10	9	9	10	10	10	10	9	9	10
	10	10	10	10	9	10	9	9	9	9	10	8
	10	9	10	9	9	9	8	9	9	9	8	9
	9	9	9	.	.	.	.	.	.	.	.	.
	.	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	9							
29	3	3	1	1	3	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	7
	6	6	8	6	6	6	6	6	6	6	6	6
	6	6	6	6	6	6	7	7	7	7	7	7
	7	7	7	7	7	5	6	5	5	5	6	6
	6	6	6	5	6	5	5	5	5	6	8	8
	5	6	6	6	6	6	6	6	6	7	7	7
	6	7	6	6	6	6	6	6	6	6	6	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5							
30	11	3	0	3	3	2	2	3	3	3	3	3
	2	3	2	2	1	1	1	2	1	2	2	2
	2	2	2	1	1	2	2	2	2	2	2	3
	3	2	3	2	2	1	1	1	3	2	1	1
	1	1	1	1	1	1	1	.	.	.	.	.
	.	.	.	.	.	0	1	0	0	0	1	0
	0	0	0	.	.	.	.	.	.	.	.	.
	.	3	2	2	2	2	2	2	2	2	2	2
	2	2	2	3	3	3	2	2	2	1	1	2
	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1							
31	11	3	1	3	3	3	3	3	3	3	3	3
	4	4	4	5	4	5	5	5	5	4	5	5
	4	4	3	4	4	4	4	5	4	5	5	7
	6	6	7	7	7	6	7	7	7	3	5	4
	3	5	5	5	5	6	6	2	2	2	2	3
	3	3	3	3	3	4	5	5	5	5	5	6
	5	5	5	7	7	7	7	7	6	7	7	7
	7	4	5	5	4	4	6	5	5	4	5	6

	5	5	5	6	6	6	5	6	6	3	3	4
	4	4	5	4	4	4	5	5	6	4	5	5
	6	5	6	6	7							
32	3	2	1	1	3	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	3	3	3	3	4	3	4	3	3	3	4
	4	4	4	4	4	4	4	4	4	3	3	3
	3	4	3	3	3	3	3	3	2	2	3	3
	2	3	2	2	2	5	4	4	4	4	4	4
	5	5	5	.	.	.	.	.	.	.	.	.
	.	4	6	5	6	5	6	5	5	5	5	6
	5	6	5	6	6	5	5	5	5	5	4	5
	5	4	4	5	5	5	5	4	5	5	5	5
	5	5	5	5	5							
33	7	2	1	2	3	2	3	2	5	4	3	4
	5	5	5	5	5	6	5	6	5	5	5	5
	5	6	6	5	6	6	6	5	6	6	5	5
	3	4	3	4	4	4	4	5	5	4	3	3
	4	4	3	3	5	3	3	3	3	3	3	4
	3	3	4	3	3	.	.	.	.	.	.	.
	.	.	.	4	4	5	5	5	5	5	5	4
	4	6	5	5	5	5	6	5	5	5	5	4
	5	4	4	5	5	5	5	5	5	4	5	4
	5	4	3	3	6	3	4	4	4	4	5	4
	4	3	4	5	3							
34	11	1	1	3	3	7	7	7	7	6	6	5
	5	5	5	6	7	6	6	6	6	6	6	7
	7	10	10	9	9	10	9	9	9	8	9	8
	7	7	7	7	8	7	8	8	7	9	9	9
	9	9	9	9	8	9	9	8	8	8	8	7
	8	7	7	8	8	8	8	8	8	8	8	8
	8	8	8	9	9	9	9	9	9	9	9	9
	9	8	9	8	8	8	8	8	9	8	8	8
	8	8	7	7	7	7	8	8	8	9	9	9
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	9							
35	3	1	0	1	3	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	3	3	3	3	3	3	3	3	5
	5	5	5	4	5	5	5	5	5	3	4	4
	1	3	2	4	4	4	3	5	5	4	3	3
	4	3	3	4	4	4	5	5	5	5	5	4
	4	4	4	4	4	7	6	4	5	5	6	6
	4	4	4	3	3	3	3	3	4	4	4	4
	4	4	3	3	4	4	4	4	3	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.							
36	11	3	0	3	3	3	3	4	4	4	4	4
	3	3	4	4	3	4	4	4	4	4	4	4
	4	5	5	6	6	6	5	6	6	6	5	6
	6	6	6	6	6	6	6	6	6	.	.	.
	.	.	.	.	.	.	.	2	3	2	3	2
	3	3	3	3	3	6	6	5	6	5	5	5
	6	6	6	6	5	5	6	7	6	4	5	4
	4	5	6	5	6	6	6	5	6	5	6	5
	5	7	6	5	7	7	7	8	6	6	6	6

	6	6	5	6	5	6	5	5	6	5	5	5
	6	6	5	5	5							
37	4	3	0	2	3	4	3	3	4	3	3	3
	3	4	4	3	4	3	4	3	3	3	3	3
	3	4	4	4	4	4	4	2	3	2	3	2
	2	2	2	2	2	3	2	2	2	3	3	3
	2	3	3	3	2	3	3	.	.	.	.	.
	.	.	.	.	.	1	3	3	2	2	3	2
	2	2	2	5	4	3	5	4	4	4	4	3
	4	4	4	4	3	4	4	4	4	4	4	5
	4	4	5	4	5	5	5	5	5	3	4	4
	3	3	3	5	4	4	4	3	3	3	4	3
	3	3	4	3	4							
38	7	3	1	2	3	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	.
	.	.	.	.	.	.	.	.	.	8	8	8
	8	8	8	8	8	8	8	7	7	7	7	7
	7	7	7	7	7	9	10	9	9	10	10	9
	9	9	9	.	.	.	.	.	.	.	.	.
	.	10	10	10	10	10	10	10	10	10	10	10
	10	10	10	10	10	10	10	10	10	10	10	9
	10	9	10	10	10	10	10	10	10	10	10	10
	10	10	10	10	10							
39	8	1	0	2	4	6	6	6	6	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	5	5	5	5	5	5	5	5	5	5	7
	6	7	7	8	8	8	5	7	7	6	6	6
	6	6	6	6	6	6	6	6	6	5	6	6
	6	6	6	6	6	5	5	4	5	5	5	5
	5	5	5	6	6	6	8	8	8	6	6	7
	6	6	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	3
	5	5	5	5	5	5	4	5	5	5	5	5
	5	5	5	5	5							
40	12	2	1	3	4	10	10	10	7	9	10	10
	9	10	8	8	8	10	9	7	10	9	10	10
	10	8	8	8	7	8	8	8	8	8	7	7
	7	7	7	7	7	7	7	7	7	7	7	7
	6	7	7	7	7	7	7	6	7	8	8	7
	7	7	7	7	8	10	9	10	10	10	10	7
	10	9	7	8	9	8	7	7	9	10	9	8
	8	10	9	10	10	10	10	9	9	10	10	10
	10	10	10	10	9	9	10	9	10	7	8	7
	6	7	7	6	6	6	6	6	6	6	6	6
	9	7	6	8	8							
41	4	3	1	1	4	9	9	9	9	9	9	9
	9	10	10	9	9	9	9	9	9	9	9	8
	9	7	5	6	6	8	6	6	6	5	6	.
	.	.	.	.	.	.	.	.	.	8	8	8
	8	8	8	8	8	8	8	9	9	10	9	10
	9	9	9	9	9	.	.	.	.	.	.	.
	.	.	.	9	9	10	9	10	10	9	9	10
	9	9	8	9	8	9	8	8	9	10	10	9
	9	10	8	9	9	9	10	8	8	9	9	9
	9	9	9	10	9	10	10	10	9	9	9	7
	7	7	9	8	10							

42	4	1	1	1	4	10	10	10	9	8	9	9
	10	10	10	10	10	9	10	10	10	10	10	10
	10	7	7	8	8	8	8	8	7	7	7	8
	7	7	7	7	7	8	6	7	7	7	8	8
	8	8	8	8	8	7	7	9	9	9	9	9
	9	9	9	9	9	7	8	8	7	8	9	8
	9	8	9	10	10	9	10	10	10	10	9	9
	9	9	9	9	9	9	9	9	10	10	10	10
	10	10	10	10	9	9	9	9	9	8	8	9
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	8							
43	8	1	1	2	4	7	7	7	7	7	7	7
	7	7	7	7	7	7	7	7	7	7	7	7
	7	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	10	10	10	10	10
	10	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	8	8	9	10	9	10	10	10	10
	10	9	9	9	8	9	8	9	8	9	8	8
	8	9	9	9	9	9	8	8	8	10	9	10
	10	10	10	10	10	10	10	10	10	10	10	10
	10	10	10	10	10							
44	12	1	1	3	4	8	8	8	8	7	7	8
	7	8	7	7	7	7	7	7	7	8	7	7
	7	5	6	6	6	6	6	6	6	6	6	5
	4	4	5	5	3	5	5	5	4	.	.	.
	.	.	.	.	.	.	.	4	5	4	5	5
	5	5	4	4	4	5	5	5	5	5	5	5
	5	5	5	6	6	6	6	6	6	6	6	6
	5	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	6	6	6	6	6	6	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5							
45	4	2	1	1	4	6	6	6	6	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	7	7	6	7	7	7	7	6	6	6	8
	8	8	8	8	8	8	8	8	8	.	.	.
	.	.	.	.	.	.	.	7	7	7	7	6
	7	6	6	6	6	8	7	8	8	8	8	8
	8	8	8	9	9	10	10	9	9	10	10	10
	10	10	8	8	8	7	9	8	8	8	8	8
	7	7	8	8	8	8	8	8	8	10	8	10
	10	8	8	9	9	9	9	10	9	9	8	8
	8	9	9	10	9							
46	8	1	1	2	4	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	7	8	8	8	8	8	8	8	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	5	5	6	6	6	6	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	6	6	6	6	6	6	6	6	6
	5	6	7	6	5	5	5	5	5	6	5	5
	5	5	5	6	6							
47	8	1	1	2	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4

	4	4	4	4	4	4	4	4	4	4	5	6
	6	6	6	6	6	6	6	6	6	8	6	6
	6	6	6	6	6	6	6	8	9	8	8	9
	8	9	9	10	9	7	7	8	8	8	8	7
	7	7	7	7	7	8	8	8	8	7	7	7
	7	9	9	8	8	8	8	8	8	8	9	9
	9	9	9	8	8	8	8	9	8	9	8	8
	9	9	9	9	8	9	9	9	8	8	8	8
	9	8	8	8	8							
48	4	2	1	1	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	5	5	5	5	5	5	5	5	5	5	7
	6	7	6	7	7	6	7	7	7	7	7	6
	6	7	6	7	6	5	7	7	6	7	7	8
	8	8	8	8	8	8	8	8	8	8	9	9
	8	8	8	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5							
49	12	1	1	3	4	2	2	2	2	2	2	2
	2	2	2	2	2	2	2	2	2	2	2	2
	2	3	4	4	4	4	3	3	3	3	3	.
	.	.	.	.	.	.	.	.	.	7	6	7
	7	7	7	7	7	7	7	2	3	3	3	3
	3	3	3	3	2	4	4	4	3	4	3	4
	3	3	3	6	5	6	5	4	4	6	4	5
	5	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	4	4							
51	1	1	1	1	1	9	9	10	9	10	10	10
	10	10	10	10	10	10	10	10	10	10	9	10
	10	7	7	7	8	7	8	7	7	8	8	10
	10	9	10	10	10	10	9	10	10	9	9	9
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	9	9	9	9	9	9	9	9	9
	9	9	9	.	.	.	.	.	.	.	.	.
	.	9	9	9	9	9	9	10	9	9	9	9
	10	10	9	9	9	9	9	9	9	9	9	9
	9	10	10	10	10	10	9	9	9	7	8	8
	8	9	9	8	9							
53	3	3	0	1	3	4	4	5	4	5	5	4
	4	4	4	5	4	4	3	4	4	4	4	4
	5	5	5	5	5	5	5	5	4	4	4	6
	7	7	7	7	6	6	7	7	7	4	6	6
	6	4	4	5	5	5	5	5	5	5	5	5
	5	6	5	6	6	7	7	7	7	7	7	7
	7	7	7	5	6	6	6	6	6	6	6	6
	6	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	5	5	5	5	5	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.							
54	3	2	0	1	3	8	7	6	7	7	6	7
	7	7	6	6	6	7	6	6	5	6	6	6
	7	6	6	6	6	6	6	6	6	6	6	6
	6	6	6	6	7	6	6	6	6	5	5	6

	5	5	5	5	5	5	5	7	7	7	7	7
	7	6	7	7	7	7	8	8	8	8	8	8
	8	8	8	.	.	.	.	.	.	.	.	.
	.	5	5	5	6	7	6	7	7	7	6	7
	6	6	6	6	6	6	6	6	6	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.							
55	12	3	1	3	4	8	7	7	8	8	8	8
	8	8	8	8	8	8	8	8	8	8	8	8
	8	6	6	6	6	6	6	6	6	6	6	.
	.	.	.	.	.	.	.	.	.	9	9	9
	9	9	9	9	9	9	9	8	7	7	7	7
	7	7	7	7	7	10	9	8	9	9	10	9
	9	10	9	10	10	10	10	9	10	10	9	10
	9	8	8	8	8	8	8	8	8	8	8	8
	8	8	8	8	8	8	8	8	8	7	8	8
	8	8	8	7	8	8	8	8	7	8	8	8
	8	8	8	8	8							
85	2	2	1	2	4	.	.	.	.	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.
	.	4	4	4	4	4	5	5	5	5	5	7
	5	6	5	5	4	5	5	6	6	.	.	.
	.	.	.	.	.	.	.	.	.	.	.	.
	.	.	.	.	.	6	9	9	9	9	9	9
	9	9	9	7	8	8	8	8	8	8	8	8
	8	8	8	9	10	9	9	9	10	9	9	9
	9	9	9	9	9	9	9	9	9	9	9	8
	8	9	8	9	10	9	9	9	8	9	8	8
	8	9	9	9	8							

SAS Program for Cognitive Processes Subscales

```
dm "output; clear; log; clear";
data one;
/* 40 item questionnaire with the first number subject id*/
infile 'e:\dissertation-the real one\confirmatory analysis\first attempt
confirmatory analysis\cognitivegolf.txt';
input id $ 1-2 condition 4 section 5 skill 6 t1 7 t2 8 t3 9 t4 10 t5 11 t6 12
t7 13 t8 14 t9 15 t10 16 t11 17 t12 18 t13 19 t14 20 t15 21 t16 22 t17 23 t18
24
t19 25 t20 26 t21 27 t22 28 t23 29 t24 30 t25 31 t26 32 t27 33 t28 34 t29 35
t30 36 t31 37 t32 38 t33 39 t34 40 t35 41
t36 42 t37 43 t38 44 t39 45 t40 46;
run;

Data two;
/* reversal items, six minus the response of each question (answered on a 5
point likert scale)*/
set one;
t01=6-t1;
t013=6-t13;
t017=6-t17;
t031=6-t31;
t035=6-t35;
t025=6-t25;
t010=6-t10;
t022=6-t22;
t036=6-t36;
t019=6-t19;
t037=6-t37;
t08=6-t8;
t012=6-t12;
t024=6-t24;
t028=6-t28;
t034=6-t34;
t015=6-t15;
selfeff = (t017 + t21 + t035 + t40)/4;
problem = (t14 + t26 + t39 + T32 + t33)/5;
prior = (t16 + t08 + t20 + t024)/4;
keep ID t017 t21 t035 t40 t14 t26 t39 t32 t33 t16 t08 t024 t20 selfeff
pro


*roc print data=two;
*run;

title "problem solving-critical thinking";

class condition section skill ID;
model problem = skill*condition skill condition ;
random section section*condition;
lsmeans condition*skill/pdiff adj = tukey;


title "self-efficacy";
proc mixed data=two covtest method = reml;
```

```
class condition section skill ID;
model selfeff = skill*condition skill condition;
random section section*condition;
lsmeans condition*skill/pdiff adj = tukey;
run;

title "prior experience";
proc mixed data=two covtest method = reml;
class condition section skill ID;
model prior = skill condition skill*condition;
random section section*condition;
lsmeans condition*skill/pdiff adj = tukey;
run;
```

Data from Cognitive Processes Questionnaire

```
input id $ 1-2 condition 4 section 5 skill 6 t1 7 t2 8 t3 9 t4 10 t5 11 t6 12 t7 13 t8 14 t9 15
t10 16 t11 17 t12 18 t13 19 t14 20 t15 21 t16 22 t17 23 t18 24
t19 25 t20 26 t21 27 t22 28 t23 29 t24 30 t25 31 t26 32 t27 33 t28 34 t29 35 t30 36 t31 37 t32 38
t33 39 t34 40 t35 41 t36 42 t37 43 t38 44 t39 45 t40 46;


3  2114544243222422423251322332442443244242332
11 2133542345441511442251454423533542331122545
15 1135523122111243333425325325421125142555111
51 1112344345243421332143252331333432244132545
39 2413433332321323333232223332334333433433333
36 3332344442332431323134332331442444233122343
1  3133444445242431414142452421442542342111545
54 1322334344432422122222223243223432223444322
7  2122343444442421433242342422442542442222444
42 1412545444142411514152442412541453551111454
47 2413544444242421444243442422443342342122444
46 2412554544443531344131454433554541444122434
41 1433555545152511515151554323332542443211555
45 1422231433533321434124435322342331232122434
43 2411445555241454455141441211244511444122445
44 3413232244243443242224323442244323422324442 3
55 3432314132311223123122232142212211223122122
33 2321452555552551324142253242432442443122545
38 2332424444242422424242442424244434424224442
34 3313434334234342432432334423423442343242333
31 3332244432244444232324243343233222323424232
53 1335523323232322323234325325322235233543232
37 2333443343232422434422332432443344343332343
35 1315535433231415555352555511551255552111555
29 1333543344341522525252542422541343442111434
27 1211443444342422333142332322332331233132424
17 1224531131522313321251223315441232443222342
23 1222443445441521115153553221442431332123445
26 2223444455241411515142452312552443441122454
22 2232443344243431534131353531543531133133545
24 3222444445242422334242444442443432232432444
21 2213353555443541322133354442243441133132555
20 3223433334322322343322233442322442243443233
25 3212441343532453431432132353243333355233343
8  3112444545241411512144152522551441554111555
16 1112444443244442444342443432434442434242444
10 2133554454241511221141231443441341534213444
4  1134523231411312331333224342331532345322242
18 1133544544231431423153442311532453442122444
12 3123322222222322322233222332333333233222332
13 1134352345533442343321153531454442142111555
6  2123341343531333343343223224332233432423222
14 2123431343521551522151231441453543555111443
9  3121445555254431425133551511553551352111545
5  3132544444242421324243242332442442242222444
40 3424323222231422423245444222422445242222444
28 2222344345242521424244442322443443441111445
19 1223333334232321312132142212322432332334334
30 3332533334332321314141352311351333232132434
```

32 1323324325243342244323553244325234252354322
49 3412545554511151151315135151155355354111 2555
48 1422323231443432313151352143543322223244313
2 3121544545241411514143452411443551342112555

Written Responses on Open-Ended Questionnaire

	Day5 -During practice, what did you do to be successful?
41	I just relaxed and stayed focused
42	Tried to keep my knees from moving
48	Nothing, I still do not know what to do
45	Focus on the target and used more controlled swing for distance
43	Used the distance control method
85	Let the club fall on it's own
39	I concentrated on my distance control and using the loft of the club
46	I was getting correct distance with the right loft to have a successful shot
49	Kept my head down and tried to have a stroke that skimmed the ground as opposed to digging in. It helped with my chips
44	Try not to think about the shot
55	Technique
40	During practice I aimed closer to me than the pin so I would get the role to my advantage. Nice smooth strokes
27	Very Little. I hit 2 in the ring today by an act of god
9	I tried to release my hands through the ball. Kept my eye on the ball. Nice smooth swing
5	Left foot back, concentrate on swing
2	Left foot back. Try to open club face but usually end up closing it mid swing. Kept hitting so odds improve in my favor
1	Left foot back with my athletic stance. Learning not too chop but a smooth pendulum swing works best
8	Today I tried to make adjustments with my backswing. It was not successful. I also tried to concentrate on my form. Again, not successful.
16	The balance of short swing during pre and back for the pitching
4	I tried opening the face of my club. This seemed to help in getting the ball in the air
15	I tried to take my frustration out on the ball because I suck and I believe that I am worse now than I was at the beginning of the test. I am really frustrated because I don't know what I am doing and nobody can tell me what I am doing wrong.
13	Try to keep the right position of my standing (head down, left hand straight and not moving, bend my knees, and hit the ball with a smooth swing but a long follow-through
18	Worked on my stance. Watched tall guy that can pitch well
51	Tried to keep eye on the ball and be soft with hands. Pull club back a shorter distance then swing through
29	Try to hit it up only did it 2 times during filming. I do much at practice. I try to make my swing consistent
32	Remember to follow through with the club. Also, to use correct form when swinging. I also remember to keep my head down.
11	I try to concentrate and relax, and use different strength to find the one which

	suit me the most
14	Lossen up, remember what I was instructed to do, not hit so hard
7	Try to remember all forms. Need to relax more
3	Tried to hit as many balls as I could. Listen to instruction and try to incorporate it into my swing. Make a hypothesis and see how the question was answered
10	I try to relax and concentrate on all of the concepts that we have been taught so far.
31	Tried to let the club do all the work. Don't force it. Don't rush. Concentrate.
30	Today I tried to let my left hand lead. I also tried to let the club come down naturally so it could lift the ball. However, I did not notice that the higher you bring the club up, the further the ball will go. I also remember to keep my alignment correct.
34	During practice I worked on keeping my head down. I also concentrated on my foot placement as well as my grip
37	Stay down, bend my knees, don't stand up
38	I tried to hit under the ball
33	Today I stayed down
53	Try to keep the club face open
35	Try to get under the ball
54	Nice and easy. get under it. Aim.
6	Try different experiment go with what worked best
36	Person to person instruction. Demonstration by instructor
12	I just try to stay calm
17	Well, I can't seem to figure out how to get the ball to go up like a rainbow. I tried holding the club differently i.e., different angles, looser etc… I also shortened my swing so that I could focus more on getting under the ball. But none of those things worked.
19	Straight left arm. Little bend in knees. Relax. Concentrate
28	Focusing on consistency and I pay attention what I did when I hit the ball right
21	I tried to concentrate on my swing and not get frustrated with a bad hit.
26	Try to keep my swing tempo consistent and vary my backswing until I get the right distance. Also, let gravity pull the club down from my backswing and keep less muscle tension
22	Focused on my stroke and club face, to lift the ball in the correct manner
25	Shortened my stance and kept my head down
52	Closed my stance and had a bigger backswing. I tried to get a good loft on the ball and make it bounce only once
24	I shortened my stance, took a bigger backswing and concentrate on hitting the ball
20	Calmed down, relaxed, took my time.

	Day 2- What did you do to be successful?
54	Head down. Bring club slightly back
5	Concentrate on stance, club placement
1	Left foot back with relaxed athletic posture
12	Tried really hard, to no avail. I am very bad.
8	Just concentrated on my grip and keeping form
37	Bend my knees, don't dig into the ground, keep my eye on the ball
38	Open my club face to the sky
40	To be successful I tried to remain as relaxed as possible and try to have smooth steady strokes
49	I have never tried pitching that way with the wrist bend so I wasn't successful at all. With a little practice though, it will be a good shot for me because my chips are usually so low. I didn't know there was a difference between a chip and a pitch, but I'm glad I learned
2	Keep hitting, concentrate on bending my wrist as to make the ball fly higher
9	Made sure I got the ball in the air
25	Tried to keep my head down and lift the ball up rather just hitting it
33	Not open club face. Smoothing swing. Hit ball at right spot and angle
55	Worked on technique
17	Relaxed and tried to get the club under the ball
19	Left clubface open, hit the pole
23	Watch people practice (stance, form etc). relax, keep it fun. Listen to advise from good "pitchers"
6	Listen to instructor and before each swing try to remember what he said and put it into play
14	I try to be as fluid as possible, and be more relaxed
11	Calm myself down and concentrate and have a correct swing
3	Listen to the instructor. Try and understand and think about the concept he was teaching
7	Concentrate on keeping form. 3 points. 1) Left arm straight. 2) don not turn with my shot 3) wrist action
4	Tried to ball further toward front of stance
26	Keep correct posture, knees bent, back straight. Use a little wrist bend. Usually need a little more wrist action than I naturally do t get a good slicing motion on the ball
21	I used the loft hitting style to be successful
22	Focused on my stroke. The softball like pitch and also on my stance
28	Paid attention to what worked and I tried very hard to reproduce that swing. Such things included a steady follow through, relaxed swing and focusing on technique
52	Keep my open stance, c –shaped posture, back straight, butt out, elbows down, swing level and smooth, trying to make the ball react to the club
24	I try to concentrate before each shot as if I was playing a real golf round.

	Taking my time on each shot is something I find to be useful
10	Tried to concentrate on the concepts that we have gone over
30	I try to keep my feet aligned properly. I try to keep my butt out, back straight and up along with my head. Today I am trying to remember to lead with my left hand
34	Remember to keep my head down
31	Head down, butt out, try to control my arms
48	Keeping the clubface open, but the ground was too hard and that threw me off
42	Tried to swing smooth
41	I relaxed and concentrated on what I had to do
46	I was getting pretty good loft and the ball was checking really well
39	Keep my head down, loose grip, use the loft of my club
43	I used the loft the head concept
85	I used a concept that uses the head of the club for loft
47	Loft the head concept, keep the clubface open through swing
13	Follow the basic rules of golf: not break my wrist, left arm straight, head down and still, not move my feet off the ground and try to lift the ball off the ground
15	I tried to use correct stance, but I suck so I wasn't successful
18	Tried not to get too frustrated when I mess up. Practiced swinging. Went through mental and then physical steps of the positions and stance
51	Kept my eye on the ball and tried to keep the correct form and posture
35	I am not very successful during practice
53	I swung more softly and kept the ball further behind me
32	Form and position of club face.
29	Try to work on my mechanics and work on my power. Try not to hit it too hard

SAS Program for Chi-Square by Treatment- Frequencies from Open-Ended Questionnaire

```
data one;
length trt $6 cat $2;
input trt @;
Do cat="tp", "ts", "sa", "ms", "cs";
input count@;
output;end;
*day 2-first administration of the open-ended questionnaire;
cards;
guided 11 12 5 3 15
control 10 7 6 9 9
correct 18 7 9 3 4
;
data two;
length trt $6 cat $2;
input trt @;
Do cat="tp", "ts", "sa", "ms", "cs";
input count@;
output;end;
*day 5- second administration of the open-ended questionnaire;
cards;
guided 2 3 3 8 19
control 11 6 14 8 15
correct 15 6 4 8 14
;

proc freq data=one;
tables trt*cat/ chisq cellchi2 expected;
weight count;
run;

proc freq data=two;
tables trt*cat/ chisq cellchi2 expected;
weight count;
```

SAS Program for Chi-Square by Skill- Frequencies from Open-Ended Questionnaire

```
data one;
length trt $6 cat $2;
input trt @;
Do cat="tp", "ts", "sa", "ms", "cs";
input count@;
output;end;
*day 2-first administration of the open-ended questionnaire;
cards;
High 9 1 7 0 8
Medium 8 12 10 8 10
Low 22 13 3 7 10
;
data two;
length trt $6 cat $2;
input trt @;
Do cat="tp", "ts", "sa", "ms", "cs";
input count@;
output;end;
*day 5- second administration of the open-ended questionnaire;
cards;
High 9 3 6 2 12
Medium 8 5 7 13 16
Low 11 7 8 9 20
;

proc freq data=one;
tables trt*cat/ chisq cellchi2 expected;
weight count;
run;

proc freq data=two;
tables trt*cat/ chisq cellchi2 expected;
weight count;
```

SAS Program for Item Analysis and Exploratory Analysis

```
dm "output;; clear; log; clear";

/* item analysis*/
infile 'e:\dissertation-the real one\confirmatory analysis\first attempt
confirmatory analysis\data.txt';
input id $ 1-3 t1 5 t2 6 t3 7 t4 8 t5 9 t6 10 t7 11 t8 12 t9 13 t10 14 t11 15
t12 16 t13 17 t14 18 t15 19 t16 20 t17 21 t18 22
t19 23 t20 24 t21 25 t22 26 t23 27 t24 28 t25 29 t26 30 t27 31 t28 32 t29 33
t30 34 t31 35 t32 36 t33 37 t34 38 t35 39
t36 40 t37 41 t38 42 t39 43 t40 44;

Data two;
/* reversal items, six minus the response of each question (answered on a 5
point likert scale)*/
set one;
t01=6-t1;
t013=6-t13;
t017=6-t17;
t031=6-t31;
t035=6-t35;
t025=6-t25;
t010=6-t10;
t022=6-t22;
t036=6-t36;
t019=6-t19;
t037=6-t37;
t08=6-t8;
t012=6-t12;
t024=6-t24;
t028=6-t28;
t034=6-t34;
t015=6-t15;
keep t01 t2 t3 t4 t5 t6  t7 t08  t9 t010  t11  t012  t013  t14 t015  t16
t017  t18 t019  t20  t21  t022  t23  t024  t025  t26  t27  t028  t29  t30
t031  t32  t33  t034  t035 t036  t037  t38  t39  t40 ;
run;

proc univariate data=two all;
run;

Proc Corr data=two;
Var t01 t2 t3 t4 t5 t6  t7 t08  t9 t010  t11  t012  t013  t14 t015  t16  t017
t18 t019  t20  t21  t022  t23  t024  t025  t26  t27  t028  t29  t30  t031
t32  t33  t034  t035 t036  t037  t38  t39  t40;
Run;

title "Prior experience factor";
proc freq; tables t4 t08 t012 t16 t20 t024 t028 t034 ; *frequency
dist ibut

var t4 t08 t012 t16 t20 t024 t028 t034;
run;
```

```
title "self-efficacy factor-item analysis";
proc freq; tables  t01 t5 t7 t9 t013 t017 t21 t025 t29 t031 t035 t38 t40 ;
*frequency distribution for each item;
proc corr alpha nomiss; *item analysis-self-efficacy;
var t01 t5 t7 t9 t013 t017 t21 t025 t29 t031 t035 t38 t40;


title "attention-item analysis";

distribution for each item;
proc corr alpha nomiss; *item analysis;
var t2 t010 t14 t18 t022 t26 t30 t32 t036 t39;
run;

title "problem-solving-item analysis";

dist ibut

var t3 t6 t11 t015 t019 t23 t27 t33 t037;
run;

*The items that refer to specific factors;
*self-efficacy;
*Frustration 01 013 017 025 031 035;
*Confidence  5 7 9 21 29 38 40;

*Other cognitive factors;
*Problem 2 010 14 18 022 26 30 32 036 39;
*Attention 3 6 11 015 019 23 27 33 037;
*Prior experience 4 08 012 16 20 024 028 034;

title "exploratory analysis";
proc factor data=two method=prin rotate=promax N=4 scree EV flag=.4;
Var t08 t012 t16 t20 t024  t034 t017 t21 t025 t29  t035 t38 t40  t14 t18 t26 t32 t036 t39 t33 t037 ;
run;
```

Data For Exploratory Analysis

1 23554541435112251215315124524433411111343
2 2331231213311344233244432345553222133345
3 2323425352322543121321424242144324523232
4 4233231331242553243245441353421353532315
5 3545445151411525153552321541553442121555
6 2435334442511533153442322433443232122555
7 3555353132522423143322522551213151351253
8 2232334442431322232353321323233533524231
9 3542333432322144235334323424224223344344
10 2333535352321322132353232432443343333333
11 1444545254421425141552221442551342131545
12 1433444313311314143331411533441142141544
13 4443343222412332342212453442225344322444
14 1554445141421354252452421542421241132435
15 3545244121422444242432422442343242242444
16 3453555342531333232343332344434243132535
17 2344424443422423231142332343432233122534
18 1553355333511313141331411443431333123534
19 1344333333413314443344333334332344243334
20 4222222424244442434224345424223432543232
21 3412413232222342235332323442334433223344
22 3545444142411515242442424544354334543524
23 1442545442431324141342422442442342132545
24 2332535443341323113254241324.21133143535
25 1434534333321323134353221422543343132434
26 2555454141512524151553211553554451111554
27 2353555352521324132254422442541233123435
28 1544544242421522142252222432421452121444
29 3531334422323432332222314442344334332233
30 25555551545125452525552421544552551111555
31 1545445142415514242551412442442442122444
32 1444554153521414152552434444452442111445
33 1445254141511535151551511551552551111555
34 2222222322244243423222334223234424434222
35 2544345331411524152452411442543132321445
36 4535434131411424253542422541454342111444
37 2322144234242323343332332324332332423242
38 2344434242412422132343324322332223134424
39 3444344443421314142442421333442323333333
40 1155534133433331423432423342551455543545
41 1552555455541452252252541544552414121525
42 1554544544521535131453521551452342132445
43 2454555254521324142453422443551442132545
44 2343244444441212132344432443232144244424
45 1555555545225555135513355553551551111545

46 2544445142421434232453421444542333133535
47 1544445142421324142442321453442441112545
48 2444444342432324243443432432443342222444
49 2555555453521425142552511552452551111555
50 2333335231521333142452221442433242222445
51 2443445242421425241441222344442341132544
52 2455555252522425252552422543552252222545
53 2445544142421443133332432123331324544221
54 3443544232432324233433422132334232222444
55 3442444531334333332333535431135433422343
56 2433333232322323233333222332332332222533
57 1543444142521323141452321433442132141545
58 1554455354521424152452421541551242134525
59 2434424442322343235233232322334224243423
60 2525313241221225255542211532553342111455
61 1555444242451413142351442452552242152555
62 1555555151511515151551111555551551111555
63 1442445344421422424414344224214122543422
64 2535554242422545242442322432442442111434
65 1444544144441424141442222442441444111444
66 1555555152511525151551511255551251151555
67 3454554232521333122332311342432443122544
68 2433444332321323133332321222332333122334
69 2344444343421344243343322433432222142322
70 2343344232322323233442222332333232133434
71 3443343232422424242432222442342442222343
72 4543444343422233232444232443433332122444
73 1545535151511335154551411421554454111555
74 1544444243521424142442521443453352122445
75 3443444141411515151542511551542451111454
76 4454343443422424243442432443543442242454
77 2444544245432534135441111412441441134444
78 2344444243421314222343242233442243142424
79 2324433343543244353333421333432232313434
80 3545444243422424142432422443442442122444
81 2454555453521313131342321352452442121445
82 2245445244431224122443222144322242142434
83 3243343434332433222332322233432323121323
84 5225324131224245225434114223323112313413
85 2442344341431334253442322432442232122444
86 2435535144321424132542321444453422142435
87 2213212323234333433222233333223433443232
88 2444344334423413543433333311224113244324
89 2333435244521424133452321333541142132445
90 2444444243422324233542421432442242242444
91 1554555152411313142451221343551352111555

92 244434423222142552444322224223222242322333
93 2555555253553325243443522444552142141444
94 1443544242421333243342332334551242132544
95 2232434434431232224244242224422221443422
96 1345545253421251333552321223442244244434
97 2454454242522322233252431331432143142435
98 2444444242432434243443432434442442222444
99 2244444341223223222332332122333122123323
100 1354234132311113132341113122331221121313
201 2453434343321332123343322433323122154424
202 2445544252421423242442422442442442122444
203 1354555252411424133452421432444232142535
204 1554454342521425141441321542451133153435
205 2425445232321424352534221122451442111555
206 2233344323321422223222122222332222244323
207 1551415153511414241552411533233444121545
208 2533425131224423334552422234444432513331
209 2544344131411532242334431533444342222434
210 1434445355441223111344331433552342122445
211 1455155155511515151555151155155155111155 5
212 1251425143511511153443513131454111155535
213 2533434342332433243343332432444442222444
214 1445545153411525152555252154355444111155 5
215 1554555153511524152552411553551441111555
216 1534235142421415333441321441452441132434
217 2334445343331313131121451433423434242342
218 4543444342422521442242442442344444222444
219 2544545142422422224224244144244244422255 5
220 2443343232422434233243422344443432132434
221 2342425434332323234233223433342342234545
222 2135534244421325143455521334552413121555
223 2444444244421424142442423443442332122444
224 3242343243324234321332343234322323234332
225 4445443242421534341332411443443442222444
226 3555455252534534142442241442454442122444
227 4332232322333223333232243222242222444222
228 2555345132511313153541321431552252141535
229 2434334342421313132352431344432123112545
230 2544444444423425243442422443453341111554
231 3545345232422534243443432443443342222444
232 2444444242422433242442322333442332223434
233 2445445144541425142442241444452441121545
234 1343333231311421243242421431442241142441
235 2432334232312342243252321522433342233335
236 1554555452521314141441431441552342122445
237 2544445242422424242442422442442442222444

238 2544545254421424141451321554551542111555
239 2544544353432323242452421442423342122545
240 2544454241512535152542411453442141111444
241 2343444443422323232232332333342242232444
242 2543444241511514151341421533553353121444
243 1433211415145423542412345215235532523221
244 3434334232321422243444432442543433123445
245 2444444342421434142443421443532242132544
246 2544434232422322152243232533332142122534
247 2434434342322433244342432433443242122445
248 2544444242421333344442322444443442122545
249 1455455151511425142552421552551232142525
250 2454354141511525151541311443431121144425
251 3444354242413324233432111322544352221454
252 2343343333342422232332332423432343132434
253 2355554153511525253552311544552551111555
254 3555555151511515151551511543551551111555
255 3334334242422433344344323322323242232445
256 1231535255341414125454321233451134132435
257 1231535255341414125454321233451134132435
258 2445343142411525244532211331342341111344
259 2445344242412434243141513441442141151444
260 3223323131213234224233222333324223343323
261 3454354233522322235234522341432124152424
262 2434334234422323233443221323442232133444
263 2335433233312324232442322333432332132444
264 2443444342422323232343222322332232122433
265 5355555355351333135353332335332233115535
266 3442343421443422333224343442334324432333
267 2334343343421323233343321232432332122435
268 1355555153511555133553311335541231131535
269 2354455243532433132442331432431232143434
270 1251353533531543331553531112353353131355
271 2445443133411423231432422343441132243434
272 2344444244422333222442422243442243232434
273 1544445253521314143453311432441342111335
274 2432224233322344344432222332434234222434
275 3443345445542132454244422343433145142445
276 3555355353533533355555555355355553535535
277 1555555154521525151552521552551552111555
278 2555545353421514151551523254551352131555
279 1433334342411332233332222432442233133414
280 1443544342421512121142431334541153131555
281 2324335242342424124442222421532242121434
282 4434333333333434343334343432444433443444
283 2253444243431322222342322333432223243333

284 25555552525215153535522115335523511315555
285 14444443325115331423324224423442432424444
286 23535542434213342435422112224311231435454
287 15555551525115151555151155355115114215555
288 12111114111243315351151152111155435331111
289 13555551553212341344532214244512411535455
290 14443442544233342434342343333332424333433
291 13435453433213231243333213425512421424444
292 13434453534312242323422322334421331445255
293 15334353423215452244442112124533211115355
294 15555555535314351415535212515511431315555
295 23544542444213242224424213234422421444355
296 25545552535211132122414224514411432424355
297 21432232442333324234234232423134242421333
298 33445451434214343344533223233433321124355
299 13234253522114242554441114134511521515444

SAS Program for Confirmatory Analysis

```
m "output;; clear; log; clear";

/* 40 item questionnaire with the first number subject id*/
infile 'e:\dissertation-the real one\confirmatory analysis\first attempt
confirmatory analysis\datasecondhalf.txt';
input id $ 1-3 t1 5 t2 6 t3 7 t4 8 t5 9 t6 10 t7 11 t8 12 t9 13 t10 14 t11 15
t12 16 t13 17 t14 18 t15 19 t16 20 t17 21 t18 22
t19 23 t20 24 t21 25 t22 26 t23 27 t24 28 t25 29 t26 30 t27 31 t28 32 t29 33
t30 34 t31 35 t32 36 t33 37 t34 38 t35 39
t36 40 t37 41 t38 42 t39 43 t40 44;


Data two;
/* reversal items, six minus the response of each question (answered on a 5
point likert scale)*/
set one;
t01=6-t1;
t013=6-t13;
t017=6-t17;
t031=6-t31;
t035=6-t35;
t025=6-t25;
t010=6-t10;
t019=6-t19;
t022=6-t22;
t036=6-t36;
t037=6-t37;
t08=6-t8;
t012=6-t12;
t024=6-t24;
t028=6-t28;
t034=6-t34;
t015=6-t15;
keep t01 t2 t3 t4 t5 t6  t7 t08  t9 t010  t11  t012  t013  t14 t015  t16
t017  t18
t019  t20  t21  t022  t23  t024  t025  t26  t27  t028  t29  t30  t031  t32
t33  t034  t035
t036  t037  t38  t39  t40 ;
run;

Proc Calis data=two covariance residual modification;
LINEQS /* specify the equations linking factors with variables */
/*factor1=self-efficacy, factor2=problem-solving, factor3=attention,
factor4=prior experience */


t017 = lt017f1 F1 + E1,
t21 = lt21f1 F1 + E2,
/*t025 = lt025f1 F1 + E3,*/
/*t29 =  lt29f1 F1 + E3,*/
t035 = lt35f1 F1 + E3,
/*t38 = lt38f1 f1 +  E6,*/
t40 = lt40f1 F1 + E4,
```

```
t14 = lt14f2 F2 + E5,
/*t18 = lt18f2 F2 + E9,   */
t26 = lt26f2 F2 + E6,
/* t036 = lt36f2 F2 + E7, */
t39 = lt39f2 F2 + E7,
t32 = lt32f2 f2 + E8,
t33 = lt33f2 f2 + E9,
/*t037 = lt037f2 f2 + E15,*/

/*t012 = lt12f4 F4 + E14,  */
t16 = lt16f4 F4 + E10,
t08 = lt08f4 F4 + E11,
t20 = lt20f4 F4 + E12,
t024 = lt24f4 F4 + E13;
/*t034 = lt34f4 f4 + E19;  */


STD /* specify variances of common and unique factors */
f1=1,
f2=1,
f4=1,

E1-E13 = vare1-vare13;
COV /*specify covariances among common factors */
F1 F2 = CF1F2,
F1 F4 = CF1F4,
F2 F4 = CF2F4;

VAR  t017 t21 t035 t16 t40 t14 t26 t32 t33 t39 t08 t20 t024 ;
run;
```

Data For Confirmatory Analysis

300 1344445253411224142451321332542431122435
301 1555555152511415152551511554552551111555
302 2443443343432224233343432334433334233434
303 1545143242324215152551231232221441151555
304 1444334243431424132342421443451342131544
305 1454455253511515252542321352543341132444
306 2444442333421443131443322341442232122524
307 1545544455541515153315331155542151553445
308 2335335431312344234434234321433343431535
309 3544444231422433143432222442342342222444
310 3435434142412234253543321333443341111444
311 2445444242421424243441211441444342122444
312 3422323332424444455452433423554221112425
313 2554555253511514141452321343542341121445
314 1454555253531323242352331443452342122445
315 4521222421523521543213435531134354521252
316 3535534131411534343332323533443341122445
317 2544444242421414143442422532422142122444
318 2544444242424424242442311442442442222444
319 3443344242411423253442321532443442222444
320 2344434314431423122332222342422334232343
321 2355554242521534151452332353442553111545
322 1315555351531413141353531454531343133535
323 2434434442422424242442422442432342121444
324 3544343432422524152442322532443452121454
325 3434234232422323242332432442323343232343
326 4545444242422424253442323532343451222544
327 2334334233421323244332231442323133143535
328 3343343343221332232343234322343343221234
329 3444444253521434242442422432543232232444
330 1534433442321232134443422444443442221443
331 3212313432211221243343222122323124244323
332 3255454242411323132343323442432142142444
333 3443334232223122232342421233443132152315
334 1554444241414121324242241225452222242444
335 1555155152511551515525415521551552111555
336 3334333242322424232432322333443332222444
337 2454454243421323143342331432442134152434
338 3442344432422434434444433343444145443433
339 2444444242321433133342321442542342122444
340 3434333232322333233333333432333234343333
341 2323143412222222341212132314221112332342
342 5444344232421414142432431442444442122444
343 3544444242422424243442424432333442322333

344 243333423232233424333333432243233433333
345 3555555155511525152551411554553151151555
346 3544444232521524152432321442443252141454
347 2444444251421424243442421432543442122544
348 1354232431311334353435113421333111355334
349 2555454141521515151551522553553552222555
350 2544343243421424242433223423442242232444
351 1153155354541334114252234133541145152545
352 3554455243531344151451411553553453131545
353 3455544333523534333343332333443143151434
354 2455544144422424242342421432451542121544
355 2455455242522433242442322432442342122545
356 2345455353412433233442321312551332152555
357 3443344331431333125343235322333233223323
358 2345444142412435143442321433443341211444
359 3343553151512432345334221321433232142445
360 3344444243423424343443422333443442222344
361 3332233233332323343333342323323444332344
362 2533344343342444324332433243243423344434
363 1355155151511515151515132514451515151513
364 1555554552511535151551321554551442111555
365 1443444242421324142432432442442341122444
366 2545443332421423132342311533541242111555
367 1444444143411414242342221442441442122444
368 1343334334331324142334332323331233133434
369 1122131315335111312311325114111113555111
370 3555455253421333243442221443443342222444
371 2543554343422424141344431544544532121455
372 3354454234421423342442422242344111335333
373 1452555253511514141542111532554352111554
374 1444445242421435142553321352511542121445
375 1254454243531423131353322443441342122444
376 1454455231521514151555511551551341511545
377 1444445242411435142554231452511542121445
378 1444544142411414142441421443543442121544
379 2545443132412415142532212542342341212444
380 1555355442521535342555521555553553111555
381 155455.343451551514145343514524545243415
382 2454454242421424141442322442542242121444
383 1443444242421313132442321433431232142434
384 4532434242321333134342311331534123153535
385 4334334231422322234233442322445234243234
386 2544545231421544243244432443543442132345
387 3545544251421325154552221551553331111345
388 2433434232422423233442422232433342223434
389 1345544243421533233554321343432422113435

390 2344343252421323141342431442443232111445
391 2545445241412423142441421443442442112544
392 2234333232322424233433222323332122243334
393 2544544144441515152553321544452252111555
394 1515155151521313133351512533353333333555
395 1544444452514141141441111441451511151445
396 1151355555151111111155151155511115111515
397 2345555254421234133452424233442232132235
398 1155555152511515134554431344551131131535
399 3434244232341222143442222422242242122424
400 15445451525214242425552521554551441115545
401 4545341314422113143442123432354432112333
402 3545444121511414232422311542444241131444
403 4554454252521524243443422443544242222445
404 2543444342322422233343322431443442122545
405 3454555242511523242352412443334242133445
406 2545445153411425152541211543442341111555
407 1444534252422424232442421442442442122444
408 2444444242422424141442431332341142142444
409 2444455242421424252442422443443242142444
101 2443344552411244142453411451552231133535
102 1555555255521525152553521543551552151555
103 1553444353332424242344423234432342243424
104 2333443333334422343433433433433334334344
105 3331332512151321151131551313223325234333
106 3322223433322232224224233223323234334333
107 3412113423331232222334234232422322432143
108 23454441224213243241424.3142134213523134
109 1341344442431432223243433343231323133434
110 2454344342422222234242422442344242242444
111 2444344243422324232442322333432242242444
112 3443444242422523132342322232442332222434
113 1554554151511315141551511553551551111555
114 2534434232522533342322522534443342122441
115 1355555152511515141451421423542441111445
116 3423222222223423444323322422344442222343
117 2444343431412434233443434344333333333333
118 2254545443431333233342342333443232122434
119 4234221523214341435215135211115215555222
120 1255555453421323111452432452431113131324
121 1544545152411514142451321413541452121545
122 2324322433345323533444221333431233132534
123 14444444344421233345444332433433133132445
124 2445445244421423233452423443442232221435
125 1345445244431513243452341143542452121555
126 2555455533511525251542211551453351111455

127 2523455453541554151343245352343525342545
128 1155545353513541224544435434544313343215
129 3344244242421424342442422443442242222444
130 1555333111551545151254511552551521133453
131 1444444242421323242443222343433242142535
132 1335435142512434245442321233551342323444
133 2424323233321435245435132412443153131323
134 2355555255511435153551211434552451111555
135 2555555153521434143454211244441441133335
136 1353555354531213121353331254551124153515
137 1354455252521414141452421442541352122545
138 1254444444431323122353431344442243144445
139 1442344332433441435234332233442232123435
140 1354445552531334234343243444243412323 2
141 1333234445431211123245251324422244155515
142 2133234342423234232323422432531132154435
143 3333334232123333233342322333333343133434
144 2155454251511525152552411542441551111555
145 1453555252511423135342321332432133142545
146 2544444243412323233333422342334342234135
147 1333434242331333424333333333333134323333
148 1353345243531323142343321234432342122545
149 3432433332322233234332231223334224232334
150 1545545352511435251552421552551341121555
151 1345455242511435244353421452543454111545
152 2111211211222121212112222112112112222111
153 1555555154551514144451451553551354111555
154 1553455153521414152451421542551351111545
155 1443444343431233234342222323442232232434
156 1455454244332433153544431532343454433345
157 2122214434342544134255342224421321113535
158 2544444253521515152552422553551451111555
159 1544445153421525152553311432552551111445
160 2244445243422524233442321233542342122445
161 1355233345421314133352432353441233145453
162 3222224432232323332333322432342233243425
163 3545353231412433343332523233334233322444
164 2444444343421444142441511443552342122545
165 2553555353511533151353541551553151131555
166 3555455153511515154551514534453451111555
167 2545545143511545153543421533552551111555
168 3244444342424422332342342332333442222434
169 2543334333321533143343332323333223122444
170 2555555151511515252551311551555551111555
171 2444343232411425242532321442442442222444
172 4544524433531555454555522545554453132555

173 144344424342143324244232234344234212244 4
174 332222233243233223432333233223423444323 2
175 134444424342123413244342243343233312343 4
176 255544514252153515254232224315533421334 44
177 234354544452134213434343343342512314323 3
178 134434525353141213245232143354214213144 5
179 155555515251152515255453154455154122155 5
180 244444424342142424344332234344224213233 4
181 254544424241134114344242123254333321243 4
182 345435424252144423445221254555242524245 5
183 443452424242224243434323414434432422224 44
184 244244424242224242424424225444444422224 44
185 355555525251153515355342134255355111155 5
186 153343554334243424344433243444344413244 5
187 245555525352142515444242223434421424415 45
188 235445514151152414354131144145345111144 5
189 154444434353123514343342243353233223353 4
190 244244554242122213324343133344213414254 5
191 444334424242143424344242143244224213242 4
192 145555533352151515155354125455255311155 5
193 234344444344111411135322134244115413144 5
194 243343434443233423344233243344343212243 4
195 125545534543121411245331123532134213243 5
196 355554424252151425344242225424524421224 44
197 354534313151152535253241254235325233134 3
198 111511111551151515155151155255555111155 5
199 155545515251151515255121144344224112254 5
200 244344424242142414244342244244322224424 4

APPENDIX C – INSTRUMENTS

Consent Form, Code Sheet for Form Scores, Previous Experience Questionnaire, Cognitive Processes Physical Activity and Golf Questionnaires, Qualitative Coding Categories and Number Assignment According to Treatment Group

Consent Form

Title of the study: The effect of scaffolding movement challenges on students task-related thoughts and practice quality

Location: Louisiana State University Golf Course

Investigators: The following investigators will be around M-F 10am to 4pm
Paul Rukavina, 578-5714
Amelia Lee, 578-2913

Purpose: The purpose of the study is to determine how teachers can provide information to students to facilitate learning sports skills

Inclusion: Participant inclusion in the study is university students ages 18-50.

Number of participants: 200

Procedures: On the first day, participants will fill out a short questionnaire on their previous golf and sport experience and be videotaped pitching 20 golf balls. Days 2-6, participants will receive instruction, practice, and finish each of the days with 10 videotaped pitches. Also, they will fill out two short questionnaires during the practice days. On the last day, participants will take a learning test.

Benefits: No direct benefits will be gained by the participants but information learned during this project will help teachers better design practice for students to learn skills.

Risk: There is low risk. The risk is equivalent to participating in a university golf activity class.

Right to refuse: Participants may choose an any time not to participate or to withdraw from the study at any time without penalty or loss of any benefit to which they might otherwise be entitled.

Privacy: Results of the study may be published, but no names or identifying information will be included in the publication. Subject identity will remain confidential unless the law requires disclosure.

Signatures: The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Robert C. Mathews, Institutional Review Board, (225) 578-8692. I agree to participate in the study described above and acknowledge the investigator's obligation to provide me with a signed copy of this consent form.

____

NAME DATE

Code Sheet for Form Scores

Each subject has a different posture/grip and swing mechanics, however, there are some concepts/principles when applied will produce better performance despite their form.

Scoring

2= Obvious the subject understands the concept
1= Subject's behavior resembles some understanding
0 = Person has no clue about the concept

1. **MAINTAINING STANCE-**
   - **Concept:** The subject maintains their stance throughout the shot minimizing unnecessary movement.
     - Style 1 - The lower body and trunk should remain relatively in place during swing with a slight movement of the back knee towards front knee
     - Style 2- The twist/movement of the hips does not interfere with correctly placing the club at impact (okay to have knee movement forward/back associated with hip rotation)
     - Head position is relatively stable (does not bob up and down) prior to contact and body does not shift from side to side
   - **Coding errors:**

     2 = No additional movement (maintains stance like models)
     1 = Maintaining stance, but some unnecessary movement (is moving only in one plane)
       - **Shifting from side to side**
       - **Standing up or learning back**
       - **Lifting front foot**

     0 = Lots of additional movement (is moving in multiple planes) or movement is extreme in one plane
       - **Shifting from side to side and lifting front foot**
       - **Dipping excessively**
       - **Bending trunk and shifting**

2. **USING LOFT OF THE CLUB (FRONT ARM LEVER ON SWING)**
   - **Concept:** Swinging club like a pendulum allows golfer to use the loft of the club to project the ball.
     - Left arm is relatively straight and subject is not trying to scoop the ball.
   - **Coding:**

     2 = Subject has a straight left arm during backswing and downswing prior to contact (needs wrist bend to keep it straight)
     1 = The arm is kind of straight
       - **Arm is not straight because wrist is not bent**

- **Arm bends at elbow but not as extreme as v-swing**

0 = Bend front elbow a lot

- **V-swing**

3. **USING LOFT OF THE CLUB (EARLY WRIST ACTION)**
   - **Concept:** Using initial wrist release positions the clubface in an "open position" to increase loft of the ball
     - As the back swing starts, the golfer initially releases the wrist near the back leg area
   - **Coding:**

     2 = Subject uses initial wrist release (before or around back leg area)

     1 = Subject has wrist bend toward the end of the backswing
     - **Waits until top of backswing to bend the wrist**

     0 = Subject does not bend wrist at all or does excessive wrist cocking
     - **Using only the wrists to move club (excessive wrist)**
     - **Does not bend wrist (evidenced by straight club extending from arm)**

4. **USING THE LOFT OF THE CLUB (BALL PLACEMENT)**
   - **Concept:** Placing the ball forward in the stance places the loft of the clubface in "open position" that increases the loft of the ball
     - The ball is forward in the stance. Forward means that the ball is beyond midpoint of the feet
   - **Coding:**

     2 = Ball is toward the front of the stance

     1 = Ball is in the middle of the stance

     0 = Ball is in the back of the stance

5. **GREATER SENSITIVITY AND LESS JERK**
   - **Concept:** Allowing the club to fall during swing (using gravity) without imparting muscle tension allows for more sensitivity and a shot less prone to jerkiness
     - Letting the club do the work-
     - The golfer doesn't muscle the ball, but simply lifts the club up on the backswing and drops the club using muscle tension or muscle only to guide the club toward the ball.
     - Subject used "big muscle groups" instead of small muscle of arms to generate club movement
     - Club rising up on the backswing to down swing resembles "throwing a ball into the air"
   - **Coding:**

     2= Dropping club- Relaxed swing taking advantage of gravity before contact

     1= Somewhat dropping club- relaxed swing with some muscle imparted on downswing
     - **Path of the club is jerky (adding force on back swing or down swing)**

        - **Doesn't follow the analogy tossing a ball into the air, reaching zero velocity then accelerating to achieve greater velocity on downfall.**
    - **Subject uses muscle to stab at the ball**
- **0=** All muscle-swing hard or controlling ball solely with arms (extreme)
    - **brings club back far, is jerky, uneven swing**
      Really stabs at the ball

Previous Experience Questionnaire

Print name_________________________ Age_______Male or Female____________

Respond in writing to each of the three questions:

1) List the sports and types of exercise that you do or have done. For sports, give the name of the sport, at what level you played at and how many seasons. If sports are recreational activities, report how many years you have played them. For exercise, denote the type and how many days per week you exercise.
2) List your golf experience (how much) and what level you play at.
3) List the LSU classes before or after this golf class? If so, write the times of your classes. If you go to a job after class, indicate this also.

Cognitive Processes Physical Activity Skills Questionnaire

Instructions
This questionnaire is designed to gather information about your behavior practicing sport skills during a physical activity class. There are no right or wrong answers. Your identity will not be linked to your answers in anyway. Therefore, please **do not** put your name on this question sheet or the scantron.

On the scantron provided for you, please answer the corresponding question by marking a response. Please complete all items. To help you decide which responses to mark, below is an explanation of each term and the corresponding letter to mark on the scantron for each term.

Not at all true of me = the statement would only be typical of you in rare instances
Not very true of me = the statement would be generally not true
Somewhat true of me = the statement would be true of you half the time
Fairly true of me = the statement is generally true of you
Very much true of me = the statement is true of you almost all the time

Not at all true of me	Not very true of me	Somewhat true of me	Fairly true of me	Very much true of me
A	**B**	**C**	**D**	**E**

1. I get discouraged when I practice skills
2. When I make mistakes during practice I ask myself what I did wrong
3. It is easy for me to concentrate while I practice skills
4. While practicing, I recall a lot of things from past experience to help me learn
5. I feel optimistic when I practice skills
6. It is easy for me to concentrate while I practice skills
7. I believe I can do well when I practice skills
8. While practicing, I usually don't think about my past experience
9. I feel confident when I practice skills
10. I rarely have to check if I am making errors or not
11. I concentrate when I practice skills
12. I have little need to use my prior experience to help me do better during practice

13. Practicing skills is too hard so I feel like giving up

14. I compare and contrast my performance from one practice attempt to the next

15. While I practice I feel like I am just going through the motions

16. While practicing this task, I try to find relationships between the skill I am learning and the skills I can already do

17. I feel bad because tasks are too hard

18. I analyze my practice attempts as to what I did wrong or right

19. My mind wanders while I practice skills

20. I try to relate the skill I am learning to other skills I already know

21. I am confident I will be able to do well when I practice skills

22. I just try things when I practice but don't really think about them

23. When I practice, I try only to think about the skill I am practicing

24. I didn't need to relate information about other skills to help me learn skills

25. Everything I try while practicing doesn't seem to help me get better

26. When I practice, I try to find a reason for my errors

27. My center of attention is on my practice not other things happening in the room

28. The errors I make during practice usually fix themselves

29. I feel confident because I feel like I am improving

30. I think about what is the most efficient way to perform the skill I am learning

31. When I practice skills, I get frustrated

32. I form hypotheses (movement plans) and test them during practice

33. I monitor my performance during practice

34. I rarely relate what I am doing to my prior experience with other skills

35. I feel like I will do terrible no matter how hard I try

36. I rarely form hypotheses about the best way to move when I practice

37. I rarely monitor what I do during practice

38. I have beliefs in my ability to do good when I practice skills

39. I check my performance during practice and draw conclusions on how successful I am

40. I feel I can do well when I practice skills

Cognitive Processes Golf Questionnaire

Instructions
This questionnaire is designed to gather information about your behavior practicing the golf pitch. There are no right or wrong answers.

On the scantron provided for you, please answer the corresponding question by marking a response. Please complete all items. To help you decide which responses to mark, below is an explanation of each term and the corresponding letter to mark on the scantron for each term.

Not at all true of me = the statement would only be typical of you in rare instances
Not very true of me = the statement would be generally not true
Somewhat true of me = the statement would be true of you half the time
Fairly true of me = the statement is generally true of you
Very much true of me = the statement is true of you almost all the time

Not at all true of me	**Not very true of me**	**Somewhat true of me**	**Fairly true of me**	**Very much true of me**
A	**B**	**C**	**D**	**E**

1. I get discouraged when I practice the golf pitch
2. When I make mistakes while practicing the golf pitch, I ask myself what I did wrong
3. It is easy for me to concentrate while I practice the golf pitch
4. While practicing the golf pitch, I recall a lot of things from past experience to help me learn
5. I feel optimistic when I practice the golf pitch
6. It is easy for me to concentrate while I practice the golf pitch
7. I believe I can do well when I practice the golf pitch
8. While practicing the golf pitch, I usually don't think about my past experience
9. I feel confident when I practice the golf pitch
10. I rarely have to check if I am making errors or not
11. I concentrate when I practice the golf pitch
12. I have little need to use my prior experience to help me do better during practice of the golf pitch

13. Practicing the golf pitch is too hard so I feel like giving up
14. I compare and contrast my performance from one practice attempt to the next
15. While I practice the golf pitch I feel like I am just going through the motions
16. While practicing, I try to find relationships between the golf pitch and the skills I can already do
17. I feel bad because pitching golf balls is too hard
18. I analyze my practice attempts as to what I did wrong or right
19. My mind wanders while I practice the golf pitch
20. I try to relate the golf pitch to other skills I already know
21. I am confident I will be able to do well when I practice the golf pitch
22. I just try things when I practice the golf pitch but don't really think about them
23. When I practice, I try only to think about pitching the golf ball
24. I didn't need to relate information about other skills to help me learn the golf pitch
25. Everything I try while practicing the golf pitch doesn't seem to help me get better
26. When I practice the golf pitch, I try to find a reason for my errors
27. My center of attention is on practicing the golf pitch not other things happening in the room
28. The errors I make while I practice the golf pitch usually fix themselves
29. I feel confident because I feel like I am improving
30. I think about what is the most efficient way to perform the golf pitch
31. When I practice the golf pitch, I get frustrated
32. I form hypotheses (movement plans) and test them while I practice the golf pitch
33. I monitor my performance while I practice the golf pitch
34. I rarely relate practicing the golf pitch to my prior experience with other skills
35. I feel like I will do terrible no matter how hard I try

36. I rarely form hypotheses about the best way to move when I practice the golf pitch

37. I rarely monitor what I do while I practice the golf pitch

38. I have beliefs in my ability to do good when I practice the golf pitch

39. I check my performance when I practice the golf pitch and draw conclusions on how successful I am

40. I feel I can do well when I practice the golf pitch

Cognitive Processes Questionnaire- Questions Grouped According to Subscale

Problem Solving subscale
2-- When I make mistakes during practice I ask myself what I did wrong
010-- I rarely have to check if I am making errors or not
14-- I compare and contrast my performance from one practice attempt to the next
18-- I analyze my practice attempts as to what I did wrong or right
022-- I just try things when I practice but don't really think about them
26-- When I practice, I try to find a reason for my errors
30-- I think about what is the most efficient way to perform the skill I am learning
32-- I form hypotheses (movement plans) and test them during practice
036-- I rarely form hypotheses about the best way to move when I practice
39-- I check my performance during practice and draw conclusions on how successful I am

Prior experience
4-- While practicing, I recall a lot of things from past experience to help me learn
08-- While practicing, I usually don't think about my past experience
012-- I have little need to use my prior experience to help me do better during practice
16-- While practicing this task, I try to find relationships between the skill I am learning and the skills I can already do
20-- I try to relate the skill I am learning to other skills I already know
024-- I didn't need to relate information about other skills to help me learn skills
028-- The errors I make during practice usually fix themselves
034-- I rarely relate what I am doing to my prior experience with other skills

Self-efficacy subscale
01--I get discouraged when I practice skills
5--I feel optimistic when I practice skills
7--I believe I can do well when I practice skills
9--I feel confident when I practice skills
013-- Practicing skills is too hard so I feel like giving up
017-- I feel bad because tasks are too hard
21-- I am confident I will be able to do well when I practice skills
025--Everything I try while practicing doesn't seem to help me get better
29-- I feel confident because I feel like I am improving
031-- When I practice skills, I get frustrated
035-- I feel like I will do terrible no matter how hard I try
38-- I have beliefs in my ability to do good when I practice skills
40-- I feel I can do well when I practice skills

Attention subscale
3-- It is easy for me to concentrate while I practice skills
6-- It is easy for me to concentrate while I practice skills
11-- I concentrate when I practice skills
015-- While I practice I feel like I am just going through the motions
019-- My mind wanders while I practice skills
23--When I practice, I try only to think about the skill I am practicing
27-- My center of attention is on my practice not other things happening in the room
33-- I monitor my performance during practice
037-- I rarely monitor what I do during practice

Qualitative Coding Categories

TP	Technique-Posture and grip	**Student talks about a specific posture or grip technique or about technique in general.** 1) e.g., bend knees, back straight, keep my head down, kept eye on the ball 2) e.g., focused on technique, or I worked on technique
TS	Technique-swing mechanics	**Student talks about using body parts during the swing or use of force during the swing** e.g., Use wrist bend, try to control my arms, tried to swing smooth, lead with my left hand, try not to hit it too hard, try to make my swing consistent, following through with the club, work on my power, try not to swing too hard, swing softly
SA	Degree of effort or success	**Student perceives their performance as successful or unsuccessful or comments on their effort** e.g., I wasn't successful at all, I suck, I was getting good loft and ball checking well, I tried hard, nothing, I still do not know what to do, I hit two in the target by an act of god, I can't figure out how, today I stayed down, is something I find useful, the ground was too hard, that threw me off, I was getting correct distance, very little, nobody can tell me what I am doing wrong, Tried to hit as many balls as I could, I do much at practice, kept hitting so odds would improve in my favor, I kept hitting, practice swinging
MS	Stress management and focus	**Anything referring to a focusing on some target during performance or statements referring to stress management** e.g., I relaxed, I concentrated, tried not to get too frustrated when I mess up, taking my time, mental practice, stayed focused, focus on the target, loosen up, need to relax more, aim, I tried to stay calm, calmed down, took my time, concentrate on hitting the ball, not get frustrated with a bad hit, hit the pole, keep it fun, I tried to take my frustration out on the ball
CS	Concept/critical thinking	**Talked about a concept that would improve outcome or refers to a concept in general or critical thinking (or trial and error) that would lead to understanding a concept** e.g., left clubface open, I put the ball further in my stance, I used loft of the club, made sure I got the ball in the air, left clubface open, tried to let the club do all the work, let gravity pull the club down from my backswing, keep less muscle tension, I tried to incorporate it into my swing, make a hypothesis, see how the question was answered, try different experiment, go with what worked best

Assignments of subject numbers Skill Groups (3 groups) and Treatment Group

Control	skill	Guided	Skill	Correct	Skill
13	3	11	3	1	3
15	3	10	3	5	3
4	3	6	2	12	2
18	3	7	2	2	2
16	1	14	2	9	2
51	1	3	1	8	1
23	2	22	3	20	2
19	2	28	2	25	1
27	1	26	2	24	2
17	2	21	1	30	3
29	3	38	3	34	1
32	2	37	3	36	3
35	1	33	2	31	3
54	2	39	1	40	2
53	3	43	1	44	1
41	3	47	1	49	1
48	2	46	1	55	3
45	2	85	2 or 3		
42	1				

Note: Skill Groups (Higher skilled=1, Medium skilled = 2 and Lower skill = 3). Treatment Groups (Control=1, Guided Discovery =2, Correct=3).

Assignments of subject numbers Skill Groups (2 groups) and Treatment Group

Control	skill	Guided	Skill	Correct	Skill
13	3	11	3	1	3
15	3	10	3	5	3
4	3	6	3	12	3
18	3	7	1	2	1
16	1	14	3	9	1
51	1	3	1	8	1
23	3	22	3	20	3
19	1	28	1	25	1
27	1	26	1	24	1
17	1	21	1	30	3
29	3	38	3	34	1
32	3	37	3	36	3
35	1	33	1	31	3
54	3	39	1	40	1
53	3	43	1	44	1
41	3	47	1	49	1
48	3	46	1	55	3
45	1	85			
42	1				

Note: Skill Groups (High skill = 1, Low skill =3). Treatment Groups (Control=1, Guided Discovery =2, Correct=3).

Concept Score Coding Sheet

Coding sheets (non retention or transfer) Coder______________

Tape_______Subject #_____________

	1	2	3	4	5	6	7	8	9	10
Stance										
Arm										
Wrist										
Ball										
Jerk										

Tape_______Subject #_____________

	1	2	3	4	5	6	7	8	9	10
Stance										
Arm										
Wrist										
Ball										
Jerk										

Tape_______Subject #_____________

	1	2	3	4	5	6	7	8	9	10
Stance										
Arm										
Wrist										
Ball										
Jerk										

Tape_______Subject #_____________

	1	2	3	4	5	6	7	8	9	10
Stance										
Arm										
Wrist										
Ball										
Jerk										

Tape_______Subject #_____________

	1	2	3	4	5	6	7	8	9	10
Stance										
Arm										
Wrist										
Ball										
Jerk										

APPENDIX D – SCRIPTS AND TASK CARDS

Timeline of Events, Recruitment Script, Basic Instruction Script, Treatment Teacher Scripts, Critical Thinking Steps Task Card, Guided Discovery Task Cards,

TIMELINE OF EVENTS

Date	**Activity**
Mon. June 1, 2002	Recruitment of students in Louisiana State University Maddox Fieldhouse • Sign Consent forms
Tues. June 2, 2002	Train Teachers at Louisiana State University Golf Course • Run-through scripts, practice teaching and practice scoring
Wed. June 3, 2002	Pre-test subjects 15 m pitch (1 m barrier)
Thurs. June 4, 2002	Day 1 – Instruction • Maintaining Stance Concept
Fri. June 5, 2002	Day 2 – Instruction • Pendulum Swing Concept
Mon. June 8, 2002	Day 3 – Instruction • Early Wrist Action Concept
Tues. June 9, 2002	Day 4 – Instruction • Ball Placement Concept • Openness of Clubface Concept
Wed. June 10, 2002	Day 5 – Instruction • Vary height of Backswing Concept
Thurs. June 11, 2002	Day 6 – Instruction • Greater sensitivity/ less jerk Concept
Fri. June 12, 2002	Post-tests-Retention practice 15 m pitch, transfer 20 m pitch (2 meter barrier)
Mon. June 15, 2002	Make-up post-test

DAY 1: RECRUITMENT SCRIPT

1. Consent forms and prior experience form (Monday, June 1, 2002)
    - At the beginning of the hour, get them together, explain the consent form, and have them fill out the prior experience. Have a system of those that are coming late. Find out who comes late and leaves early.
2. Script
    - Hello. My name is Paul Rukavina. I am a graduate student in Kinesiology. I have obtained permission from your instructor to perform my dissertation project using summer golf classes. Today I am here to explain what the study is about.
    - We are investigating how people learn to pitch a golf ball. The golf pitch is a short range shot that flies high in the air.
    - Our goal is gather information so that we can use this information to help instruct teachers and coaches about different ways to teach. I don't know if you ever heard of clinical trials in medical research to try out new techniques. We are doing the same here, except we are investigating how to teach golf. The techniques we are trying are just a couple ways of teaching, I am sure the golf instructors use a combination of techniques that are really good.
    - In this study, we will divide this class into six different groups. We have two different teaching methods we want to investigate. Some groups will be taught with one method while other groups will be taught with others. One of the groups is called a control where some of you will practice without any instruction so we can compare how the teaching methods work. In other words, After the study is over, the golf instructor will teach the stroke over again so you won't be missing anything.
    - In sport teaching studies, we usually have part of the class be taught with one method while the other part of the class be taught with another method. Tomorrow when you come, we'll have a list as to what group you are in.
    - I am going to pass the consent form around for you to sign. Two issues are important. We will videotape your form. Only people from my research team will see the videotapes; they will be erased when we are done coding them. We will assign you to a number. We will have a sheet linking your name to a number. When the study is completed, the names will be erased.
    - Second issue, at any time during the study, you feel uncomfortable or experiencing muscle problems, you may stop without any consequence to your grade

BASIC INSTRUCTION

Action Goal

- The goal of the task is to pitch the ball (using the golf club) over the barrier and onto the middle of the target.
- A successful pitch requires the ball to be projected high into air, having it land softly minimizing the distance the ball rolls after it hits.
- A pitch is different than chip. A chip has a low arch causing the ball to roll a longer distance after it hits the green. A pitch "flies farther than it rolls" and a chip "rolls farther than it flies".

Stance and grip instruction

- Open & Narrow stance- An open stance (front foot 1-2 inches back) with subject's feet close together less than should width apart
- A "C" posture (flexion of knees, hips flexed-punched in gut, back straight) will be obtained by providing the cues "butt out, chest out and head up".
- From this posture, the arms hang down naturally about a "fist and a thumb" distance apart from the body.
- Overlapping grip
    - Palms face each other…Thumbs and forefinger form a "V", pointing between your neck and right shoulder
    - The participant will "choke-down" on the club (in middle) using an overlapping grip while opening the clubface (clubface points to the sky)
    - Grip pressure is medium
- Subjects will be instructed to swing back and through
- Keeping your clubface pointed toward the sky throughout the follow through.

GUIDED DISCOVERY SCRIPT- DAY 1

1. **Paul does basic instruction**
2. **Introduction-teachers read this-(only first day)**

- The way we will learn how to pitch the golf ball is called guided discovery. I will provide you with problems to solve that will allow you to discover movement concepts you may use to improve your pitching performance.
- You will get approximately 5 minutes (about 20-30 attempts) to explore the problem then I will give you a task card to check your answer.
- After you check your cards, you will have 10 minutes to practice regularly. During this time, I will rotate everybody to shoot 10 shots in front of the camera.

3. Read This….

For each challenge, I will give you two different techniques to try.
You should compare and contrast the results of the two different techniques

Explore the difference between the following:

1--"Maintaining your stance" throughout the shot. Your stance is maintained by keeping your lower body still and eyes on ball till the end of the follow-through or

2--"Standing up" out of your stance by extending your knees or looking at where the ball is going during the swing.

Focus your attention

- **Focus your attention on what the two techniques do to the swing mechanics, where the clubface hits the ball and the flight of the ball.**
- **In other words, your attention is on the club and the ball, not your form during your swing.**

3. **Hand out "steps to thinking sheet"…read this**

The steps to thinking are 1) Understand the problem I give you, make a hypothesis, explore for five minutes, look at the task card and check your hypothesis then I tell you the correct answer.

4. Students explore for 5 minutes-15m pitches
5. Give the task cards to students for them to check answer, give students 1 min to look at it, then tell them the correct answer

If you didn't get the correct answer, you need to explore this challenge again in a couple days

****don't engage the group in a discussion****

6. Regular practice

Everybody practice here, on the white line (15 m pitches), I will call you over one by one to hit 10 shots in front of the camera on the target.

At some point, collect task cards and steps to thinking*

GUIDED DISCOVERY SCRIPT-DAY 2

1. **Basic Instruction-Paul**
2. Review-Read this…

Yesterday, we tried two ways of swinging: "standing up out of the swing" or "maintaining our stance throughout the swing"….By trying 10 trials of each of the two ways, you should have noticed that if you straighten your knees during the swing, you "top the ball"…The concept we should have learned is "minimizing the lower motion" helps us make a more consistent swing. We will come back to this challenge next week.

Today, I will give two new different things to try,…. Remember, before you practice, make a hypothesis, compare and contrast the results of the two different things and at the end we should come up with a concept to help our golf game.

3. Read This….

Explore the difference between the following:

1) Imagine like you are chopping wood with an ax (chopping motion). Raise the club back bending your wrist so the club becomes vertical. Then like a pendulum (or an ax), follow a semi-circle swing arc to hit the ball. Keep your left arm straight while your left hand leads the pendulum back and then also, the left hand leads the club through.
2) Perform a V-Swing. Bend your elbows to move your hands back, down to hit the ball and then bend again to go up for the follow-through. The hand follows along the path shaped like a V. (the elbows are bent on the backswing and on the follow-through with most of the power coming from bending the elbow)

Focus your attention

Remember, focus your attention on the club, where the club hits the ball, and the flight of the ball,…. do not focus on your form.

3. Check for understanding-have one student repeat back the two things to try, Make hypothesis and go explore
4. Students explore for 5 minutes-15m pitches
5. Give the task cards to students for them to check answer, give students 1 min to look at it, then tell them the correct answer

GUIDED DISCOVERY SCRIPT-DAY 3

1. **Basic Instruction-Paul**
2. Review-Read this…

Last week, we tried two challenges: standing up during our swing vs freezing our lower body motion and…..scooping the ball vs cutting through the ball. Cutting through the ball and the grass lets us use the angle of clubface, letting the club do the work, not us.

If you feel you did not understand the concept of the first two challenges based on what your body and club did, I encourage you to go back and try them again. I want you to understand them with your body, not just the words. If you did not understand it, I will individually come by and re explain them.

Today, I will give you a new challenge to try,…. Remember, before you practice, make a hypothesis, compare and contrast the results of the different things and at the end we should come up with a concept to help our golf game. In other words, I am not teaching you a correct form, but I am having you perform a couple different things with the club so you can come up with a concept. So today after you explore for 10-25 shots, you should work on a technique that will give you the best performance.

3. Read This….

Explore the following:

1) We are going to experiment with the role that the initial wrist release plays during the swing. Start by freezing your wrists and swinging only your arms to hit the ball. Little by little, unfreeze the wrists until about 15 trials later, there is too much wrist bend in your swing. Remember, keep your left arm straight but relaxed. Also, have your left hand lead into the backswing and lead into the swing. In the end, find the swing where it feels like you are tossing a ball underhand or imagine the clubface as a knife and the ball as an apple….you are slicing a thin layer of the peel of an apple as the clubface goes under the ball.

Focus your attention

Remember, focus your attention on the club, where the club hits the ball, and the flight of the ball,…. do not focus on your form.

3. Check for understanding-have one student repeat back the challenge to try
4. Make hypothesis and go explore
5. Students explore for 5 minutes-15m pitches
6. Give the task cards to students for them to check answer, give students 1 min to look at it, then tell them the correct answer

GUIDED DISCOVERY SCRIPT-DAY 4

7. **Basic Instruction-Paul**
8. Review-Read this…

> Yesterday, we systematically varied the amount of wrist bend. You should have noticed that too little wrist bend….you hit the ball like a chip (low trajectory) and too much wrist bend…you the hit the grass before the ball. There should have been somewhere in the middle a wrist bend that helps you get the ball into the air. The wrist bend should have started immediately when you started the backswing.The other concepts are "minimizing the lower body motion, and don't scoop the ball but hit through the ball.
>
> Today I will give two new things to try……Remember, before you practice, make a hypothesis, compare and contrast the results of the two different things and at the end we should come up with a concept to help our golf game.

3. Read This….

> **Explore the following:**
>
> 1) Explore the following: Systematically vary how much the clubface faces the sky. Start with the club faced closed then little by little open the clubface to the sky. If you open your clubface, most golfers also open their stance. Also, opening the clubface will make the ball go off to the right (righthander) so you will have to aim off to your left.
>
> 2) Explore the following: Systematically vary the placement of the ball in your stance. Start with it near your rear foot and little by little bring the ball forward in your stance until it ends up on the inseam of the left/front foot.
>
> **Focus your attention**
>
> **Remember, focus your attention on the club, where the club hits the ball, and the flight of the ball,…. do not focus on your form.**

9. Check for understanding-have one student repeat back the challenge to try
10. Make hypothesis and go explore
11. Students explore for 5 minutes-15m pitches (Teachers may practice here too!)
12. Give the task cards to students for them to check answer, give students 1 min to look at it, then tell them the correct answer

GUIDED DISCOVERY SCRIPT-DAY 5

1. Basic Instruction-Paul

2. Review-Read this…

We have completed 4 challenges: 1) minimizing lower body motion vs standing up, 2) chopping like an ax, don't scoop like a v-swing, 3) don't' hit the ball head-on like a chip, use wrist-bend to "peel the apple", and 4) increasing the angle of the clubface to increase the ball trajectory. If you only understood these challenges by reading the words, then you need to go back to the challenge and feel how the club hits the ball and notice what the ball does.

Today I will give you a different challenge to try…Remember before you practice, make a hypothesis, compare and contrast the results of the two different things and at the end we should come up with a concept to help our golf game.

3. Read This….

Explore the following:

Vary the amount of muscle force you use to swing the club with. At first, use muscle force to impact forces on the ball. Little by little let gravity do most of the work with the only muscle force you use is to keep correct form. At the end, feel like you are tossing underhand a baby bird (or something light and soft) unto the green. In other words, your arms should be soft as the clubface drops to the ball.

Focus your attention

Remember, focus your attention on the club, where the club hits the ball, and the flight of the ball,…. do not focus on your form.

13. Check for understanding-have one student repeat back the challenge to try
14. Make hypothesis and go explore
15. Students explore for 5 minutes-15m pitches (Teachers may practice here too!)
16. Give the task cards to students for them to check answer, give students 1 min to look at it, then ask them for the correct answer

17.Basic Instruction-Paul

18. Review-Read this…

Yesterday we learned that increasing the height of the backswing creates more impact force on the ball. Remember, minimize lower body motion, chop like an ax, utilize the angle if the clubface by sliding the club on the ground instead of digging into the group (e.g., ball forward in stance and clubface open) etc…

Today I will give you a different challenge to try……Remember, before you practice, make a hypothesis, compare and contrast the results of the two different things and at the end we should come up with a concept to help our golf game.

3. Read This….

Explore the following:

Vary the amount of muscle force you use to swing the club with. At first, use muscle force to impact forces on the ball. Little by little let gravity do most of the work with the only muscle force you use is to keep correct form. At the end, feel like you are tossing underhand a baby bird (or something light and soft) unto the green. In other words, your arms should be soft as the clubface drops to the ball.

Focus your attention

Remember, focus your attention on the club, where the club hits the ball, and the flight of the ball,…. do not focus on your form.

19. Check for understanding-have one student repeat back the challenge to try
20. Make hypothesis and go explore
21. Students explore for 5 minutes-15m pitches
22. Give the task cards to students for them to check answer, give students 1 min to look at it, then ask them for the correct answer

GUIDED DISCOVERY TASK CARDS

Challenge #1

Explore the difference between the following: Try both 1 and 2!! 1) "Maintaining your stance" throughout the shot. Your stance is maintained by keeping your lower body still and eyes on ball till the end of the follow-through or 2) "Standing up" out of your stance by extending your knees or looking at where the ball is going during the swing.	
Possible answer	**"More power" concept**--Standing up during the swing allows you to dig under the ball and gives you more power because you are using your legs. Maintaining the stance doesn't give you the power.
Possible Answer	**"Minimize lower body motion concept"**--Standing up during the swing causes you to "top the ball". Topping the ball occurs when the clubface hits the top or middle of the ball instead of sweeping the club between the ball and the grass. The extra motion makes the swing inconsistent. We can generate enough power by letting the club fall from the height of the backswing.

Challenge #2

Explore the difference between the following: Try both 1 and 2!! 3) Imagine like you are chopping wood with an ax (chopping motion). Raise the club back bending your wrist so the club becomes vertical. Then like a pendulum (or an ax), follow a semi-circle swing arc to hit the ball. Keep your left arm straight while your left hand leads the pendulum back and then also, the left hand leads the club through. 4) Perform a V-Swing. Bend your elbows to move your hands back, down to hit the ball and then bend again to go up for the follow-through. The hand follows along the path shaped like a V. (the elbows are bent on the backswing and on the follow-through with most of the power coming from bending the elbow)	
Possible answer	**Digging concept.** The v-swing allows me to dig under the ball like a scoop. The pendulum doesn't give me much control and it is hard to get the ball into the air.
Possible Answer	**Use the loft of the clubface concept.** Using the club like a pendulum allows me to use the "loft of the clubface" to get the ball into the air. The loft of the club is the angle of the face of the club. I don't need to scoop it. I use a pendulum swing and let the club do the work, I don't have to dig the ball into the air.

Challenge #3

<u>Explore the following:</u> 1) We are going to experiment with the role that the initial wrist release plays during the swing. Start by freezing your wrists and swinging only your arms to hit the ball. Little by little, unfreeze the wrists until about 15 trials later, there is too much wrist bend in your swing. In the end, find the location where it feels like you are tossing a ball underhand or imagine the clubface as a knife and the ball as an apple….you are slicing a thin layer of the peel of an apple as the clubface goes under the ball.	
Possible Answer	**<u>Using the loft of the club concept.</u>** The greater the wrist bend, the more the ball flies into the air until a point. Two much wrist bend and the club chops into the ground. Thus, there is an optimal amount of wrist bend where clubface slices around ball and the swing feels like you threw a ball underhand.
Possible Answer	**<u>Hitting the ball head-on concept.</u>** The ball goes into the air by mostly using my arms. The more I keep my wrist from moving, the better I can hit the ball into the air.

Challenge #4

Two Challenges: 1) Explore the following: Systematically vary how much the clubface faces the sky. Start with the club faced closed then little by little open the clubface to the sky. If you open your clubface, most golfers also open their stance. Also, opening the clubface will make the ball go off to the right (righthander) so you will have to aim off to your left. 2) Explore the following: Systematically vary the placement of the ball in your stance. Start with it near your rear foot and little by little bring the ball forward in your stance until it ends up on the inseam of the left/front foot.	
Possible Answer	**<u>Hitting it sooner concept</u>**. Hitting the ball earlier in the swing allows the ball to have a higher trajectory. You can hit it earlier by having the ball further back in your stance. Also, you can hit the ball higher in the air if you close your clubface allowing the club to hit the ball earlier in the swing.
Possible Answer	**<u>Angle of the clubface concept</u>**. The farther the ball is to the front foot or the more the clubface points to the sky, the greater height of the ball that can be achieved. If the ball is farther back in the stance or the face of the club is closed, the ball will have a lower trajectory. If the clubface is open (increasing the angle of the club) or the ball is forward in the stance, the ball should have a higher trajectory. The same concept happens if you go from a pitching wedge to a sandwedge, the angle of the clubface increases.

Challenge #5

Explore the following: Vary the height of the backswing each time you hit the golfball. For example, start with a small height on the backswing, then increase the height gradually throughout twenty trials. To do this challenge, you need to significantly reduce the muscle tension in your arms and let gravity drop the club from the height of the backswing. Reducing muscle tension does not mean don't stop controlling the path of the club, it just means let gravity do the majority of the work while you guide the club.	
Possible Answer	**<u>Greater distance concept</u>**. The greater height of the backswing increases the impact force that the club has on the ball. In other words, the ball goes further when I maintain my swing tempo, but increase the height of the backswing.
Possible Answer	**<u>Out of control concept.</u>** The height of the backswing does not make any difference especially when I don't use muscle tension. Increasing the backswing makes me loose control the club.

Challenge #6

Explore the following: Vary the amount of muscle force you use to swing the club with. At first, use muscle force to impact forces on the ball. Little by little let gravity do most of the work with the only muscle force you use is to keep correct form. At the end, feel like you are tossing underhand a baby bird (or something light and soft) unto the green. In other words, your arms should be soft as the clubface drops to the ball.	
Possible Answer	**<u>Greater sensitivity concept</u>**. Tension reduces your sensitivity for clubhead position and speed. Swinging too hard with the club tends to slide your body out of correct form. Muscle force puts a jerky motion putting the timing off making your shot inconsistent.
Possible Answer	**<u>More control concept.</u>** By having more muscle tension in my arms and using more muscle force to hit the ball I achieve more control over where I can place the ball. Also, I can hit the ball farther.

STEPS YOU SHOULD TAKE WHILE EXPLORING

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Understand the problem -Figure out what to explore	**Make an hypothesis** - What will each form do your swing and impact on the ball	**Explore for 5 min** -Test if your hypothesis is correct by exploring what each form does to your swing and contact with the ball	**Compare and contrast your results –** Is your hypothesis similar to what you found during your exploration	**Look at the task card** -Did you get one of the possible answers?	Go onto next problem tomorrow regardless. If you feel you did not figure it out, finish solving problem later on a later date. **Finish time with regular practice**

******Your attention should be on what the club and the ball does, not your technique/form while you are exploring.**

CORRECT MODEL SCRIPT

1. Paul does basic instruction
2. Read this to the group at Beginning First Day

"The way I will teach you is a traditional approach to learning the golf pitch. I will provide you with a video where an expert demonstrates a correct way of pitching. I will give verbal information that will point out key elements to the model's performance".

3. Read this concept during video

The concept to we need to understand is that we want to minimize lower body motion. A typical error that beginners make is "not maintaining your stance" during the swing (like paul just showed you). Standing up during the swing or looking up too early causes you to "top the ball". Topping the ball occurs when the clubface hits the top of middle of the ball instead of sweeping the club between the ball and the grass. The extra motion makes the swing inconsistent and we don't need extra power by flexing our legs. We can generate enough power just letting the club fall from the height of the backswing. Again, to repeat the concept, The concept we are talking about is that we want to minimize lower body motion.

4. After you show the video, read this

"For the next 5 minutes, go practice what you learned from the video, after 5 min, you should practice regularly (practice like you are pitching a golf ball in a match)…practice only 15 meters pitches and I will call you over one by one to hit 10 shots in front of the camera"

CORRECT MODEL GROUP CONCEPTS

Note: The correct model group script remained similar from day to day except that each day had a different concept. Located below is the different concepts for each of six days.

Day #1 Concept

The concept to we need to understand is that we want to minimize lower body motion. A typical error that beginners make is "not maintaining your stance" during the swing. Standing up during the swing or looking up too early causes you to "top the ball". Topping the ball the ball occurs when the clubface hits the top of middle of the ball instead of sweeping the club between the ball and the grass. The extra motion makes the swing inconsistent and we don't need extra power by flexing our legs. We can generate enough power just letting the club fall from the height of the backswing. Again, to repeat the concept, The concept we are talking about is that we want to minimize lower body motion.

Day #2-Concept

The concept for today is "using the loft of the clubface", don't try to scoop the ball.. (read first) A common mistake by beginners is to perform a v-swing instead of swinging the club like a pendulum. A V-swing is bending the elbows to lift the club back then bend the elbows to follow through with the ball. They try to dig or scoop the ball instead of swinging through the ball or chopping like an ax (play the video here). You can see Wirt lifts the club to vertical, his left hand leads the pendulum back , and the left hand leads the pendulum through keeping his left arm straight. Notice he chops through the ball like an ax and doesn't try to scoop it. He lets the angle of the clubface propel the ball into the air. Again, The concept for today is "using the loft of the clubface", don't try to scoop the ball.

Day #3-Concept

Today's concept is using the loft of the club concept, don't hit the ball head-on. The club swing is like a pendulum ….you can use the wrist bend to slice through the ball. Too little wrist bend and the ball is hit head-on by the club and too much wrist bend the club chops into the ground before it hits the ball. Imagine you are tossing a ball unto the green. That's how the swing should feel. Or, imagine the ball is an apple and the clubface is a knife…..you are slicing a thin layer of the peel of an apple as the clubface goes under the ball. You can use the wrist bend to get underneath the ball to make it go slightly higher without trying to scoop it like people do in a v-swing. Again, use the wristbend to advantage of the loft of the club, don't hit the ball head-on.

Day #4 -Concept

The concept is increasing the angle of the clubface produces higher trajectory. The farther the ball is to the front foot or the more the clubface points to the sky, the greater height of the ball that can be achieved. If the ball is farther back in the stance or the face of the club is closed, the ball will have a lower trajectory. If the clubface is open (increasing the angle of the club) or the ball is forward in the stance, the ball should have a higher trajectory. The same concept happens if you go from a pitching wedge to a sandwedge, the angle of the clubface increases. Again, increasing the angle of the clubface creates a higher trajectory.

Day #5-Conept

Yesterday, we talked about opening the clubface to increase the height, we talking about chopping wood like an ax not scooping, we talked about getting wrist bend to "peel the apple" or have the feeling of the swing be like tossing a ball underhand onto the green, we talked about minimizing the lower body motion.

Today, the concept is increasing the distance of the shot by increasing the impact force on the ball. Wirt and most golfers don't increase the amount of muscle force to increase the distance of their shot. Most golfers keep the swing tempo or the muscle force the same,… they just increase the height of the backswing to increase the force. These golfers usually reduce most muscle tension in their arms letting gravity do all the work. Reducing muscle tension does not mean that you loose control of the club. Again, if the golfer wants to increase the distance of the pitch, they increase the height of the backswing, which increases the force, not the muscle tension. Beginners who increase the muscle force end up twisting their upper body excessively sending the ball off the left.

Day #6-Concept

The concept for today is increasing sensitivity and reducing jerkiness in the swing. By removing arm muscle tension and muscle force to hit the ball, you are able to feel how the club hits the ball and you reduce any jerkiness that might cause inconsistency in the shot. However, this does not mean you shouldn't use your muscle to maintain correct form throughout the shot. The feeling of the shot should feel like you are underhand tossing a little bird (or something soft) onto the green.

DISCOVERY GROUP SCRIPT

1. Paul does basic instruction
2. Read this… to the group at Beginning

Over the next six days, we are going to learn through a "trial and error approach". In other words, you should try something to get the ball in the air, if that doesn't work,… you try something else until you find something that works for you.

3. Read golf facts not related to swing mechanics or posture
4. After reading golf facts, read this…

Now you will practice for 7 minutes. Practice only 15 meters pitches and I will call you over one by one to hit 10 shots in front of the camera"

Correct model Script-Day 5

1. Paul does basic instruction-
2. Read this during video …concept

Yesterday, we talked about opening the clubface to increase the height, we talking about chopping wood like an ax not scooping, we talked about getting wrist bend to "peel the apple" or have the feeling of the swing be like tossing a ball underhand onto the green, we talked about minimizing the lower body motion.

Today, the concept is increasing the distance of the shot by increasing the impact force on the ball. Wirt and most golfers don't increase the amount of muscle force to increase the distance of their shot. Most golfers keep the swing tempo or the muscle force the same,… they just increase the height of the backswing to increase the force. These golfers usually reduce most muscle tension in their arms letting gravity do all the work. Reducing muscle tension does not mean that you loose control of the club. Again, if the golfer wants to increase the distance of the pitch, they increase the height of the backswing, which increases the force, not the muscle tension. Beginners who increase the muscle force end up twisting their upper body excessively sending the ball off the left.

3. Go practice then after 5 minutes or so, rotate in front of camera 10 shots (be efficient today, get 2 people)..after they pitch, do the camera, fill form, tell them to pitch some more.

Correct model Script-Day 6

1. Paul does basic instruction-
2. Read this during video …concept

The concept for today is increasing sensitivity and reducing jerkiness in the swing. By removing arm muscle tension and muscle force to hit the ball, you are able to feel how the club hits the ball and you reduce any jerkiness that might cause inconsistency in the shot. However, this does not mean you shouldn't use your muscle to maintain correct form throughout the shot. The feeling of the shot should feel like you are underhand tossing a little bird (or something soft) onto the green.

3. Go practice then after 5 minutes or so, rotate in front of camera 10 shots (be efficient today, get 2 people)..after they pitch, do the camera, fill form, tell them to pitch some more.

APPENDIX E: LITERATURE REVIEW

Abstract

Physical Education research has provided clear evidence that providing successful and appropriate practice is correlated with learning motor skills. A major consideration when designing practice is the interaction between student skill level and the difficulty of the task. The purpose of this article is to delineate a research agenda on teaching approaches using a mediational processes perspective to highlight the influence of student characteristics. Mediational processes perspective involves investigation of teaching approaches, learning processes and achievement outcomes

Mediational Processes Approach: Providing Scaffolding Environments for Problem Solving

Over the years there has been a variety of research attempts designed to understand and enhance teacher effects and student learning in physical education. The level of productivity during the last half of the 20th century was substantial, establishing a set of general principles to guide teachers in their planning and teaching. At the same time researchers have uncovered information leading to a greater understanding of the complexities involved in the teaching-learning process. Early pedagogical research assumed a direct relationship between what the teacher does and student achievement in motor skills. More recently, conceptions of the role of teachers and students have changed, allowing for new and hopefully more productive ways of thinking about teachers (Schuell, 1996) and the teaching functions essential for effective instruction. Teaching functions in physical education might include a variety of teacher behaviors and the selection of an assortment of methods and strategies (Rink, 1998).

The type of approach that the teacher selects is an organizing framework for the behaviors and methods that teachers use to physically educate students. A teaching approach is the way a teacher organizes learning experiences and delivers content to students (Graham, Holt/Hale, & Parker, 1998; Nicholls, 1986; Rink, 1998; Rukavina, in press). Approaches teachers can take are situated along a continuum depending on the nature of the problem to be solved and prominently based upon the type of learning processes and responses employed by students in response to a particular teaching approach (Mosston & Ashworth, 1994). Teachers that provide students solutions to problems elicit “reproductive” responses like memorizing facts, replicating demonstrations and practicing skills. On the other hand, teachers may design problems requiring students to “construct” or discover their own solutions. Each different approach will influence the way students go about the task of learning and ultimately the learning outcomes (Schuell, 1996).

One of the important goals of physical education is transfer of skills and problem-solving abilities (NASPE, 1995; Rink, 1998). However, to teach for transfer, teachers should provide developmentally appropriate practice making it highly probable students will exhibit adaptive engagement patterns. A developmentally appropriate challenge is a task that is designed in regard to changing student characteristics such as developmental status, previous movement experiences, fitness levels, skill levels, body size, and age (Graham, et al., 1998). Children are challenged sufficiently to grow in skill and motor maturity, but are allowed to experience enough successes to keep them from being frustrated by the challenge. Teachers use a strategy of scaffolding as a means of providing developmentally appropriate challenges. Scaffolding is a strategy where the teacher designs stepwise supportive learning environments where each step provides appropriate levels of meaningful challenges. As soon as students become comfortable and are able to produce more mature fundamental movement patterns, the environment is tweaked by introducing complexity to accommodate the changing characteristics of the students. Scaffolding learning experiences has shown to be an important teacher method for accomplishing NASPE (1995) standards (Chen, Taubman, Gable, Kleinert, & Rabenda, 2002).

The use of scaffolding environments using a reproductive approach is a viable and positive way to achieve many psychomotor and cognitive objectives. Including constructive approaches in teachers' teaching repertoires is, however, an alternate and possibly more effective way to achieve cognitive and affective objectives requiring complex learning processes. In order to increase our understanding of how teachers can effectively use scaffolding as a means to structure the learning environment to facilitate the development of problem-solving abilities and transfer of skills, it is important to interpret relevant research findings from a theoretical perspective and use that interpretation to develop a research agenda that can inform future study, and that is the goal of this paper.

Initially, research on teaching is examined from an historical perspective, and an argument is made that the mediating process paradigm provides a framework for the investigation of this process. Following the presentation of the theoretical perspective, research that has examined teacher effects on student learning is reviewed. Cognitive effort is offered as a rationale for interpreting these findings, and the case is made that when teachers structure learning activities that appropriately increase cognitive effort, then development of problem solving abilities and transfer of skills is facilitated. Studies that have investigated task and practice manipulations are examined, and the interaction of task difficulty and initial skill level is presented as a critical factor in understanding how to design appropriate tasks. Practice schedules, learning models, discovery learning, and environmental designs are presented as ways that researchers have examined teaching and learning from this perspective. Next, approaches to problem solving are reviewed with a focus on critical thinking and problem solving transfer. It is concluded that the evidence presented in this paper supports the notion that different environments designed by the teacher elicit particular learning processes from students, and that these processes lead to different kinds of learning. The mediating processes paradigm can be used to investigate these processes, but most of the research using that paradigm has focused on motivational variables as mediators rather than examining other cognitive processes that are critical factors in the learning process. In light of the research reviewed in this paper, it is apparent that this paradigm can be used to further our understanding of how teachers can structure tasks and learning environments to achieve situated objectives such as problem solving and transfer, and the paper concludes with suggestions for a research agenda to advance that effort.

Conception and Assumptions of Teaching and Learning

Initial conceptions and assumptions. One of the initial approaches to investigate teaching was the process-product paradigm, which assumed a direct and linear relationship between teaching and motor skill with student achievement. Using this paradigm, researchers quantified types and frequencies of teachers' behaviors (process) and subsequently correlated them with student outcomes. Stemming out of this process-product era was the conception of the role of teachers as disseminators of knowledge and students as passive recipients. A majority of instruction involved teachers making the majority of decisions and students following passively during instruction. Teachers trained students to respond to commands subsequently shaping and reinforcing student responses moving them closer to a target skill pattern. Content was broken down into component parts and carefully sequenced from simple to complex (Rink, 1998).

The basic assumptions of the process-product paradigm lead to erroneous views of teaching and learning (Doyle, 1977). The first assumption was that a greater frequency in the amount of a teacher variable is better. Researchers using the paradigm had mixed and inconsistent results (e.g., Yerg, 1981a; 1981b) especially when the provision of feedback about task performance were process-variables (Lee, Keh, & Magill, 1993). Contemporary research shows that the amount and timing of teacher variables like feedback are important and that too much feedback can be detrimental to learning (Lee, Swinnen, & Serrien, 1994). Second, teaching success is attributable to discrete classroom events that create the view that there is no history or physical or social context in which teaching events occur. Research on designing the physical environment (Barrett & Collie, 1996; Sweeting & Rink, 2000) and social context (e.g., Azzarito & Ennis, in press; Palincar, 1998) describe how these constructions can benefit learning.

The last two erroneous assumptions outlined by Doyle (1977) are also inherent in the methodology used by researchers to compare teaching approaches (e.g., movement education and Mosston teaching styles research) (Rink, 2001). Both paradigms of research assumed that one teaching method was superior to another purporting the view of the teacher as a technician rather than a thoughtful professional. The line of thinking leads to the belief that there is one right way to teach and teachers can learn a specific set of skills to ensure student achievement. Lastly, a notion existed that the teacher or the teaching method was the only variable that led to or was correlated with student learning. Both paradigms failed to consider the mediating student learning processes implying that students do not play an active role in creating classroom conditions, that they do not come to class with variable amounts of prior knowledge and skill, and do not have the ability to select information they want to pay attention to (Lee & Solmon, 1992). These research paradigms tried to support laws of stability and generalization across settings, learning and task conditions. Moreover, this line of research led to a belief that teachers should use an approach that has the same effects all the time and if the variables do not have a generalization capability then the teaching methodology is of little value.

New Conceptions and Assumptions

As researchers realized that process-product models and research that compared teaching approaches produced inconsistent results, they did not discard all aspects of these early procedures. These two frameworks were extended to include different perspectives of research on teaching and learning in physical education. Borrowing from education and psychology, physical education researchers formed paradigms for study to create their own research lines

(Lee & Solmon, 1992). Studies based on these research paradigms of student cognition (e.g., Lee & Solmon, 1992) and teacher cognition (e.g., Dodds, 1994) brought about new assumptions and different ways of thinking about teaching and learning process. From these perspectives changes emerged and new conceptions of the role of the teacher, role of the student, and the beliefs about how learning occurs evolved. Implementation of these conceptions takes in consideration who is learning, who is teaching, what is being taught and where it is being taught. Teachers are viewed as thoughtful professionals executing teaching within a complex environment with students as active participants who are capable of making their own meaning and interacting with context. How researchers conceptualize these elements within the teaching and learning environment has a profound effect on what questions are asked and how the curricular and instructional decision-making occurs (Clark & Peterson, 1986).

Research comparing teaching approaches. Initial research in physical education comparing teaching approaches went under the assumption that one approach was better than another (i.e., a "versus" notion) (Byra, 2000) and assumed that learning processes were in fact taking place. For example, movement education proponents believed that an "indirect" approach or an approach that had students construct their own answers to solutions was superior to that of direct instruction. Researchers assumed that an indirect learning approach would engage students in such a way that their responses would be more adaptable (Logsdon et al., 1977). However, movement education failed to provide any evidence that one approach was better than another and that the learning processes assumed to be associated with indirect approaches were in fact taking place. Mosston (1981) changed his conceptual premise to state that no one style is more important than another style with each approach having its place in reaching a specific set of objectives (Goldberger & Gerney, 1986). Researchers who investigated Mosston's styles used the new premise but failed to provide evidence of learning processes. Rink (2001) postulates that all teaching approaches have roots in particular learning theories and make assumptions about how students learn. She and others recommend that when researching teaching approaches, evidence of learning processes purported by the approach should be provided (Rink, 2001; Wittrock, 1986).

Mediational processes perspective. A mediational process perspective begins with the notion that learning does not occur automatically. Rather than the teacher having all responsibility for learning, students' mental activities or implicit processes (e.g., motivation, affective and cognitive components of student thinking) are believed to mediate between instructional processes and the teacher's instruction (Lee & Solmon, 1992). Researchers try to understand teaching and learning through investigating the cognitive activities and involvement of the learner while engaged. Researchers are focused on revealing the complexities and interconnections among cognitive components like attention, student perspectives, motivation, and learning strategies underlying performance. Based upon influence from cognitive psychology, the mediational processes perspective assumes cognition governs action; the learner is an active participant in constructing his or her own knowledge (Lee & Solmon, 1992). In other words, students can construct their own knowledge as long as they have the willingness to exert physical and mental effort, persist in meaningful practice and are in a class where the teacher designs the learning environment to allow it (Solmon & Lee, 1997).

The complex array of students' thoughts and behaviors that impact learning can be conceptualized into three broad categories: entry characteristics, cognitive processes students employ as they learn, and the actions that result from those thoughts (Solmon & Lee, 1997). First, physical education students bring "entry characteristics" with them to class that are notions about the subject matter, perceptions of their own competence, initial skill, prior knowledge and experience (Solmon & Lee, 1997). Students use entry characteristics as a framework from which they perceive class events and interact uniquely within the learning environment. Second, students actively filter what information to process and how much is processed and interpret teachers' actions in unique ways (Lee & Solmon, 1992). Also, students determine which, if any learning strategies or metacognition they will use during instruction and practice (Solmon & Lee, 1997). Learning strategies are procedures used to enhance the acquisition and retention of information or skills (Wittrock, 1986). Finally, student engagement or the quality of practice is the best predictor of achievement or motor skill gains (Ashy, Lee, & Landin, 1988; Buck, Harrison, & Bryce, 1991; Silverman, 1990, 1993). In other words, students who complete more appropriate or successful practice trials demonstrate superior skill learning.

Teachers as thoughtful professionals. Research from teacher cognition in physical education has also impacted the conception of teachers. Researchers have studied differences between novice and more experienced teachers and have identified the qualities of more experienced teachers. One of the major qualities of experienced teachers is the accumulation of pedagogical content knowledge (PCK). Pedagogical content knowledge is "a configuration of specific knowledge (sometimes tacit) based on experience and strongly embedded in action. A teacher's PCK is what enables content problems and knowledge to be adapted to the abilities and interest of the learner" (Amade-Escot, 2000, p. 80). In other words, experienced teachers have an accumulation of instructional routines specific to the domain and the children being taught.

Acquiring pedagogical content knowledge related to the nature of the task and level of the student was reported by preservice teachers as a reason for improved teaching and observing whereas inadequate PCK led to problems in teaching and observing (Rovegno, 1992). Teachers learned to shift their focus from a general level (i.e., providing the action goal) to a more detailed level of breaking the content down into smaller stepped progressions (Rovegno, 1992). PCK accumulation is limited by constraints of the preservice and inservice teaching environment and evolves over the long term. Also, teachers may not have dispositions that support and drive the process of acquiring more knowledge and acquiring more skills (Rovegno, 1992; Rovegno & Bandhauer, 1997).

In summary, teachers are individuals; they possess differing amounts of PCK and abilities that enable them to plan, make interactive judgements about teaching and learning based on the current situation and action/reaction of the students, and reflect upon their experience (e.g., Amade-Escot, 2000; Clark & Peterson, 1986; Dodds, 1994). Also, considering the role of students' thoughts and behaviors as mediators, researchers have considered a different view of teaching where the teachers' role shifts from a disseminator of knowledge to a flexible and knowledgeable facilitator that structures the learning environment so that students act in ways to maximize learning opportunities. Thus, teachers do not cause student achievement, they impact how students think and behave which in turn, affects achievement.

Task and Practice Manipulations

The initial conceptions of teaching and learning viewed teachers as exclusively information givers and students as passive recipients of knowledge. Viewing teaching and learning with these conceptions limit teachers to using direct instruction. More recent conceptions have viewed teachers as facilitators of the learning environment and students as thinkers who are capable of self-direction and regulation. Each student is an individual who brings his or her own "intrinsic dynamics" and prior experiences to the gym (Solmon & Lee, 1997; Ulrich, 1997, 2001). Although direct instruction is a positive and viable way to physically educate students, new conceptions of teaching and learning allow teachers to take full advantage of all tools the learning environment affords to successfully facilitate student learning. Through the accumulation of specific and distinctive pedagogical content knowledge, teachers can use the physical environment, various task structures (i.e., practice conditions and types, timing and amounts of information) and student interest to facilitate learning motor skills. In other words, the teacher views the environment as interrelationships among the task, physical environment and student (Barrett & Collie, 1996) that can be manipulated to increase the amount of student cognition during practice or through student interactions with the environment. However, teachers need to provide developmentally appropriate challenges, and that requires adapting the difficulty of the task to fit the learners' entry characteristics.

Interaction of task difficulty and initial skill. In physical education classes, students vary in the quality and number of practice trials providing evidence that students respond to instruction in different ways (e.g., Silverman, 1993; Solmon & Lee, 1996). The variability of performance appears to be influenced by two interacting factors: student ability and task difficulty. Lower skilled students typically have lower success rates and perform fewer appropriate practice trials than higher skilled students (e.g., Buck, Harrison, & Bryce, 1990; Grant, Ballard, & Glynn, 1990). Student practice, when task difficulty exceeds the skill level of the learner, is typically unsuccessful and inappropriate (e.g., Rikard, 1992; Silverman, 1985a, 1985b, 1993). Teachers can design practice so task difficulty is appropriate for students' entry characteristics. Scaffolding practice using progressive conditions (i.e., easy-difficulty task progressions and part-whole practice) positively impacted students practice behavior and self-efficacy (i.e., student's belief or confidence that they can execute a task to produce a desired outcome) and was most advantageous for lower skilled students self-efficacy (Hebert, Landin, & Solmon, 2000).

Teachers can design practice so the amount of cognitive effort produced matches students' entry characteristics. Cognitive effort is defined as mental work involved in making decisions or the intense use of processing resources such as anticipation, planning, regulation, application of rules or interpretation of motor performance (Lee, Swinnen & Serrien, 1994). The cognitive effort hypothesis states that when certain conditions are present to promote cognitive effort or decision-making activities, students should perform better in learning, especially in transfer. However, transfer within the framework of cognitive research is different than the "movement similarity" transfer that may be experienced by students when prior learning of one skill provides an advantage when learning a skill with topological similarities (Lee, 1988; Magill, 2001). When teachers manipulate practice conditions to promote cognitive effort, transfer is postulated to result from transfer appropriate processing or learning conditions having similarity in the processing requirements involved in successful performance (Lee, 1988; Magill, 2001). If processing activities of practice are similar to that of transfer tests, those groups should have an advantage or fare better than in situations where the processing activities are different.

One way to induce cognitive effort is manipulating practice conditions so students experience a variety of movement and context characteristics during practice (Magill, 2001). A common type of practice variability is arranging practice schedule variations or contextual interference. The interference that results from student practice variations or alternating different skills produces cognitive effort (Lee, Swinnen & Serrien, 1994). Hebert, Landin and Solmon (1996) found that low skilled students performed better after practice in low CI conditions as compared to those in high CI conditions. In a follow-up study, Landin and Hebert (1997) had university subjects with some high school basketball experience practice the set shot in either a low, moderate or high CI. Results suggest that a moderate level of CI is most beneficial for transfer of learning. Thus, the level of cognitive effort should be adjusted to the entry characteristics of the students. However, it is unclear how to adjust practice schedules during physical education to managerially accommodate the wide variety of skill levels (French, Rink & Werner, 1990).

Another way to elicit cognitive effort is to arrange for students to watch a learning model receiving augmented information. In this scenario, students watch a practice by a classmate, hear the feedback from the teacher and observe future attempts. The observers become actively involved vicariously in the error detection and correction and problem-solving process of observational learning. Lee, Swinnen & Serrien (1994) hypothesized that when compared to students who view a correct model (i.e., viewing an expert performer perform the skill), those who view learning models should enhance cognitive effort and performance will be similar or better in transfer tasks. McCullagh and Meyer (1997), using a squat lift task found no difference between a correct and a learning model but did not assess transfer of learning. Other studies using transfer tests found equivocal results (Rukavina, Lee, & Solmon, 2001; Rukavina, Lee, Solmon & Hill; 2002). Evidence from an open-ended strategy questionnaire suggests students were attentive to the verbal technique information from the teacher and the correct model obtained similar information visually (Rukavina, Lee, & Solmon, 2001). In the future, careful attention needs to be paid to methodological issues such as type of task, the type, quality and amount of feedback from the teacher, and skill level achieved by the learning model (e.g., how soon does the learning model look like the correct model).

Teachers can use a discovery learning technique to increase cognitive effort. A discovery learning technique is where teachers provide students no information about how to solve the action goal forcing them to explore the perceptual motor workspace independently (Rose, 1997). With a discovery approach, students experience errors while trying to discover a movement pattern to solve the action goal. For example, Edwards and Lee (1985) had subjects complete a serial movement-timing task with either a trial and error or a prompted instructional strategy. Results suggest that the group receiving a successful solution was more expedient and learned the initial task at a faster rate than the trial and error group. Subjects from the trial and error group performed better on the transfer test than participants in the direct group. In other words, experiencing error or increased cognitive effort was advantageous for transfer but not necessarily for retention. Other motor learning research using the ski simulator has found discovery learning equally effective and some cases more advantageous than receiving critical information (e.g., Vereijken & Whiting, 1990; Wulf & Weigelt, 1997).

Rukavina, Lee, Solmon, and Hill (2001) compared discovery learning and a correct model, providing evidence that the discovery group was engaged in cognitive effort. Students in the discovery group reported they more frequently compared their performance to prior experience. They were not as expedient as those that receiving correct information but performed similarly in transfer and retention tests, and adapted their own movement pattern from prior experience. Those who received correct information from a correct model engaged in response mimicry copying the form used by the model they observed.

<u>Environmental design</u>. In physical education, structuring the task or environment is called environmental design. An environmental design approach is when the teacher manipulates aspects of the physical surroundings and the task constraints to have particular motor patterns

emerge naturally (Rink, 1998; Ulrich, 2001). Using this approach, mature movement patterns can emerge with a minimum of direct teaching but necessitate the acceptance of the assumption that students' learning processes are not exclusively cognitive in nature and motor patterns can emerge through law-based interactions within the learning environment. Although recent studies (Barrett & Collie, 1996; Sweeting & Rink, 1999) used dynamical systems and/or Newell's (1986) constraint theory as a theoretical framework, the idea of manipulating the environment to aid skill acquisition is not new. Halvorsen (1966), in an early paper summarizing the direction of motor development, described ways to design the environment (task goals, setting environment and use of equipment) that would elicit fundamental movement patterns naturally with a minimum of direct instruction.

Over two decades ago, Herkowitz (1978) proposed developmental task analyses as a way to utilize environmental factors to sequence tasks from simple to complex. Researchers have designed developmental sequences (Roberton, 1982) to see if their interventions of orchestrating situational constraints worked and to determine if the patterns are progressing or regressing. Several early studies (e.g., Belka, 1985; Issacs, 1980; Morris, 1976; Strohmeyer, Williams, & Schaub-George, 1991) were conducted to identify the positive and detrimental effects of manipulating task constraints on fundamental movement performance of young students in catching (e.g., factors relating to catching such as size of object, weight of object, and object trajectory). Developmental sequences are accepted as a necessary form of PCK for teaching students fundamental skills. These sequences allow teachers to understand how the movement form develops over time and the processes students might go through to learn the skill. Having this PCK allows teachers to assess and gain information on students' level of performance, which in turn, is used to scaffold developmentally appropriate challenges. Also, recent research has found that equipment modification can positively influence children's shooting performance and self-efficacy (Chase, Ewing, Lirgg, & George, 1994).

In addition to the research on task constraints, Sweeting and Rink (1999) investigated differences between environmental design and direct instruction to learn fundamental skills. Sweeting and Rink (1999) had three conditions: Direct instruction group, environmental condition group (Swamp), control condition (no instruction). Results indicated that both instructional conditions experienced similar learning as evidenced by outcome scores but acquired different form characteristics. The direct group, or students who performed their jumps on a flat mat, changed more in the use of the arms during the preparation phase. On the other hand, the environmental condition produced more changes in the legs during flight than the direct instruction group. Researchers called for further analysis using the class as the unit of analysis and by combining direct instruction and environmental design at different points in the lesson based on student movement deficiencies.

In a qualitative teaching-learning research study, Barrett and Collie (1996) described PCK within the context of teacher learning to teach students learning the lacrosse vertical cradle. During the workshop, teachers were provided PCK about teaching lacrosse and the process and steps students would take as their performance evolved to a mature level in terms of Newell's (1986) task constraint model. The significance of the study was the way results were reported between teachers' actions (tasks, cues, feedback, explanations, content sequence, organizational patterns, observational focus) and student movement patterns. The researchers found that certain environmental conditions and goals naturally brought out the mature form of the lacrosse cradle. They concluded that for students to develop skill in the vertical cradle, teachers must be able to help students use certain elements of skill to their advantage like the "natural opposition of arms and legs that occurs when they run, the effect of the their running speed on their range of movement, the critical role played by their stick positions, top hand grip hand placement and available space" (p. 306).

Teachers can acquire PCK that allows them to design a progression of tasks based on relationships among the physical environment, the task and students' current skill level. Once students are involved in a task and seek to achieve the action goal, they are forced to try to use a particular pattern. The teacher sets up the environment, observes student performance, sees the effect of the interactions and subsequently changes part of the task or environment to keep children moving toward a mature form. On the other hand, students' movement patterns can regress if teachers do not successfully manipulate these constraints. To use PCK successfully, teachers need to be more than technicians. They should be professionals who can skillfully observe, manage and creatively manipulate the environment to allow for developmental progress.

Problem-Solving

Contemporary researchers are beginning to explore teaching and learning processes in physical education using an indirect approach. This research involves setting up a series of circumstances or situations to evoke student or students' problem-solving behaviors. Solving psychomotor problems with a discovery learning approach, however, is different from discovering a movement concept using physical activity as a catalyst. A movement concept is "a group of motor responses or movement-related ideas that share particular characteristics" (Rink, 1998, p. 359). When teaching motor skills with discovery learning, teachers provide only an action goal (e.g., throw the ball and hit the target). In contrast, setting up problems to learn movement concepts necessitates the design of cognitive questions in addition to providing the action goal. For students to solve the problem, they must engage in some type of cognitive processing that reconstructs and combines prior knowledge with new information to dynamically create a solution (Phye, 2001).

Critical thinking. Recently, McBride (1991) has identified and theorized about learning processes of constructive approaches that aid students in gaining a deeper understanding of movement concepts and developing them more holistically (i.e., achieving cognitive and affective objectives at the same time as psychomotor). McBride (1991) explored the various critical thinking definitions from education theorists (e.g., Lipman, 1988; Paul, 1987; Beyer, 1987) and created an explanation and description appropriate for physical education. According to McBride (1991), critical thinking is "reflective thinking that is used to make reasonable and defensible decisions about movement tasks or challenges". Defensible implies that students should be held accountable for the decisions that are made. The word reasonable refers to logical thought processes while the word reflective refers to students' ability to draw upon their general and specific knowledge base (McBride, 1991). McBride has also created a theoretical model to hypothesize the sequence and components of critical thinking in physical education by reviewing information on critical thinking and contemporary problem-solving models (Bransford & Stein, 1984; Polya, 1957). Each step of McBride's (1991) model represents components or cognitive processes that students use, from receiving information from the teacher to responding with a solution to a problem. The component processes in the model are as follows: cognitive organizing, cognitive action, cognitive outcomes and psychomotor outcomes.

McBride's (1991) first step in his critical thinking model is cognitive organization or a student's ability to focus on the problem provided by the teacher. When students accept the goal of the task, they will become actively involved (i.e., cognitive dissonance) or enter a state of cognitive acquiescence. Cognitive acquiescence includes the cognitive processes involved in passively accepting information from the teacher. After receiving the problem to be solved, students organize and assess the information to establish a hypothesis. Lastly, the student will practice and test the hypothesis developed during cognitive organization. Responses may be expressed cognitively (i.e., cognitive outcomes) or presented in form of a motor response (i.e., psychomotor outcomes). Based on students' success with the response, they may receive a new problem to solve or generate a new hypothesis for more attempts on the existent problem. Critical thinking dispositions or affective desires to be open-minded and willing to engage drives students to use critical thinking when they encounter problems in the gym (Tishman & Perkins, 1995).

To be successful in solving a problem, students are required to analyze the information generated while trying to solve the problem and orchestrate their cognitive processes as they work toward a solution. Student management and orchestration of their own cognition is called metacognition. Metacognition directs and monitors the organizing of the problem, the assessment of the requirements of the problem, the selection and application sequence of strategies, processing and general principles, and subsequently the testing of a hypothesis to the problem (Mayer & Wittrock, 1996; McBride, 1991). Literally, metacognition is thinking that is above (meta) and about a student's own cognition (Tishman & Perkins, 1995). In other words, metacognition is the students' awareness or knowledge of their "controllable cognition" used to reflect on their thinking processes. Metacognition is used to plan a solution, monitor progress toward reaching a goal and revising the plan if necessary (Mayer & Wittrock, 1996). Without metacognition, students may be using thinking skills but not knowing why or even if they are using them (McBride, 1991). With metacognitive control of general and specific skills, students are viewed as active participants who manage and orchestrate their prior knowledge and their own skills to solve problems (Mayer & Wittrock, 1996). In sum, critical thinking theory is still in its early development but in general, critical thinking involves metacognitive control or oversight of decision-making, problem-solving, and creative thinking. Students who possess critical thinking skills make reasonable and defensible decisions about their movement and the solutions they create.

Traditionally, teachers have assumed students are all capable of thinking divergently to solve movement problems. Divergent movement ability (DMA) or the capacity to create and perform different fundamental movement skills involves parts of critical thinking and motor creativity (Cleland, 1994). Motor creativity is the ability to produce and combine thoughts or ideas into new and fresh motor patterns as a solution to a problem or the expression of an idea or emotion through movement (Cleland, 1994; Wyrick, 1968). According to Wyrick (1968), motor creativity components include fluency and flexibility. Fluency is the total number of responses and flexibility is the number of thematic changes. Thematic changes result from students making changes as a result of using effort (e.g., slow or fast), space (e.g., direction or pathway) and relationship (e.g., over, under or through) to change the movement. Cleland and Gallahue (1993), the first researchers to investigate DMA, studied divergent movement patterns of elementary aged students to establish a baseline performance of fundamental tasks.. Students who were asked to solve a problem using a discovery approach were able to demonstrate through their actions that they could modify, adapt or combine fundamental movement patterns to produce divergent movement. Older students (ages 6 to 8) could produce more patterns than younger students but gender and level of gross motor development were not factors. The only other variable contributing to DMA was past experience in movement activities (e.g., youth sports).

Using McBride's (1991) model as theoretical support, Cleland (1994) explored the effects of Mosston's teaching styles and content on second and third graders' DMA. Two different teaching styles and a control group were compared: Mosston's divergent production style, command practice style on low-organized games (e.g., basketball) and no instruction. Results indicated that students in the divergent movement style group generated a significantly greater number of movement patterns than those in direct instruction or no instruction. Cleland (1994) concluded that the combination of indirect teaching styles, creative thinking skills and creative thinking strategies significantly improved children's ability to generate divergent movement patterns. However, because each group had different content, Byra (2000) suggested that the content, not the teaching style or critical thinking might have attributed to the differences.

Cleland and Pearse (1995), investigated how teachers can structure a learning environment to promote students' critical thinking behaviors and accomplish the teachers' objectives, using McBride's (1991) critical thinking process as a guide. For example, initial lessons were geared to helping children learn to focus on the problem whereas latter lessons involved aspects of cognitive organization. During the first weeks of the school year, the fifth grade students were confused and excessive divergent responses were made. They had many questions before being able to focus on the task and due to the extensive number of divergent responses they could not decide on the one to use. Also, students had to learn the social skills needed to work in groups during critical thinking tasks. After 8 to 10 weeks, students became more self-reliant, were able to produce psychomotor outcomes, and relied on domain information more fully. As time elapsed, students learned to judge their movement responses related to some criterion. However, when students designed their own criteria they were quite general and did not include thematic concepts (i.e., space, effort, body and relationships). When interviewed, students reported that they enjoyed the critical thinking activities, liked working in groups, and generating their own ideas, but at the beginning of the school year they had difficulty with written problems because of a lack of understanding. Cleland and Pearse (1995) concluded that students' ability to critically think depends on teachers' ability to use indirect teaching styles and the nature of the movement task.

Chen (2001) investigated how an expert dance teacher used critical thinking teaching strategies (i.e., constructivist oriented) to engage elementary students in critical thinking while learning creative dance. The researcher videotaped 16 sessions and interviewed both the teacher and her students. This author reported several strategies used by the teacher to encourage and facilitate students' divergent movement responses and creative products. For example, the teacher encouraged open-ended learning tasks with sequential steps to help students think divergently. She gave some initial ideas to get started and then guided them through the task allowing opportunities to make independent decisions about how to move. After students explored movement variations, they were instructed to create their own dance based on exploration and a story they wrote about the theme of the lesson. In a study by Chen & Rovegno (2000), using an expert-novice paradigm, expert teachers asked students to design their own obstacle course after exploring a theme involving dribbling a basketball. In both studies, the teacher used positive congruent feedback and suggestions for eliciting more movement variations to guide the process of inquiry when students were limited in their ideas.

Researchers have documented that teachers do use strategies to promote students' metacognition to help refine the quality of their movements (Chen, 2001; Chen & Rovegno, 2000; Ennis, 1991; McBride & Bonnette, 1995). For example, Ennis (1991) found that teachers used deductive and inductive strategies in both teaching and student-centered approaches. The results indicated that teachers can set up learning environments that evoke students' metacognitive processes. For example, teachers can help students focus their attention on the movement task, identify problematic or successful movement (i.e., comparing and contrasting movement to a specific criteria) and draw conclusions about movement responses or evaluate their own learning outcomes (i.e., analyzing). In Chen's (2001) study the teacher used similar behaviors, as well as others like providing time for students to plan out their ideas, using questioning and verbal cues or providing music to assist students in the self-regulation of their movement sequences. For example, students listened to dance music before performing their creative dance to help them concentrate on moving to the rhythm.

Teachers can learn to use approaches along the direct-indirect continuum to incorporate critical thinking objectives in physical education (Cleland-Donnelly, Helion, & Fry 1999; Cleland & Pearse 1995). Teachers in the Cleland-Donnelly et al., (1999) study were provided McBride's (1991) theoretical framework, learned strategies to promote an atmosphere of inquiry, and had opportunities to team-teach with one of the co-authors. Quantitatively, from pre to post intervention, teachers increased the number of behaviors coded as indirect. After intervention a qualitative analysis indicated that teachers used questioning strategies that helped students to analyze movements, compare and contrast different movements and ideas, and evoke them divergently.

However, according to (Cleland & Pearse, 1995) it would not be wise for teachers to immediately place students in an inquiry-learning environment using indirect approaches (Cleland & Pearse, 1995). They must start teaching critical thinking using direct approaches and gradually provide students chances to make decisions during the learning process. As students are able to handle some decision-making, and develop enough cognitive resources to operate on their own, teachers can shift to more indirect methods to encourage more convergent and divergent thinking. Also, involving students in exploratory exercises does not guarantee that students will critically think (Rovegno, 1998). Teachers must use tools like probing, suggesting, and providing congruent feedback to elicit and guide student thinking. Although this literature review does not focus on social strategies teachers might use to promote critical thinking, a growing literature base documents such practices for eliciting motivation to think critically and describes how the sharing of ideas in a "community of learners" fosters critical thinking (Chen, 2001; Chen & Rovegno, 2000; Palincsar, 1998; Rovegno, 1998).

Problem-solving transfer. An important goal of education in physical activity settings is to prepare students to solve novel movement-related problems (NASPE, 1995). Problem-solving transfer occurs "when a person uses previous problem-solving experience with one kind of problem to devise a solution for a new and different problem" (Mayer & Wittrock, 1996, p. 47). Teachers have limited amounts of time to provide students with enough problem-solving activities to encompass all possible situations and types of problems they might face. One way to teach for transfer is to provide instruction geared toward helping students learn to use critical thinking or problem-solving strategies that will assist in the acquisition of movement concepts. Thus, researchers are beginning to ask the questions about which teaching behaviors lead to students' problem-solving transfer. Stated differently the questions might be related to the types of methods that will enable students to use prior knowledge to solve problems in novel contexts.

The ability of students to transfer problem-solving ability (i.e., cognitive skills) raises several issues (Mayer & Wittrock, 1996). The first issue, Salomon and Perkins (1989) divide problem-solving transfer into two categories based the mechanisms or the amount of mindfulness required for transfer. Low road transfer is spontaneous and automatic transfer of highly practiced skills. People who have behaviors that transfer on the low road tend to respond to events without any a priori reflection before they act. For example, using the strategy of relaxing during a freethrow. The principle becomes so well learned that when a student steps to the free throw line, the behavior automatically presents itself. The amount of improvement and distance (i.e., how different the context is) of transfer is hypothesized to occur with a greater amount of practice and how variable the practice is. However, consciously interfering with these automatic connections achieved through large amounts of practice will decrease the amount of transfer (Salomon & Perkins, 1989). On the other hand, high road transfer is the mindful or conscious abstraction of knowledge. Transfer occurs by reflecting on past behavior or prior knowledge, abstracting the behavior and using some strategy or principle in the novel context. High road transfer fits nicely with critical thinking theory and the role of metacognition in learning.

The second issue is the similarity of the domain from which behaviors may be transferred or problem-solving methods. A weak method involves transferring learning from one problem-solving domain to a completely novel domain. For example, strategies learned during chess may be helpful while playing basketball. These behaviors are such that students can use them in most situations. Conversely, strong methods are transfer of learning within the same domain. For example, there are some strategies used to learn motor skills that do not apply to solving physics problems. Lastly, a generality-specificity issue applies. The question is which type of instruction is better for problem-solving. Some proponents argue for the transfer of specific behaviors (e.g., Thorndike's Identical Elements Theory) (Thorndike, 1914). Teachers build problem-solving ability by having students learn prerequisite skills that subsequently transfer to situations that involving parts of previous problems. Conversely, other theorists argue for transfer of general principles or processes. In this case, transfer is a strategy or principle learned in one situation that can be used in another. This view is similar to the transfer view taken by proponents of movement education where students use movement to learn concepts of movement and critical thinking.

Taking these issues into consideration, Mayer and Wittrock (1996) reviewed four types of instructional philosophies that might enable a learner to use previously acquired knowledge to solve problems based on one of the issues just reviewed. Mayer and Wittrock's (1996) description spans from the *general transfer of general skills* (e.g., teaching Latin to acquire logic), to *specific transfer of specific behaviors* (e.g., direct teaching) ending with *specific transfer of general skills* (e.g., understanding a concept). They argue that the latter two teaching philosophies have both merits and faults that can be combined to form a new view of problem-solving transfer. For example, in defense of direct teaching of thinking skills, automation of low-level skills enables the learner to acquire higher-level cognitive skills. Also, automation of higher problem solving skills prevents overloading students' memory capacity while solving problems. On the other hand, the understanding of a principle or concept allows students to transfer skills in new situations. For example, for years research has shown that rote problem solving learning is not as beneficial as learning a general principle (e.g., Katona, 1940). Learning for understanding is more effective when students are forced to construct their own meaning and outcomes based on a principle. Students are required to use cognitive processes to organize incoming knowledge, connecting it with prior knowledge leading to better retrieval and transfer (Mayer & Wittrock, 1996).

The fourth view of problem-solving transfer is *metacognitive control of general and specific skills*. In this view of transfer, the teacher employs approaches that help develop students' metacognitive control of their problem-solving abilities. These abilities are general principles, strategies and specific higher order thinking processes. This view is consistent with McBride's (1991) model of critical thinking in physical education. Students are seen as active participants who manage their skills and prior knowledge to solve new problems in the learning environment. However, students must be taught how to use their metacognition so they can mindfully abstract cognitive elements (e.g., principles, strategies, knowledge) from their past problem-solving experience (i.e., high road transfer) and use skills that were transferred though the low-road. Several studies in academic settings provide evidence that teaching metacognitive skills facilitates transfer in comparison to control groups not receiving instruction (e.g., Belmont, Butterfield, & Ferretti; 1982; Cardelle-Elawar, 1992).

Physical education researchers using qualitative methodology have observed teachers and reported the extent to which they teach for problem-solving transfer. According to Perkins and Salomon (1989) high road transfer is possible when general cognitive elements (e.g., general principles) are taught together with metacognitive training. In other words, teachers can teach a skill or knowledge in one context and then cue, prime and guide in the novel context. McBride and Knight (1993) reported that teachers failed to teach for transfer in a study involving students at a summer camp for at risk boys. The students were initially successful in solving a Meatgrinder task but subsequently failed in the Nitro crossing task that was similar. On the other hand, in a study by McBride and Bonnette (1995), teachers taught for transfer when teaching critical thinking. Students in the study had previously used or were familiar with strategies such as brainstorming or generating a "menu of ideas". One teacher reported that he questioned and prompted students not to stick with one idea if it is not working, but make a menu of ideas like they previously they had been instructed to do. Teachers had helped students make a necessary conceptual link and made them aware that strategies could be used in other contexts if the situation was similar. However, some researchers debate that no "general skills" and thinking skills are entirely context-bound and domain-specific (Ennis, 1989; Glaser, 1984; Pea & Kurland, 1984). Moreover, transfer can only occur if students have sufficient practice and instruction focusing on transfer across the whole educational curriculum.

Conclusion

New conceptions of teaching and learning allow researchers to change from asking questions about how teachers directly influence student outcomes to asking how and under what conditions teachers can help students practice appropriately and successfully. Teachers can manipulate task, practice or environmental characteristics to elicit particular learning processes ultimately leading to specific outcomes. Regardless of the approach, a growing amount of evidence supports the argument that when practice is too difficult, practice is of less value then when it is scaffolded to fit learners' entry characteristics.

Teachers need to know when to provide students with information and when is it best for students to acquire understandings as a function of their own construction. Taken together, the literature reviewed suggests that both constructive and reproductive approaches may be used to teach for motor skill transfer. However, it is hypothesized that students exposed to constructive approaches will acquire problem-solving heuristics that will better aid problem-solving in the future. In other words, some constructive approaches will elicit types of learning processes in students that can better facilitate problem-solving transfer and acquisition of dispositions for critical thinking and lifelong learning. While there is no one best way to teach, there may be a best way to deliver content to a specific set of students learning a specific task (Rink, 2001)

Research Agenda. Investigation of teaching approaches and the underlying learning assumptions involves conducting research from both a teaching and learning orientation (e.g., Griffin & Placek, 2001; Rink, 2001; Woods, Goc Karp, & Escamilla, 2000). A teaching orientation involves directly studying instructional behaviors and the subsequent effects on learning processes. For example, researchers might study a teacher's provision of feedback on student learning or how different student thought processes mediate teachers' instruction. Researchers need to employ methodology to ensure the treatment is validated by theory, that treatment fidelity is evident and that learners are employing learning processes claimed to be elicited by theory. On the other hand, a learning orientation places emphasis on how and what students learn and the student variables that impact their learning must continue to be studied. For example, the nature of the learning processes actually taking place during activities needs to be studied and reported. Research from a learning orientation however, can investigate student learning without placing emphasis on how teachers induce students to learn a certain way (i.e., investigating the connection between learning theories and outcomes). Use of both teaching and learning orientations complement each other and provide a more holistic view of the complex teaching-learning process. Also, using a mixed methodology approach (i.e., both qualitative and quantitative research methods) provides freedom for researchers to use the methodology that best answers the question (Silverman, 1996; Tashakkori & Teddlie, 1998).

Rink (2001) reviewed assumptions of pedagogical research in a recent article, but does not propose a framework that will facilitate a research agenda. The mediational processes perspective has the potential to provide an organizational structure to investigate teaching approaches and learning outcomes. The framework includes both teaching variables (i.e., instructional behaviors) and learning variables (i.e., student processes and student outcomes) with the main investigational links being: 1) relationships between teaching and student cognition/learning processes, and 2) relationships between classroom processes and student outcomes. Other reciprocal links between these variables are possible, such as how student achievement affects student processes or the effect of student processes on teacher behaviors (Wittrock, 1986). However, the main contribution of the framework continues to be the influence of teaching on student thought processes. To date, student mediation research in physical education has been focused primarily on motivational and affective aspects (Lee & Solmon, 1992) of student thinking. Researchers investigating critical thinking, although they are not using student mediation as a framework, have begun to investigate critical thinking processes and dispositions (e.g., divergent thinking, and metacognition) that mediate achievement and the teacher behaviors that facilitate these processes. Research designed to determine how variations in teaching approaches might affect student processes is an area in need of further study, or how different types of movement tasks influence ways students mediate teacher behavior.

References

Amade-Escot, C. (2000). The contribution of two research programs on teaching content: "pedagogical content knowledge" and "didactics of physical education*". Journal of Teaching in Physical Education, 20*, 78-101.

Ashy, M. H., Lee, A. M., & Landin, D. K. (1988). Relationship of practice using correct technique to achievement in a motor skill. *Journal of Teaching in Physical Education, 7*, 115-120.

Azzarito, L. & Ennis, C. A. (in press). Sense of connection: Social constructivist physical education. *Sport Education and Society*.

Barrett, K. R., & Collie, S. (1996). Children learning lacrosse from teachers learning to teach it: The discovery of pedagogical content knowledge by observing children's movement. *Research Quarterly for Exercise and Sport, 67*, 297-309.

Belka, D. E. (1985). Effects of selected sequencing factors on the catching process of elementary school children. *Journal of Teaching in Physical Education, 5*, 42-51.

Belmont, J. M., Butterfield, E. C., & Ferretti, R. P. (1982). To secure transfer of training, instruct self-management skills. In D. K. Detterman & R. J. Sternberg (Eds.), *How and how much can intelligence be increased*? (p. 147-154). Norwood, NJ: ABLEX.

Beyer, B. (1987). *Practical strategies for the teaching of thinking*. Boston: Allyn & Bacon.

Bransford, J., & Stein, B. (1984). *The IDEAL problem solver: A guide for improving thinking, learning, and creativity.* New York: W. H. Freeman.

Buck, M., Harrison, J.M., & Bryce, G. R. (1991). An analysis of learning trials and their relationship to achievement in volleyball. *Journal of Teaching in Physical Education, 10*, 134-152.

Byra, M. (2000). A review of spectrum research: The contributions of two eras. *Quest, 52*, 229-245.

Cardelle-Elawar, M. (1992). Effects of teaching metacognitive skills to students with low mathematics ability. *Teaching and Teacher Education, 8*, 109-121.

Chase, M. A., Ewing, M. E., Lirgg, C. D. & George, T. R. (1994). The effects of equipment modification on children's self-efficacy and basketball shooting performance. *Research Quarterly for Exercise and Sport, 65*, 159-168.

Chen, W. (2001). Description of an expert teacher's constructivist-oriented teaching: Engaging students' critical thinking in learning creative dance. *Research Quarterly for Exercise and Sport, 72*, 366-375.

Chen, W., Taubman, B., Gable, K., Kleinert, D. D., & Rabenda, D. (2002). *Levels of implementation of the national standards in elementary and secondary physical education*. Paper presented at the meeting of the American Education Research Association-Research on Learning and Instruction in Physical Education, San Diego, CA.

Chen, W., & Rovegno, I. (2000). Examinations of expert and novice teachers' constructivist oriented teaching practices using a movement approach to elementary physical education. *Research Quarterly for Exercise and Sport, 71,* 357-372.

Clark, C. M., & Peterson, P. L. (1986). Teachers' thought processes. In M. C. Wittrock (Ed.), *Handbook on research on teaching* (3rd ed.), (pp. 255-296). New York: Macmillan.

Cleland, F. E. (1994). Young children's divergent movement ability: Study II. *Journal of Teaching in Physical Education, 13,* 228-241.

Cleland, F. E., & Gallahue, D. L. (1993). Young children's divergent movement ability. *Perceptual and Motor Skills, 77*, 535-544.

Cleland, F. E., & Pearse, C. (1995). Critical thinking in elementary physical education: Reflections on a yearlong study. *Journal of Physical Education, Recreation and Dance, 66(6),* 31-38.

Dodds, P. (1994). Cognitive and behavioral components of expertise in teaching physical education. *Quest, 46*, 153-163.

Donnelly, F. E. C., Helion, J., & Fry, F. (1999). Modifying teacher behaviors to promote critical thinking in K-12 Physical Education. *Journal of Teaching in Physical Education, 18*, 199-215.

Doyle, W. (1977). Paradigms for research on teacher effectiveness. *Review of Research in Education, 5*, 163-198.

Edwards, R. V., & Lee, A. M. (1985). The relationship of cognitive style and instructional strategy to learning and transfer of motor skills. *Research Quarterly, 56*, 286-290.

Ennis, C. D. (1991). Discrete thinking skills in two teachers' physical education classes. *The Elementary School Journal, 91*, 473-487.

Ennis, R. H. (1989). Critical thinking and subject specificity: Clarification and needed research. *Educational Researcher, 18*, 4-10.

French, K. E., Rink, J. E., & Werner, P. H. (1990). Effects of contextual interference on retention of three volleyball skills. *Perceptual and Motor Skills, 71*, 179-186.

Glaser, R. (1984). Education and thinking: The role of knowledge. *American Psychologist, 39*, 93-104.

Goldberger, M., & Gerney, P. (1986). The effects of direct teaching styles on motor skill acquisition of fifth grade children. *Research Quarterly for Exercise and Sport, 57*, 215-219.

Graham, G., Holt/Hale, S. A., & Parker, M. (1998). *Children moving. A reflective approach to teaching physical education*. Mountain View, Ca: Mayfield Publishing Company.

Grant, B. C., Ballard, K. D., & Glynn, T. L. (1990). Teacher feedback intervention, motor-on-task behavior, and successful task performance. *Journal of Teaching in Physical Education, 9, 123-139.*

Griffin, L. L., & Placek, J. H. (2001). The understanding and development of learners' domain-specific knowledge: Introduction. *Research in Teaching Physical Education, 20, 299-300.*

Halversen, L. E. (1966). Development of motor patterns in young children. *Quest, 6*, 44-56.

Hebert, E. P., Landin, D., Solmon, M. A. (1996). Practice schedule effects on the performance and learning of low- and high-skilled students: An applied study. *Research Quarterly for Exercise and Sport, 67*, 52-58.

Hebert, E. P., Landin, D., & Solmon, M. A. (2000). The impact of task progressions on students' practice quality and task-related thoughts. *Journal of Teaching in Physical Education, 19, 338-354.*

Herkowitz, J. (1978). Developmental task analysis: The design of movement experiences and evaluation of motor development status. In M. V. Ridenour (Ed.), *Motor development: Issues and application* (pp. 139-164). Princeton, NJ: Princeton Book Co.

Isaacs, L. D. (1980). The effects of ball size, ball color and preferred color on the catching process by young children. *Perceptual and Motor Skills, 51*, 583-586.

Katona, G. (1940). *Organizing and memorizing*. New York: Columbia University Press.

Landin, D. L., & Hebert, E. P. (1997). A comparison of three practice schedule along the contextual interference continuum, *Research Quarterly for Exercise and Sport, 68*, 357-361.

Lee, A. M., Keh, N. C., & Magill, R. A. (1993). Instructional effects of teacher feedback in physical education. *Journal of Teaching in Physical Education, 12*, 228-243.

Lee, A. M., & Solmon, M. A. (1992). Cognitive conceptions of teaching and learning motor skills. *Quest, 44*, 57-71.

Lee, T. D. (1988). Testing for motor learning: A focus on transfer-appropriate processing. In O. G. Meijer & K. Roth (Eds.), *Complex motor behaviour: "The" motor-action controversy* (pp. 210-215). Amsterdam: Elsevier.

Lee, T. D., Swinnen, S. P., & Serrien, D. J. (1994). Cognitive effort and motor learning. *Quest, 46,* 328-344.

Lipman, M. (1988). Critical thinking- What can it be? *Educational Leadership, 46(1)*, 38-43.

Logsdon, B., Barrett, K., Broer, M., Ammons, M., & Roberton, M. (1977). *Physical education for children: A focus on the teaching process.* Philadelphia: Lea & Febiger.

Magill, R. A. (2001). *Motor Learning: Concepts and Applications* (6th ed.). Dubuque, IA: Brown and Benchmark.

Mayer, R. E., & Wittrock, M. C. (1996). Problem-solving transfer. In D.C. Berliner & R.C. Calfee, (Eds.) *Handbook of educational psychology* (pp. 926-944). New York: Simon & Schuster Macmillan.

McBride, R. E. (1991). Critical thinking-An overview with implications for physical education. *Journal of Teaching in Physical Education, 11*, 112-125.

McBride, R. E., & Bonnette, R. (1995). Teacher and at-risk students' cognitions during open-ended activities: Structuring the learning environment for critical thinking. *Teaching & Teacher Education, 11,* 373-388.

McBride, R. E., & Knight, S. (1993). Identifying behaviors during critical-thinking tasks. *Clearning House, 66(6),* 374-378.

McCullagh, P., & Meyer, K. N. (1997). Learning versus correct models: Influence of model type on the learning of a free-weight squat lift. *Research Quarterly for Exercise and Sport, 68*, 56-61.

Morris, G. S. D. (1976). *How to change the games children play*. Minneapolis: Burgess.

Mosston, M. (1981). *Teaching in physical education* (2nd ed.). Columbus, OH: Charles E. Merrill Publishing.

Mosston, M., & Ashworth, S. (1994). *Teaching in physical education* (4th ed.). New York: Macmillan.

National Association for Sport and Physical Education (1995*). Moving into the future: national standards for physical education*. St. Louis, MO: Mosby.

Newell, K. M. (1986). Constraints on the development of coordination. In M.G. Wade & H.T.A. Whiting (Eds.) *Motor development in children: Aspects of coordination and control*. Martinus Nijhoff Publishers: Dordrecht.

Nickerson, R. S. (1987). Why teach thinking? In J. B. Barron & R. J. Sternberg (eds.), *Teaching thinking skills: Theory and practice* (pp. 127-148). New York: W. H. Freeman.

Nichols, B. (1986). *Moving and learning, the elementary school physical education experience*. St. Louis, MO: Mosby.

Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology, 49*, 345-75.

Paul, R. W. (1987). Dialogical thinking: Critical thought essential to the acquisition of rational knowledge and passion. In J. B. Barron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 127-148). New York: W. H. Freeman.

Pea, R., & Kurland, D. (1984). On the cognitive effects of learning computer programming. *New Ideas in Psychology, 2*, 137-168.

Perkins, D. N., & Salomon, G. (1989). Are cognitive skills context-bound? *Educational Researcher, 18(1)*, 16-25.

Polya, G. (1957). *How to solve it*. Princeton: Princeton University Press.

Rikard, G. L. (1992). The relationship of teachers' task refinement and feedback to students' practice success. *Journal of Teaching in Physical Education, 11*, 349-357.

Rink, J. E. (1998). *Teaching physical education for learning* (3rd ed.). Boston: McGraw-Hill.

Rink, J. E. (2001). Investigating the assumptions of Pedagogy. *Journal of Teaching in Physical Education, 20*, 112-128.

Roberton, M. A. (1982). Describing 'stages' within and across motor tasks In J.A.S. Kelso & J.E. Clark (Eds.), *The development of movement control and coordination* (pp. 293-308). New York: Wiley.

Rose, D.J. (1997). *A multilevel approach to the study of motor control and learning*. Boston: Allyn & Bacon.

Rovegno, I. (1992). Learning a new curricular approach: Mechanisms of knowledge acquisition in preservice teachers. *Teaching and Teacher Education, 8*, 253-264.

Rovegno, I. (1998). The development of in-service teachers' knowledge of a constructivist approach to physical education: Teaching beyond activities. *Research Quarterly for Exercise and Sport, 69*, 147-162.

Rovegno, I., & Bandhauer, D. (1997). Psychological dispositions that facilitated and sustained the development of knowledge of a constructivist approach to physical education. *Journal of Teaching in Physical Education, 16,* 136-154.

Rukavina, P. B. (in press). What teaching approach to use and when? A decision-making strategy for physical educators. *Strategies*.

Rukavina, P. B., Lee, A.M., & Solmon, M.A. (2000, March). *The impact of task communication strategies on motor skill learning.* Paper presented at the meeting of the American Alliance of Health, Physical Education, Recreation and Dance, Orlando, Fl.

Rukavina, P. B., Lee, A.M., & Solmon, M.A. (2001). Maximizing student learning: A comparison of task communication studies. *Journal of Sport Pedagogy, 7*, 61-75.

Rukavina, P. B., Lee, A. M., Solmon, M. A, & Hill, K. (2001, April*). Cognitive processes in direct and indirect task communication strategies*. Paper presented at the meeting of the American Education Research Association-Research on Learning and Instruction in Physical Education, Seattle, Wa.

Salomon, G., & Perkins, D. N. (1989). Rocky roads to transfer: Rethinking mechanisms of a neglected phenomenon. *Educational Psychologist, 24*, 113-142.

Shuell, T.J. (1996). Teaching and learning in a classroom context. In D.C. Berliner & R.C. Calfee, (Eds.), *Handbook of educational psychology* (pp. 726-764). New York: Simon & Schuster Macmillan.

Silverman, S. J. (1985a). Relationship of engagement and practice trials to student achievement. *Journal of Teaching in Physical Education, 5, 13-21.*

Silverman, S. J. (1985b). Student characteristics mediating engagement-outcome relationships in physical education, *Research Quarterly for Exercise and Sport,* 56, 66-72.

Silverman, S. J. (1990). Linear and curvilinear relationships between student practice and achievement in physical education. *Teaching and Teacher Education, 6*, 305-314.

Silverman, S. J. (1993). Student characteristics, practice, and achievement in physical education. *Journal of Educational Research, 87*, 54-61.

Silverman, S. J. (1996). How and why we do research. In S. J. Silverman and C. D. Ennis (Eds.), *Student learning in physical education: Applying research to enhance instruction (pp*. 35-51). Champaign, IL: Human Kinetics.

Solmon, M. A., & Lee, A. M. (1996). Entry characteristics, practice variables, and cognition: Student mediation of instruction. *Journal of Teaching in Physical Education, 15*, 136-150.

Solmon, M. A., & Lee, A. M. (1997). Development of an instrument to assess cognitive processes in physical education classes. *Research Quarterly for Exercise and Sport, 68*, 152-160.

Strohmeyer, H. S., Williams, K., & Schaub-George, D. (1991). Developmental sequences for catching a small ball: A prelongitudinal screening. *Research Quarterly for Exercise and Sport, 62*, 257-266.

Sweeting, T., & Rink, J. E. (1999). Effects of direct instruction and environmentally designed instruction on the process and product characteristics of a fundamental skill. *Journal of Teaching in Physical Education, 18*, 216-233.

Tashakkori, A. & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative.* Thousand Oaks, CA: Sage.

Thorndike, E. L. (1914). *Educational psychology: Briefer course*. New York: Columbia University Press.

Tishman S., & Perkins, D. N. (1995). Critical thinking and physical education. *Journal of Physical Education, Recreation and Dance, 66(6),* 24-30.

Ulrich, B. D. (1997). Dynamic systems theory and skill development in infants and children. In K.J. Connolly & Forssberg, H. (Eds.), *Neurophysiology and neuropsychology of motor development (pp. 319-345)*. London: MacKeith Press.

Ulrich, B. D. (2001). *Developing Motor Skills: How complexity engenders coordination and control*. Paper presented at the meeting of the American Alliance of Health, Physical Education, Recreation and Dance, Cincinnati, OH.

Vereijken, B., & Whiting, H. T. A. (1990). In defense of discovery learning. *Canadian Journal of Sport Science, 15*, 99-106.

Wittrock, M. C. (1986). Students' thought processes. In M.C. Wittrock, (Ed*.), Handbook of research on teaching* (3rd ed., pp. 297-314). New York: Macmillan.

Woods, M., Goc Karp, G., & Escamilla, E. (2000). Preservice teachers learning about students and the teaching-learning process*. Journal of Teaching in the Teaching in Physical Education, 20*, 15-39.

Wulf, G. & Weigelt, C. (1997). Instructions about physical principles in learning a complex motor skill: To tell or not to tell… *Research Quarterly for Exercise and Sport, 68*, 362-367.

Wyrick, W. (1968). The development of a test of motor creativity. *Research Quarterly, 39*, 756-765.

Yerg, B. J. (1981a). Reflections on the use of the RTE model in physical education. *Research Quarterly of Exercise and Sport, 52*, 38-47.

Yerg, B. J. (1981b). The impact of selected presage and process behaviors on the refinement of a motor skill. *Journal of Teaching in Physical Education, 1(1)*, 38-46.

VITA

Paul B. Rukavina received his Bachelor of Science from the University of Wisconsin at River Falls in May of 1996, and his Master of Science in motor development and learning from Arizona State University. He then continued his education by attending Louisiana State University, to earn a doctoral degree in pedagogy from the Department of Kinesiology. He expects to complete his degree in December 2003.

Paul holds membership in many professional organizations such as Louisiana Association of Health, Physical Education, Recreation and Dance (LAPHERD), American Alliance of Health, Physical Education, Recreation and Dance (AAHPERD), and American Education Research Association (AERA). Paul presented papers at AAHERD and AERA; in addition, he has published articles in Strategies and Journal of Sport Pedagogy. His scholastic rewards include the Corbett Summer Research Scholarship and AERA Student Travel Award, as well as obtaining a State of Louisiana Teaching Certificate. After graduation, Paul plans to further his career at Mississippi State University's Department of Health, Physical Education, Recreation and Sport as an Assistant Professor.