ABSTRACT

Title of Dissertation: MODELING THE INTERRELATIONS AMONG KNOWLEDGE, INTERESTS, AND LEARNING STRATEGIES IN PHYSICAL EDUCATION

Bo Shen, Doctor of Philosophy, 2004

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In domain-learning theory, learning in a specific knowledge domain is postulated as a progressive process that is characterized by interactions of knowledge, interests, and learning strategies accrued during each of the acclimation, competency, and proficiency learning stages (Alexander, Jetton, & Kulikowich, 1995). The purpose of this study was to examine the interrelations among prior knowledge, individual and situational interest, and learning strategies and their interactive impact on learning in physical education. The Model of Domain Learning (MDL) was used as the theoretical framework to guide this research. Data were collected from 202 sixth-grade learners from three middle schools and consisted of their individual interest in softball, their knowledge and skill levels in softball, their rating of situational interest in their softball classes, and their self-reported learning strategy use during learning. Learners' physical engagement (recorded in total steps using Yamax Digiwalkers) were measured to represent learning process outcome. Learners' knowledge achievement and individual interest change were assessed using arithmetic difference between pretest and posttest scores of the measures. The data were analyzed using correlation and path modeling analysis. Findings suggest that the learners

brought various prior knowledge and skill to the learning process with different individual interest in the content. The learners at the acclimation stage demonstrated fragmented and incoherent interrelations of knowledge, interests, and learning strategies, while those at the competency stage showed a coherent pattern of the interrelations. During learning, situational interest played a role as a primary motivator for the learners at the acclimation stage and facilitated the learners at the competency stage. Knowledge acquisition and individual interest development were found occurring simultaneously as a result of interactions among prior knowledge, individual interest, situational interest, and learning strategies. Results also indicate that situational interest was internalized into individual interest for the learners at the acclimation stage when they were acquiring new knowledge. The findings suggest that the MDL is tenable model to explain the effect of the interactive relationships among knowledge, interests, and learning strategies on learning in physical education.

MODELING THE INTERRELATIONS AMONG KNOWLEDGE, INTERESTS, AND LEARNING STRATEGIES IN PHYSICAL EDUCATION

By

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CHAPTER I

INTRODUCTION

Learning is the most important mission of education. According to Shuell (1986), learning is the way in which learners acquire new knowledge and skills and modify existing knowledge and skills. Learning results from practice or experience that leads to an enduring change in behavior or ability.

Given that physical education is education about movement, education through movement, and education in movement (Arnold, 1979), learning in physical education is often accomplished through physical training. This movement-based learning is the primary goal of physical education in K-12 schools (National Association for Sport and Physical Education [NASPE], 2004). In general, learning in physical education is usually defined as a relatively permanent change in behavior resulting from experience of physical movement coupled with cognitive understanding of the movement (Rink, 2001).

Behavior change without cognitive understanding should not be considered as learning in physical education (Griffin & Placek, 2001). Psychomotor learning is inseparable from cognitive learning (Jewett, Bain, & Ennis, 1995). In other words, learning in physical education can be thought to be an active and goal-oriented process of cognitive knowledge and physical skill construction that involves deep cognitive understanding of the knowledge and skills being constructed. This process is believed to lead to desired behavior change in the learner (Rink 2001).

Darling-Hammond (1997) argued that learning occurs when learners actively engage in cognitive thinking processes and apply their prior knowledge to the process of learning new knowledge. During the learner-content interaction, learners are expected to become self-responsible for their learning actions. This conceptualization of learning places a high value on the role of prior knowledge / skill and learners motivation in the learning process. The learner is thought to be the center of learning.

As a cognitive process, learning is influenced by the learner's thoughts associated with the subject matter. The complex array of learner thoughts can be understood in three related dimensions: prior knowledge, learning strategies, and motivation. These thoughts comprise an interrelated mental network that determines achievement of learning in the classroom (Alexander, in press) and gymnasium (Solmon & Lee, 1996).

Theoretical Framework

Prior Knowledge

Knowledge has been defined from a behavioral perspective as objective, definable, measurable facts that are agreed upon by scholars as worth knowing (Nespor, 1987). Cognitive theorists argue, however, that knowledge should be conceptualized as "an individual's personal stock of information, skills, experiences, beliefs, and memories" (Alexander, Schallert, & Hare, 1991, p. 317). In other words, knowledge is personally meaningful information and facts residing within an individual. Existing knowledge can also be described as *prior knowledge* defined as the total sum of personal knowledge that an individual possesses prior to acquiring additional new knowledge (Alexander et al., 1991).

There have been consistent findings that prior knowledge plays a positive role in learning new knowledge. Prior knowledge functions as a conceptual scaffold or scheme into which new information can be assimilated or accommodated for acquisition (Anderson, 1987). It guides new information organization and representations by associating new information with the old and by personalizing all new experiences (Alexander & Murphy, 1999). Well-established prior knowledge permits individuals to better interpret text and enables extensive and accurate interpretations of new textual information (Fincher-Kiefer, 1992). In motor skill learning, prior knowledge and physical skills are found to be associated with new knowledge and skill acquisition (Silverman, Subramaniam, & Woods, 1998).

Knowledge is usually recognized and institutionalized in subject domains for learning in school (Alexander, 1997). Different tasks and performances across a domain are connected together by shared features or common underlying processes. In a subject domain, individual's existing subject-matter knowledge is broadly described as the prior knowledge that an individual possesses relative to a specific domain (Alexander et al., 1991). This type of knowledge has been conceptualized as domain knowledge and topic knowledge (Alexander, Jetton, & Kulikowich, 1995). Domain knowledge refers to generality of the knowledge encompassing all knowledge components in a knowledge domain. It signifies the breadth. Topic knowledge, on the other hand, refers to the depth of one's knowledge about a specific component in the knowledge domain (Murphy & Alexander, 2002).

Subject-matter knowledge can also be conceptualized as declarative, procedural, and conditional in nature (Alexander & Judy, 1988). Declarative knowledge refers to factual information about the meaning or perceptual characteristics of phenomena. Procedural knowledge is defined as knowledge about performing specific tasks, including those that help learners acquire declarative knowledge, transform information from abstraction to practical application, and apply existing knowledge to solve new problems.

Conditional knowledge is individuals' understanding of the learning context in terms of when and/or where to access specific facts or utilize particular procedures. Anderson (1982) postulated that knowledge acquisition usually moves from declarative forms to procedural and condition-action forms.

Development of declarative and procedural knowledge is an interrelated process (Thomas & Thomas, 1994). As learners practice, they increasingly acquire procedural knowledge that allows them to solve problems successfully and develop additional declarative knowledge. Alexander and Judy (1988) identified strategic knowledge as a special form of procedural knowledge. It includes goal-directed procedures that are used prior to, during, or upon completion of a task to assist in performing, assessing, and regulating learning behavior. In school, learners' strategic knowledge can be reflected in their application of learning strategies during the learning process.

Learning Strategies

Learning strategies are mental operations or techniques that learners use to solve problems or to enhance achievement (Alexander & Jetton, 2000). Paris, Wasik, and Turner (1991) suggested: "Strategies are like tools. When there is a job to perform, you reach your strategic toolbox and select the right implement" (p. 612). Strategy use during learning relates to both general cognitive procedures used in performing a task (e.g., summarization) and meta-cognitive strategies (self-testing or self-evaluation) used in monitoring or regulating learning (Garner & Alexander, 1989).

Learning strategies can be conceptualized as general strategies and domain-specific strategies (Alexander, in press). General learning strategies are mental operations that can be applied in a broad array of tasks across different knowledge or content domains. On the other hand, domain-specific strategies are those effective for learning in only one specific knowledge domain.

Appropriate learning strategies enhance learning achievement (Weinstein & Mayer, 1986). They can help learners capture and organize information efficiently (Armruster, 2000), enhance their ability to understand and remember what they read and hear (Pressley, Goodchild, Gleet, Zajchowski, & Evans, 1989), and keep them on tasks (Winne, 1985). A successful learner often relies on a repertoire of effective strategies to achieve complex learning goals.

Similarly, learning strategy in physical education can be defined as a mental operation used by the learner to enhance motor skills needed to perform a physical activity and to acquire cognitive knowledge related to the physical activity. Because learning motor skills involves both cognitive and physical effort, learners in physical education are expected to be able to determine "which, if any, learning strategies they will employ during practice of movement activities" (Lee, 1997, p. 272). Empirical studies have shown that learning strategies can improve knowledge and motor skill acquisition in physical education (Fahleson, 1988; Lee, Landin, & Carter, 1992).

Choosing and applying appropriate learning strategies require the learner to be an active agent in the learning process, rather than merely a passive recipient of knowledge or a mindless imitator of a physical movement. Learners must be motivated to be able to search, experiment, evaluate, and eventually adopt effective learning strategies (Pintrich, Marx, & Boyle, 1993). Motivation in this context serves as a primary force that leads the learner to develop useful learning strategies to achieve the learning goal.

Motivation

Motivation has been found to play a fundamental role in learning. Motivation can be defined as "the process whereby goal-directed activity is instigated and sustained" (Pintrich & Schunk, 2002, p. 5). Learners' motivation is usually reflected in four types of observable behavior including learners' choice of task, effort and persistence on engaging learning activities, and their learning achievement (Pintrich & Schunk, 2002). As an internal process, motivation gives behavior its energy, direction, and regulation (Reeve, 1996). Motivation can derive from many internal (intrinsic) and external (extrinsic) sources. Interest as one of many useful motivation sources, has been identified as a powerful motivator in learning (Alexander, in press; Chen & Darst, 2001).

Interest-based motivation theory suggests that interest arises as individuals interact with the environment (Hidi, 2000). It is a psychological state that involves focused attention, increased cognitive functioning, persistence, and affective involvement. In research, two types of interest have been identified: individual interest and situational interest. Individual interest is defined as an individual's relatively enduring predisposition of preference to certain objects, events, and activities (Renninger, 2000). Situational interest, on the other hand, is the momentary appealing effect of an activity on an individual in a particular context and at a particular moment (Hidi, 2000). Research in education (Hidi, 2000) and physical education (Chen & Darst, 2001) has shown that interests can attract learners to particular learning tasks, increase engagement time on task, improve information storage, and enhance achievement.

Model of Domain Learning

It can be assumed that the interaction of prior knowledge, learning strategies, and motivation directly influence learners' individual choice and willingness to engage in and persist on particular tasks during learning. From this integrated perspective, Alexander et al. (1995) proposed the Model of Domain Learning (MDL) to delineate and explain the multidimensional interplay of prior knowledge, interest, and learning strategies during learning in a specific content domain.

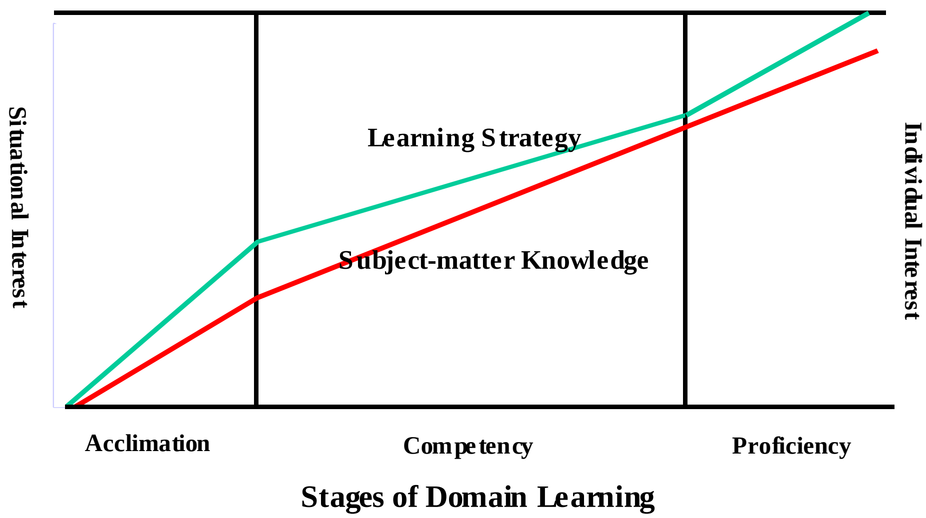
One of the most salient characteristics of MDL is domain-specificity. Charness and Schultetus (1999) reasoned:

> Each domain has a different set of demands and, consequently, each requires different skills. This is a critical feature in determining how best to quantify performance and in deciding what types of tasks would be most representative of the domain. It may also be important in terms of exploring the structure of the underlying knowledge base. (p. 60)

The MDL postulates that learning should be formulated and conceptualized in specific subject domains in order for educators to efficiently interpret learners' learning achievement in meaningful ways (Shulman & Quinlan, 1996).

Figure 1 below provides a visual description of the MDL in which learning encompasses both cognitive and affective components (Alexander et al., 1995). Specifically, it is presumed that success in learning depends on the interactive effects of prior knowledge, interests, and learning strategies accrued during each of the acclimation, competency, and proficiency learning stages (Alexander, in press).

Figure 1: Model of Domain Learning (based on Alexander et al, 1995)



At the acclimation stage, learners may have limited, fragmented, and incoherent prior subject-matter knowledge and they may learn new knowledge in a limited, fragmented and incoherent way. Cognitive efforts in this stage are directed toward constructing a framework of subject-matter knowledge that can serve as an adequate scaffold for subsequent learning. The learners rarely have a strong individual interest in the knowledge domain. They are often more concerned with completing the task than developing competency. Situational interest is the primary motivator for learners to be attracted to learning tasks and put forth continuous cognitive effort.

At the competency stage, learners are beginning to master knowledge. Although they continue to be attracted to situationally interesting information and learning tasks, they may begin to develop individual interest. Situational interest may be internalized as individual interest. During this stage, much of the declarative and procedural knowledge start to form hand in hand and be organized in cognitive schemata. As a result, subject-matter knowledge becomes more coherent and individual interest-based intrinsic motivation becomes a major driving force in pursuing new knowledge. Learning strategies are used frequently than before to help construct and reconstruct knowledge (Alexander, in press). Learners at this stage are likely to gain greater subject-matter knowledge than at the acclimation stage.

Learners at the proficiency stage have developed a high level of individual interest in the subject domain and have become proficient in using learning strategies. The attainment of proficiency in learning motivates individuals to set goals and pursue them and helps them enhance the subject-matter knowledge with quantity and quality. Learners at this stage experience a level of comprehension that they may not have experienced before.

The multidimensional, multistage MDL has been studied in classroom-based learning environment. For example, Alexander and Murphy (1998) examined college students' development of knowledge, interest, and strategy over an academic semester in learning educational psychology. The findings showed that the integrating cognitive process with motivation is a dominant predictor of learning achievement. Those who began the semester with high individual interest, strategic processing, and with a moderate level of domain knowledge were more likely to achieve at a high level than others. The study has revealed that learning is influenced by the integrated function of prior knowledge, learning strategies, and interest; rather than one factor alone. Similarly, consistent results have been found with learners in physics (Alexander, Kulikowich, & Shulze, 1994) and immunology (Alexander et al., 1995).

Although the MDL has enriched our understanding of learning in the specific knowledge domains, it has been studied mostly with samples of college students and conducted in classroom setting. The MDL and its functions in K-12 physical education have not been investigated and, therefore, remain unknown.

Statement of the Problem

Physical education is a subject-matter domain (Allison, Pissanos, Turner, & Law, 2000) in which acquisition of knowledge and movement skills is accomplished gradually and characterized by learning stages (Schmidt & Wrisberg, 2000). The MDL provides great potential for an in-depth understanding of the interrelations among knowledge, strategic processing, and interest-based motivation during learning in physical education.

Learners' motivation, cognitive thinking, and prior knowledge have been found to be related in physical education (Lee & Solmon, 1992). However, the nature of the relations and their effects on knowledge and skill acquisition have not been fully explored and understood. In fact, few studies have been conducted in physical education to explore the interactions among prior knowledge, learning strategies, and interest-based motivation, although prior knowledge, learning strategies, and interest-based motivation have been studied separately in research (Chen & Darst, 2001; Lee & Solmon, 1992; McBride, Xiang, & Wittenburg, 2002).

As Burke (1995) argued, researchers have approached curriculum design and learner motivation in separate ways. When learner's knowledge acquisition is emphasized in a study, the affective or motivational consequences of knowledge acquisition are likely to be overlooked. During teaching, educators may design curriculum with little consideration of the motivational effects of the tasks (Burke, 1995). Conversely, when designing a motivation strategy, it is usually assumed that motivation is an entity independent from learning tasks or learning outcome (O'Reilly, Tompkins, &

Gallant, 2001). To enhance learner motivation in physical education, teachers often forego in-depth, long term knowledge development; instead giving learners immediate rewarding experiences in games with little knowledge development. In this type of curriculum and instruction, keeping learners happy, busy, and good replaces purposeful learning (Placek, 1983). It is likely that learners are led to a belief that learning the content is a secondary goal in physical education or that physical education offers little to learn (Cothran & Ennis, 1998).

Assumptions

For this study, it is assumed that physical education is an institutionalized subject matter domain. The most important subject-matter knowledge that learners need to acquire includes information about human movement patterns, skills, skill themes (Allison et al., 2000) and health-related knowledge of physical activity (Corbin & Lindsey, 1997). The content should be sequenced for K-12 learners for them to understand and appreciate complex functions and benefits of specific movement forms such as dance, team and individual sports, and fitness activities (NASPE, 2004). In other words, physical education presents a setting similar to other school subject matter content in which learners are expected to achieve in learning the subject-matter knowledge and skills in the domain of physical education.

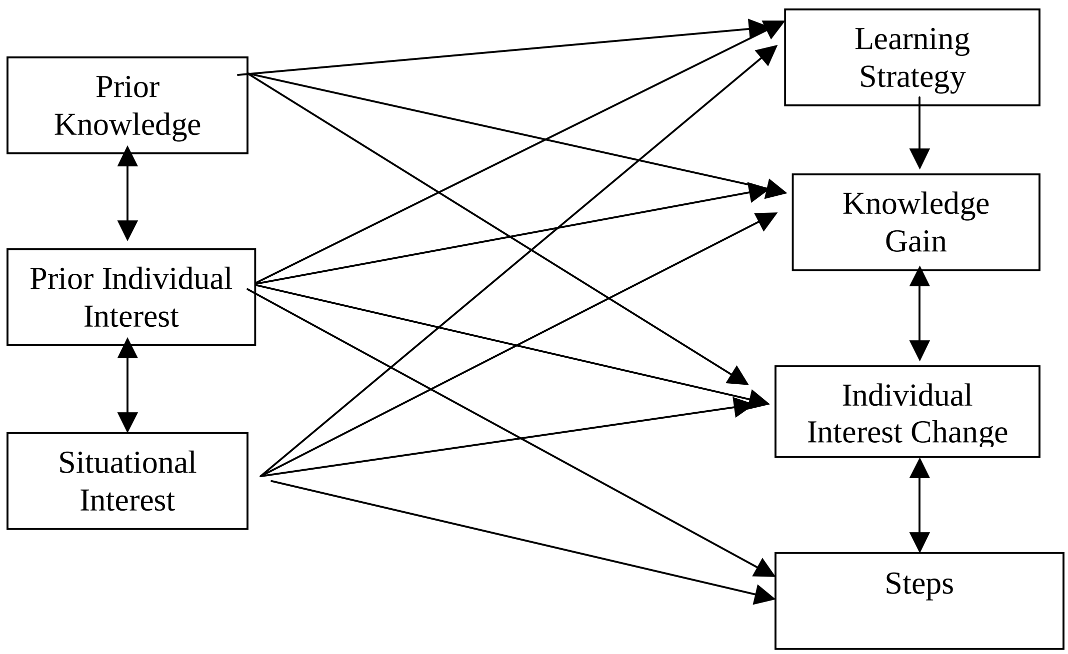
It was also assumed for this study that physical education content consists of two forms of subject-matter knowledge defined in the MDL theory (Alexander & Murphy, 1998). Domain knowledge refers to one’s broad understanding of the principles or concepts and motor procedures needed to perform physical movement and participate in physical activities. Topic knowledge, on the other hand, is one’s knowledge about specific concepts or motor procedures for a specific activity, such as the players' positioning in a softball game, the rules of basketball, or the principles of training for fitness development. Overall, these two forms of subject-matter knowledge are highly associated in that growth in one's domain knowledge is accompanied by increases in topic knowledge (Alexander et al., 1995). For example, within the broad domain of physical education, there are many topics that learners may experience, including particular skill development in individual and team sports, fitness concepts and related physical activities, and health-related behavior change strategies. Learners' knowledge relative to a particular topic will enrich their domain knowledge in physical education.

In addition, given the fact that learning in physical education is through physical activities, learning behavior can be thought to be a process outcome. How physically active learners are in a lesson should be taken into account as a form of learning outcome (Center for Disease Control and Prevention [CDC], 1996). From the motivation perspective, this process outcome can represent effort and persistence of the learner to reflect motivation levels in a physical education lesson. Learners are expected to be physically active at a moderate to vigorous physiological intensity level to receive health benefits from physical activities and to facilitate knowledge acquisition (NASPE, 2004). In this study, learners' physical engagement was assumed to be a viable process outcome demonstrated by learners accompanied with their learning in physical education.

Purpose of the Study

The primary purpose of this study was to examine the MDL by investigating the interrelated role of knowledge, interest, and learning strategies in middle school physical education. In this study, I applied the MDL theory in exploring the interrelations among knowledge, interests, and learning strategies, and tested whether the interrelations supported the MDL that learning was an outcome of their interaction in the learning process. A hypothesized model, as described in Figure 2, has been developed to present hypothesized relationships among knowledge, interests, learning strategies, and learning outcomes in physical education.

Figure 2: The Hypothetical Model of Learning in Physical Education



In this model, prior knowledge was hypothesized to be positively associated with prior individual interest. It was also hypothesized that their interactions with situational interest would influence learners' application of learning strategies. Situational interest, which is often stimulated by environmental factors, was hypothesized to contribute to the development of a long-lasting individual interest. The interactions among prior knowledge, prior individual interest, situational interest, and learning strategies were hypothesized to influence knowledge gain and individual interest change. In addition, prior individual interest, situational interest, and their interaction might influence the physical engagement recorded in total steps taken in the class, which, in turn, might be associated with the individual interest change.

In the hypothesized model, the indicator variables described in the MDL, represented by squares, were actually measured in this study. The single-head arrows represent the direction of possible directional influence of a variable on others. The double-headed arrows represent a covarying relationship between the variables, indicating possible a mutual, interactive influence between the variables, such as predicted between knowledge and individual interest.

This hypothesized model was saturated to represent all possible interactive relations described in the MDL. According to the MDL, learning is a staged process. At different stages, the interactive relationships among the variables are expected to differ from one another (Alexander et al, 1995). Therefore, the inter-relations described in the hypothesized model should be subject to testing and modification under different learning-stage conditions defined within the MDL. These hypotheses led to the following specific research questions for this study.

1. What are the interrelations among knowledge, interests, and learning strategies in middle school physical education? Do the interrelations support the hypotheses detailed in the MDL that learning in physical education is an interactive process of the learning variables?

2. Based on the MDL, to what extent can the learning process in softball be modeled in terms of the interrelations among knowledge, interests, and learning strategies?

Significance and Limitations of the Study

The exploration of MDL in physical education may facilitate an understanding of the interactive function between cognitive involvement and motivation on learning in physical education. The specific focus of the study on the relationship of knowledge, strategies, and interests with learners' learning provides holistic evidence in that the role of motivation and knowledge are explored simultaneously. This study is one of the few that attempts to explore the interplay among knowledge, learning strategy, and motivation in physical education. It addresses an important issue in physical education: Can knowledge acquisition and individual interest development be inter-functional? In other words, in addition to the motivational function of individual interest on knowledge acquisition, this study investigates whether knowledge acquisition or the consequence of knowledge acquisition can influence learners' long-lasting individual interest development.

Learners in middle school are transforming from childhood to adolescence when their body is undergoing rapid cognitive and physical changes. It is at this developmental period that adolescents' interest and participation in physical activities start to decline dramatically (Kemper, 2002; CDC, 1996). Studying middle school learners' cognitive and motivational process of learning in physical education may assist us in understanding the extent to which the learners respond to learning physical movement in terms of their knowledge, interest and strategies. Data from the study may be useful in designing motivating curricula to enrich learning experiences and enhance knowledge and skill acquisition in middle school physical education.

In addition, middle school learners begin to develop their personal interest (Hidi, 1990). Their engagement in learning becomes “selective” in that their motivation is primarily based on their personal interest that will have a strong influence on their future learning achievement. It has been found, however, situation-based motivators (e.g., situational interest) may override the influences of individual interest and keep learners motivated (Shen, Chen, Scrabis, & Hope, 2003). Studying the interrelations between selected variables (e.g., situational and individual interest) with this age group may provide significant insights to the understanding of the extent to which situation-based motivators can be internalized into individual interest.

This study was limited in that it focused only on the learner part of the learning process. Learning in physical education is a dynamically interactive process that involves the curriculum, the learning context, teachers’ instruction, and learner engagement (Ennis, 1992). Given the time and resource limitation of a dissertation, including curriculum, context, and instruction variables would increase the breadth of the study but might limit the depth of the understanding of the relationship of the identified variables in the MDL. I chose to minimize the influence of the curriculum, the learning environment, and teachers’ instruction by carefully selecting research sites and teachers (considering school, curriculum, and teacher factor). I believe that this approach enabled me to generate valid and reliable data needed to answer the research questions.

This study was a field-based investigation. Interpretation of the findings from this study should be based on specific contextual factors, such as characteristics of the participating schools, physical education curricula, and participating learners. In addition, implications derived from the findings should be adopted with a careful assessment of specific physical activity content in which the data were collected. It is necessary that the study be replicated in other settings with additional physical activity content with similar learner samples.

Definitions of Major Terms

Knowledge refers to "an individual's personal stock of information, skills, experiences, beliefs, and memories…whether or not it is verified in some external or objective way" (Alexander et al., 1991, p. 317).

Subject- matter knowledge is the knowledge "about the specified domain exists, including an understanding of what principles or fundamental concepts distinguish that body of knowledge from others" (Alexander et al., 1995). Subject-matter knowledge is usually associated with a particular domain and has two forms: domain knowledge and topic knowledge.

Domain knowledge refers to the breadth of one's subject-specific knowledge. It entails the person's knowledge relative to a designated field (Murphy & Alexander, 2002).

Topic knowledge refers to the depth of one's knowledge about domain-specific concepts or procedures (Alexander et al., 1991).

Declarative knowledge involves factual information, a component often described as knowing something (Anderson, 1987).

Procedural knowledge involves information about and capability of doing something and is typically characterized in terms of a production system. A procedure is an if-then statement for completing a sequence of action (Anderson, 1983).

Subject domains are those recognized and institutionalized educational fields or subjects in school (Alexander, 1997). Different tasks and performance across a domain should be bound together by shared features or underlying processes.

Individual interest is defined as an individual's relatively enduring predisposition of preference to certain objects, events, and activities (Renninger, 2000).

Situational interest is defined as a momentary appealing effect of an activity on individuals in a particular context and at a particular moment (Hidi, 2000).

Learning strategies are essentially mental operations or techniques that learners employ to solve problems or to enhance our performance during learning process (Alexander & Jetton, 2000). The two specific characteristics of learning strategies are consciousness and purposefulness.

General learning strategies are general cognitive procedures, like capturing and retaining information, and monitoring and regulating performance, that can apply to a broad array of tasks in many domains (Alexander, in press).

Domain-specific strategies are the specific cognitive procedures typically applied in only one subject domain, such as basic algebra operation procedure (Alexander, in press).

Model of domain learning (MDL) is a theoretical learning model that delineates the multidimensional interplay of prior knowledge, interest, and learning strategies during learning in a specific content domain (Alexander et al., 1995).

CHAPTER II

REVIEW OF RELEVANT LITERATURE

The purpose of this review was to articulate the Model of Domain Learning and explore the potential to test its tenability in relation to learning in K-12 physical education. In this chapter I reviewed, articulated, and critiqued related theories and empirical evidence and organized my discussion in four major sections. Namely, these sections are Perspectives on Definition of Learning; Influential Factors in Learning; The Model of Domain Learning; and Issues for Future Research. In these sections, classroom learning refers to learning that occurs in subject areas rather than physical education. Learning in physical education refers to that happens in K-12 physical education.

Perspectives on Definition of Learning

Learning is the most important mission of education (Nespor, 1987). Although psychologists and educators have defined learning in many different ways, learning essentially can be understood from a behavioral perspective or from a cognitive perspective. In this section, I focus on how learning is conceptualized from both perspectives and discuss learning in physical education and learning theories.

Learning Defined

Since Ebbinghaus' pioneering study (1885) on memory, research on learning had been conducted within a *behavioral* framework for almost 100 years (Shuell, 1986). This framework focuses primarily on forms of behavior change and defines learning as an association between a stimulus and a response (Thorndike, 1913). Knowledge that an individual might acquire internally is thought irrelevant for understanding the factors responsible for learning. Farnham-Diggory (1977) depicted the behavioral description of learning as “a stimulus goes in, a response comes out, and what happens in between is summarized by a hyphen” (p. 128). It becomes apparent that this stimulus-response perspective is limited in explaining what actually is occurring in an individual’s mind during behavior changes. In general, the behavioral perspective provides little explanation about the nature of learning from a within-the-learner perspective.

During the 1950s-1960s, cognitive psychologists started to explore the process of learning from a *cognitive* perspective, which focuses on how minds work to influence behavior (Bruner, 1957; Shuell, 1969). It was realized that meaningfulness embedded in learning tasks could influence learning behavior through human being’s cognitive processing of information (Shuell, 1969). Cognitive psychology has provided strong empirical evidence about how information is processed, stored, and applied. In other words, “instead of a hyphen, we have mental structures and processes” (Farnham-Diggory, 1977; p. 128).

Cognition is defined in general as “the act or process of knowing; perception” (Webster’s Universal College Dictionary, 2002). In education, cognition is used interchangeably with thought processes (Peterson, 1988). Cognitive theorists believe that thought governs action (Roberts, 2001; Shuell, 1986). Individuals’ behavior is under control of an array of cognitions or thought processes in achievement settings.

From the cognitive perspective, learning is viewed as an active, accumulative, and constructive process. Learning is associated with learners’ interpretation of meaning of the content and is manifested through cognitive understanding, rather than behavioral performance of a task alone. In other word, learning is the outcome of acquisition of knowledge that governs the behavior instead of the behavior alone (Stevenson, 1983).

Although there is a general agreement among behavioral and cognitive conceptions that learning is a change in an individual's behavior, the two perspectives differ in explaining the nature of learning in important ways. From the behavioral perspective, learning is viewed as a passive process in which the learner merely responds to a series of stimuli. With positive reinforcements given to correct responses, expected behavior starts to emerge and learning occurs. The cognitive perspective, on the other hand, stresses that learning is an active, constructive, and goal-oriented process. (Shuell, 1986). During this process the learner's mental actions that associate with the goals of the behavior construct the behavioral response. The stimuli alone without individual's cognitive involvement will not generate meaningful learning.

From the behavioral perspective, learners are considered "blank slates" who unconditionally receive anything taught to them. In the learning process, personal experiences and prior knowledge are considered trivial and overlooked as contributing factors to learning outcomes. However, advocates of cognitive conceptions of learning value the role of personal experiences and prior knowledge in acquisition of new knowledge. From this perspective, learners' thoughts often mediate what to be learned. The learner will actively filter through what is being taught and learn only those knowledge components meaningful to them (Doyle, 1977).

In contrast to the simple stimulus-response nature of behavioral perspective, cognitive conceptions of learning acknowledge the complex hierarchical nature of the psychological processes (Anderson, 1987; Rumelhart & Norman, 1978). It is assumed that in learning humans organize representations of the outside world (knowledge) in an internal structure that logically stores knowledge in an intermediate, short-term, and long-term memory system. These knowledge structures consist of nodes that represent particular concepts, facts, or theories and relate hierarchically to other nodes in an array of relationships known as a propositional network.

Learning, from the cognitive perspective, can be defined as "…the way in which people acquire new knowledge and skills and the way in which existing knowledge and skills are modified" (Shuell, 1986, p. 411). Therefore, it is an active and goal-oriented process that involves active and deep cognitive construction of knowledge and skills. It has been suggested (Darling-Hammond, 1997) that learning occurs best when learners actively engage in cognitive thinking processes, apply their prior knowledge to the process of learning new knowledge, and become self-responsible for their actions in the learning process. Based on this understanding of learning, Wiske (1998) argued that any behavior change without cognitive understanding should not be considered as learning. Subsequently, cognitive conceptualization of learning places a high value on the role of prior knowledge in the acquisition of new knowledge and skill. Behavior change is a display of outcomes resulting from learning intended to change the behavior.

Conceptualization of Learning in Physical Education

Given that physical education is education about movement, education through movement, and education in movement (Arnold, 1979), learning in physical education is often accomplished through physical training. This movement-based learning is the primary goal of physical education in K-12 schools (NASPE, 2004). In general, learning in physical education is usually defined as a relatively permanent change in behavior resulting from experience of physical movement coupled with cognitive understanding of the movement (Rink, 2001).

Behavior change without cognitive understanding should not be considered as learning in physical education (Griffin & Placek, 2001). Psychomotor learning is inseparable from cognitive learning (Jewett et al., 1995). In other words, learning in physical education can be thought to be an active and goal-oriented process of cognitive knowledge and physical skill construction that involves deep cognitive understanding of the knowledge and skills being constructed. This process is believed to lead to desired behavior change in the learner (Rink 2001).

Learning in physical education is multi-dimensional. The learning goals of physical education are summarized in the national standards for physical education (NASPE, 2004). According to these standards, a physically educated person should be able to "demonstrate competency in motor skills and movement patterns needed to perform a variety of physical activities (standard 1); demonstrate understanding of movement concepts, principles, strategies, and tactics as they apply to the learning and performance of physical activities (standard 2); participate regularly in physical activity (standard 3); achieve and maintain a health-enhancing level of physical fitness (stander 4); exhibit responsible personal and social behavior that respects self and others in physical activity settings (standard 5); value physical activity for health, enjoyment, challenge, self-expression, and/or social interaction (standard 6) " (p. 11).

Cognitive involvement in physical movement can directly influence learning in physical education. Lee and Solmon (1992) proposed a mediating processes paradigm based on their research on learners' thinking process in motor skill acquisition in physical education settings. They argued that learners' thinking mediates, and sometimes determines, their motivation and achievement. The motivational, affective, and cognitive components of learners' thinking often lead learners to different ways to interpret the purpose of learning and thus influence their learning behavior and achievement.

Learners' cognitive mediation in learning is not always consistent with instructional goals. For example, Solmon and Carter (1995) studied elementary school students' understanding about teacher expectations for learning and found learners interpreted the expectations in different ways. A salient influential factor was gender, for example. Girls believed that the teacher was teaching them how to follow the rules, whereas boys thought they were being taught how to learn motor skills.

Learning Theories from Cognitive Perspective

Early Theories

Educational researchers have used cognitive theories to understand human learning since 1950s. Ausubel (1962)'s subsumption theory of meaningful verbal learning is an important milestone of cognitive learning. Ausubel articulated that learning is concerned only with meaningfulness and discovery as opposed to memorization and reception. New and potentially logical information (new knowledge) can be subsumed into the learner's existing cognitive structure (prior knowledge). The availability of an existing cognitive structure is hierarchically organized with progressive differentiation within a given field of knowledge.

Having explored relationships between new and prior knowledge, Wittrock (1986) suggested that individuals learn meaningful material by generating or constructing relationships among new information and knowledge already stored in their long-term memory. Individuals may process same information differently because of their different prior knowledge. Learning occurs when an individual "codes something in a generic manner so as to maximize the transferability of the learning to new situations" (Bruner, 1957, p. 51). Bruner (1957) identified four general sets of conditions under which such learning will occur. They are the readiness of or the attitudes toward learning; an optimal level of motivation to engage in learning; prior knowledge and experience; and diversity of training to acquire new knowledge.

Contemporary Theories

More recent learning theories are developed with recognition of the complexity involved in the learning process. These theories center on the process of meaning making. They all acknowledge that meaningfulness and cognitive understanding are two most evident characteristics of learning. This school of thoughts is reflected in several contemporary cognitive theories. They include schema theory, the ACT theory of skill acquisition, and phase theory.

Schema theory. The first comprehensive theory of learning was Rumelhart and Norman's (1978, 1981) schema theory. According to Rumelhart and Norman (1981), a schema is "a data structure for representing the generic concepts stored in memory" (p. 34). Schema theory describes how knowledge components are represented and how that representation facilitates use of the knowledge in particular ways. There are schemata that represent our knowledge about all concepts, such as those underlying objects, situations, events, sequences of events, actions, and sequences of actions (Rumelhart & Norman, 1981).

In schema theory, learning is a process to integrate the outside world into internal knowledge structures stored in short-term, intermediate, and long-term memories (Shuell, 1986). These knowledge structures consist of nodes that represent isolated knowledge components such as facts, concepts, and principles. These nodes relate to each other in a hierarchical network that allows the individual to find relevant locations to store new knowledge components and retrieve stored knowledge components in application.

Cognitive schema change when learning occurs. The changes can be accretion, tuning, and restructuring (Norman, 1978; Rumelhart & Norman, 1978). Accretion is the process of encoding new information in terms of existing schemata. During this process, new information is encoded and added to the existing knowledge structures. Accretion may occur most often in learning that involves acquisition of factual information. After accretion, factual information is instantiated within a schema as a result of task comprehension or understanding of some event (Rumelhart & Norman, 1981).

Tuning is a result of using schema in different situations which involves gradual refinement of knowledge structures by adapting the knowledge to fit different application contexts over time. Rumelhart and Norman (1978) suggested that this process accounts for minor schema modifications that are necessary to refine existing knowledge. For example, when the learner encounters with new exemplars of concepts and principles that have been learned, the new information refines his/her existing knowledge structure to make it more consistent with both prior and new experiences.

Finally, restructuring involves creation of entirely new schemata that replace or incorporate old ones (Rumelhart & Norman, 1981). This may occur through schema induction in which a new schema is configured from repeated, consistent experiences. Or, as Rumelhart and Norman (1981) argued, restructuring occurs most of the time through learning by analogy in which a new schema is created by modeling it on an existing schema. The learner may already have all necessary information and the only cognitive action that occurs is reorganization of existing knowledge components.

Some researchers (Chinn & Brewer, 1993) address how knowledge is restructured in more detail, particularly with respect to the learning of contradictory, discrepant, or anomalous information that is not consistent with one's current understandings. Weak restructuring occurs when minor changes are made as new information is acquired or new relationships forged among existing nodes without significant changes in the core nodes. In contrast, radical restructuring entails changes in core concepts or major shifts in relationships among knowledge components in the overall knowledge structure (Posner, Strike, Hewson, & Gertzog, 1982).

In physical education, schema theory has been used to explain differences in knowledge structures of teachers' (Ennis, Mueller, & Zhu, 1991; Rink, French, Lee, Solmon, & Lynn, 1994; Rovegno, 1998). For example, Ennis et al (1991) found that novice teachers' knowledge structures of movement concepts are processed at accretion (adding concepts to the network) and tuning (refining categories) levels. They were not able to restructure knowledge representations to accommodate a different framework. In contrast, expert teachers exhibit a logical framework with a coherent conceptual representation of knowledge components.

*Anderson's ACT***.** Although schema theory (Rumlehart & Norman, 1981) has clarified fundamental relationships of knowledge components and their structure, it seems to focus on the acquisition mechanisms of factual information. The difference between knowing "what" (declarative knowledge) and knowing "how" (procedural knowledge) during learning is difficult to explain using the schema theory alone. To further understand the mechanisms of acquiring the procedural knowledge, John Anderson (1982; 1987) developed a computer program called ACT to describe individuals' learning process of how declarative and procedure knowledge are acquired.

ACT is based on the assumption that learning involves "the full range of skill acquisition, from language acquisition to problem solving to schema abstraction" (Anderson, 1983, p. 255) relevant for constructing both declarative and procedural knowledge. The distinction between declarative and procedural knowledge is important in that it declares that learning may differ not only because individuals are different but also because what is to be learned is different (what vs. how). *Declarative knowledge* refers to factual information about the meaning or perceptual characteristics of phenomena. *Procedural knowledge* is defined as knowledge about performing specific tasks, including those that help learner transform information from abstraction to practical application and solve new problems. According to ACT, declarative knowledge is represented as a network of propositions, for example the statements of the relationships among concepts and events. Procedural knowledge is represented as a system of production that determines what should be done under certain circumstances (Anderson, 1987). Learning, therefore, is about the mechanisms of acquiring both declarative and procedural knowledge and the cordination between the two.

According to ACT, knowledge in a new domain always begins as declarative; procedural knowledge is learned by making inferences from facts available in the declarative knowledge network. Similar to Fitts and Posner (1967) three phases of skill learning model (See details in next part), learning procedural knowledge involves three stages which include the declarative stage, the knowledge compilation stage, and the procedural stage (Anderson, 1982). By using problem solving processes such as planning, causal inference, analogy, and deductive reasoning, the learner uses the ACT system to organize a hierarchical, goal-oriented structure and control his/her actions.

Phase theory. When a learner is growing from a novice to an expert learner, he/she is supposed to go through several phases of knowledge acquisition. Although many cognitive theorists recognize that learning is a cumulative process (Anderson, 1982; Rumlhart & Norman, 1978), how a novice learner acquires knowledge and become an expert is not clear. There have been only limited systematic attempts to explore this issue in depth. Based on a broad review of the literature, Shuell (1990) proposed a phase theory of meaningful learning to articulate knowledge acquisition in three phases: initial, intermediate, and terminal phases.

During the initial phase of learning, learners encounter a large array of facts and pieces of information. They mostly rely on memorizing facts and using preexisting schemata to interpret the isolated pieces of data. Because the learners have little specific knowledge of the content, they use general problem solving methods, such as causal inference, to make comparisons and contrasts with prior knowledge to find analogies that appear relevant to the new content (Anderson, 1983, 1987).

In the intermediate phase, learners gradually begin to see similarities, differences, and relationships among conceptually isolated pieces of information. The information acquired during the initial phase is now applied to the solution of various problems that the learners encounter. As the knowledge becomes more abstract and can be generalized to a variety of situations, it becomes less dependent on the specific context in which it was originally acquired (Karmiloff-Smith, 1986).

During the terminal phase, the knowledge structures and schemata formed during the intermediate phase become integrated and function more autonomously. Performance becomes automatic, unconscious, and effortless. Learners rely heavily on content-related strategies for solving problems and answering questions.

These learning phases are not separate processes. In contrast, they are a continuous process without clear boundaries between them (Shuell, 1986). The transitions between phases are gradual and incremental rather than rapid and sudden. During the transition, characteristics of both phases are operating in an overlapping manner. For instance, when learners move from initial phase to intermediate phase, they may rely on both mnemonics and organizational learning methods even though the usefulness of the former has diminished and the later becomes paramount. “Such duplication could even serve a functional purpose in that new behavior is often unstable and the involvement of more than one factor could minimize the potentially negative effect of phenomena such as regression and forgetting” (Shuell, 1990, p. 543).

Motor Learning Theories

In physical education, motor skill acquisition has been described as the improvement of internal processes that determine an individual’s capability for producing a motor action. In this context, an individual’s motor skill acquisition is usually inferred through relatively stable motor performance (Schmidt & Wrisberg, 2000). Generally, motor learning theories parallel the findings in cognitive learning research in that motor skill acquisition has been found to be associated with cognitive activities and can be manifested in progressive stages.

Fitts and Posner (1967) described that motor skill learning includes cognitive, associative, and automatic stages. In cognitive stage, the leaner uses information about how a movement skill is to be performed to develop an executive/motor plan for implementing the skill. As a learner consciously attends to the skill and attempts to sequence the components of the skill, he/she tends to be involved in a deep thought process. However, the learner is unable to manage small details of the movement and to adapt the movement to environmental changes because of possible inability to coordinate actual physical movement with action formulated in thoughts (motor action plan). At associative stage, the learner begins to concentrate on the temporal patterning of the skill and the mechanics of refined performance. The learner benefits from feedback and becomes able to cope with environmental demands. The learner's performance starts to become consistent and suitable with the environment. At automatic stage, the learner can perform the skill automatically with little cognitive attention to the movement itself. Performance is consistent and can be adapted to the environmental changes.

Still using three-stage structure, Schmidt and Wrisberg (2000) elaborated motor learning as the verbal-cognitive stage, the motor stage, and the autonomous stage. Instead of emphasizing a learner's displayed behavioral characteristics; these stages were developed to describe learners thinking processes in learning motor skills.

Learners in the verbal-cognitive stage spend much time talking to themselves about what they will do and what learning strategies might work. Questions they tend to ask usually deal with issues of identifying goals (what am I trying to accomplish?) and evaluating performances (what went wrong? did I get that right?). During this stage, the learners take environmental information through visual, auditory, tactile, and kinesthetic stimuli. In the motor stage, learners' thinking focuses on refining the skill by organizing movement patterns in connection with effective action. The learners can transform incoming stimuli, assess specific environmental context, consider several possible action plans, and select the appropriate action. After extensive practice at this stage, the learners may enter the autonomous stage where they are able to produce their actions with little attention. During the autonomous stage, learners' attention start to shift to the affective variables associated with motor skill performance, such as self-confidence. Their cognitive attention is focused on detecting and correcting performance errors to achieve perfection that often leads to satisfaction of affective needs.

Summary

Cognitive learning theories have demonstrated that learning is an active and complex process. Learning in physical education results from experiencing physical movement coupled with cognitive understanding of the movement. There are different learning theories to interpret how individuals' internally knowledge structure represents the outside world. In schema theory, it is emphasized that meaningful learning is characterized by inter-dependant stages during which the knowledge components are accreted, tuned, and restructured. Prior knowledge can facilitate the new knowledge learning by guiding organization and representations, associating with new information, and coloring and filtering all new experiences (Alexander & Murphy, 1999). In ACT theory, the acquisition of procedure knowledge is emphasized. In terms of ACT, declarative knowledge can be thought to be a network of propositions while procedural knowledge is a system of production to determine what should be done under certain circumstances. Declarative knowledge and procedural knowledge are developed hand-in-hand in learning. In physical education, it is acknowledged that learners' motor skill development is associated directly with their cognitive involvement and can be manifested in the different, progressive learning stages.

Cognitive learning theory enriches our understanding that learning is an active and personally meaningful process. However, it has been realized that learning cannot be assumed to be a purely rational, "coldly cognitive" enterprise (Pintrich et al., 1993). Non cognitive factors, such as motivation, play an important role during learning process, especially in the socially and culturally interactive learning environments of school (Alexander et al., 1995).

Learning and the Learner

Thoughts and ideas that learners bring to the learning process have a critical and idiosyncratic meaning to what they will construct in learning (Alexander, in press). The complex array of learner thoughts can be understood in three related types: prior knowledge, learning strategies, and motivation. These thoughts comprise an interrelated mental network that determines achievement of learning in the classroom (Alexander, in press) and gymnasium (Solmon & Lee, 1996).

Prior Knowledge

Knowledge has been defined from a behavioral perspective as objective, definable, measurable facts that are agreed upon by scholars as worth knowing (Nespor, 1987). Cognitive theorists argue, however, that knowledge should be conceptualized as "an individual's personal stock of information, skills, experiences, beliefs, and memories" (Alexander, Schallert, & Hare, 1991, p. 317). In other words, knowledge is personally meaningful information and facts residing within an individual. Existing knowledge can also be described as *prior knowledge* defined as the total sum of personal knowledge that an individual possesses prior to acquiring additional new knowledge (Alexander et al., 1991).

In education, it has been argued that one of the primary goals of schooling is construction of new knowledge and skills in various subject domains (Schrag, 1992). Subject domains are those subjects that are recognized and institutionalized in schools (Alexander, 1997). Different tasks and performances across a domain are connected together by shared common features or underlying processes. In a subject domain, individual's existing subject-matter knowledge is broadly described as the prior knowledge that an individual possesses relative to a specific domain (Alexander et al., 1991). This type of knowledge has been conceptualized as domain knowledge and topic knowledge (Alexander et al., 1995). Domain knowledge refers to generality of the knowledge encompassing all knowledge components in a knowledge domain. It signifies the breadth. Topic knowledge, on the other hand, refers to the depth of one's knowledge about a specific component in the knowledge domain (Murphy & Alexander, 2002).

Subject-matter knowledge can also be conceptualized as declarative, procedural, and conditional in nature (Alexander & Judy, 1988). Declarative knowledge refers to factual information about the meaning or perceptual characteristics of phenomena. Procedural knowledge is defined as knowledge about performing specific tasks, including those that help learners transform information from abstraction to practical application and to problem solution (Anderson, 1987). Conditional knowledge is an understanding of when and how to use particular declarative or procedural knowledge (Alexander & Judy, 1988). For instance, in volleyball games, players can execute (procedural knowledge) a particular serve technique (spin or float serve) (declarative knowledge) based on their assessment of the game situation (conditional knowledge).

Anderson (1982) postulated that knowledge acquisition usually moves from declarative forms to procedural condition-action forms. However, it is suggested that the development of declarative and procedural knowledge is co-varied (Thomas & Thomas, 1994). As learners practice, they acquire more procedural knowledge which allows them to solve problems successfully and develop declarative knowledge more easily.

Subject-Matter Knowledge in Physical Education

Physical education is an institutionalized subject matter domain. In other words, physical education presents a setting similar to other school subject matter content in which learners are expected to achieve in learning the subject-matter knowledge and skills in the domain of physical education. Based on the NASPE (2004), the most important subject-matter knowledge that learners need to acquire includes information about human movement patterns, skills, skill themes (Allison et al., 2000) and health-related knowledge of physical activity (Corbin & Lindsey, 1997). The content should be sequenced for K-12 learners for them to understand and appreciate complex functions and benefits of specific movement forms such as dance, team and individual sports, and fitness activities (NASPE, 2004).

Knowledge in physical education can be further conceptualized as domain knowledge and topic knowledge. Domain knowledge refers to one’s broadly understanding of the principles or concepts and motor procedures needed to perform physical movement and participate in physical activities. Topic knowledge, on the other hand, is one’s knowledge about specific concepts or motor procedures for a specific activity, such as the players' positioning in a softball game, the rules of basketball, or the principles of training for fitness development. Overall, these two forms of subject-matter knowledge are highly associated in that growth in one's domain knowledge is accompanied by increases in topic knowledge (Alexander et al., 1995). For example, within the broad domain of physical education, there are many topics that learners may experience, including particular skill development in individual and team sports, fitness concepts and related physical activities, and health-related behavior change strategies. Learners' knowledge relative to a particular topic will enrich their domain knowledge in physical education.

Function of Prior Knowledge

In learning, prior knowledge serves as a conceptual scaffold or scheme into which new information can be assimilated or accommodated (Anderson, Reynolds, Schallert, & Goetz, 1977). The more knowledge individuals possess prior to engaging in a learning task, the more new knowledge they are likely to acquire. Alexander and Murphy (1999) suggested that "learners' existing knowledge serves as the foundation of all future learning by guiding organization and representations, by serving as a basis of association with new information, and by coloring and filtering all new experiences" (p. 5-6).

For example, Chi (1978) studied the influence of prior knowledge on future learning in chess. Participants in this study were children from the third to eighth grade (mean age 10.5) who were chess experts and adults who were novice chess players. When the participants were asked to remember the placement of pieces on a chess board, the performance of the 10-year-old experts surpassed that of adults, although adults demonstrated superiority in memory span tests. Similarly, Fincher-Kiefer (1992) showed that individuals with high prior knowledge base were able to generate more extensive and accurate interpretations of texts than those with low knowledge base.

Research in motor learning and physical education supports the function of prior knowledge on skill and knowledge learning. Abernethy (1988) tested expert and novice badminton players on a video task designed to simulate the perceptual demands of the game. He found that prior knowledge and skill in badminton influence the players' progression in both earlier information-extraction and critical anticipatory information. Williams, Weigelt, Harris, & Scott (2002) confirmed that the prior skill level and practice in soccer strongly influence learners' learning in lower limb interceptive tasks.

In addition, Silverman et al. (1998) investigated the influence of different skill levels on practice variables and achievement during middle school physical education classes. Their findings suggest that learners' entry level of skill directly influence practice during lessons and achievement. High-skilled learners had more appropriate practice trials and time spent on practice than low-skilled learners. As a result, high-skilled learners performed better in skill and knowledge tests. Hebert, Landin and Solmon (2000) studied the influence of prior knowledge and skill on learning process and learning achievement in a physical education tennis unit. The findings revealed that learners who had more prior skill and knowledge could complete more appropriate and successful trials than their lower skilled peers.

Learning Strategies

Development of declarative and procedural knowledge is an interrelated process (Thomas & Thomas, 1994). As learners practice, they increasingly acquire procedural knowledge that allows them to solve problems successfully and develop additional declarative knowledge. Alexander and Judy (1988) identified strategic knowledge as a special form of procedural knowledge. It includes goal-directed procedures that are used prior to, during, or upon completion of a task to assist in performing, assessing, and regulating learning behavior. In school, learners' strategic knowledge can be reflected in their application of learning strategies during the learning process.

Defining Learning Strategies

Learning strategies can be defined as the mental operations or techniques that learners use to solve learning problems or to enhance performance (Alexander & Jetton, 2000). Paris et al. (1991) suggest that "strategies are like tools. When there is a job to perform, you reach into your strategic toolbox and select the right implement." A successful learner can create and use a repertoire of strategies to achieve complex learning goals.

Learning strategies can be used across knowledge domains to assist performing, regulating, and evaluating the execution of a task. Learning strategies relate to both general cognitive procedures used in task performance and meta-cognitive strategies used in monitoring and regulating learning behavior (Alexander & Murphy, 1999). General cognitive strategies are those involved in the execution of a learning task and are considered having six broad functions. These functions include capturing and retaining information, improving memory, comprehending and recalling task, organizing information, motivating performance, and regulating learning (Paris & Winograd, 1990). Meta-cognition, on the other hand, is characterized as the awareness of one's own thinking so that one is able to control one's own beliefs, attitudes, and commitment to tasks. In addition, meta-cognition enables one to monitor learning plans, cognitive actions, and evaluations of tasks (Garner & Alexander, 1989).

Thinking strategically in learning is more than a skillful performance of learning. Although strategies and skillful performance of learning both are forms of procedural knowledge, strategies and skillful performance of learning are not equivalent (Alexander, in press). Skillful performance of learning is procedures that have been customized and generally function at an unconscious level or requiring minimal cognitive effort (Fitts & Posner, 1968). Strategies, instead, have very specific characteristics and function with awareness and purposes. During learning, learners need to consciously and purposefully use learning strategies in making decisions about how to approach a task in order to accomplish the learning goal (Alexander, in press).

From an educational standpoint, Alexander (in press) argued that teachers should facilitate learners to acquire learning strategies so that learners can use theses strategies to construct a base of relevant knowledge, articulate reasonable goals, and make appropriate decisions. Teaching learning strategies should integrate with students' knowledge and skill learning.

Teaching Learning Strategies

Research in education supports that teachers can influence learners' strategic thinking through instruction (Guthrie, Meter, Hancock, Alao, Anderson, & McCann, 1998; Guthrie, Wigfield, & VonSecker, 2000). For example, Guthrie and his colleagues (Guthrie et al., 1998) examined a concept-oriented reading strategy designed to facilitate children's engagement in reading. Central to this strategy was the emphasis on learners' self-direction, collaboration, and connection during reading. By comparing the achievement of learners instructed with this strategy with that of other learners, the researchers concluded that this strategy yielded greater achievement. Rosenshine, Meister, and Chapman (1996) reviewed intervention studies in which learners have been taught to generate questions as a means of improving their comprehension. They found that teaching learners the strategies of generating questions facilitated comprehension, and further in-depth exploration.

In physical education, critical thinking is considered as an important learning strategy. Critical thinking is defined as “the mental processes, strategies and representations people use to solve problems, make decisions, and learn new concepts.” (Sternberg, 1985, p. 46). Ennis (1991) suggested that physical education teachers should integrate critical thinking into their teaching to enhance learners’ learning efficiency. As learners begin to associate thinking skills and strategies with activities in which they are successful, the association can facilitate learners’ further learning.

Teaching learning strategies to learners strengthens learners’ conceptual understanding of physical education content. Chen and Rovegno (2000) revealed that teaching learners’ critical thinking skill could facilitate learners’ conceptual understanding of new content in a creative dance unit. Teachers’ use of questioning, metaphors, and examples that link learners’ prior knowledge and experiences to new information can develop learners’ active and critical thinking skills, and then enhance their understanding. McBride and Bonnette (1995) found that when the teacher provides opportunities for inquiry, promotes cooperation among learners, and encourages learners to think critically, learners’ scores on critical thinking measured using the New Jersey Test of Reasoning Skills (Shipman, 1983) increased significantly. Nevett, Rovegno, Babiarz, and McCaughtry (2001) examined the effects of instruction on fourth-grade learners' tactical thinking in invasion-game activities. The finding suggested that teachers' instruction was directly associated with the learners' development of tactical thinking skills in game settings.

Factors Related to Learning Strategies

Learners' actual thinking mediates, and sometimes determines, their learning (Doyle, 1977). Their academic strengths, personal interests, values, and perceived competencies can be reflected in the application of the learning strategies (Alexander, in press). Learners are responsible for using their knowledge and strategic abilities to blaze their own trails toward academic development.

Application of learning strategies is associated with prior knowledge and skill. There is a strong but shifting relation between individuals' knowledge and their successful use of strategies in academic learning (Alexander, et al., 1991). The more relevant knowledge learners have, the more likely they are to use learning strategies. Also, learners at different learning stages may use different types of learning strategies to enhance their learning effect. For example, Alexander and Murphy (1998) investigated college learners' application of learning strategies in reading. When learners have very little prior knowledge in the learning content, they tend to rely on surface-level strategies to build a base of subject-matter knowledge. Surface-level strategies refer to techniques, such as rereading or omitting unfamiliar words to facilitate the initial apprehension or deciphering of a task. In contrast, when the learners have enriched their knowledge in the learning content, they start to rely on deep-processing strategies characterized by procedures that relate current tasks to prior knowledge or develop a mental image to personalize or transform the tasks for understanding.

Application of learning strategies is correlated with interests. Alao and Guthrie (1999) found in a fifth-grade science class that learners who were interested in science were more likely to use learning strategies such as monitoring of comprehension, connection among ideas, elaboration, to understand main ideas and concepts than those who were not interested in science. Interestingly, the association between interests and the use of learning strategies was found to be independent of prior knowledge and skill. In other words, after controlling for prior knowledge, the researchers still observed a significant portion of variance in strategy use accounted for by interest.

The application of learning strategies also may relate to the characteristics of the learning content. For example, Solmon and Lee (1996) investigated the association of sixth-grade learners' (N=56) using of learning strategies with their skill improvement in a 4-day instructional volleyball unit to teach the forearm pass. The results showed that the level of difficulty in the learning task may influence the application of learning strategies. In particular, the lower the difficult level of the learning task, the more unlikely learners would like to apply learning strategies. Solmon and Lee assumed that learning strategies are useful for those who need them, but may not be necessary to apply when the learning content could not provide optimal challenge for the learners.

Learning Strategies in Physical Education

Given that movement-skill learning is the primary goal of physical education (Arnold, 1979) and a learner needs to "know what to do and do it correctly" (Schmidt & Wrisberg, 2000, p. 15), learning strategy in physical education can be defined as mental operations used by the learner to acquire knowledge and movement skills needed to perform physical activity. Lee (1997) argued that instead of teachers choosing learning strategies for the learner, it is the learner who should determine “which, if any, learning strategies they will employ during practice of movement activities” (p. 272).

In an early investigation of learning strategies in physical education, Locke and Jensen (1974) examined learners’ cognitive involvement during different physical education classes. Using a thought-sampling technique, the researchers asked learners to recall and record in writing their thoughts during learning. The finding revealed that learners were involved in a variety of cognitive thinking during the learning process and used various strategies to enhance or mediate their learning.

Effective learning strategies may influence learning achievement in physical education. Fahleson (1988) used a stimulated –recall interview, where learners viewed a videotaped lesson and responded to interview questions about their thoughts during the lesson, to examine learners’ cognitions. By comparing learners’ engagement during lessons, Fahleson found that learners’ learning strategies such as self-regulation, were positively related to posttest scores and favorable attitudes toward physical education. Lee et al. (1992) investigated the association between learners’ learning strategies and learning performance. In this study, 30 fourth-grade learners were provided two 30-minute lessons on the tennis forehand ground stroke. The learners and the teacher were videotaped, and following each lesson, the learners were interviewed using a stimulated-recall procedure. Frequency measures of successful practice trials were coded for each learner during each practice session. The analysis supported that a significant positive relationship between the application of learning strategies and successful performance during class. Learners who experienced a higher level of success during instruction were able to recall specific strategies they used to improve their performance, whereas low-success learners usually performed the skill inappropriately and could not select and implement learning strategies.

Measurement of Learning Strategy

In examining learners' learning strategies, valid and reliable measurement of the strategies is critical in order to acquire meaningful and accurate research results. Because learning strategies are mental operations which cannot be observed directly, researchers have been working for a long time to explore ways to measure learning strategies.

Strategies are usually measured using self-report. Ericsson and Simon (1980) examined a model of verbalization and concluded that "verbal reports, elicited with care and interpreted with full understanding of the circumstances under which they were obtained, are valuable and thoroughly reliable source of information about cognitive processes (p. 227)". To preserve validity and reliability, self-report data should be carefully collected using appropriate guidelines, and the time between the actual occurrence of the thought process and reporting it should be as short as possible (Brown, Bransford, Ferrara, & Campione, 1983). Commonly used techniques in collecting self-report data include think-aloud, stimulated recall, and questionnaire survey.

Think-aloud. Think-aloud techniques in which subjects are asked to verbalize their thoughts as they complete a task have been used to explore students' cognitive processes. Wade, Buxton, and Kelly (1999) used tape-recorded think-aloud technique to ask college students to stop at any point during silent reading to think aloud about their cognitive activities. Pressley and Afflerbach (1995) suggested that think-aloud verbal reporting has least interference with reading, while still close enough in time to capture the readers' thinking. In physical education, Hare and Graber (2000) put a wireless microphone on learners during lessons to determine what elementary learners thought about in learning. Their results showed that the think-aloud procedure is an effective way to elicit verbal reports from participants while they are performing a motor task.

However, some disadvantages of the think-aloud technique were found in actual teaching-learning environment for young children (Hare & Graber, 2000). Young children had difficulty describing what they were thinking when they were listening to teacher's instruction. In addition, when learners were trying to convey what they were thinking during learning, they were likely to disrupt teacher's teaching and would be admonished by the teacher for doing so.

Stimulated recall. Investigators of learning strategies have typically utilized a stimulated recall procedure in which learners are asked to view or to listen to video or audio taped recordings of a lesson and to respond to interview questions about their mental operations during the lesson. For example, Peterson, Swing, Stark, and Waas (1984) used video recording method to gather data on fifth grade learners' (N=38) learning strategies during mathematics instruction. In physical education, the techniques were also used in many studies (e.g., Fahleson, 1988; Lee, Landin, & Carter, 1992) to explore learners' thinking and strategies.

Even though stimulated recall has been used in many studies, the limitation is also evident. It is difficult to ensure the consistency between what learners actually thought during the lesson and what they report. Learners' recall may be based on what is showing on the recordings rather than what they actually were thinking during the lesson (Lee &

Solmon, 1992). The immediate and retrospective stimulated recall is suggested to enhance the data accuracy and reliability.

Questionnaires. Paper-and-pencil instruments are considered an effective way to measure learners' learning strategies, especially in large sample-size studies. Instruments like the Learning and Study Strategies Inventory (Weinstein, Palmer, & Schulte, 1987) and the Learning and Study Strategies Inventory-High School Version (LASSI-HS) (Weinstein & Goetz, 1988) are commonly used strategy assessment tools. Their validity and reliability have been widely examined in different populations. Also, researchers often design specific instruments to study specific problems. For example, Meece, Blumenfeld, and Hoyle (1988) designed a questionnaire to assess fifth and sixth-grade learners' learning strategies in science. Items include cognitive strategies and dimensions of self-regulated learning such as attention, planning, connecting, monitoring, as well as help-seeking and effort avoidant strategies. Guthrie et al. (2000) developed a strategy inventory to investigate the third and fifth grade learners' strategy use in reading. In this study, strategy use was defined as a learners' report of using a range of cognitive strategies to comprehend texts. Alao and Guthrie (1999) designed a questionnaire to investigate the influence of fifth-grade learners' both basic and higher level strategies on their conceptual understanding of ecological science.

Using questionnaire instruments to investigate learners learning strategies have many advantages, such as high acceptability, low cost, low interference with class. But its validity varies according to the length of time being recalled, and learners' ability and motivation to report accurately.

Empirical studies support that carefully designed measures of self-report can provide valid and reliable data about elementary and secondary school learners' strategy use. Elementary and secondary school learners are aware of the cognitive strategies they employ and can recall these strategies in various forms of self report measurement (Peterson et al, 1984). It should be noted, however, that it is difficult for any form of self-report that is feasible and low- interfering in a learning setting to meet all the criteria for high reliability and validity of the data. The methods must depend on the research question to be addressed and the constraints imposed by sample size, time, and setting.

Motivation

Motivation has been found to play a fundamental role in learning. Motivation is a psychological process "involved in the direction, vigor, and persistence of behavior" (Bergin, Ford, & Hess, 1993, p.437). It is an internal process that gives behavior its regulation (Reeve, 1996). In other words, motivation can be summarized as something "gets us going, keeps us moving, and helps get job done" (Pintrich & Schunk, 2002, p. 4).

Needs has been identified as a primary motivator. As described in Maslow's (1954) needs hierarchy, individuals are motivated to meet a specific needs ranging from physiological needs to psychological ones. Deci and Ryan (1985) suggested that human needs can be categorized into two aspects, intrinsic and extrinsic motivational orientation. Intrinsic motivation is the degree to which an individual chooses to participate in an activity for its own sake, such as its inherent satisfactions. Extrinsic motivation, on the other hand, is the degree to which an individual engages in an activity as a means to an end. Extrinsic motivation occurs whenever action is taken to attain external goals, such as monetary rewards, high grades, or public recognition (Ryan & Deci, 2000).

General Motivation Theories

Motivation can also be explained using social-cognitive theories including self-efficacy theory (Bandura, 1997; Halliburton, & Weiss, 2002), expectancy-value theory (Wigfield, 1994), and achievement goal theory (Ames, 1984; Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002). These theories place emphasis on the motivation effects of learners' beliefs about their abilities and perceptions about contextual factors in an achievement situation.

Self-efficacy theory. Developed within the framework of a social cognitive theory (Bandura, 1997; Halliburton &Weiss, 2002), self-efficacy theory describes an important cognitive mechanism that determines motivation, thought patterns, and behavior. Self-efficacy beliefs are defined as people's judgment of their capability to perform a specific task. It is a product of self-persuasion that relies on cognitive processing of efficacy information from diverse sources (Bandura, 1997). Individuals who hold high self efficacy in an activity are more likely to be motivated to engage in the activity than in others. Halliburton and Weiss (2002) reported that learners' self-efficacy is directly associated with students' physical activity level and adherences of exercise.

Expectancy-value theory. Jacobs, Lanza, Osgood, Eccles, and Wigfield (2002) suggested that perceived values of an activity and expected success in the activity serve as effective motivators in achievement settings. Individuals who perceive high value in an activity are more likely to be motivated to engage in the activity than those who perceive low value in the activity. Wigfield (1994) have identified four aspects of task values that can influence motivation. Attainment value refers to perceived importance of doing well on a task; utility value is the extent to which the current task is related to individuals' future goals; intrinsic value refers to the positive emotional experiences such as interest and enjoyment derived from the activity; perceived cost is the perceived expenses of energy or other personal capital in pursuit for success in the activity. Xiang, McBride and Guan (2003) investigated the tenability of using expectancy-value theory in physical education and found that elementary learners' attainment value of physical activities (importance) is associated with their intention of participation in physical activities in the future. Solmon (2003) suggested that pursuing the intrinsic value (e.g., having fun and enjoyment) is the primary motivator for adolescents in physical activities.

Achievement goal theory. In education, goals can be defined as why learners want to achieve what they achieve (Urdan, 1997). The achievement goal theory is based on a dichotomous framework of achievement goals: mastery (task) goals and performance (ego) goals. The mastery goal emphasizes the development of competence for a task, whereas performance goal focuses on demonstration of superior ability relative to peers. At the individual psychological disposition level, different achievement goals are found to be associated with different patterns of cognition, affect, and behavior. Elliott and Thrash (2001) found that learners pursuing mastery goals are likely to select challenging tasks, persist in the face of difficulty, and held positive attitudes toward learning. Conversely, learners pursuing performance goals are likely to choose easier tasks, and withdrew effort when difficulty is encountered.

At the instruction level, different instructional structures (e.g., cooperative groups, individualistic or competitive structures) may be perceived by learners as emphasizing a particular achievement goal (Ames, 1992). Identified as either task-involving or ego-involving, an instructional structure provides a unique motivational climate that consequently influences how learners interpret success and failure. It has been documented that a task-involving instructional structure leads to greater cognitive engagement, better performance, and higher level of affective response to learning (e. g., satisfaction) than an ego-involving instructional structure, especially for minority learners (Kaplan & Maehr, 1999).

Although there is little doubt about the positive effects of the task oriented goal, recent reviews of the achievement goal research suggest that the conclusion about negative effects of the ego oriented goal may be premature (Harackiewicz et al., 2002). Some theorists have argued that the ego goal can have positive effects because they also motivate learners to develop competence and promote adaptive achievement behaviors (Harackiewicz et al; Urdan, 1997). Empirically, Pintrich (2000) found that learners with both high ego oriented and high task oriented goal were as adaptive and motivated as those with a high task oriented goal.

Interest-based Motivation

In recent years, interest-based motivation theory has been drawing a strong attention from educational researchers (Krapp, Hidi, & Renninger, 1992). Interest has been recognized as an important motivator that helps engage individuals in activities. Interest arises as individuals interact with the environment (Krapp et al., 1992) and can be conceptualized as individual interest and situational interest. Individual interest has been defined as an individual’s relatively enduring predisposition to prefer to certain objects, stimuli, and events, and to engage in certain activities (Renninger, 2000). Situational interest, on the other hand, is defined as the momentary appealing effect of an activity on an individual in a particular context and at a particular moment (Hidi, 2000).

Interest researchers (Krapp et al., 1992) have found that personal interest is developed over time during a person's constant and consistent interaction with certain activities in a particular environment. It is based on increased knowledge, positive emotions, and increased value in these activities. Situational interest, on the other hand, is generated by certain stimulus characteristics in an activity (e. g., novelty) and tends to be shared among individuals (Hidi & Anderson, 1992). Situational interest is based on a short, tentative relationship between a person and an activity at a given moment (Reeve, 1996). Its motivation effect is short-lived (Hidi, 2000). In learning, situational interest results from learners' recognition of appealing features associated with a specific learning task (Mitchell, 1993) and can be manipulated by teachers to generate temporary but maximal motivation effects (Chen & Darst, 2001).

Although there is a fundamental distinction between individual interest and situational interest, they are not dichotomous phenomena that occur in mutual isolation (Hidi, 2000). On the contrary, it has been suggested that individual interest and situational interest could interact and influence each other's development (Hidi, 2000). Situational interest, which is stimulated by environmental factors, may evoke or contribute to the development of a long-lasting personal interest. High situational interest may enhance learners' engagement in learning activities that help form learners' personal interest in a subject matter (Alexander et al., 1995).

Research in education (Alexander et al., 2001) has shown that interests can attract learners to actively participate in learning. High interest can increase learners' engagement time, improve information storage, and enhance understanding. In a meta-analysis Schiefele, Krapp, and Winteler (1992) found significant correlation between interest and achievement in a variety of school disciplines. Specifically, interests have a greater effect on achievement of male learners than on that of female learners. Schiefele and Krapp (1996) reported that individual interest can display significant effects on text comprehension in reading after controlling for previous knowledge, intelligence or text readability. They noticed that individual interest did not simply enhance the quantity of the recalled text information but had its most remarkable effect on the quality of learning. The findings suggest that interests facilitated the readers' understanding of the underlying meaning and the main ideas in the texts instead of merely recognizing superficial facts.

Situational interest, sometimes known as interestingness, also plays an important role in learning and academic achievement. A high level of interestingness will lead to a high degree of attention and mental readiness of a learner (Krapp, 1999). In a meta-analysis of interest studies, Hidi and Anderson (1992) found that situational interest was more powerful than other factors (e.g., readability) in explaining difference of text comprehension. They concluded that interestingness is a powerful determinant of children's learning.

In physical education, interest was conceptualized in earlier studies as preferences or liking of specific physical activities. Lumpkin and Avery (1986) surveyed university learners' preference of physical activities offered in colleges. They found that most learners were interested in individual sports. This interest led them to taking more individual sport courses. Van Wersch, Trew and Turner (1992) investigated age and gender differences in preference of physical activities as content of physical education. They reported that at a younger age, girls' interest in physical education is higher than boys, while at an older age, boys' interest is stronger. For both boys and girls, interest in physical education declined with increase of age.

Adopting the theoretical framework of interest (Krapp et al., 1992), Chen and his colleagues examined interest in physical education. Chen (1996) revealed that learners' situational interest was dependent on a diverse personal interpretation of meanings in the activities and learning tasks. Based on Deci's (1992) theoretical articulation, Chen, Darst, and Pangrazi (1999) further tested the tenability of a multi-source construct model of situational interest with physical education learning tasks. Their findings indicate that those physical activities that provide new information, demand high level attention, encourage exploration, generate instant enjoyment are situationally interesting to middle school learners.

It was also found that different cognitive and physical demands of learning tasks influence the extent to which learners perceive situational interest of the tasks (Chen, 2001; Chen & Darst, 2001). Learners considered those tasks with high cognitive demand, regardless of physical demands, highly interesting. Tasks with low cognitive and physical demand were evaluated particularly low in situational interest. Shen et al. (2003) examined the effects of interests on learners' learning outcomes in a middle school physical education dance unit. Situational interest was found directly associated with physical engagement measured in steps taken in the lessons while individual interest was associated with students' knowledge and skill performance. The findings suggested that situational interest may have strong motivation effect on learners' engagement in the learning process, but it is necessary to develop learners' individual interest to enhance learning.

Summary

Learning is a highly cognitive process and can be understood in terms of three related dimensions: prior knowledge, learning strategies, and motivation. Prior knowledge serves as a conceptual scaffold or scheme to assimilate and accommodate new information for acquisition. In education and physical education, prior knowledge often guides the learner's initial interpretation of the content to be learned. The more knowledge and skills learners possess prior to learning, the better learning outcomes they are likely to achieve. Knowledge acquisition usually progresses from declarative forms to procedural and condition-action forms. But acquisition of declarative and procedural knowledge is an associated, holistic process. As learners practice, they acquire more procedural knowledge that facilitates the learners to solve problems successfully and develop more declarative knowledge. Strategic knowledge is a special form of procedural knowledge that learners use intentionally and purposefully to solve learning problems for achievements. In schools, learners' strategic knowledge can be reflected in their application of learning strategies during the learning process.

Learning strategies are mental operations or techniques that learners employ to enhance achievement. Appropriate learning strategies can help learners capture and organize information efficiently. A successful learner often relies on a repertoire of effective strategies to achieve complex learning goals. In physical education learning settings, learners are expected to be able to determine whether learning strategies should be employed during practice of movement activities.

Choosing and applying appropriate learning strategies require the learner to be an active agent in the learning process, rather than merely a passive recipient of knowledge or a mindless imitator of skill performance. Learners must be highly motivated in order to become able to search, experience, evaluate, and, eventually, adopt effective learning strategies (Pintrich et al., 1993). Motivation, in this context, serves as a primary force that leads the learner to developing useful learning strategies to achieve the learning goal.

Motivation is the psychological process that involves direction, vigor, and persistence of behavior (Bergin et al., 1993). Individuals who are motivated move through the problems with an appropriate sense of direction, energy, and commitment. Among many useful motivation constructs, interest has been identified to be a powerful motivator in learning. Research has shown that interest can attract learners to particular learning tasks, increase engagement times in learning processes, and enhance understanding and achievement.

Although research on motivation enriches the understanding of human behavior, motivation study in education and physical education should extend beyond the realm of psychology (Burke, 1995). It is suggested that motivation theory should coordinate with other learning variables, such as personality, cognitive processing, educational environment (Midgley, Kaplan, & Middleton, 2001) for a fully understanding of students' learning behaviors.

The Model of Domain Learning

Although research on learners' cognition has clearly demonstrated the process of knowledge acquisition, isolating cognition processes from socially and culturally interactive learning environments is not applicable in schools (Pintrich et al., 1993). Cognition-only models may be useful for investigating the general cognitive competence in an experimental setting, but they do not adequately explain learners learning in a social context that is usually based on the characteristics of a particular subject matter knowledge domain (Alexander et al., 1995).

Alexander and her colleagues (1995) proposed the Model of Domain Learning (MDL) to help conceptualize learning as a process encompassing cognitive and non-cognitive factors and explain their interactive influences on learning. Specifically, it is presumed that learners' development in a particular knowledge domain can be characterized as a progression from an acclimated or naïve stage of learning, to a more competent stage, and potentially, to one of proficiency or expertise. In this framework, the continuous interplay of cognitive and affective factors unique to the knowledge domain is acknowledged. Learning progression from a lower stage to a higher stage is dependent on the level of involvement and interrelationship of subject-matter knowledge, interest, and general learning strategies (Alexander, in press).

Domain Learning Defined

The distinction of model of domain learning (MDL) from other models (e.g., Anderson, 1982; Rumelhart & Norman, 1981; Shuell, 1990) is its domain-specific nature and its explicit recognition of learning in any domain as encompassing both cognitive and non-cognitive factors, such as motivation (Alexander et al., 1995). In MDL, subject-matter domains are those recognized and institutionalized educational fields or subjects in school (Alexander, 1997). Different tasks and performance within a domain share common features or underlying processes.

Alexander (in press) has identified four dimensions that tie a knowledge domain together: mode of inscription, typical tasks, underlying processes, and instructional issues. Inscription means that every domain is typically inscribed or represented in a recognizable manner. Inscription can be numeric, linguistic, graphic, or formulaic. As part of its inscription, a domain has its own lexicon or vocabulary that students must come to understand. Also, in a domain there are typical tasks or activities shared with common characteristics in the context of schooling. As learners become involved into a domain, they should become increasingly familiar with and competent in the performance of these typical tasks. Similarly, a domain is reflected from the specific fundamental and underlying processes of learning. Those processes are determined in part by the typical tasks that signify the domain, as well as the modes of inscription by which domain-specific content is documented, internalized, and communicated. Along with the social and environment constraints, a domain comes with its own set of instructional issues that must be effectively addressed if optimal learning is expected.

There is a trend toward greater domain specificity in the education research. Shulman and Quinlan (1996) argued that formulating general laws of human learning and development have not proven particularly fruitful. Learners' performance is domain-specific and does not fit in a global way. Charness and Schultetus (1999) concluded:

> Each domain has a different set of demands and, consequently, each requires different skills. This is a critical feature in determining how best to quantify performance and in deciding what types of tasks would be most representative of the domain. It may also be important in terms of exploring the structure of the underlying knowledge base (p. 60).

The Model of Domain Learning

In the MDL, interests, learning strategies, and knowledge have been acknowledged to be critical factors contributing to learning. The inter-relations among the factors and their interactive effects on learning have been hypothesized to be changing in association with the learner's progression through the acclimation, competency, and proficiency stages.

At the *acclimation* learning stage, the learner has limited knowledge/skill. Cognitive efforts are directed toward constructing a framework of domain knowledge. During this stage, deep-seated individual interest in the domain is quite low (Hidi, 1990). Learners are often concerned with getting through the task. Situational interest, a transitory or short-lived interest, is the primary motivator for the learner to be attracted to the learning task and put forth continuous cognitive effort and energy.

At the *competency* stage, the learner is beginning to master key knowledge and skills. Although learners may continue to be attracted to interesting information in the task, individual interest begins to replace situational interest as a major motivator while situational interest is being internalized into individual interest. Learning strategies will help reconstruct the learner's knowledge structure by tuning and personalizing pieces of new information. Effective learning strategies become the major learning tool for the learner. A competent learner can demonstrate greater comprehension and better performance of the domain knowledge than does a learner in the previous stage.

At the *proficiency* stage, the learner becomes an expert in applying effective learning strategies for learning. Individual interest becomes the sole motivator for the learner. The attainment of proficiency calls for the learner to set goals and pursue them. With increased quantity and quality of domain knowledge, proficient learners experience deep comprehension with ease.

The multi-dimensional, multi-stage structure of learning described in MDL has been observed in several studies in various academic domains. Alexander, Kulikowich, and Schulze (1994) investigated the interrelations between prior domain knowledge, interests, and recall test. College learners (*N* = 209) classified as acclimated, competent, or proficient learners in physics were provided two physics-related passages to read. During reading, the learners rated how interesting they thought the passages and paragraphs were. After reading, learners completed an information recall test that assessed how much they had learned. Results showed that prior domain knowledge significantly influenced learners' learning achievement and interest. The findings support the three-stage MDL and indicate that learners' prior domain knowledge and interests are interactively influence students learning.

To further understand the interactions between prior domain knowledge, interest, and recall, Alexander, Jetton and Kulikowich (1995) used a hierarchical cluster analysis to create dynamic, individualized learner profiles. College-level learners' prior domain knowledge and interests in biology and physics were recorded before they read the relevant texts in these domains. In analysis, interest and recalls were used to determine emergent profiles while prior domain knowledge was used as an external criterion to validate the differences among those profiles. Three unique clusters of students were revealed that confirmed the three learning stages. It was also found that higher prior domain knowledge was most often associated with higher interest drawn from that domain, as well as with higher scores on learning assessment.

The learning development of the model was also examined. In another study, Alexander and Murphy (1999) examined college learners' development of knowledge, interest, and strategy in learning educational psychology over an academic semester. It was found that motivation integrated within prior domain knowledge and learning strategies is predictive of learners' learning achievement. Learners who began the semester with high interest, strategic processing, and with a moderate level of prior domain knowledge were more likely to have a high learning achievement than others at the end of the semester. Prior domain knowledge, interest, or learning strategies alone, however, did not contribute to the optimal academic performance in learning educational psychology. Additional replication studies (Murphy & Alexander, 2002) revealed similar results in different subject-matter domains, such as special education, reading, and science.

By acknowledging the gradual transformation in learners' knowledge, interests, and strategic processing in different learning stages, educators can better facilitate learners at different stages in the learning process (Alexander, 1997). The MDL may need to be further developed in several ways. For example, most studies on domain learning were conducted with college students. There are few reports on domain learning in K-12 learners. The interaction of prior domain knowledge, motivation, and strategies in children/young learners remains unknown. Also, the MDL does not incorporate the influences from other important variables such as learner belief (Cothran & Ennis, 1998), achievement goal orientation (Harackiewicz et al, 2002), and perceived competency (Halliburton & Weiss, 2002). These variables are considered important motivators in the learning process. The role of these variables in domain learning needs to be understood as well. In addition, all investigations of the MDL are conducted in classroom settings. The effect of this model in other settings, such as in physical education, needs to be examined.

Summary

The Model of Domain Learning (MDL) depicts that learners' development in a particular knowledge domain can be characterized as a progression from an acclimated or naïve stage of learning to a more competent stage, and potentially to the proficiency stage. Learners at different stages need to be motivated with different types of interest and are likely to use different learning strategies to facilitate learning. For example, at the knowledge acclimation stage, situational interest is assumed to be the primary motivator for the learner to put forth continuous cognitive effort and energy. At the competency stage, individual interest should replace situational interest as a major motivator and learning strategies are used more frequently than before to help in constructing and reconstructing the knowledge. At this stage, situational interest begins to be internalized into personal interest. The learner becomes proficient in learning. At the proficiency stage, the learner becomes an expert in applying effective learning strategies and individual interest becomes the sole motivator for the learner.

Based on the MDL, learning is a process that encompasses cognitive and motivation factors. Prior knowledge, interest, or learning strategies alone will not ensure optimal learning achievement. Effective learning depends upon the interactive functions among them.

Issues for Further Research

Although it has been suggested that learners' motivation, cognitive thinking, and knowledge are related in physical education (Solmon & Lee, 1996), very few studies have been conducted to explore the interactions among knowledge, learning strategies, and interest-based motivation. The nature of their association and their interactive effect on skill and knowledge learning in physical education remains unknown.

As Burke (1995) argued, researchers and teachers have approached curriculum design and student motivation in separate ways. In physical education, prior domain knowledge, learning strategies, and interest-based motivation have been studied separately. During teaching, teachers design curriculum with little consideration to the motivational effects of learning tasks. Conversely, when designing a motivation strategy, it is usually assumed that motivation is an entity independent from learning tasks or learning outcome. To enhance motivation in physical education, teachers often forego in-depth long-term learners' knowledge and skill development, instead giving learners immediate rewarding experiences in games that call for little skill or knowledge development (O'Reilly, Tompkins, & Gallant, 2001). In this type of curriculum, keeping learners' busy-happy-good replaces purposeful learning (Placek, 1983). Learners are led to a belief that learning knowledge and skills is a secondary goal in physical education or that physical education offers little to learn (Cothran & Ennis, 1998).

Physical education is a subject domain (Allison et al., 2000) and learning in physical education progresses gradually through different learning stages (Schmidt & Wrisberg, 2000). Consistent with the features of domain specific and stage learning in physical education, the MDL may provide a great potential for examining the interrelations among knowledge and skill, learning strategies, and interest-based motivation in physical education.

The primary purpose of this study was to examine the MDL in physical education. In particular, this study was designed to explore the interrelations between knowledge, learning strategies, and interests in middle school physical education. Further, this study was aimed to model the learning process in physical education in terms of knowledge, interest, and learning strategies.

The exploration of the interrelations among knowledge, interests, and learning strategies in this study will help us validate the MDL in middle school physical education and may contribute to the understanding of domain learning theory as it is applied to physical education in general. The expected interplay between knowledge and interests in different learning stages will enhance our understanding of the association between the cognitive and motivational factors in learning in physical education, and may provide the evidences to support the role of knowledge acquisition play in motivation. Finally, Studying middle school learners' cognitive and motivational process of learning in physical education may assist us to understand the extent to which the learners respond learning physical movement in terms of their knowledge, interest and strategies. Data from the study may be useful in designing motivating curricula to enrich learning experiences and enhance knowledge and skill acquisition in middle school physical education.

CHAPTER III

METHODOLOGY

The purpose of this study was to explore the interrelations among topic knowledge, learning strategies, and interests as middle school learners were learning softball in physical education. Specifically the study tested the MDL by examining the interrelations of the variables in the model. It was assumed that learning in physical education is characterized by stages of learning described in the MDL. The interrelations among knowledge, interests, and learning strategies were hypothesized to vary for learners at different learning stages. The varied interrelations and their interactions were hypothesized to contribute to learning in physical education. In the following sections the procedures of data collection and analysis were discussed to demonstrate how the research was conducted to address the purpose of the study and the specific research questions. The discussions include (a) the research settings and participants, (b) variables and measures, (c) data collection procedure, and (d) data analysis.

Settings and Participants

The Research Settings

Setting selection. The purpose of this study determined that it should be conducted in physical education programs where the learning of physical skills, movement concepts, and movement principles was the primary goal for instruction. A set of criteria was developed to guide the selection of schools to be used as the research sites for this study. First, the research sites should include teacher or teachers who (a) were certified for teaching physical education; (b) taught both concepts and skills in physical education; (c) were able to use effective teaching strategies to create a positive environment for learning; and (d) evaluated learners' learning achievement using measurable means such as skill and knowledge assessments.

Secondly, the physical education curriculum should be in line with both national and state standards and emphasize the learning of movement concepts and principles and associated skills (NASPE, 2004). Consistently, instructional tasks and activities must be learning-oriented rather than entertaining- or recreation-oriented (Placek, 1983). All physical education classes should be coeducational in which boys and girls have equal opportunities to access the same content.

To select appropriate research sites, I conducted a pre-sampling investigation in two school districts around the Baltimore-Washington metro area. I collected teacher information from district and school offices and reviewed curriculum documents. I also interviewed physical education coordinators/supervisors for their recommendations of schools and teachers who met the criteria. I visited the recommended schools to determine if other factors might affect the criteria for the study, such as instructional space, equipment, class sizes, and scheduling. Based on the on-site assessment in schools, four schools were selected initially as the research sites. One school was eliminated because physical education was scheduled with health education. During the anticipated data collection period, a considerable number of learners would be pulled out of physical education classes to attend health education classes. The final research sites included the remaining three schools. One school was recognized as the State Physical Education Demonstration School in 2002, an award by the state American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD) for high achieving physical education programs. I provided an overview of this study to the teachers in these schools prior to my entry into the schools.

*The schools.*The three schools in this study enrolled approximately a total of 2300 learners in the sixth, seventh, and eighth grade at the time of the study. The majority of learners in the three schools came from middle socio-economic class background and represented a range of ethnic groups: 81.5% Caucasian, 10.3% African, 7% Asian, and 1.2% Latino Americans.

All three schools used a 90-minute block, three-day (A-, B-, C-day) rotating schedule. There were four periods in a school day. The first period was designated to classroom learning. Physical education was scheduled in the subsequent three periods. Learners had a physical education class on every third day. Learners from the same grade had physical education in the same period.

The number of physical education teachers in the three schools ranged from 2 to 4 depending on learner enrollment sizes. All teachers were certified and were teaching physical education full-time. Their teaching experiences ranged from 3 to 25 years. Three teachers (1 male and 2 female) participated in the study, one from each school. Their teaching experiences ranged from 5 to 25 years. One of them was the 1999 National Teacher of the Year, an award given by the National Association of Sports and Physical Education to one expert physical education teacher in a state each year. The teachers were all active AAHPERD members.

Participants

Learner participants in this study were 202 sixth-graders from the three schools. I chose to conduct the study in the sixth grade because as first-year middle school learners, they are usually experiencing a physical education curriculum that is different from what they have in elementary school. The possible confounding between prior knowledge and grade-related learning content could be alleviated. In addition, sixth-grade learners are mature enough to have acquired an initial understanding of the value of using learning strategies and are capable of expressing their thinking clearly (Paris & Lindauer, 1982). They begin to actively use strategies in learning to remember information, monitor learning behavior, and selectively attend to content that interests them. Table 1 summarizes the information of learner participants in the three schools.

Table 1

School and Participants Information

	Participants		Ethnicity of Participants		
School	Male	Female	Caucasian	African	Asian
A	33	28	82%	10%	8%
B	40	39	88%	6%	6%
C	30	32	85%	8%	7%
Total	103	99	85%	8%	7%

Among the 202 learners, 25 were unable to complete all the measures due to absences and other reasons. The final sample consisted of 177 learners. Parental consent forms and learner assent forms were received prior to data collection. Appendices A and B contain a copy of the informed forms.

Content (Topic Knowledge)

Softball was chosen as the content for the study for three reasons. First, softball is one of the most popular activities offered in middle school physical education curriculum. The study of softball is likely to have a profound implication for teaching and learning in middle school physical education. Second, softball is a “thinking-oriented” physical activity (Kneer & McCord, 1994). It involves both cognitive and physical tasks in order to achieve the learning goals. With appropriate instruction, a softball unit can provide a learning context with high cognitive challenge for the learners to develop and use learning strategies. Third, softball is a physical activity to which the sixth grade learners might have had various exposures outside physical education classes. Learners are likely to demonstrate different degrees of individual interest, skill, and knowledge. According to my survey about after-school program along with individual interest questionnaire conducted in this study, about 10% of total participants had engaged in softball or baseball outside school. Therefore, it was likely that the participants might have been at different MDL learning stages when they began learning softball in physical education. Studying the interrelations among knowledge, strategies, and interests with learners at different learning stages would allow me to gather data associated with the characteristics of the learning stages, which were needed in order to answer the research questions.

The softball unit was three weeks long in all three schools. The class size in the three schools ranged from 27 to 32 learners. The softball unit was taught as a new content to all the 6th graders. Major learning tasks in the unit centered on concepts (e.g., basic rules, tactical concepts, strategy concepts) and basic skills (e.g., throwing, catching, bunting, and hitting). The concepts and skills were learned through skill practices in groups and modified (simplified) games. The teachers used both direct and problem-solving instructional methods in teaching. Learning achievement was assessed using skill performance and written knowledge tests.

Variables and Measures

Topic Knowledge

In this study, I operationalized topic knowledge in physical education as those individualized concepts and motor procedures that were incorporated with specific physical activity such as softball in the curriculum. Before the unit began, declarative and procedural softball knowledge was assessed using (a) a knowledge test that measured learners' conceptual understanding of softball and (b) teacher subjective rating on skills, respectively. In physical education research, teacher rating of learner skills has been considered a valid, reliable, and efficient way to measure learners' skill levels (Graham, 1987; Martinek, 1988; Silverman et al., 1998).

Knowledge test. The knowledge was measured using a 14-item multiple-choice test, which is attached in Appendix C. All items in this test represented the content chosen from the county's physical education curriculum guide for 6th graders. As illustrated in the two sample items below, the purpose of this test is to assess learners' cognitive understanding of softball.

Question 1: A right handed pitcher will step with the _____ foot as he/she release the ball toward home

(a) right (b) left (correct answer) (c) either

Question 2: There are runners on 1st and 2nd base with no out. As the person who is playing 3rd base, you field a ground ball near the base, your next action should be

(a) throwing the ball to the 1st baseman

(b) stepping on 3rd base (correct answer)

(c) tagging the runner running from 2nd base

The items in the multiple-choice test were dichotomously scored as correct (1 point) or incorrect (0 point). The maximum score of this test was 14 points.

In order to examine the effectiveness of the softball knowledge test, experienced physical education teachers (*N* = 4, 3 female and 1male, with 10 to 25 years experience of teaching softball) were asked to rate content representativeness (1= not appropriate at all, 6=appropriate very much) and the difficulty level for the 6th grade learners (1 = not appropriate at all, 6 = appropriate very much) of each item. The teachers' evaluation form for the knowledge test is attached in Appendix D. Based on their rating, the range of ratings for each item was from 5 to 6 suggesting that the knowledge test had acceptable face validity.

Teacher subjective rating on skills. The participating teachers were asked to rate each learner's overall softball skill level in their class twice on a 7-point scale (1=lowest, 7=highest) based on their perceptions after the first and the second lesson of the unit. Appendix E is the teacher subjective rating form. The inter-rating consistency coefficients were 83%, 85%, and 91% for the three teachers, indicating that the reliability of the ratings were acceptable.

Learning Strategies

Learning strategies were defined as mental operations learners use to acquire cognitive knowledge related to a physical activity and to enhance motor skills needed to perform the physical activity. The strategies were measured using Cognitive Process Questionnaire in Physical Education (CPQPE) (Solmon & Lee, 1997). In this questionnaire, learners' confidence-efficacy, attention-concentration, willingness to engage, and strategies were measured using 32 items. Each item asked learners to identify themselves with a described learning behavior and to rate on a 5-point scale with 1 meaning "not like me at all," 5 "very much like me."

Solmon and Lee (1997) reported internal consistency coefficients (Cronbach's α) of .75, .79, .72, and .66 for confidence-efficacy, attention-concentration, willingness to engage, and strategies subscales, respectively. Appendix F was a version of CPQPE modified with "softball" replacing "physical education" to situate the items in the specific topic knowledge of this study.

For this study, the measures of cognitive process dimensions other than strategy were of little relevance. Although they were all measured, I only used scores of the five-item strategy subscale to represent the learners' strategy application during learning. These strategy-related items included, "I try to go over the right way to perform the skill I learn in softball in my mind," "when I am practicing a skill, I try to think how it is like something I already know," "I talk to myself during practice to help me do better," "When the teacher explains a skill, I practice the skill in my mind," "I try to practice skills I learn in softball at home".

Individual Interest

Individual interest in softball was measured using Physical Activity Interest Survey (Chen & Darst, 2002). The survey instrument asks learners to rate their individual interest in various physical activities that are relevant for a study on interest-based motivation. A 7-point Likert-type scale (7 = highest interest, 1 = lowest interest) is attached to each activity. To avoid self-determined reference frame for rating, the instrument asks the respondent to identify an activity (any activity) he/she is most interested in and give a rating score of 7. Then the respondent is instructed to use the identified activity as a reference to compare and rate other activities. According to Tobias (1994), this measurement context will decrease the possibility that individual learners interpret the rating scale inconsistently. Thus, the internal validity of the measure can be better maintained. The survey in this study included 18 physical activities offered in the physical education curriculum. The learners' rating score on softball were used to represent their individual interest in softball. The Physical Activity Interest Survey was shown in Appendix G.

Situational Interest

Situational interest was measured using a 24-item Situational Interest Scale (Chen, Darst, & Pangrazi, 1999). Items representing situational interest and its source dimensions (Novelty, Challenge, Attention Demand, Exploration Intention, and Instant Enjoyment) are rated on a 5-point scale (5=strongly agree, 1=strongly disagree) in terms of specific learning tasks the learner is experiencing. Appendix H is the Situational Interest Scale used in this study.

According to Chen et al. (1999), the construct validity of Situational Interest Scale was established using a factor analytical approach with exploratory and confirmatory factor loadings ranging from .50 to .90. The reliability coefficients (Cronbach's α) are .78, .80, .90, .91, .90, and .95 for Novelty, Challenge, Attention Demand, Exploration Intention, Instant Enjoyment, and Total Interest subscales, respectively. The evidence indicates that Situational Interest Scale can generate valid and reliable data.

In this study, I used the sum score of the four Total Interest items (20 points) to represent the direct measure of situational interest. These items included, "what we were learning today looked fun to me," "It was fun for me to try what we were learning," "what we were learning was interesting for me to do," and "what we were learning attracted me to participate."

Learning Outcomes

In this study, learning outcomes were operationalized as the degree to which learners' knowledge and individual interest changed as a result of learning in the softball unit. Also, physical engagement in the class was considered to be a learning process outcome demonstrated by learners accompanied with their learning.

Specifically, the arithmetic difference between the scores of pre- and post-knowledge-test was used to represent the learner's knowledge gain. The arithmetic difference between the scores of pre- and post-individual-interest survey was used to indicate the learner's individual interest change. In order to control the learning effect from the pre-unit measurement, the questions and items in the post knowledge test and post individual interest survey were rearranged randomly.

Physical engagement in the class was considered as a viable process outcome in physical education. After all, learning in physical education classes is expected to occur through active physical movement. Learners' physical engagement was measured using Yamax SW-200 Digi-walker pedometer (Tokyo, Japan) that recorded total steps taken during a lesson. The Digiwalker is an electronic pedometer that operates on a horizontal, spring-suspended lever arm. The leveler arm moves up and down with vertical accelerations. When the accelerations reach a certain level, the lever arm makes an electrical contact to record an activity event (Bassett, Ainsworth, Leggett, Mathien, Main, Hunter, & Duncan, 1996).

The validity of the Digi-Walker has been demonstrated in clinical research (Bassett et al., 1996; Tudor-Locke & Myers, 2001) and field-based research (Chen & Shen, 2004; Shen et al., 2003). In physical education, Shen et al. (2003) found the correlation coefficients ranging from .65 to .92 between steps recorded using Digi-Walker and heart rate data recorded on Polar heart rate monitors (Vantage XL model, Finland) in different physical education classes, suggesting an acceptable concurrent validity of Digi-Walker pedometer data. In addition, in order to keep the accuracy of the measure, all Digi-walker pedometers were checked using a walking test and a manual shake test (Vincent & Sidman, 2003) prior to distribute them to the participants.

Data Collection Procedure

Trained fellow graduate students and I collected all the data during regular physical education classes in the three schools. During the process, the researchers were responsible for distributing and collecting the survey instruments, answering questions, and collecting Digi-Walkers data. The teachers taught the classes as they normally did and assisted in managing learner seating during the data collection process. On average, a questionnaire data collection session lasted about 12 minutes.

The pre-individual interest survey and knowledge test were administered at the beginning of a lesson before the softball unit began. During the lesson, the learners were also trained how to use the Digi-Walker pedometers and practiced how to use them correctly.

Situational interest data, learning strategy data, and Digi-Walker data were collected in the first three lessons where major concepts were taught repeatedly and the development of the basic softball skills was the lesson focus. Before each lesson began, the learners were asked to put on the Digi-Walker pedometers and reset the step reading to zero. Immediately after the lesson, the learners were asked to remove the pedometer from the waist band and record the number of steps on a recording sheet, then completed the Situational Interest Scale and Cognitive Processes Questionnaire. The researchers verified recorded number of steps with the display on the pedometer while monitoring learners independently completing the questionnaires. At the last lesson of the unit (the fifth lesson), a post individual interest survey and a softball knowledge test were administered.

To maintain the independence of the learners' responses during data collection, the researchers asked the participants to spread out in the gymnasium to minimize interferences among them. To control for socially desirable responses, the researchers encouraged the participants to respond as truthfully as they could. The learners were ensured that their responses would not affect their grades. They were also informed that their teachers would not have access to their individual responses.

During the data collection, I was responsible for collecting all individual interest and knowledge data (both pre- and post-unit). Occasionally other researchers helped in collecting pedometer and situational interest data.

Data Analysis

In a preliminary analysis, all data were subject to accuracy screening, descriptive analyses, and a series of statistical assumption tests. Reliability of the questionnaire data was examined using Cronbach's approach for internal consistency. A multivariate analysis of variance (MANOVA) was used to verify the classification of learners' into the learning stages, which was based on a mean-split of pre-knowledge test scores. The scores of situational interest and learning strategies from the three lessons were aggregated and averaged for subsequent analyses.

To address the research questions of general interrelations among knowledge, interests, and learning strategies, Pearson Product-Moment correlation analysis was conducted. Further, the strength of the interrelations observed in the data was used to warrant further testing of the MDL model.

To address the research question of testing the MDL model, a path analysis was conducted to map out the meaningfulness of the interrelations among the variables. Path analysis is an analytical approach of structural equation modeling which involves steps of model specification, estimation, and path revisions of related variables (Bentler, 1997). Thus it is a viable approach to the examination of the model. Path analysis uses an omnibus algorithm so that all parameters can be estimated simultaneously. Using path analysis can avoid mapping the interrelations of the variables in an unrealistically linear pattern, as often criticized for multiple regression modeling, and may prevent erroneous uni-directional conclusions.

During the path analysis, the extent to which the hypothesized model described in Figure 1 fit the sample data was tested to provide validity information about the model (Byrne, 1994). In addition, the error variances in the model were also estimated, which allowed me to clarify the interrelations among the variables.

The indices-of-fit of the model was computed using EQS Structural Equations Program Version 6.0, which is designed specifically for the purpose of testing both path models and other structural equation models (Bentler, 1997). The values of model-data-fit indices in EQS enable us to assess the overall model fit by examining the extent to which the hypothesized model fit the data from the sample. According to Hu and Bentler (1999), multiple indices should be used to strengthen the estimation of the model fit.

To assess model-data-fitness, I selected to use several conservative model-data-fit values in the analysis. They include the ratio of X^2 to the degree of freedom (X^2/df $\leq$2.00) to evaluate the overall fit of the model and the influences of the individual pathways. Comparative fit index (CFI), which should be equal or greater than .96, was used to evaluate model's absolute or parsimonious fit relative to the null or hypothetical model. Standardized Root Mean Squared Residual (SRMR) was also used, which evaluate the model-data-fit by estimating the overall discrepancy between observed and model-implied covariances. An SRMR value of .10 or less indicates a fit. Also, the root mean square error of approximation (RMSEA) was estimated to estimate the difference between the hypothesized covariance matrix and actual sample covariance matrix. A value of .10 or less indicates model-data-fit. The 90% confidence interval (low, high) for

RMSEA should contain an interval that is over .05 to reject not close fit (Hu & Bentler, 1999).

CHAPTER IV

RESULTS

The purpose of this study was to examine the MDL by investigating the interrelated role of knowledge, interests, and learning strategies in middle school physical education. The study was designed to answer the research questions of the interrelations among the knowledge, interests, and learning strategies, and to what extent their interactions could be modeled. In this chapter, I report the analyzed data in the order of (a) preliminary analysis, (b) correlation analysis, and (c) path model analysis to answer the research questions.

Preliminary Analysis

The preliminary analyses were conducted to examine whether (a) the data were reliable, (b) any major assumptions for the statistical analyses were violated, and (c) the learners were at different MDL learning stages.

Data Reliability

The reliability of the questionnaire data was examined using Cronbach's internal consistence approach. The internal consistency reliability coefficients (Cronbach α) were .73 for the learning strategy data and .87 for the situational interest data. Also, according to learners' pre-knowledge test score, the Cronbach's α for the entire knowledge test was .66. The α coefficients indicated an acceptable level of reliability for these measures.

Assumption Test

The descriptive statistics for each measure are reported in Table 2. Analyses of skewness for all measures yielded a range of skewness indices between -.787 and .768, indicating that the assumption of distribution normality was not violated. The assumption of homogeneity of covariance was examined using the Box *M* test. The calculated Box *M* on the measures of knowledge, interests, and learning strategies was 32.02, $F_{(21, 107631)}$ = 1.47, p = .08, indicating that the equal covariance assumption was not violated. Overall, the results showed that the data met the assumptions for the statistical analyses chosen.

Table 2

Descriptives for Knowledge, Interests, Learning Strategies, Steps, Knowledge Gain, and Individual Interest Change

Variable	Possible Scores	Mean	Standard Deviation
Pre-knowledge Test	14	8.89	2.05
Pre-Skill Evaluation	7	3.84	1.45
Pre-Individual Interest	7	4.30	1.94
Steps	----	1895	712
Situational Interest	20	15.06	3.60
Learning Strategy	25	15.88	4.62
Post-Knowledge Test	14	10.31	2.40
Post-Individual Interest	7	5.03	1.57
Knowledge Gain	----	1.42	2.33
Individual Interest Change	----	.73	1.53

A MANOVA was conducted to examine school effect on learners' responses. That is, whether learners' pre- and post-instruction responses differed simply because they were in different schools. The results revealed that there were no significant differences among schools in either individual interest $F_{(2, 174)}$ = 2.365, p = .097, *MSE*=2.29, or knowledge $F_{(2, 174)}$ = 2.259, p = .107, *MSE*=2.26. Therefore, data from the three schools were collapsed into one data set for further analyses.

Classification of Learning Stages

Based on the MDL, learners at different learning stages may have different learning characteristics reflected in their knowledge, interest, and learning strategies (Alexander et al., 1998). In the preliminary analysis, learners' learning characteristics were classified and examined to reveal if they were indeed at different learning stages in terms of their knowledge, interests, and learning strategies.

According to the MDL, learning in a domain should develop gradually from an acclimation stage to a competency stage, and eventually to a proficiency stage. A proficient learner would show a high level of knowledge, deep-strategic processing of information, and high individual interest in the topics in the knowledge domain. Because learners' knowledge is the most important indicator of their learning stages (Alexander et al., 1994), the difference of knowledge in softball was used as the classification criterion variable in the analysis.

It can be assumed that K-12 learners have not achieved at the proficiency or expertise level in any knowledge domains taught to them (Alexander, 2000). A similar assumption can be made for the learners in this study and the learners were expected to be at either acclimation or competent level. In the classification, the mean of pre-knowledge test score (M = 8.89, see table 2) was used as the cutoff criterion to group the learners into the two levels. Those with scores below the mean were classified to be acclimation learners (n = 82). The learners who scored above the mean of the pre-knowledge test were classified as competent learners (n = 95). Table 3 reports descriptive statistics of the two groups.

Table 3

Descriptives for Knowledge, Interests, Learning Strategies, Steps, Knowledge Gain, and Individual Interest Change by Groups

	Acclimation Group (n=82) M / SD	Competency Group (n=95) M / SD
Pre-Knowledge Test	6.66 / 1.42	10.82 / 1.49
Pre-Skill Evaluation	3.30 / 1.28	4.29 / 1.44
Pre-Individual Interest	3.35 / 1.85	5.12 / 1.63
Situational Interest	14.66 / 3.83	15.40 / 3.38
Learning Strategy	15.07 / 4.82	16.58 / 4.34
Steps	1882 / 657	1907 / 759
Post-Knowledge Test	9.02 / 2.22	11.43 / 1.96
Post-Individual Interest	4.47 / 1.59	5.50 / 1.40
Knowledge Gain	2.36 / 2.46	.61 / 1.88
Individual Interest Change	1.13 / 1.81	.39 / 1.13

A MANOVA was conducted to analyze the extent to which the two groups differ in knowledge, interests, and learning strategies. Also, because learning in physical education is directly associated with physical training, number of steps (as a learning process outcome) was also tested in the MANOVA. In the analysis, learners' pre-knowledge, interests, learning strategy, and steps served as the dependent variables, and the learning stage group was used as the grouping independent variable.

Results of the MANOVA indicated significant overall differences between the two groups, $F_{(6,170)} = 59.78$, $p < .001$. A follow-up univariate analysis revealed that the learners in the competency group scored higher than those in the acclimation group in individual interest ($F_{(1, 175)} = 45.72$, $p < .001$, $MSE = 3.00$) and received higher teacher subjective rating on skill, $F_{(1, 175)} = 23.07$, $p < .001$, $MSE = 1.87$. During the learning process, learners in the competency group applied more learning strategies $F_{(1, 175)} = 4.83$, $p < .05$, $MSE = .83$, than that of the acclimation group. However, the differences in situational interest and steps between the groups were not statistically significant ($F_{(1, 175)} = 1.82$, $p = .179$, $MSE = 12.93$, $F_{(1, 175)} = .06$, $p = .814$, $MSE = 510151$; respectively). The results were consistent with the MDL assumptions, indicating that the classification was acceptable.

Correlation Analysis

The correlation analysis was conducted to address the first research question: what the interrelations among knowledge, interests, and learning strategies were in learning softball and whether the interrelations supported the hypotheses of the MDL that learning was an outcome of the interaction of the variables. The strength of the interrelations observed in the data was used to warrant further testing of the MDL model. Specifically, the correlation analysis included knowledge, interests, learning strategies and learning outcome variables. Table 4 reports the results for the entire sample from the correlation analysis.

Moderate correlations were found between knowledge, skill level, and individual interest in pretest. Strong negative correlations were found between pre-knowledge and knowledge gain and between pre-individual interest and individual interest change. Moderate negative correlations were observed between pre-individual interest and knowledge gain, and between pre-knowledge and individual interest change. In addition, there was a moderate correlation between learners' knowledge gain and individual interest change.

Table 4

Correlation Coefficients between Knowledge, Interests, Learning Strategies and Steps for the Entire Sample (N=177)

	2	3	4	5	6	7	8
1. Pre-Individual Interest	.52**	.32**	.34**	.16*	-.15	-.61**	-.20**
2. Pre-Knowledge	__	.45**	.22**	.09	-.01	-.32**	-.52**
3. Pre-Skill		__	.10	.04	.09	-.22**	-.15*
4. Learning Strategy			__	.46**	.05	-.10	-.19*
5. Situational Interest				__	-.05	.06	-.03
6. Steps					__	.24**	-.13
7. Interest Change						__	.35**
8. Knowledge Gain							__

Note. * $p < .05$ (2-tailed); ** $p < .01$ (2-tailed)

Further, correlation coefficients were computed separately for the acclimation and competency groups to determine if the interrelations among the variables shared similar characteristics. Table 5 reports the results for both groups. In concert with the predictions of the MDL, the correlations between pre-individual interest, skill level, and pre-knowledge were found for the competency group but not for the acclimation group. Learning strategies were correlated with pre-individual interest and pre-knowledge for the competency group but not for the acclimation group. A moderate correlation was found between learning strategy and situational interest for both acclimation and competency groups. But neither situational interest nor learning strategy associated with the knowledge gain for both groups.

Table 5

Correlation Coefficients between Knowledge, Interests, Learning Strategies, and Steps by Groups

	2	3	4	5	6	7	8
				Acclimation Group (n=82)			
1. Pre-Individual Interest	.03	.05	.20	.05	-.27*	-.62**	.05
2. Pre-Knowledge	__	.17	.10	-.02	.02	-.04	-.45**
3. Pre-Skill		__	-.00	-.05	.14	-.10	.01
4. Learning Strategy			__	.45**	.12	-.04	-.15
5. Situational Interest				__	.03	.15	.10
6. Steps					__	.34**	-.12
7. Interest Change						__	.24*
8. Knowledge Gain							__
				Competency Group (n=95)			
1. Pre-Individual Interest	.52**	.31**	.42**	.22*	-.10	-.54**	-.16
2. Pre-Knowledge	__	.43**	.21*	.04	-.08	-.46**	-.34**
3. Pre-Skill		__	.10	.06	.05	-.23*	-.07
4. Learning Strategy			__	.46**	-.02	-.09	-.13
5. Situational Interest				__	-.11	.00	-.11
6. Steps					__	.19	-.15
7. Interest Change						__	.36**
8. Knowledge Gain							__

*Note. * p < .05* (2-tailed)*; ** p < .01* (2-tailed)

No correlation was found between learners' steps and their pre knowledge, situational interest, and knowledge acquisition. However, there was a negative correlation between learners' pre individual interest in softball and their steps for the acclimation group. A moderate correlation between learners' steps and their individual interest change was found for acclimation group but not for the competency group.

Path Model Analysis

The path model analysis was conducted to address the second research question: to what extent learning in softball could be modeled in terms of knowledge, learning strategies, and interests. Based on the MDL hypotheses and the results from preliminary and the correlation analysis, it became apparent that learning softball at the 6-grade level can be characterized by the acclimation and competency stages. Further, the interrelations revealed among learning variables warranted using the path analysis to test the tenability of the MDL model in physical education.

Path analysis was selected because it is the most direct modeling approach with an omnibus algorithm (Loehlin, 1998), and can address the hypothesized relations among variables at different points in learners' academic development. Also, in studies with a relatively small sample size, such as that in this study, path analysis is a choice for effective data analysis. A two-step procedure, model construction and path comparison, was followed in the analysis.

Model Construction

The first step in the path analysis was to operationalize the theoretical model of MDL for empirical testing. In the hypothesized model (Figure 2, Chapter One, p. 13) the relationships were saturated, indicating an ideal representation of the MDL theory. In this path model, pre-knowledge, pre-individual interest, and situational interest served as independent (exogenous) variables, which were likely to influence learners' use of learning strategies and learning outcomes. Learning outcomes were dependent (endogenous) variables. Their changes were determined, at least in part, by learners' prior knowledge, interests, and learning strategies.

The hypothesized model was tested under two conditions defined within the MDL model. The first test was conducted with the scores from the entire sample to examine the fitness of the model in the specific topic knowledge parameter of softball. Then, the model was tested separately using scores from the acclimation group and competency group to determine variations in the path relations for learners at different learning stages. According to the results of Lagrange multiplier test and Wald's test (Kline, 1998) for model modification, teachers' subjective rating on learners' skill was excluded in this path model because of the overall low path coefficients with other variables.

The indices-of-fit for the model are listed in Table 6. According to the values, the hypothesized models displayed a good fit indicating that in general, the MDL is applicable to the learning of softball.

Table 6

Goodness-of-Fit Indices for the Model of Learning in Softball

Data Source	X^2/df	CFI	SRMR	RMSEA	90% CI RMSEA
Entire Sample	*1.75*	.987	.047	.065	.001, .135
Acclimation Group	*.696*	.999	.037	.001	.001, .127
Competency Group	*1.25*	.992	.042	.048	.001, .156

Note. X^2/df represents the ratio of X^2 to the degree of freedom. CFI represents Comparative fit index. SRMR represents Standardized Root Mean Squared Residual. RMSEA represents the root mean square error of approximation. 90% CI represents the 90% confidence interval.

To evaluate the goodness-of-fit of these models more closely, it was necessary to examine the statistical significance of each individual path to estimate the meaningfulness of the path between two variables. As recommended by Bollen (1987), *Z* statistics can be used for this purpose because of its robustness for multivariate normal data. A Z statistic is obtained by using the unstandardized path coefficient divided by its standard error. Thus, at an alpha level of .05, the Z would need to be greater than ±1.96 so that the parameter estimate can be considered to differ from zero with statistical significance. In other words, a Z ≈ or > $|2|$ indicates that an individual path has a significant role on the variables. Depending on the theorized direction, the path can be determined as uni-directional or interactive. Figures 3, 4, and 5 present the models and their path coefficients for entire sample, the acclimation group, and the competency group, respectively.

Figure 3: Model of Learning in Softball (Entire Sample Scores)

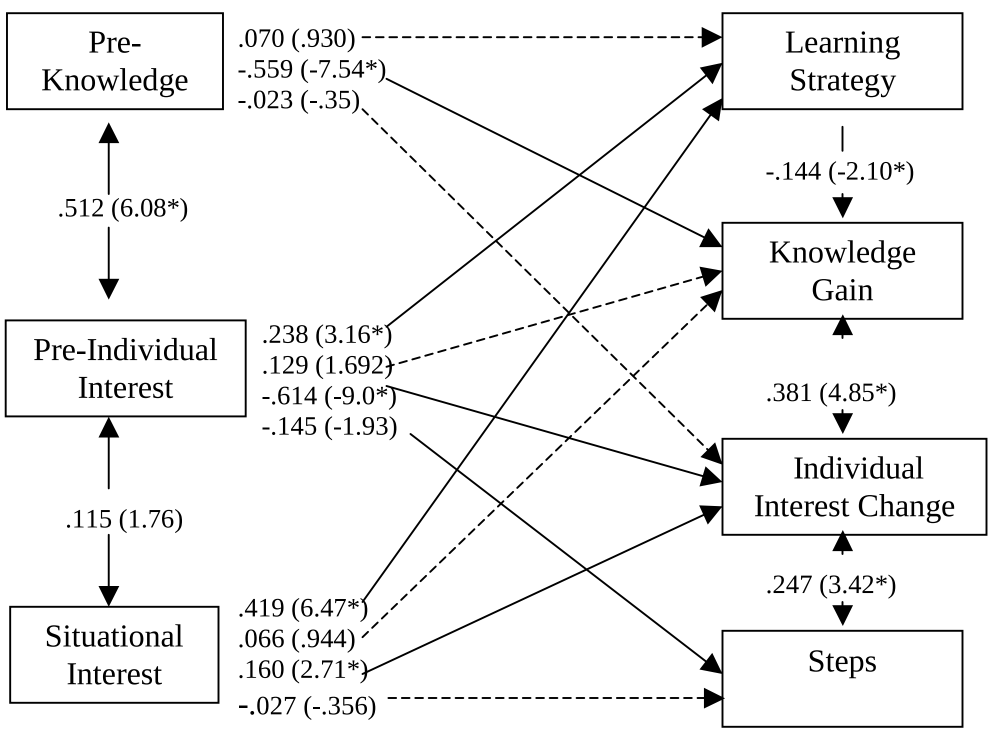


Figure 4: Model of Learning in Softball (Acclimation Learning Group)

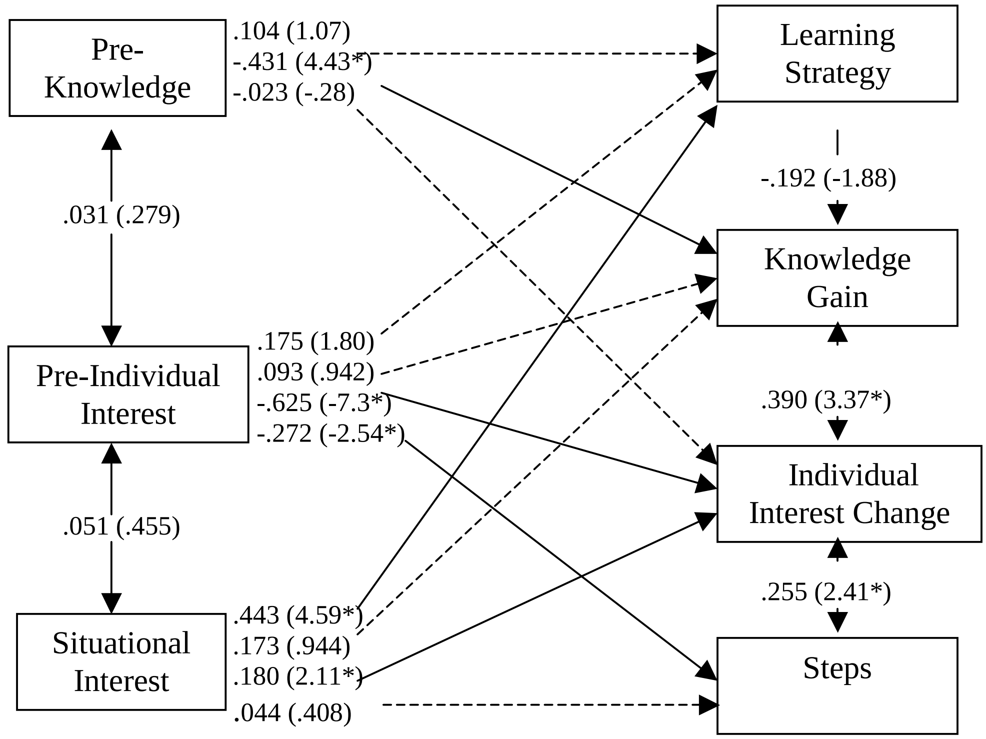
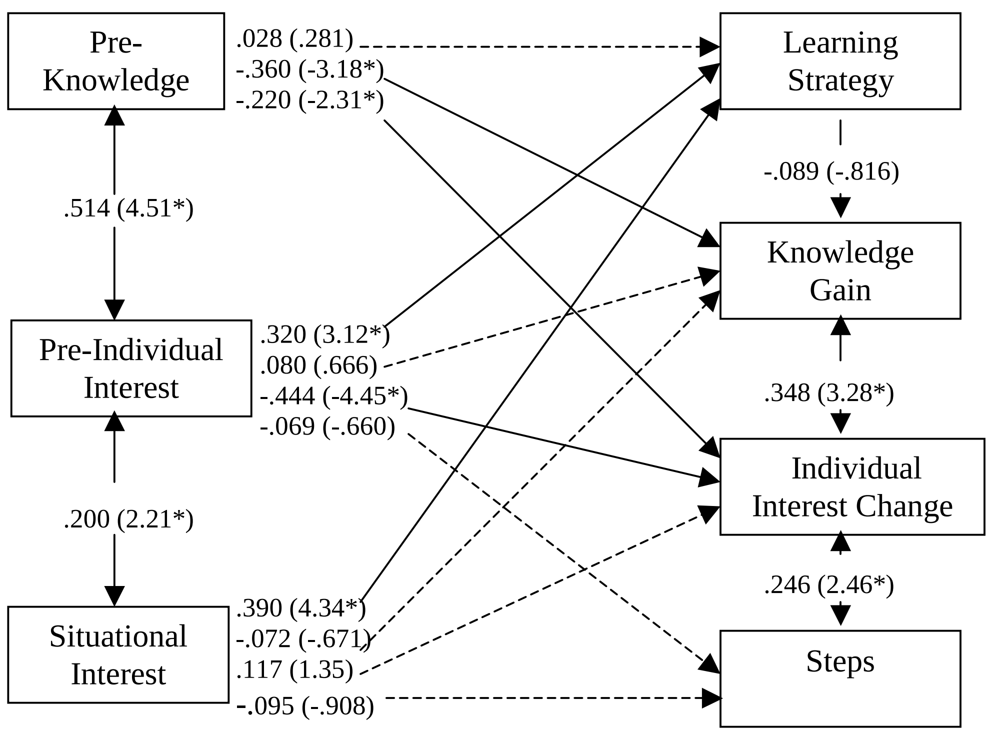


Figure 5: Model of Learning in Softball (Competency Learning Group)



Based on the results shown in Figures 3, 4, and 5, the hypothesized model had an overall acceptable tenability. However, by examining the path coefficients in the models, several theorized paths became questionable. For example, pre-individual interest did not contribute directly to knowledge gain for either the acclimation or the competency groups. The influence of situational interest on knowledge gain was limited. Although it was not significant, a negative directly influence of learning strategies on the knowledge gain was found in the models. These discrepancies were further examined and discussed in the following section.

Path Comparison

Although the hypothetical model was tenable for learners both at the acclimation and competency learning stages, the discrepancy of coefficients and *Z* scores for the pathways between the two models (see Figures 4 and 5) may indicate that there was a strength difference in the pathways of the two models. In other words, the direct influences of certain exogenous variables on endogenous variables were different for the acclimation learning group from those for the competency group. Therefore, the further investigation of those differences is necessary to distinguish the learning features in the acclimation and competency groups.

In order to investigate the extent to which the paths differed across the two groups, multisample structural equation modeling (Kline, 1998) was used in this study. Multisample structural equation modeling is a statistical measure to evaluate whether the theoretical paths differ across populations or they are invariant (Kline, 1998). Specifically, in this statistical measure, different groups' model structures were added simultaneously in a system of equations as a multisample. The overall model fit for the multisample was assessed. Then, all the parameters in the equation equal across groups were constrained to increase the model X^2 from the original one. The model modification indices (Lagrange multiplier tests) are calculated to estimate the benefit of releasing each individual equality constraint. The statistical significance of the change in model-data-fit (model X^2 decrease) is used as the criteria to release the constraints. When complete, parameters whose constraints have been released are inferred to differ across populations; parameters with constraints still remaining in the equation are deemed having tenable equality across the samples. Figure 6 shows the multisampling process as well as the indices of fit in this study.

Figure 6: The Indices of Fit for the Multisample in Softball

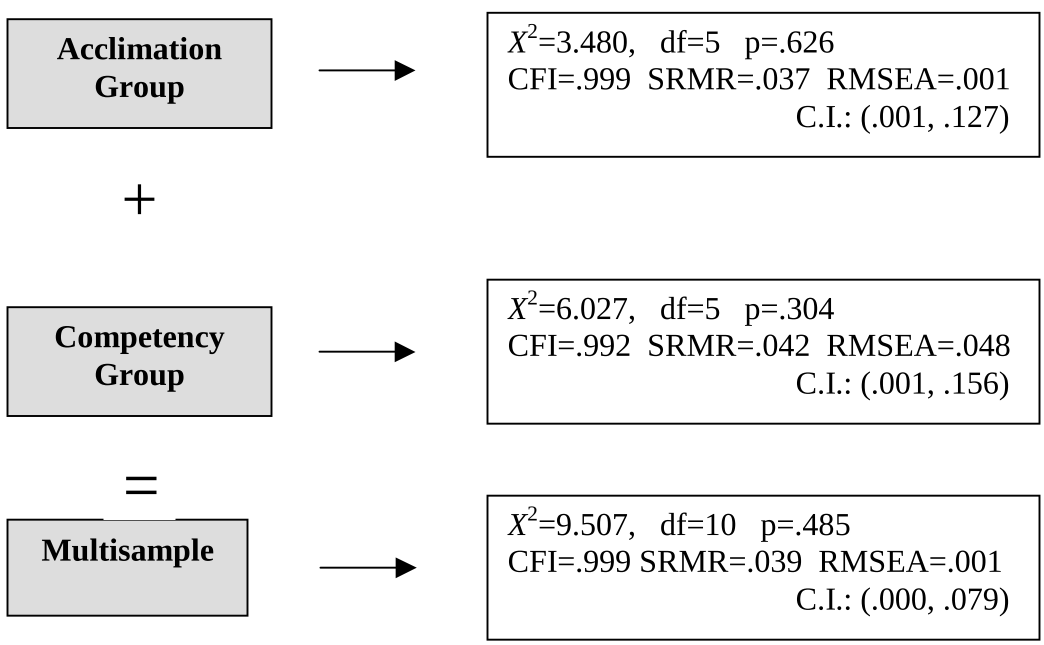


Table 7 reports the results of the Lagrange multiplier test (Kline, 1998). Based on the results, two pathways in the model showed significant difference between the acclimation and competency groups. The pathway between pre-knowledge and pre-individual interest was significantly differ between the two models (X^2 Decrease = 8.29, *p*

< .01) suggesting the covariance between pre-knowledge and pre-individual interest in competency group was significantly stronger than that in acclimation group. Also, the pathway from pre-knowledge to individual interest change significantly differed between the two models (X^2 Decrease = 4.01, $p < .05$) suggesting that the direct impact of pre-knowledge on individual interest change was more powerful for the competency group than that for the acclimation group. In general, the results support the hypothesis of strength differences in the pathways of the two models, and generally conform to the predictions of the MDL.

Table 7

Result of Lagrange Multiplier Test for the Multisample

	Estimated	
Cross-Group Constraint	X^2 Decrease	*P*-value
Pre-Knowledge→Learning Strategy	.680	.410
Pre-Knowledge→ Knowledge Gain	1.095	.245
Pre-Knowledge→ Individual Interest Gain	4.010 [a]	.021
Pre-Knowledge←→ Pre-Individual Interest	8.286[a]	.004
Pre-Individual Interest→Learning Strategy	.068	.410
Pre-Individual Interest→ Knowledge Gain	.098	.754
Pre-Individual Interest→ Individual Interest Gain	.394	.531
Pre-individual Interest←→Situational Interest	1.000	.318
Situational Interest→Learning Strategy	.075	.784
Situational Interest→Knowledge Gain	1.350	.245
Situational Interest→Individual Interest Gain	.321	.571
Learning Strategy→Knowledge Gain	1.009	.315

Note. Superscript "a" represents parameters whose constraints were released. One-directional arrows indicate the directional influence of a variable on others; two-directional arrows indicate a covarying relationship between the variables.

CHAPTER V

DISCUSSION

The purpose of the study was to explore the interrelations among topic knowledge, learning strategies, and interests in middle-school physical education. The MDL (Alexander et al., 1995) was used as the theoretical framework to guide this research. The framework postulates that learning in a specific knowledge domain is a staged process. This process is characterized by various, dynamic interactions among prior knowledge, interests, and learning strategies that learners bring in at different learning stages. In this exploratory study, I measured learners' interests, knowledge, and learning strategies when they were learning softball in middle-school physical education. The data were analyzed using correlation analysis and path modeling to reveal the interrelations among the variables and the extent to which the interrelations could be modeled meaningfully.

The results support that learning in physical education is an active and goal-oriented process that involves the learner to actively construct cognitive knowledge and physical skills. The evident interplay among knowledge, interests, and learning strategies in different learning stages suggests that learning in physical education occurs when learners actively engage in thinking processes, relate their prior knowledge to the process of learning new knowledge, and become motivated to achieve (Darling Hammond, 1997). The interactions among prior knowledge, interests, and learning strategies reiterate that prior knowledge and individual interest play an important role in the acquisition of new knowledge and skill (Wiske, 1998). The results further suggest that learning in physical education involves active cognitive engagement as well as physical participation. Learning in the psychomotor domain is inseparable from that of cognition (Jewett et al, 1995).

It is apparent from the results that learning in physical education can be understood and explained using the Model of Domain Learning. For the learners at the acclimation stage, the association among knowledge, interest, and strategy use appeared to be limited and the interaction among the variables were fragmented and incoherent. Consistent with the MDL, situational interest was found to be the primary motivator for them. In contrast, the learners at the competency stage demonstrated a more coherent learning profile. Individual interest-based motivation seemed to be a significant driving force in pursuing new knowledge. Their application of learning strategies was directly associated with their prior knowledge and individual interest. Although they were attracted to learning tasks through situational interest, their learning showed a coherent interaction between knowledge and individual interest.

Function of Prior Knowledge and Individual Interest

Prior Knowledge

From cognitive learning perspective, prior knowledge can serve as a conceptual scaffold or scheme to facilitate the assimilation or accommodation of new knowledge (Anderson et al., 1977). The more knowledge individuals possess prior to engaging in a learning task, the more likely they perform better during the new knowledge learning. It is suggested that learners' existing knowledge can serve as the foundation of all future learning to guide organization and representations (Alexander & Murphy, 1999).

The results from this study showed that prior knowledge has a strong influence on learning new knowledge in physical education. As conceptualized in the MDL, learners' knowledge development in a particular domain can be characterized by different learning stages. Prior knowledge is the most critical indicator of the stages. The learners in the study demonstrated that their prior knowledge and skill of softball were different, indicating that learners in the same grade are very likely to have been at different learning stages in physical education. The MDL is supported with the results that the learning stages observed among the learners shared the characteristics described in the MDL theory (Alexander et al., 1995). For example, the preliminary MANOVA analysis revealed that the learners in the acclimation and competence groups differed in prior knowledge, motor skills, and individual interest in softball prior to learning. In addition, their demonstrated motivational and strategic processing characteristics also differed in learning.

During learning, declarative and procedural knowledge grow simultaneously to enhance learner understanding of the content (Thomas & Thomas, 1994). With the development from the acclimation learning stage to the competency stage, the relationship between declarative and procedural knowledge is expected to become stronger. In this study, the relationship is represented by the correlation between prior knowledge and movement skill level (See Tables 5). The significant correlation between prior knowledge and skill level for the learners at the competent group indicates that the relationship between conceptual understanding and skill level was more salient for the competent learners than their counterparts at the acclimation learning stage. It can be speculated that the coupling of declarative and procedural knowledge enabled the learners to better solve problems in learning to further develop their knowledge and skills.

Association between Prior Knowledge and Individual Interest

Learners' knowledge level in a particular domain or topic is consistent with the level of their individual interest (Hidi, 1990; Alexander et al., 1995). The data from the preliminary MANOVA analysis supports this notion in that the learners at competency stage scored higher in both prior knowledge and individual interest measures (see table 3). The difference may indicate that knowledge acquisition in physical education occurs with the development of individual interest (Alexander et al., 1995).

Results from the correlation and path analysis further suggest that the relationship between prior knowledge and individual interest was an interactive one. As observed in Table 5, the correlation between prior knowledge, skill level, and individual interest for the learners at the acclimation stage was very weak, *r* ranging from .03 to .17, representing a typical fragmented and incoherent learning profile of acclimated learners (Alexander et al, 1995). In contrast, the stronger correlation coefficients (*r* ranging from .31 to .52) between these variables were observed for the learners at the competency group. The relationship may indicate that the competent learners' knowledge, skill, and individual interest might have grown together to form a cohesive learning profile. Results from multi-sample structure modeling analysis (Table 7) provide additional evidence that shows statistically different pathway strength between prior knowledge and individual interest in the two groups. Based on the MDL articulation, it can be concluded that the learners at the competency group had a more coherent and richer learning profile than the learners at the acclimation group to begin with in learning softball.

Function of Prior knowledge and Individual Interest in Learning

Prior knowledge and individual interest can directly influence learning process. Learners at different learning stages can demonstrate different learning characteristics. The function of prior knowledge and individual interest in learning can be manifested in the application of learning strategies and cognizance of situational interest (Alexander et al., 1995).

Individual interest often guides the application of learning strategies (Alao & Guthrie, 1999). Learners who were interested in the learning content were more likely to use learning strategies to understand main ideas and concepts than those who were not interested in the content. Therefore, when the learners develop from the acclimation learning stage to the competency stage, the relationship between prior individual interest and application of learning strategies is expected to become stronger. The result in the correlation analysis is consistent with this notion. The significant correlation between learning strategies and pre individual interest for the learners at the competency group suggests that the relationship between learners' strategic processing during learning and their prior individual interest was more evident for the competent learners than acclimated learners. Moreover, the path analysis (Figure 5) revealed that the association between prior individual interest and the application of learning strategies was independent of prior knowledge for the learners at the competent group. In other words, after prior knowledge was controlled (co-varied), there still was a significant impact of individual interest on the application of learning strategies. It can be assumed that competent learners' individual interest have an independent role in their cognitive learning (Alao & Guthrie, 1999). Their cognitive involvement during learning was effortful and planful as the results of high individual interest (Alexander & Judy, 1988).

It is suggested that application of learning strategies is associated with prior knowledge (Alexander, et al., 1991). Strong relationship between individuals' knowledge and successful use of strategies has been observed in academic learning (Murphy & Alexander, 2002) and physical education (Lee et al., 1992). However, this relationship is not evident in the results. Based on the path analysis (Figures 4, 5), the direct influence of prior knowledge on the application of learning strategies was not found for either the acclimated learners or the competent learners though there was a weak but significant correlation between prior knowledge and learning strategies for the learners at the competent group (see Table 5). The results indicate that the influence of prior knowledge on the application of learning strategies was indirect in this learning environment. The function of prior knowledge on learning strategies may need the individual interest as a mediator to transfer.

In physical education, learners with high individual interest in an activity may be more cognizant about situational interest and its effect than those with low individual interest (Chen & Darst, 2002). They often view the activity as more interesting and attractive. It is expected that the competent learners' prior individual interest may have a stronger relationship with situational interest than that for the acclimated learners. The correlation analysis revealed a weak but significant correlation (r=.22, p<.05) between pre-individual interest and situational interest for the competency group. Further, the results from the path analysis (Figures 4) indicated that the competent learners' individual interest was interactive with the motivational effect of situational interest. The evidence may suggest that the competent learners' high individual interest might help enhance the motivation effect of situational interest associated with learning tasks.

Function of Prior Knowledge and Individual Interest on Learning Outcomes

Learning in a specific domain should result in the enhancement of knowledge and individual interest (Alexander, in press). In physical education, learning should yield valued learning outcomes (Ennis, 1998). During learning, prior knowledge can serve as a scaffold for new knowledge to build on. Individual interest, which is developed over time during the learners' constant and consistent interaction with certain activity in a particular environment (Krapp et al., 1992), can improve learners' information storage, enhance understanding, and increase the quality of learning. Learners with high prior knowledge and individual interest are able to generate more extensive and accurate interpretations of learning contents than those with low prior knowledge and individual interest (Fincher-Kiefer, 1992).

Descriptively, comparing the scores from the pre-unit knowledge test with those from the post-unit test revealed that the learners did gain additional knowledge in softball (see Table 3). A small but positive change was observed in their individual interest as well. Correlationally, however, the knowledge gain and individual interest change were found negatively correlated with (see Table 5) and attributed to (see Figure 4 and 5) prior knowledge and individual interest for learners at both the acclimation and competency stages. The learners with higher prior knowledge and individual interest gained less on both variables than those with lower prior knowledge and individual interest. Further, the significantly higher pathway power from prior knowledge to individual interest change for the competent learners in the multi-sample structural modeling analysis (see Table 7) suggests that the interactive role of prior knowledge and individual interest on individual interest change was more influential for the competent learners than that for the acclimated learners.

It may be speculated that the smaller knowledge gain for the competent learners might result from the nature of softball and the instruction objectives of the unit. In this introductory unit, the teachers might have placed high curricular and instructional effort to help the learners at the acclimation stage. The instructional methods were conventional (drills for basic concepts and skills followed by low-structured games to reinforce them) rather than constructivist. Those learners at the competency stage did not have enough opportunity to construct their knowledge and skills at a level appropriate to their prior knowledge and individual interest. The results (and my informal observation) seem to suggest that the instruction might not be consistent with the constructivist teaching approach that addresses the dynamic complexity involved in the process to enhance learning achievement for all learners.

In physical education, learners' physical activity level is considered as a viable process outcome (NASPE, 2004). It was hypothesized in this study that learners' prior knowledge and individual interest might associate with their steps taken in the class. However, the hypothesized relationships were absent in the data. The weak correlations of steps with prior knowledge and skill for the learners at the both stages suggested that learners' physical involvement did not relate to their prior knowledge. In addition, a negative correlation was found between steps and prior individual interest for the learners at the acclimation group. It appears that acclimated learners' discrete individual interest did not evolve into a motivation source that encourages high level physical engagement.

Silverman et al. (1998) argued that high-skilled learners are likely to practice with the physical engagement appropriate for the activity. It is possible that the learners at the competency learning stage might practice at a physiologically efficient state that was sufficient for them to perform well in softball, a low physically intense activity. For the acclimated learners, learning to play softball demands them to acquire highly cognitive understanding of the game, skills, and, more critically, the timing of using appropriate skills. It is likely that for this group of learners, constructing the tactics cognitively became a learning focus more important than becoming fully physically engaged in physical practices. In addition, their low skill level might also prevent them from fully engaging in the physical aspect of the game. It is suggested that the disconnection of prior knowledge and individual interest with steps may be due to different reasons for learners at different stages. A systematic observation study on learners' learning behavior is needed for further understanding this issue.

Summary

Prior knowledge, skill, and individual interest interact dynamically to form a foundation for learners to construct new knowledge and skill and to develop individual interest. The interactive relationship of prior knowledge and individual interest, however, are likely to differ in learners at different learning stages. Learners at the acclimation stage are likely to demonstrate fragmented and incoherent relationships of the two variables and between them and other variables such as strategy use and knowledge gain. In this study, the learners with low prior knowledge and individual interest seemed to have gained new knowledge and strengthened their individual interest more than their counterparts in the competency stage.

It seems that the findings may indicate a need for a more coherent curriculum (Ennis, Solmon, Satina, Loftus, Mensch, & McCauley, 1999). All learners, regardless of their level of prior knowledge and individual interest, should be given opportunities to actively construct new knowledge and skill and further develop their individual interest in the domain or topic. The different profile each learner brings to class should be appreciated and utilized as scaffold on which new knowledge and skills are to be constructed. In such a curriculum, learners will become aware of the connection between their prior knowledge and interest and the role they play in the learning process and will use them as assets for furthering their learning experiences in physical education.

Role of Situational Interest and Learning Strategies

Situational Interest and Learning Strategies

Situational interest, which results from the recognition of appealing features associated with a specific learning task (Mitchell, 1993), can be a significant and viable motivator to facilitate new knowledge learning (Hidi, 1992). In physical education, situational interest derives from appealing characteristics of learning tasks such as novelty, cognitive/physical challenge, attention demand, opportunities to explore, and instant enjoyment (Chen & Darst, 2001). A high level of situational interest is considered necessary to lead the learner to a high degree of attention and mental readiness for achievement (Krapp, 1999) and may directly attribute to learners' physical involvement (Shen et al., 2003).

Acclimated learners are presumed to have little individual interest and rely heavily on situational interest to put forth continuous effort and energy (Alexander, 1997). Thus, situational interest is hypothesized to be the primary motivator for them. In this study, this presumption is supported by the results from the correlation and path analysis (Table 5 and Figure 4). The weak path coefficient between prior individual interest and situational interest for the learners at the acclimation stage suggests little or no interaction between situational interest and prior individual interest at this stage.

As a primary motivator for the acclimated learners, situational interest is expected to associate with the learners' cognitive effort during the learning process (Alexander et al., 1995). High situationally interesting learning environment may enhance learners' cognitive involvement. The moderate correlation between situational interest and the learning strategies for learners at the acclimation stage (Table 5) suggests that the situational interest related to the application of learning strategies for the acclimated learners in softball. The path analysis results lent addition support (see Figure 4) by revealing a direct, significant influence of situational interest on the learners' application of learning strategies. It can be reasoned that in a highly situationally interesting learning environment, situational interest may override the un-motivational effect of low individual interest during learning and play an important role for learners' cognitive involvement.

Interestingly, a similar result was found for the learners at the competent learning stage. The difference, however, is that for these learners, prior individual interest played an equally important role as situational interest did in influencing strategic processing and individual interest development (see Table 5 and Figure 5). Evidently, at this learning stage, individual interest began to replace situational interest as a major motivator. The learners, nevertheless, still continued to be motivated by situational interest. It can be speculated from the data that the competent learners are capable of internalizing situational interest into personally meaningful motivator to influence their strategic processing (Alexander et al 1998).

Roles of Situational Interest and Learning Strategies on Learning Outcomes

As hypothesized in the MDL, when learners progress from the acclimation stage to the competency stage, situational interest can be internalized into individual interest to facilitate long-lasting learning (Alexander et al., 1995). High situationally interesting learning environment is expected to “catch” and “hold” learners’ individual interest (Mitchell, 1993) especially for the learners at the acclimation learning stage. In this study, the hypothesis was supported from the path analysis. Individual interest of the learners at the different learning stages changed over the course of the softball unit (see Table 3). The share of contribution of situational interest to this change differed for the learners at the different learning stages. It seems that situational interest had a stronger impact on individual interest change for the acclimated learners than that for those at the competency stage (see Figures 4 and 5). Speculatively, the results show a possibility that situational interest can be internalized into individual interest for the acclimated learners.

It is worthwhile to notice that situational interest did not directly influence the knowledge gain for either the acclimation or the competent groups (see Figure 4 and 6). This result is consistent with Hidi and Anderson’s finding (1992) that situational interest may not directly contribute to knowledge outcome measures. The impact of situational interest on measurable knowledge outcome may be indirect.

Appropriate learning strategies enhance learning (Weinstein & Mayer, 1986). Learning strategies can help learners capture and organize information efficiently and enhance their ability to understand and remember the content (Armruster, 2000; Pressley et al., 1989). It is expected that application of learning strategies is associated with learning outcomes in learning softball. However, the data did not provide convincing evidence to suggest this association for the learners at both learning stages. A weak, negative path coefficient from learning strategies to knowledge gain was found in the models for learners at the two stages.

There could be plausible explanations for this result. Solmon and Lee (1996) argued that the role of learning strategy on competent learners' learning in physical education might depend upon the learning context. The level of difficulty in the learning task may influence their application of learning strategies. When the content does not provide optimal challenge for the competent learners, learning strategies may not be applied during the learning. As a unit for beginning middle school students, the learning tasks in the unit was introductory in nature and could be viewed by the competent learners as of little or no challenge. Their ratings on application of strategies (M = 16.58 out of 25, Table 3) reflected that their use of strategies was at an intermediate level. For the learners at the acclimation learning stage, however, their even lower score on application of strategies (M=15.07 out of 25, Table 3) indicated that they could not use the learning strategies effectively because of their little prior knowledge and skill. Their most cognitive efforts were directed toward attending to the skill rather than using learning strategies to reconstruct the knowledge structure (Schmidt & Wrisberg, 2000). Also, it is likely that within 3-week long softball unit, the acclimated learners could not convert their strategic efforts into a rich score in their knowledge test.

In physical education, learners' situational interest can directly associate with their physical engagement in the class (Shen et al., 2003). When learning tasks possess high situational interest, learners are likely to become physically involved in the activity regardless of their individual interest (Chen & Darst, 2001). In this study, this association was not observed. The low, insignificant path coefficients from situational interest to steps were found for the learners at both learning stages. It seems that high situational interest (see Table 4, *M* = 14.66, 15.40 out of 20 for acclimated and competent learners, respectively) did not influence their physical involvement. The result was not consistent with the previous study (Shen et al., 2003).

This discrepancy of the results from this study and previous ones (Chen & Darst, 2001; Shen et al., 2003) may result from content specificity. Softball is not highly a physically demanding activity. Successful movement in the game may depend on more cognitive engagement, for example thinking about tactics of the play, than physical effort. Physical movement is outcome of the cognitive engagement and is often in the form of short bursts after a long waiting period. The latter scenario is especially true for the learners at the acclimation stage because of their incomplete understanding of the game and low skills. In a particular lesson, learners could spend more time thinking and trying to make effective movement decisions than physically executing them. Therefore, it is likely that situational interest was high, but the opportunity to actually engage in the interesting activity with high physical involvement was insufficient for those learners. This result may imply that content-specificity (Bong, 2001) plays a significant role in physical education that may mediate the effect of situational interest on learning behavior.

Summary

It is likely that learners in physical education are aware of their affective and cognitive processes and able to report them to provide valuable information concerning how they learn. The significant function of situational interest on learning for the acclimated learners suggests that situational interest is a primary motivator for the learners at the acclimation learning stage. This piece of empirical evidence provides additional support for the tenability of the MDL in physical education. Given that the majority of learners enrolled in schools have limited knowledge of and value in school subject matter (Alexander & Jetton, 2000), situational interest may have strong implication in curriculum design. Physical educators can design situationally interesting learning tasks to maximize motivation effect to enhance learning.

Learning Progression

Learning Progression in Knowledge and Individual Interest

Learning in a particular knowledge domain can be characterized as a progression from an acclimated or naïve stage to a competent stage. Learning progression from the lower stage to the higher stage is dependent on the level of involvement and interrelations of knowledge, individual interest, and learning strategies (Alexander, in press). Learning progression is characterized by interactive, cohesive change observed in all the variables rather than an isolated one. In other words, positive changes should be manifested in knowledge, individual interest, and learning strategies as a result of their dynamic interaction.

In this study, knowledge gain and individual interest change were indicators of learning progression as specified in the MDL theory. The moderate correlation between knowledge gain and individual interest change for the acclimation group (see Table 5) suggest that their knowledge gain and individual interest development indeed occurred simultaneously as described in the MDL. The interactive, cohesive change in knowledge and individual interest may signify the start of a gradual transformation of the acclimated learners to the higher learning stage. Although the three-week softball unit may not be long enough to claim the course of positive change with strong empirical confidence, it did provide a window through which the relevance of the MDL theory in physical education was positively determined.

Learning Progressing and Physical Engagement

In physical education, learners are expected to be not only cognitively engaging in the learning process, but also physically active to facilitate knowledge acquisition and to receive health benefits of physical activities (NASPE, 2004). It is difficult to find a balanced instruction to provide learners with opportunities to learn useful movement and/or physical activity concepts and principles and to be physically active at a moderate or rigorous physical level in the short time allocated for physical education in schools (McKenzie & Sallis, 1996). The results from this study seem to reflect this difficulty.

A weak and negative correlation between steps and knowledge gain was found for the learners at both groups. The results of Lagrange multiplier test and Wald's test (Kline, 1998) for model modification also suggested that it was not necessary to further examine the relationship in the path model because of the low path coefficient. It may be speculated that the content of softball determined the disconnection. High cognitive demand and relatively low physical demand of softball might generate a gap in the content which is built in the learning process regardless how it is taught. It is also possible that the measurements used in the study might lead to the results. The knowledge gain was based on pre- and post-test results of a paper-pencil knowledge assessment rather than assessments requiring the learner to actually apply their declarative knowledge in procedural forms. Thus, the learners at the acclimation stage, who seemed to gain more knowledge because they scored low in the pre-test, were unable to fully engage in the learning process with high physical effort. Those at the competent learning stage did not gain much in knowledge because the curriculum was designed for those at the acclimation stage and there was little new knowledge for them to gain (see Table 3).

In addition, from a motivation perspective, steps taken in the class as a learning process outcome can represent effort and persistence of the learner, therefore their motivation in learning (Pintrich & Schunk, 2002). The effort demonstrated through physical involvement was found to relate to individual interest change with a significant path for learners at both stages (Figures 4 and 5). It seems that the learners' individual interest change and their physical involvement were connected. The enhancement of individual interest might result in exerting extra effort and persistence to involve into the physical activities and practice more. Therefore, the learners were likely to demonstrate relatively high physical engagement. It can be speculated that individual interest change can evolve into a motivation source that encourages learners' physical engagement.

Summary

Learning progression in physical education is represented in the increase of knowledge and individual interest. The progression is reflected in the extent of coherence to which learners gain new knowledge gain and change their individual interest. Amount of physical activities as a viable process outcome during learning in physical education is found to be associated with learners' individual interest change. However, the connection between knowledge gain and steps is not observed in the current study.

Learners in physical education are faced with two missions (Chen & Shen, 2003). On the one hand, they are expected to actively engage in a high-level of physical movement to receive health benefit provided in the physical activity. On the other hand, they are also expected to acquire cognitive knowledge and physical skills that enable them to engage in a physically active life style throughout their lives. The results seem to show that balancing the two missions for maximal learning outcomes is challenging for learners at the acclimation and competent learning stages. Physical educators should consider the challenge in teaching to better help learners construct meaningful knowledge and skills effectively (Haywood, 1991).

General Summary of Discussion

Learning in a knowledge domain involves multiple dimensions (i.e., cognitive, affective) and multiple stages (i.e., acclimation, competency, and proficiency) (Alexander et al., 1995). Learning development in a knowledge domain or topic relies on interactive contributions from prior knowledge, individual and situational interests, and learning strategies.

This study has provided empirical evidence that demonstrates complex interactions among the cognitive and affective factors at two learning stages in physical education. It is apparent that knowledge, interests, and learning strategies interactively contributed to the learners' knowledge gain and individual interest change. The contributions of the variables vary in terms of the uniqueness of learner characteristic profiles determined at each learning stage. Consistent with the MDL theory, it is confirmed that knowledge gain and individual interest change in physical education are directly or indirectly influenced by prior knowledge, prior individual interest, situational interest, learning strategies, and, importantly, their dynamic interactions. The simultaneous growth of knowledge and individual interest further supports the tenability of the MDL model and the notion that learning in physical education is a holistic developmental process (Jewett et al., 1995).

Individual interest change in the learners at the acclimation stage linked directly to the effect of situational interest, knowledge gain, and steps. The finding advances our understanding of the role of situational interest in the learning process and the possibility of situational interest being internalized into individual interest, the ultimate motivator for learning. Although nurturing individual interest in physical activity should not rely on a single source, it is helpful for physical educators to know that situationally interesting learning tasks do provide learners with opportunities to develop their personal preferences for the activity. Situational interest can be used as a catalyst to facilitate learners to overcome the disadvantages associated with low prior knowledge, and low prior individual interest in physical activities (Chen & Darst, 2001) and to nurture a long-lasting individual interest for a physically active life style.

The findings of the study suggest that content topics in the domain of physical education should be taught using a holistic, inclusive, and coherent approach. An effective physical education curriculum should address knowledge and skill acquisition and learner motivation simultaneously. It seems that the constructivist approach to physical education may provide a curricular and instructional context where learner prior knowledge, individual interest, and potential learning strategies can be taken into account in the teaching-learning process.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

General Summary of the Study

In this study, I attempted to examine interrelated role of knowledge, interests, and learning strategies in middle school physical education. Two research questions were addressed: (a) what were the interrelations among knowledge, interests, and learning strategies in physical education? Did the interrelations support the hypotheses detailed in the MDL that learning development in physical education is an interactive process of the learning variables? (b) Based on the Model of Domain Learning, to what extent the learning process in physical education could be modeled in terms of the interrelations among these variables? Data were collected from 202 sixth grade learners who were experiencing a beginning level softball unit in their physical education. Quality instruments were used to measure learners' declarative knowledge in softball (multiple-choice tests), procedure knowledge (teacher subjective rating on skill levels), learning strategies (Cognitive Process Questionnaire in Physical Education, Solmon & Lee, 1997), individual interest (Physical Activity Interest Survey, Chen & Darst, 2002), situational interest (Situational Interest Scale, Chen et al, 1999), and physical engagement in the class (Yamax SW-200 Digi-walker pedometer). Correlation and path analyses were performed on the data and the MDL was tested in relation to the learners' learning stages. The major findings of the study can be summarized as follows.

(a) Learners did bring various levels of prior knowledge and skill to the learning environment with different levels of individual interest in the content. For learners at the acclimation stage, their prior knowledge and individual interest were lower than those of the learners at the competency group. During learning, learners at the competency group were more likely to use learning strategies than the learners at the acclimation group. But all learners were likely to perceive situational interest of the content in a similar way. Importantly, the data revealed that the learners at the acclimation (lower) learning stage gained more additional knowledge than those at the competency (higher) learning stage. This phenomenon may be attributed to the non-constructivist instructional approach the teachers used in their instructions.

(b) The learners at the acclimation stage showed an incoherent learning profile while their counterparts at the competency stage demonstrated a relatively coherent learning profile in terms of the interrelations between prior knowledge, individual interest, and learning strategies. Situational interest was found to be the primary motivator for the learners at the acclimation learning stage and to motivate the learners at the competency learning stage as well. Importantly, it is found that situational interest did moderately facilitate a positive development of individual interest for the learners at the acclimation learning stage (see Figure 4). This finding indicates that situational interest may be internalized as individual interest with knowledge gain in a domain. It is suggested that situational interest may have strong implication in curriculum design.

(c) It was found that the development of knowledge and individual interest occurred simultaneously for all the learners. Amount of physical activities as a learning process outcome was not found to associate with knowledge acquisition for the learners at either learning stages. However, enhanced individual interest was found to be a possible motivation source that facilitated the learners in maintaining relatively high physical involvement.

In summary, the findings support the Model of Domain Learning and its prediction on the learning progression in physical education. The evidently different patterns of pathways among knowledge, interests, and strategy processing found in different learning stages show that the model can have different characteristics for learners at different learning stages. These variables function in an interactive, dynamic manner. Emphasizing any single variable in teaching, such as prior knowledge or individual interest, may not be sufficient enough to provide optimal learning opportunities for all learners. A holistic approach to curriculum development and instruction is needed. The role of these unique characteristics should be further explored to provide useful information for helping learners effectively construct new knowledge and movement skills.

Conclusions and Limitations

Major Conclusions

(a) For the first research question: "what were the interrelations among knowledge, interests, and learning strategies in physical education? Did the interrelations support the hypotheses detailed in the MDL that learning development in physical education is an interactive process of the learning variables?" It can be concluded that the interrelations among knowledge, interests, and learning strategies share similar characteristics of those found in classroom research. The interrelations are complex and dynamically interactive. The strongest supporting evidence from this study is mutual development of prior knowledge and individual interest, with the influence from situational interest. In addition, it can be concluded that learning development in softball is an interactive process of the learning variables. It is evident in the path models (see

Figure 4 and 5) that the interactions of the variables and the effects of the interaction differed in terms of the learning stages. For example, at the acclimation stage the variables' interrelations and interactions were fragmented and incohesive as observed in the weak association among prior knowledge, individual interest, situational interest, and application of learning strategies. In contrast, improved interrelations and interactions are evident for the competent stage learners.

(b) Regarding the second research question, "Based on the Model of Domain Learning, to what extent the learning process in physical education could be modeled in terms of the interrelations among these variables?" It can be concluded that the model of domain learning may be tenable for and applicable to physical education, at lease in a beginning softball unit. The model-fit indices suggest that the modeled interactions among knowledge, interests, and learning strategies for the two learning stages are theoretically sound and practically reasonable. Also, a strong supporting evidence for the model lies in the role of situational interest, a core variable whose functions have been articulated carefully by educational psychologists (Alexander et al., 1995; Hidi & Anderson, 1992). In this study, situational interest was found to contribute to the individual interest change for the acclimated learners implying a possibility that a situational-to-individual interest internalization process might be occurring as a result of the influence from the situationally interesting learning experiences.

Limitations

The above conclusions, however, should not be viewed as conclusive, given the limitations in the data due to limited research resources (such as time and personnel) typically associated with a field-based dissertation research. Three limitations should be remembered when the reader attempts to apply the conclusions in middle school physical education programs.

(a) Although the conclusions derive from the data considered having high internal validity and reliability, the external or ecological validity and reliability may be questionable because of the small sample size involved in the study. It is inappropriate to generalize the conclusions to any other school settings without considering the characteristics of the teachers and students in the research sites.

(b) The directional relationship identified in the path analysis should be interpreted with caution. The analysis was based on my understanding of the domain learning theory (Alexander, 2000; in press). The hypothesized path model being tested was based on my subjective reasoning. The study should be replicated to find if the identified paths can be reproduced.

(c) Although the study yielded useful information about tenability of the MDL theory, the theory was only tested within one topic knowledge area, softball. As discussed in Chapter V, some theorized interrelations were absent or unexpectedly weak in the data. The reader must interpret the results with great caution and take into account the uniqueness of softball. In other words, the findings are limited in a sense of scope. Generalizing the findings to other physical activities may be inappropriate.

Recommendations for Future Study

Influence of the Constructivist Theory

The results in this study are consistent with the constructivist learning theory. The positive effects of prior knowledge and individual interest on new knowledge and individual interest development provide convincible evidence that learning is a construction process of the learners (Solmon, 2003). Constructivist scholars argue that learning occurs best when the learners can actively integrate their prior knowledge with new knowledge to be learned. When teaching, a constructivist teacher will use learners' prior knowledge and skills and individual interest as assets and maximize the opportunity in class for all learners to use them to achieve learning objectives (Brooks & Brooks, 1993).

In this study, however, the learners at the competent stage did not seem to gain much new knowledge and skills. Future studies are needed to examine whether the phenomenon (learners at higher learning stages learn less) is due to the conventional teaching approach or is due to the "ceiling effect" of the knowledge associated with softball (not much left for them to learn). In addition, studies are needed to examine the extent to which the constructivist teaching can maintain continued knowledge growth and individual interest development for learners at all learning stages in various topic areas in physical education.

Effect of Seductive Details

Consistent with previous findings (Shen et al., 2003), situational interest was found having little impact on knowledge acquisition in this study. The finding seems to raise a question about the nature of situational interest. In learning, situational interest results from learners' recognition of appealing characteristics in learning tasks or context (Mitchell, 1993). Sources of the appealing characteristics include many that may or may not be conducive to learning. Schraw (1998) has defined those sources seemingly motivating but unrelated to the content to be learned as seductive details. Seductive details are a type of situational interest that consists of appealing characteristics unrelated to the goal of learning, and remotely related to the content. Research in reading and science education has revealed that seductive details have little impact on learning (Wade & Adams, 1990). In some cases, it may interfere with construction of new knowledge and skills. For example, Harp and Mayer (1997) found that adding an entertaining story about lightning and a colorful illustration to a scientifically factual text distracted learners cognitive functioning, and resulted in a poor knowledge acquisition and retention.

The disconnection between situational interest and knowledge gain found in this study may suggest the effects of seductive details at work. Certainly, investigating seductive details and its effect on learning in physical education is an interesting research question to pursue in the future.

APPENDIX A

Parental Permission Form

Dear Parent/Guardian:

Your child's school is participating in a research project conducted by Dr. Ang Chen and Mr. Bo Shen, in the Department of Kinesiology, University of Maryland, to determine students learning process in physical education. Your child will

a. take a knowledge test on the learning content (e.g., fitness, volleyball) (about 10 minutes);

b. complete a sport/physical activity survey (e.g., your child's interest in Archery, Soccer, and other physical activities) (about 5 minutes); and

c. rate a survey three times in three lessons to assess how interesting the physical education content is and how he/she is thinking in the physical education lessons. The sample items are as follows: "What we did in class was exciting"; "What we did in class was a new-fashioned activity for me to do"; "I try to remember the important things the teacher says about a skill when I am practicing" (about 15 minutes).

Your child's physical education classes will be assessed on

Physical engagement Your child's physical engagement will be measured using a motion sensor. Portable motion sensors are designed to be worn on a belt at the waist to provide an objective measure of physical activity engagement in physical education class.

Learning outcome. Your child's grade in physical education class will be collected to assess learning outcome.

The above information will be collected during regular physical education lessons that are taught by your child's physical education teacher. No additional time commitment is needed. There are no known physical and mental risks for your child to participate.

The above information will be used for the project only. Your child's identity (name, gender, grade, ethnicity, school, etc.) will be kept confidential. The documents with your child's identification will be sealed in a box and locked in the Curriculum and Instruction Laboratory in the Department of Kinesiology, University of Maryland. They will be destroyed five years after the study is completed.

Your child's participation is voluntary. Participating or not will have absolutely NO effect on his/her grade in physical education. You and your child are free to withdraw from the study at any time without penalty. Your child may refuse to answer any question that makes them uncomfortable. We thank you very much for your support and appreciate your timely reply. Please have this form brought to your child's physical education teacher tomorrow.

If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, Maryland, 20742; or email irb@deans.umd.edu; (telephone: 301-405-4212)

If you have any questions about this study, please call Mr. Bo Shen at (301) 405-2575; or write to him at Curriculum & Instruction Laboratory, Department of Kinesiology, University of Maryland, College Park, 20742; or e-mail him at bshen@umd.edu

I _____ permit my child (Print name) ____________________ to participate.
Parent / Guardian Name (Print): ________________________
Parent / Guardian Signature: ________________________Date: _____________

APPENDIX B

Learner Assent Form

I have my parents' or guardians' permission to participate in the research project to examine how learning is developed in my physical education class. This project will be conducted by Dr. Ang Chen and Mr. Bo Shen in the Department of Kinesiology, the University of Maryland, College Park, 20742.

I understand that the purpose of the project is to study middle school students' learning process in physical education. I will

a. take a knowledge test on the learning content (e.g., fitness, volleyball) (about 10 minutes);

b. complete a sport/physical activity survey (e.g., my interest in Archery, Soccer, and other physical activities) (about 5 minutes); and

c. rate a survey three times in three lessons to assess how interesting the physical education content is and how I am thinking in the physical education lessons. The sample items are as follows: "What we did in class was exciting"; "What we did in class was a new-fashioned activity for me to do"; "I try to remember the important things the teacher says about a skill when I am practicing" (about 15 minutes).

During the lessons, I need to wear a motion sensor around my waist to record my physical activity level. I understand that no known physical and mental risks will result from participating in the study.

My grade in physical education class will be collected to assess my learning outcome. I understand that all information collected in the study is confidential, and my name and my school name will not be identified at any time. The data I provide will be grouped with data my classmates provide for reporting and presentation.

I understand that I will not receive direct benefit from the study. But my participation will provide useful information for physical education curriculum improvement in the future. I understand I can ask questions about the study freely and can withdraw from the study any time if I wish to do so. I understand that my participation or withdrawal will not affect my grade in physical education.

Your Name (Print) ____ Date: _______

APPENDIX C

Softball Knowledge Exploration

You are invited to help us evaluate some characteristics in physical activities. This is **Not** a test or exam of any school course work. Your help is very much appreciated

1). Softball is a game that is
   a. played only by girls
   b. played by people of all ages
   c. played only by well skilled people

2). Infield players include
   a. only pitcher, catcher, 1st, 2nd, and 3rd base
   b. left, center, and right field
   c. catcher, pitcher, 1st base, 2nd base, 3rd base, and shortstop.

3). When a groundball is hit to 3rd base, which player should cover 2nd base,
   a. shortstop
   b. 3rd base
   c. 2nd base

4). When preparing to catch a ground ball, the fielder should place the glove
   a. at knee level
   b. at waist level
   c. on the ground

5). A right handed pitcher will step with the ______ foot as he/she release the ball toward home
   a. right
   b. left
   c. either

6). The batter has hit the ball to the third baseman. While running to 1st base, the batter should plan to
   a. stop quickly at 1st base
   b. cross over 1st base and stop after a few steps beyond the base
   c. touch 1st and turn toward 2nd base

7). As a pitched ball reaches home, the batter should
   a. step toward the pitcher with the front foot
   b. step toward the pitcher with the back foot
   c. pivot hips keeping feet in place

8). There are runners on 1^{st} and 2^{nd} base with no out, as the person who is playing 3^{rd} base, you field a ground ball near the base, your next action should be

a. throw the ball to the 1^{st} baseman
b. step on 3^{rd} base
c. tag the runner running from 2^{nd} base

9). In slow-pitch softball, a baserunner should leave the base as soon as

a. the pitcher releases the ball
b. the ball crosses home plate
c. the pitcher begins the wind-up

10). Which of the following should be considered an out?

a. base runner is tagged while standing on first
b. a foul pop-up is caught by the 3^{rd} base player
c. batter hits 3 consecutive foul ground balls

11). The batter has hit the ball past the right fielder, a base runner who was on 2^{nd} base should

a. stop at 3^{rd} base
b. stay at 2^{nd} base
c. run to 3^{rd} base and continue to home

12). There are two outs with a runner on 3^{rd} base when the batter hits a line drive which is caught by the short stop. The base runner from 3^{rd} base should

a. run immediately when the ball is hit
b. wait to see who catches the ball before running
c. tag up and run after the ball is caught

13). When you position yourself to catch a fly ball, the fingers of your glove should be

a. pointed upward
b. pointed to the ground
c. pointed away from your throwing hand

14). In slow-pitch softball, when positioned in the batter's box, your toes should be

a. pointed toward the pitcher
b. pointed toward home plate
c. pointed toward the catcher

APPENDIX D

Evaluation of Softball Knowledge Test

Dear Teachers,

You are invited to evaluate a softball knowledge test for the sixth grade learners. Would you read the test and rate each item of the test in terms of its content representativeness (1= not appropriate at all, 6=appropriate very much) and difficulty level (1 = not appropriate at all, 6 = appropriate very much) for the 6th grade learners? Your help would be highly appreciated. Thank you very much.

Item No.	Content Representativeness						Difficulty Level					
1	1	2	3	4	5	6	1	2	3	4	5	6
2	1	2	3	4	5	6	1	2	3	4	5	6
3	1	2	3	4	5	6	1	2	3	4	5	6
4	1	2	3	4	5	6	1	2	3	4	5	6
5	1	2	3	4	5	6	1	2	3	4	5	6
6	1	2	3	4	5	6	1	2	3	4	5	6
7	1	2	3	4	5	6	1	2	3	4	5	6
8	1	2	3	4	5	6	1	2	3	4	5	6
9	1	2	3	4	5	6	1	2	3	4	5	6
10	1	2	3	4	5	6	1	2	3	4	5	6
11	1	2	3	4	5	6	1	2	3	4	5	6
12	1	2	3	4	5	6	1	2	3	4	5	6
13	1	2	3	4	5	6	1	2	3	4	5	6
14	1	2	3	4	5	6	1	2	3	4	5	6

APPENDIX E

Teacher Subjective Rating Form

Dear Teacher,

You are invited to rate each learner’s overall softball skill level in your class. In the following form, please check “1” (the lowest skill level in softball) to “7” (the highest skill level in softball) based on your perception. Thank you very much for your help and support.

Student Name	1 (lowest)	2	3	4	5	6	7 (highest)
A							
B							
C							
D							
E							
F							
G							
H							
I							
J							
K							
L							
M							
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APPENDIX F

Cognitive Process Questionnaire in Physical Education

Please read each statement carefully and **rate each on how well the statement describes what you did in TODAY's lesson**.

1. I found that new games and skills in softball were fun once you gave them a try.

   (Not like me at all) 1 2 3 4 5 (Very much like me)

2. If I was not good in practice, I kept trying hard what I was doing wrong.

   (Not like me at all) 1 2 3 4 5 (Very much like me)

3. When the teacher explained a skill, I practiced the skill in my mind.

   (Not like me at all) 1 2 3 4 5 (Very much like me)

4. I liked to learn new and different games and skills in softball.

   (Not like me at all) 1 2 3 4 5 (Very much like me)

5. When I listened and watched the teacher explaining a skill, I thought "oh, I can do that".

   (Not like me at all) 1 2 3 4 5 (Very much like me)

6. I talked to myself during practice to help me do better.

   (Not like me at all) 1 2 3 4 5 (Very much like me)

7. During class, I talked to my friends when I should be practicing.

   (Not like me at all) 1 2 3 4 5 (Very much like me)

8. When I was practicing skills in softball, I tried to get better each time.

   (Not like me at all) 1 2 3 4 5 (Very much like me)

9. It is hard for me to correct the things the teacher says as I am doing wrong

   (Not like me at all) 1 2 3 4 5 (Very much like me)

10. During softball class I give up when the skill is hard

    (Not like me at all) 1 2 3 4 5 (Very much like me)

11. I would rather stay in the classroom than go to PE class

(Not like me at all) 1 2 3 4 5 (Very much like me)

12. I feel like I can't do well no matter how hard I try

(Not like me at all) 1 2 3 4 5 (Very much like me)

13. I only like to do games and activities that I am good at

(Not like me at all) 1 2 3 4 5 (Very much like me)

14. I avoid practicing any way I can

(Not like me at all) 1 2 3 4 5 (Very much like me)

15. When I cannot do a skill in softball, it is because it is too hard

(Not like me at all) 1 2 3 4 5 (Very much like me)

16. When the teacher tells me what I am doing wrong I do not understand it

(Not like me at all) 1 2 3 4 5 (Very much like me)

17. I tried to remember the important things the teacher said about a skill when I was practicing

(Not like me at all) 1 2 3 4 5 (Very much like me)

18. I only tried hard when the teacher was looking at me

(Not like me at all) 1 2 3 4 5 (Very much like me)

19. I missed important things my teacher said because I was not paying attention.

(Not like me at all) 1 2 3 4 5 (Very much like me)

20. When I practice, I tried to think only about the skill I was working on.

(Not like me at all) 1 2 3 4 5 (Very much like me)

21. When I practiced a skill in softball, I tried to figured it out

(Not like me at all) 1 2 3 4 5 (Very much like me)

22. I will try to practice skills I learned in softball at home.

(Not like me at all) 1 2 3 4 5 (Very much like me)

23. When I made mistakes during practice, I said to myself "I can do better".

(Not like me at all) 1 2 3 4 5 (Very much like me)

24. When my teacher was teaching, I found myself thinking about other things.

(Not like me at all) 1 2 3 4 5 (Very much like me)

25. I worked hard during practice in softball class.

(Not like me at all) 1 2 3 4 5 (Very much like me)

26. When I was practicing a skill, I tried to think how it is like something I already know

(Not like me at all) 1 2 3 4 5 (Very much like me)

27. If I didn't understand how or what to do, I asked the teacher for help.

(Not like me at all) 1 2 3 4 5 (Very much like me)

28. I felt like I can do well if I tried hard.

(Not like me at all) 1 2 3 4 5 (Very much like me)

29. I tried to go over right way to perform the skill I learned in softball in my mind.

(Not like me at all) 1 2 3 4 5 (Very much like me)

30. I listened closely when the teacher explained a skill during my softball class.

(Not like me at all) 1 2 3 4 5 (Very much like me)

31. When I can do a new skill in softball, I think it is because I am lucky

(Not like me at all) 1 2 3 4 5 (Very much like me)

32. I feel bad when my skills are not as good as my classmates

(Not like me at all) 1 2 3 4 5 (Very much like me)

APPENDIX G

Activity Survey Form

We are doing a short survey about middle school students' interests in physical education so we can design a more exciting program for you in the future. You answer to the survey will not affect your grade. Please carefully read and follow the instructions below. **You must answer the survey independently**.

Now think about all the things you do at school and at home, with your teachers, parents, classmates, friends, or by yourself; then identify one thing that you are most interested in doing. Write it down on the line below. If you need more space, keep writing in the space below the sentence.
One thing that I am most interested in doing is______________________________________.
Now, copy the answer in the first line below and circle "7" to show that it is the most interesting thing for you to do. Then, compare other activities [listed from 2 – 16] with this one and circle the number to tell us how interested you are in each of those activities.

Activity	Not Interested	Least Interested	Less Interested	Not Sure	Somewhat Interested	Interested	Most Interested
1.	1	2	3	4	5	6	7
2. Volleyball	1	2	3	4	5	6	7
3. Archery	1	2	3	4	5	6	7
4. Soccer/Speedball	1	2	3	4	5	6	7
5. Cross Country	1	2	3	4	5	6	7
6. Tumbling/balancing	1	2	3	4	5	6	7
7. Juggling	1	2	3	4	5	6	7
8. Floor/Field Hockey	1	2	3	4	5	6	7
9. Basketball	1	2	3	4	5	6	7
10. Dance	1	2	3	4	5	6	7
11. Fitness Lab	1	2	3	4	5	6	7
12. Table Tennis	1	2	3	4	5	6	7
13. Lacrosse	1	2	3	4	5	6	7
14. Badminton	1	2	3	4	5	6	7
15. Team Handball	1	2	3	4	5	6	7
16. Track and Field	1	2	3	4	5	6	7
17. Flag Football	1	2	3	4	5	6	7
18. Softball	1	2	3	4	5	6	7
19. Bowling	1	2	3	4	5	6	7

APPENDIX H

Situational Interest Scale (Middle School)

You are invited to help us evaluate some characteristics in physical activities. This is **NOT** a test or exam of any school course work. Your answer will **NOT** affect your grade. Your help is very much appreciated.

Please read each of the 24 statements carefully and **rate each on how well the statement describes what you felt about what you did in TODAY's lesson**. Please rely on your first impression when making your choice and you must work **independently**.

1. What we did was exciting.

(Disagree) 1 2 3 4 5 (Agree)

2. What we did was complex.

(Disagree) 1 2 3 4 5 (Agree)

3. What we did was complicated.

(Disagree) 1 2 3 4 5 (Agree)

4. What we did demanded my high attention.

(Disagree) 1 2 3 4 5 (Agree)

5. What we did looked fun to me.

(Disagree) 1 2 3 4 5 (Agree)

6. I was very attentive all the time.

(Disagree) 1 2 3 4 5 (Agree)

7. I like to find out more about how to do what we did today.

(Disagree) 1 2 3 4 5 (Agree)

8. What we did was an exceptional activity.

(Disagree) 1 2 3 4 5 (Agree)

9. I wanted to analyze and have a better handle on what we did today.

(Disagree) 1 2 3 4 5 (Agree)

10. What we did was appealing to me.

(Disagree) 1 2 3 4 5 (Agree)

11. It was fun for me to try what we did.

(Disagree) 1 2 3 4 5 (Agree)

12. What we did was a new-fashioned activity for me to do.

(Disagree) 1 2 3 4 5 (Agree)

13. What we did was enjoyable for me.

(Disagree) 1 2 3 4 5 (Agree)

14. There were many tricks in what we did today.

(Disagree) 1 2 3 4 5 (Agree)

15. What we did today was fresh.

(Disagree) 1 2 3 4 5 (Agree)

16. What we did today was new to me.

(Disagree) 1 2 3 4 5 (Agree)

17. What we did today demanded my focus.

(Disagree) 1 2 3 4 5 (Agree)

18. What we did demanded my concentration.

(Disagree) 1 2 3 4 5 (Agree)

19. What we did was interesting for me to do.

(Disagree) 1 2 3 4 5 (Agree)

20. What we did today was demanding.

(Disagree) 1 2 3 4 5 (Agree)

21. What we did attracted me to participate.

(Disagree) 1 2 3 4 5 (Agree)

22. What we did was interesting.

(Disagree) 1 2 3 4 5 (Agree)

23. What we did was hard for me to do.

(Disagree) 1 2 3 4 5 (Agree)

24. I like to know more details of how to do it.

(Disagree) 1 2 3 4 5 (Agree)

APPENDIX I

Descriptive Statistics for Learning Variables by School

Variable	Total M/SD	Boys M/SD	Girls M/SD
	School A		
Pre-knowledge Test	9.51/2.70	10.26/2.58	8.83/2.67
Pre-Skill Evaluation	4.12/1.68	4.74/1.51	3.57/1.65
Pre-Individual Interest	5.16/1.36	5.37/1.39	4.97/1.33
Steps	1444/361	1546/324	1351/373
Situational Interest	15.83/3.83	14.15/4.05	17.35/2.95
Learning Strategy	16.60/3.01	15.25/3.00	17.80/2.70
Post-Knowledge Test	11.27/2.03	11.30/2.08	11.23/2.01
Post-Individual Interest	5.58/1.05	5.36/1.08	5.77/1.00
	School B		
Pre-knowledge Test	8.53/2.26	8.54/2.24	8.63/2.30
Pre-Skill Evaluation	3.92/1.17	4.16/1.26	3.73/1.07
Pre-Individual Interest	3.84/2.07	3.54/2.00	4.14/2.17
Steps	2404/712	2663/765	2131/562
Situational Interest	14.86/3.20	14.26/3.13	15.40/3.27
Learning Strategy	15.95/4.00	15.64/4.28	16.23/3.81
Post-Knowledge Test	9.52/2.26	9.61/2.61	9.52/1.93
Post-Individual Interest	4.83/1.64	4.46/1.69	5.11/1.52
	School C		
Pre-knowledge Test	8.73/2.68	9.57/2.59	7.81/2.52
Pre-Skill Evaluation	3.32/1.46	3.78/1.28	2.81/1.50
Pre-Individual Interest	3.98/2.02	4.39/1.90	3.52/2.09
Steps	1602/456	1745/510	1445/334
Situational Interest	14.39/3.86	14.60/3.44	14.17/4.35
Learning Strategy	14.82/5.37	15.19/5.56	14.43/5.25
Post-Knowledge Test	10.44/2.64	11.34/2.51	9.45/2.47
Post-Individual Interest	4.66/1.84	4.96/1.46	4.33/2.18

APPENDIX J

Raw Data Set

ID	School	Sex	Skill	PI	PK	Steps	SI	LS	POI	POK
1	1	2	3	5	9	1394	13	16	6	12
2	1	1	2	5	8	1900	16	24	5	7
3	1	2	1	4	10	1658	18	17	6	9
4	1	1	4	7	11	1983	12	24	7	12
5	1	1	3	5	8	1503	4	5	5	8
6	1	2	6	5	11	1657	15	15	6	12
7	1	2	2	1	6	1694	20	5	5	9
8	1	1	3	6	9	968	18	16	6	10
9	1	2	3	6	8	751	13	13	6	11
10	1	2	1	4	2	1454	19	12	4	7
11	1	2	4	4	6	1742	19	15	5	7
12	1	1	4	4	9	1052	19	15	5	13
13	1	2	6	5	8	1399	13	16	6	13
14	1	1	7	7	13	1862	18	18	6	12
15	1	2	3	5	8	943	16	15	5	10
16	1	2	1	5	11	1180	20	20	6	12
17	1	2	3	4	12	982	13	16	3	14
18	1	2	4	4	11	476	16	21	5	14
19	1	1	7	7	13	1006	20	20	7	13
20	1	2	4	4	7	1027	18	20	6	13
21	1	1	4	6	10	1840	14	11	7	13
22	1	2	3	6	9	1158	19	16	7	11
23	1	2	3	2	7	1373	19	23	6	10
24	1	2	3	6	4	668	20	19	6	13
25	1	2	7	6	13	1576	18	22	6	10
26	1	1	5	3	11	1537	12	15	5	12
27	1	2	4	6	10	1118	20	22	7	10
28	1	2	5	4	9	1338	20	17	5	11
29	1	1	5	7	12	1223	11	15	6	14
30	1	1	6	6	10	1640	16	22	6	9
31	1	2	5	5	9	1527	20	15	7	11
32	1	1	6	5	8	1405	14	11	4	12
33	1	1	5	6	14	1819	12	16	6	10
34	1	1	7	7	13	2172	17	12	6	13
35	1	1	7	7	13	1461	18	19	7	14
36	1	2	3	6	11	1431	20	21	5	13
37	1	1	7	6	12	1062	17	18	5	13
38	1	2	4	7	12	1240	20	24	7	14
39	1	2	6	7	13	1359	18	24	7	14
40	1	1	3	1	7	1744	17	15	4	10

41	1	2	3	5	6	1994	8	15	7	11
42	1	1	4	6	14	1384	12	8	5	13
43	1	1	4	5	7	1999	7	10	3	10
44	1	1	6	5	10	1292	13	10	5	13
45	1	1	4	4	11	1572	9	12	6	13
46	1	1	3	5	8	1267	12	14	4	10
47	1	2	6	7	11	1170	18	24	7	13
48	1	1	4	5	11	1753	13	13	5	10
49	1	2	2	5	8	1209	20	25	7	12
50	1	2	1	6	6	1948	17	17	5	8
51	1	1	4	4	10	1534	19	18	4	8
52	1	2	4	5	9	1859	14	13	5	13
53	1	2	2	5	12	1371	18	19	5	10
54	1	1	6	6	13	1687	18	13	6	14
55	1	1	5	5	3	1674	9	18	4	8
56	1	2	5	5	7	1853	18	17	5	10
57	1	1	3	5	9	1404	16	21	6	11
58	2	2	3	2	7	3130	15	18	5	9
59	2	1	5	7	13	3037	11	9	7	14
60	2	2	5	7	12	1849	17	14	7	12
61	2	1	2	2	7	3339	12	18	6	10
62	2	2	3	1	8	3051	18	21	4	7
63	2	1	3	2	7	2988	13	14	3	10
64	2	1	5	4	10	3297	9	13	6	13
65	2	2	4	5	4	1584	15	13	5	10
66	2	1	5	5	7	2082	14	11	5	12
67	2	1	6	7	14	3336	14	24	7	14
68	2	2	4	5	7	2331	20	24	6	8
69	2	2	4	5	6	2237	15	14	7	11
70	2	1	3	3	9	2607	17	19	4	9
71	2	1	5	6	6	2425	16	17	6	6
72	2	2	2	6	7	1033	15	11	5	8
73	2	1	3	5	10	2831	16	21	5	8
74	2	2	2	1	4	2141	12	16	4	8
75	2	2	3	6	11	2969	20	24	7	11
76	2	1	6	5	12	3361	15	12	5	12
77	2	1	2	6	9	3794	14	15	7	9
78	2	2	4	4	9	2257	6	16	5	11
79	2	2	3	4	7	2346	20	16	6	9
80	2	1	4	5	9	3275	17	15	6	10
81	2	1	3	5	9	2493	20	20	5	10
82	2	1	4	5	12	3282	7	21	5	12
83	2	2	2	5	9	2425	16	21	5	9
84	2	2	5	3	10	1608	14	16	5	11
85	2	2	5	1	7	2970	17	15	6	12
86	2	2	3	3	9	2340	11	13	2	8
87	2	1	5	3	6	3545	15	13	3	10

88	2	1	5	4	7	3729	15	13	5	9
89	2	1	5	1	10	2860	16	9	5	12
90	2	2	3	2	9	2442	17	16	4	10
91	2	1	4	1	9	3034	15	14	2	12
92	2	2	4	1	11	2656	15	13	2	11
93	2	2	5	4	9	1711	9	11	4	9
94	2	2	4	1	8	1997	15	14	2	11
95	2	2	3	4	5	2958	17	19	6	8
96	2	1	5	1	7	3225	8	15	2	5
97	2	1	6	7	11	4165	16	18	7	8
98	2	2	6	7	10	2603	20	19	7	13
99	2	1	3	3	8	2340	15	14	7	8
100	2	2	4	6	11	826	12	14	6	11
101	2	2	4	7	11	1988	15	20	7	8
102	2	2	4	6	10	2357	12	15	4	7
103	2	2	3	7	13	2726	15	16	7	11
104	2	1	3	5	6	2809	13	18	5	7
105	2	1	2	1	8	1340	15	13	2	10
106	2	2	3	5	10	2610	20	21	6	9
107	2	1	4	4	7	2201	20	10	5	9
108	2	2	4	3	7	2394	16	18	5	9
109	2	2	4	6	11	2056	15	19	7	10
110	2	1	5	3	11	3180	16	21	5	12
111	2	2	4	6	9	2788	15	13	6	11
112	2	1	3	4	10	3371	18	23	7	13
113	2	2	5	6	7	1472	15	18	7	8
114	2	2	5	1	6	1968	18	15	5	7
115	2	1	3	1	8	1569	12	16	1	5
116	2	2	5	6	12	1463	19	20	5	12
117	2	1	5	4	8	1495	15	20	4	10
118	2	1	5	1	7	2631	17	18	2	10
119	2	1	4	5	8	1080	15	8	4	13
120	2	2	3	5	7	1505	14	13	5	9
121	2	1	2	1	7	2408	15	18	5	11
122	2	1	2	1	6	1642	10	13	4	6
123	2	1	5	2	10	2267	15	13	2	7
124	2	1	5	6	11	1841	15	18	5	10
125	2	1	5	4	6	2013	15	18	5	9
126	2	2	3	5	6	1493	14	17	3	5
127	2	2	5	2	6	1604	20	14	3	5
128	2	2	4	7	13	2425	15	14	7	11
129	2	1	5	1	5	1765	6	9	2	5
130	2	1	6	1	9	2480	15	15	3	8
131	2	1	4	3	5	1745	17	23	3	5
132	2	2	1	1	9	1816	11	9	4	12
133	2	2	3	1	8	1681	20	25	4	9
134	3	2	3	1	5	1765	8	10	4	9

135	3	2	4	3	8	1636	14	13	4	10
136	3	1	5	4	10	2598	20	17	5	10
137	3	2	5	7	13	1433	20	25	7	12
138	3	1	5	7	14	1684	17	22	4	12
139	3	1	3	2	7	2784	18	16	7	8
140	3	1	3	4	9	1593	10	5	4	10
141	3	1	3	5	11	1770	20	20	4	11
142	3	2	3	6	10	1615	18	18	7	14
143	3	2	3	3	8	1638	11	17	2	4
144	3	1	5	6	11	1209	14	15	7	13
145	3	2	4	4	11	1173	18	13	6	11
146	3	2	2	2	10	810	8	15	4	13
147	3	1	1	4	5	2083	15	16	4	10
148	3	1	2	2	9	1149	13	6	1	7
149	3	2	5	2	7	767	10	13	1	8
150	3	2	1	1	7	1594	14	10	1	7
151	3	2	1	1	5	1730	4	5	7	11
152	3	1	5	4	12	1626	13	11	3	14
153	3	2	4	6	8	1827	19	22	5	7
154	3	2	1	7	6	1192	16	25	6	9
155	3	1	4	1	5	1288	16	17	4	13
156	3	1	5	5	12	1738	13	17	4	15
157	3	2	3	2	6	1231	12	12	1	8
158	3	2	1	3	6	1647	14	15	2	7
159	3	1	5	5	13	1436	15	17	5	13
160	3	2	3	1	8	1673	13	12	1	8
161	3	1	3	6	13	1501	16	15	5	13
162	3	1	5	5	10	3000	14	15	7	15
163	3	1	3	1	5	2128	15	14	5	14
164	3	1	4	2	8	1672	15	6	4	13
165	3	1	3	2	8	1652	15	16	6	9
166	3	2	3	5	9	1394	13	16	6	12
167	3	1	2	5	8	1900	16	24	5	7
168	3	2	1	4	10	1658	18	17	6	9
169	3	1	4	7	11	1984	12	24	7	12
170	3	1	3	5	8	1503	4	5	5	8
171	3	2	6	5	11	1657	15	15	6	12
172	3	2	2	1	6	1694	20	5	5	9
173	3	1	3	6	9	968	18	16	6	10
174	3	2	3	6	8	751	13	13	6	11
175	3	2	1	4	2	1454	19	12	4	7
176	3	1	5	7	12	1223	11	15	6	14
177	3	1	6	6	10	1640	16	22	6	9

Note: PI represents pre-individual interest. PK represents pre-knowledge. SI represents situation interest. LS represents learning strategies. POI represents post-individual interest. POK represents post knowledge.

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