YOUNG CHILDREN'S CONSTRUCTION OF
PHYSICAL KNOWLEDGE ON SWINGS IN
THE OUTDOOR PLAY ENVIRONMENT

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Jill Englebright Fox, B.S., M.Ed.

Denton, Texas

December, 1993
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This investigation examined the development of young children's behaviors on swings in the outdoor play environment and their emerging understanding of the physics principles associated with those behaviors. The children’s language interactions were also examined in an effort to determine the relationship between language and cognitive development in their construction of physical knowledge. The procedures involved observing the children’s behaviors and collecting samples of their spontaneous language interactions during their swinging activities. Informal interviews were also conducted with individual and groups of children.

The findings indicate that young children’s swinging behaviors develop in eight hierarchical stages. As these behaviors develop, children experiment with the physics principles of balance, gravity, force, resistance, and resonance. Children’s swinging behaviors develop in a social context. Many early behaviors are acquired through observing and modeling other children. Language provides
the medium for more-experienced peers to assist novice swingers through encouragement and direct instruction.

The stage development of swinging behaviors is compared to Cratty's Theory of Perceptual-Motor Development and Harrow's Taxonomy of the Psychomotor Domain. Children's cognitive processing and language interactions are discussed in the context of Piagetian and Vygotskian theories of development. Implications for instruction and suggestions for further research are discussed.
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CHAPTER ONE

INTRODUCTION

Background of the Question

Constructivism is a theory of learning based upon Piaget's belief that knowledge is constructed by an individual during dynamic interactions with the environment. Elkind (1988) stated that constructivism is unique because it combines empirical and nativist traditions "with a greater emphasis upon materials and activities which encourage the child's attainment of the basic categories of knowledge" (p. 10). These basic categories of knowledge are delineated by the environmental interactions from which they emerge. Three types of knowledge are addressed in Piaget's theory. The first, logico-mathematical knowledge, is defined by DeVries and Kohlberg (1987) as that which is constructed through "actions on objects that introduce characteristics the objects do not have into the individual's ideas about those objects" (p. 21). The second, social knowledge, includes arbitrary truths and rules agreed upon by society or other coordinated points of view. The third, physical-knowledge, as defined by Kamii and DeVries (1978), is knowledge of objects that are in the environment and are observable in external reality.
Physical-knowledge is the first and most basic type of knowledge to emerge as children begin to explore physical properties of the environment. Kamii, Lewis, and Jones (1991) observed that before children are able to construct logico-mathematical knowledge, "all they can get from the experience is physical, empirical knowledge" (p. 22). The development of logico-mathematical knowledge is in many ways dependent on children's physical-knowledge. Kamii and DeVries (1978) asserted that "physical manipulation is indispensable for mental action to become possible" (pp. 19-20). Physical experiences help structure the logico-mathematical framework. A strong framework equips children to more accurately gather and use facts from their environment. This ability may be particularly beneficial to children in constructing their understanding of science principles. Kamii and DeVries (1978) stated that phenomena typically taught under the curriculum heading of "science" belong to the realm of physical-knowledge. These phenomena include principles from the field of physics.

Children's construction of physical-knowledge during play has not been systematically studied or evaluated. An investigation on the effects of the outdoor play environment on physical-knowledge construction could provide information regarding children's general cognitive development, their construction of physics principles, and the relationship of
the outdoor play environment and equipment to cognitive development.

Research Statement

This investigation examined three-, four-, five-, and six-year-old children's emerging understanding of the physics principles related to pendulum phenomenon.

Purposes of the Study

The purposes of this study were:

1. To compare and contrast the children's observed behaviors with a Guttman scale that provided a hierarchical measure organizing children's swinging behaviors into stages.

2. To identify young children's behaviors during play on swings that may be consistently observed as evidence of their construction of the physics principles related to pendulums.

3. To identify elements in young children's language and interactions which demonstrate their understanding of the physics principles related to pendulums.

Significance of the Study

During the first eight years of life, children's construction of knowledge is achieved primarily through physical activities and interactions with the environment. Physical knowledge is significant because it determines children's understanding of external reality. Physical knowledge is also necessary for the construction of logico-mathematical knowledge. Kamii and DeVries (1978) asserted
that "physical-knowledge activities are especially conducive not only to the development of children's knowledge of objects in the physical world, but also to the development of their intelligence, or knowledge, in a general sense" (p. 13). DeVries and Kohlberg (1987) further explained that because action on objects in the environment always has both physical and logico-mathematical aspects, "the general structure of thought becomes elaborated in the course of constructing specific physical-knowledge" (p. 20). Finally, physical-knowledge activities provide children with opportunities to appropriately explore principles typically included in the curriculum area of science. Simon and Simon (1978) suggested that the principles young children typically experiment with provide the basis for adult learning in areas such as elementary physics, algebra, reading, and arithmetic. Because many types of physical-knowledge activities are believed to be universal to all children (DeVries, 1988), an understanding of children's construction of physical-knowledge may contribute to the general knowledge and understanding of mental development. A study that investigates children's construction of physical-knowledge during their outdoor play could provide information regarding the time allocations of outdoor play in daily schedules, the outdoor play equipment most appropriate for facilitating physical-knowledge construction, and the emerging stages of understanding of physics principles.
Definition of Terms

The following terms are defined for this study:

**Constructivism** is a viewpoint that rests on the Piagetian assumption that children mentally construct knowledge through reflection on their experiences (Nourot, 1993).

**Physical-knowledge** is knowledge of objects which are "out there" and observable in external reality. The source of physical-knowledge is primarily in the way the objects provide the subject with opportunities for observation (Kamii & DeVries, 1978).

**Changes in objects** are one of two types of physical-knowledge activities in which observation is primary and the child’s action is secondary (Kamii & DeVries, 1978).

**Movement in objects** is one of two types of physical-knowledge activities in which the child’s action is primary and the role of observation is secondary (Kamii & DeVries, 1978).

**Pendulum** is "a body suspended from a fixed point so that it can swing back and forth under the influence of gravity" (The New Encyclopaedia Britannica (Vol. 9), 1991, p. 257).

**Bob** is the object at the end of a pendulum.

**Frequency** is the number of vibrations per second completed by a pendulum (Rawlins, personal communication, May 20, 1993).
**Period** is the amount of time required for a pendulum to complete one full vibration (Rawlins, personal communication, May 20, 1993).

**Amplitude** is the maximum displacement a pendulum achieves during a period (Rawlins, personal communication, May 20, 1993).

**Equilibrium** is the position of a pendulum when it is not affected by gravity or displacement (Rawlins, personal communication, May 20, 1993).

**Outdoor play environment** is the outside area in an early childhood education setting that is designated and planned for children’s recreational use.

**Outdoor play materials** are "portable, creative materials" (Frost, 1992, p. 118) within the outdoor play environment. Outdoor play materials may also be referred to as **loose parts** in some literature.

**Outdoor play equipment** is permanent equipment on the outdoor play environment, such as fencing, storage facilities, artificial structures for shade, water lines, water fountains, fixed play structures, and hard-surfaced areas such as wheeled vehicle paths and areas for organized games (Frost, 1992).

**Outdoor play period** is the time during the daily schedule of the child care center that is allotted for the children’s use of the outdoor play environment.

**Corporate Child Care Centers** are centers that are part of large child care chains "operated by a parent company..."
that develops a prototype and sets up a number of centers throughout a state or region, or across the nation and into Canada" (Sciarra & Dorsey, 1990, p. 21).

Teachers in this study are those adults who have immediate responsibility for the children assigned to an age-specific group within the child care center.

Director in this study refers to the individual ultimately responsible for administrative, programmatic, enrollment, and personnel decisions within the child care center.

Limitations

The design of this research focused on an investigation of children's play activities in the outdoor play environments of two corporate child care centers. The subjects in this research were not randomly selected but consisted of intact groups of children already enrolled in the three-, four-, five-, and six-year-old classes at the centers. The length of time that the subjects had been enrolled at the centers was not controlled for nor were their previous experiences in child care centers or on swings in outdoor play environments. The researcher's knowledge of the subjects and of the program's curricular activities was limited to direct observations in the outdoor play environments.
Assumptions

This study was based on the following assumptions:

1. The outdoor play sessions observed were typical of those engaged in by children at the two centers involved.

2. Young children's construction of physical knowledge occurs in developmental stages. Each stage in this process incorporates and builds upon the elements of the previous stages.

3. Individual differences in maturation, ability, background experiences, and environmental influences may influence the stage development of young children’s construction of physical knowledge.

Summary

This study was designed to investigate young children's construction of physical knowledge during their outdoor play activities on swings. Specifically, this study looked at the stage development of young children's understanding of the physics principles in pendulum phenomena. The procedures involved the observation of the children during play on swings in an outdoor environment during a six-week period.

A review of the pertinent research on play and cognitive development, physical knowledge, and related physics principles is presented in Chapter 2. Chapter 3 describes the methodology and procedures of the study.
CHAPTER 2

REVIEW OF RELATED LITERATURE

The purpose of this investigation was to study young children’s construction of physics principles during their activities on the swings in the outdoor play environment. Professional literature on play and cognitive development, research on physical-knowledge, and a description of physics principles are reviewed in this chapter.

Play in Early Childhood Education

Developmentally appropriate practice is a key issue in early childhood education. Bredekamp (1987) stated that developmentally appropriate programs are those in which program practices are based upon principles of child development. This idea suggests that learning activities and environments should focus on the means through which young children learn best: exploration, discovery, and play. Play is an essential aspect of developmentally appropriate programs for young children.

Play and Development

Fromberg (1990) described play as the “ultimate integrator of human experience” (p. 223). This description emphasizes two points. First, play is a human experience, common to adults as well as children. Sutton-Smith (1986) suggested that because most individuals have had play
experiences, they must have "some idea of its spirit" (p. 3). Second, play is an integrated activity. Garvey (1977) held that play occurs most frequently during childhood, a period of "dramatically expanding knowledge of self, the physical and social world, and systems of communication; thus we might expect that play is intricately related to these areas of growth" (p. 1). While engaged in play, young children draw upon a vast repertoire of abilities, understandings, and actions from their experiences in all developmental domains.

Definitions of Play

Play is a universal experience, one that is common to all ages, ethnicities, genders, and socioeconomic groups. As Sutton-Smith (1986) stated, "very few of us have not had some experience of ... play" (p. 3). Because of its universality, the meaning and nature of play have been topics of research and discussion in many fields. Various definitions and descriptions of play have been put forward. Garvey (1977) listed the following characteristics of play: (1) play is positively valued by the player; (2) play is intrinsically motivated; (3) play is freely chosen by the player; (4) play actively engages the player; and (5) "play has certain systematic relations to what is not play" (p. 5). This definition clearly distinguishes play from work or other adult-structured activities for young children. No matter how enjoyable the activities may be, a lack of free choice or intrinsic motivation changes the nature of the
activity for the participants. Csikszentmihalyi (1981) described play as "a subset of life..., an arrangement in which one can practice behavior without dreading its consequences" (p. 14). Fromberg (1987) described young children's play as symbolic, meaningful, active, pleasurable, voluntary and intrinsically motivated, rule-governed, and episodic.

Play is a multi-faceted activity. The emphasis on each facet differs from field to field. Common to almost all descriptions and definitions of play, however, is its value and worth in human development. Recognizing the importance of play in the lives of young children, the National Association for the Education of Young Children (Bredekamp, 1987) recommended that approaches to early childhood education be concrete and play-oriented, stating that this is the means through which "children learn most effectively" (p. 1). Levy (1978) described play as an active form of learning that brings together the mind, the spirit, and the body. This integration of domains is key to the cognitive development of young children. Rogers and Sawyers (1988) suggested that until at least the age of nine, children's cognitive structures function best in this unified mode.

Play and Cognitive Development

The relationship between play and cognitive development is well-established. Smilansky's (1968) study of disadvantaged preschool children established categories of cognitive play and identified sociodramatic play as the most
complex and most beneficial form of play for cognitive development in young children. Reifel and Yeatman (1991) audiotaped four- and five-year-olds as they played with blocks. Analysis of the data indicated that other children and objects in the play environment evoked new learning for children to experience and extend during play. Nicolopoulou (1991) also studied cognitive development during block play. Analysis of his data collected on three-, four-, and five-year-old children indicated the level of intense involvement they achieve during block play. As children build upon their initial themes and extend them to new play situations, the resulting elaborations are used to organize objects in the play environment "more ambitiously and in different ways" (p. 190). In informal studies, Bruner (1983) found that given the chance to play with materials, young children became much more efficient in using those materials in problem-solving situations.

Theories of cognitive development attempt to explain and describe the nature and changes of cognitive functioning as children mature. Piaget's theory provides a comprehensive view of cognitive development and of the environmental factors that affect children's cognitive functioning. Piaget asserted that play is very closely tied to cognitive development.

Piaget's Theory

Piagetian theory holds that play in and of itself does not necessarily result in the formation of new cognitive
structures. Piaget (1962) describes play as an expressive form of cognitive development. "Play is essentially assimilation" (p. 87). Fromberg (1990) agreed, stating that in play children practice what they already know. Play is seen as "a process reflective of emerging symbolic development, but contributing little to it" (Johnsen & Christie, 1986, p. 51). Piaget's (1962) definition of play emphasized children's exercise of schemes they have already acquired. This exercise is just for the pleasure of doing so. Rogers and Sawyers (1988) supported Piaget's theory when they stated that "play provides the opportunity to practice new skills and functions. As they master these activities, children can integrate or reorganize them into other task-oriented sequences" (pp. 57-58).

Construction of knowledge

Piagetian theory views the development of knowledge and the development of intelligence as being the same (DeVries, 1973). Thomas (1992) described Piaget's definition of knowledge as a process. "To know something is to act on that thing, with the action being either physical or mental or both" (p. 276). Wadsworth (1984) suggested that "possibly the most important and most revolutionary implication of Piaget's theory is that children construct knowledge from their actions on the environment" (p. 186). Children construct capabilities in other developmental domains as well. According to DeVries and Kohlberg (1987), children construct not only knowledge, but also intelligence
and morality. The originality of these constructions signifies the lack of influence adult modeling or interaction provides. In this construction process, Forman and Kuschner (1983) stated that "the environment is a hint and the child is an active constructor of useful hypotheses about what is" (p. 4).

Although Piaget's research focused primarily on cognitive development, language plays a key role in his theory. Piaget's (1973) study of cognitive functioning during the sensorimotor stage of development indicated that children are capable of cognitive activity at a level above that in which they can use language. During the preoperational stage, language performs three basic functions: (1) communication with others (socialization of action); (2) internalization of words in the form of thoughts and sign systems; and (3) internalization of action so that children are not dependent on physically manipulating objects in problem-solving (Thomas, 1992). In the preoperational stage, language may serve as a facilitator of cognitive development, but Wadsworth (1984) emphasized that language is not required for the development of logical thought in Piagetian theory.

**Categories of knowledge**

Piagetian theory outlines three categories of knowledge. These categories are distinguished one from the other on the basis of their source. The first category, logico-mathematical knowledge, comes from the way
individuals move themselves and other objects. Kamii, Lewis, and Jones (1991) stated that logico-mathematical knowledge consists of relationships that are created by the individual:

For instance, when we are presented with a red bead and a blue one and think that they are different, this difference is an example of logico-mathematical knowledge. The beads are observable, but the difference between them is not. The difference exists neither in the red bead nor in the blue one. If a person did not put the objects into this relationship, the difference would not exist for him or her (pp. 21-22).

Wadsworth (1984) held that children's language does not play a direct role in their construction of logico-mathematical knowledge. Instead, the development of logico-mathematical knowledge rests solely on the activity of the child.

Piaget's second category of knowledge, social knowledge, comes from other people. In social knowledge, language provides an efficient means of communication. Wadsworth (1984) suggested that communication allows children easier access to various social experiences and ultimately more sources of social knowledge. Kamii, et al. (1991) described the ultimate source of social knowledge as conventions that are worked out by groups of people.

"Examples of social knowledge are the fact that Christmas
comes on December 25 and that a tree is called a "tree" (p. 22). Children's development of social knowledge is dependent on their abilities to assume the social perspectives of others. Christie and Johnsen (1983) suggested that social knowledge involves children's abilities to assume the visual, cognitive, and affective perspectives of other people. Dramatic play offers children many opportunities for perspective-taking. Rubin (1980) asserted that informal and didactic dramatic play strengthens previously "formed rules and role conceptualizations through consolidation and practice" (p. 73). Rubin and Maioni (1975) observed the dramatic play of preschool children and found that its frequency was positively correlated to role-taking tasks measuring the ability to take the visual perspective of other players.

Much research on social knowledge has also focused on the models children utilize in building their own knowledge structures. Putallaz (1987) collected social knowledge data on 55 mothers and their first-grade children to assess the association between parental and children's social knowledge, as well as the relationships between social knowledge indices and children's social behavior. She found that ratings of children's social knowledge are related to their social status, their behavior, and their mothers' behavior as well. Putallaz hypothesized that children learn much of their social knowledge by "observing their mothers' behavioral examples rather than through their mothers'
explicit teaching" (p. 338). Clarke-Stewart (1985) found that caregivers also served as resources during the construction of social knowledge. In home care settings, where child care was provided by a nanny or a babysitter, older caregivers were identified as more effective in promoting children's social knowledge, regardless of their educational background.

Lindsey and Greene (1987) researched the use of social knowledge during verbal communication sequences. Their research focused on the individual's ability to self-monitor, or to read the audiences' cues on attentiveness and interest during communication interactions. Lindsey and Greene asserted that social knowledge is highly connected to self-monitoring. They suggested that differences in social knowledge are crucial in the communication process because "interaction goals, outcome expectations, and strategies for action are formulated on the basis of the information available to the individual" (p. 381).

Physical-knowledge. Piaget's third category of knowledge is physical-knowledge. Kamii (1982) defined physical-knowledge as "knowledge of objects in external reality" (p. 7). Wadsworth (1984) stated that "physical-knowledge is knowledge of the physical properties of objects and events: size, shape, color, weight, and so forth " (p. 22). According to Kamii and DeVries (1978), the source of physical-knowledge is primarily in the object, "that is, in the way the object provides the subject with opportunities
for observation" (p. 16). Phillips (1975) stated that one way to look at the categories of knowledge is "to classify them according to the kinds of experience from which they emerge" (p. 141). While logico-mathematical knowledge is invented and social arbitrary knowledge is accepted, physical-knowledge is discovered through meaningful interaction with objects in the environment. Wadsworth (1984) stated that much of the knowledge constructed by infants and toddlers is knowledge of the physical characteristics of objects. Language does not play a direct role in physical-knowledge construction. Instead, physical-knowledge is constructed through sensory manipulation of objects in the environment.

DeVries and Kohlberg (1987) believed that knowledge construction begins in infancy. Because the interactions of very young children with their environments are sensory, physical-knowledge is the primary type of knowledge constructed. During Piaget’s preoperational stage of development (between the approximate ages of two and seven years), although logico-mathematical thinking is evident, physical-knowledge still dominates children’s thinking and their play activities. Observing young children at play allows teachers to assess not only the physical-knowledge children have constructed but also the methods and materials they have used in the process. As Frost (1992) stated, play has a dual role in Piaget’s theory of cognitive development.
"It serves as (the child’s) vehicle for knowing and as an indicator of the child’s cognitive development" (p. 8).

Piaget (1971) stated that the category of physical-knowledge is vast and that a significant part of intellectual development is based on learning the physical properties of objects in the environment. Physical experience does not occur in isolation. The process of assimilation is always involved. According to Piaget, direct and immediate contact between subject and objects is impossible. "Any kind of knowledge about an object is always an assimilation into schemes" (p. 335). The data that children gather from physical experiences is then interpreted in terms of larger intellectual frameworks. According to Ginsburg and Opper (1979), physical experiences are essential to cognitive development, but they must be assimilated into children’s growing systems of knowledge.

Physical-knowledge activities. Kamii and DeVries (1978) stated that all young children are naturally interested in examining physical objects, acting upon them, and observing the objects’ reactions. Activities that facilitate physical-knowledge "use this spontaneous interest by encouraging children to structure their knowledge in ways that are natural extensions of the knowledge they already have" (p. 5). The objective of these activities is to provide opportunities for children to act on objects and to see how those objects react--"to build the foundations for physics and chemistry" (p. 12). Lehmongkol’s (1987)
dissertation research in three types of kindergarten classrooms in Thailand found that "the application of the Piagetian program that utilized physical-knowledge activities had a positive significant effect on the children's understanding of physical-knowledge" (p. 77). In other words, children need to participate in activities specifically designed to illustrate physical-knowledge principles in order for them to effectively construct understandings of those principles.

Kamii and DeVries (1978) described two types of physical-knowledge activities. The first type involves the movement of objects. When a child moves an object, there is a direct and immediately observable correspondence between the child's action and the object's resulting reaction. In this type of activity, the role of the child's action is primary and the role of observation is secondary. Along with constructing physical-knowledge, the child may also gain understanding in spatial and logico-mathematical relations through the movement of objects. "Actions that can be performed on objects to make them move include pulling, pushing, rolling, kicking, jumping, blowing, sucking, throwing, swinging (a pendulum), twirling, balancing, and dropping" (Kamii & DeVries, 1978, p. 6).

The second type of physical-knowledge activities involves changes in objects. In this type of activity, observation is primary and the child's action is secondary. "Only under certain circumstances does the object change in
certain ways. It is these circumstances and changes that
the child has to observe and structure" (Kamii & DeVries,
1978, p. 10) in constructing physical-knowledge.

Kamii and DeVries (1978) also discussed activities that
share elements of both types of physical-knowledge
activities:

- Finding out whether an object sinks or floats
- Sifting
- Shadow play
- Looking through a magnifying glass
- Touching various objects with a magnet
- Playing with mirrors
- Producing echoes

In these activities, actions do not produce changes in the
objects themselves, but the movement that results from those
actions is caused more by the properties of the objects than
by the actions.

Research on physical-knowledge activities. Empirical
research on physical-knowledge activities is limited.
Inhelder and Piaget (1958) investigated children's
understanding of shadow phenomena. The study of shadows is
geometrical in nature. Shadows "denote relationships
between distances and diameters in a physical phenomenon
that can be explained in terms of simple projective
gometry" (p. 199). Inhelder and Piaget asserted that
until children reach the stage of concrete operations they
do not understand the formation of shadows. During concrete
operations, children gradually construct their understanding of shadow formation, recognizing first the role of the size of the object, second, the role of the distance between the object and the light source, and third, the inverse metrical proportionality between the distances and the diameters. Only after building understanding of all three of these concepts do children begin to make generalizations in formulating the laws of physics that explain shadow formation.

DeVries (1986) conducted two studies on children's conceptions of shadow phenomena. The first study provided an activity format for children between the ages of two and nine years to experiment with objects, shadows, and light sources. As the children experimented, they were questioned by the researcher. The second study was based on Piaget's original research and attempted to replicate the verbal interviews he conducted with children between the ages of three and nine years. DeVries found statistical support for her use of a stage theory in describing children's conceptions of shadow phenomena by using a scalogram analysis on the data gathered, and by closely inspecting the age patterns. She also drew upon an unpublished manuscript of Lawrence Kohlberg entitled "Stages in Children's Conceptions of Physical and Social Objects in the Years Four to Eight." In this 1966 paper Kohlberg detailed his criteria for demonstrating stages in a given domain of thought. These criteria include:
criteria for demonstrating stages in a given domain of thought. These criteria include:

(1) A Guttman scale should order attributes of thought in a hierarchy that is the same as the order based on age of appearance and completion of each attribute.

(2) The attributes should be scalable in the same order, and the age of appearance of the attributes should form the same order in divergent cultures.

(3) The order of the attributes should follow from a plausible theory as to why each attribute is a prerequisite to other attributes (DeVries, 1986, p. 491; Kohlberg, 1987).

DeVries drew her rationale for using a Guttman scale from Piaget's assertion that "cognitive stages are qualitatively different structures that are sequential in an invariant order and hierarchical in the sense that a later stage incorporates the preceding one" (p. 491). Her first step in constructing the Guttman scale was to identify the most important aspects of children's thought. The second step was to conceptualize and order those aspects that characterize new ideas at increasingly more advanced levels. This order then had to be analyzed quantitatively in an effort to understand those characteristics specific to one level and those characteristics that spanned several levels.
1. Makes correspondence between self and own shadow.
2. Makes correspondence between objects and their shadows.
3. Knows shadows require the presence of light.
4. Knows spatial relationships among light, object, and screen at the practical level, at least by trial and error.
5. Knows light has active role in formation of shadows.
6. Has solid understanding of spatial relationship among light, object, and shadow at the practical level.
7. Explains the formation of shadows as dynamic interaction of light, object, and screen.
8. Knows shadows are not characterized by permanence as are objects (pp. 492-493).

DeVries emphasized that although each item of the Guttman scale represents what is new in the children's reasoning, it is also an incorporation of what was correct in the preceding item and demonstrates a qualitatively different reorganization in the children's psychological experience.

The findings of both of DeVries' studies provided empirical and conceptual indicators that support the scale's description of a developmental sequence. Data analysis
indicated that older subjects and, in the second study, boys were more advanced in their reasoning.

Inhelder and Piaget (1958) also studied the reactions to and explanations of pendulum phenomena by children and adolescents. A pendulum provides opportunities for observing the results of pushing, pulling, swinging, and other activities involving the movement of objects. A pendulum is a body suspended from a fixed point so that it can swing back and forth under the influence of gravity (New Encyclopaedia Britannica (Vol.9), 1991, p.257). The study of pendulums dates back to the 17th century when Galileo timed a pendulum's swings by his heartbeat. Galileo observed that a pendulum's angular displacement from equilibrium does not vary the period or the frequency of the pendulum's cycle. The amplitude of a pendulum can only be increased by coupling the application of force at a rate that corresponds to the period (Rawlins, personal communication, May 20, 1993). Rogers (1960) identified the property of equal times for all amplitudes as the isochronous principle and described its applications in clocks, watches, hairsprings, oscillating quartz crystals, and the movement of atoms.

Rawlins (personal communication, May 20, 1993) stated that the period and the frequency of a pendulum are determined by the pendulum's length and are independent of the mass of the object attached to the end of the pendulum (the bob). The forces that act upon the bob include the
length and mass of the pendulum, the acceleration due to gravity at the location of the pendulum, the restoring force, and the amount of displacement. The period of the pendulum is directly proportional to the square root of the length of the pendulum. The frequency is inversely proportional to the square root of the length.

Ruchlis (1974) described the effects of gravity on a pendulum. A force (push or pull) is required for the pendulum to move against gravity. The force exerted by a push or a pull serves to lift the pendulum's bob. The harder the initial push or pull, the more the bob will be lifted, and the greater the effect of the force of gravity on the downswing. Therefore, the speed of the pendulum as it passes its lowest point will be greater.

The swing of a pendulum illustrates the law of conservation of energy. Whenever energy is changed, the resulting amount of energy must be equal to the amount of energy before the change occurred. Ruchlis (1974) defined energy as "the ability to cause motion--and therefore to do physical work" (pp. 23-24). The greater the initial force exerted upon the pendulum, the greater the potential energy. This potential energy is manifested in the lifting of the bob to a greater height. When the pendulum is released, the potential energy becomes kinetic energy at the bottom of the swing and then is converted back to potential energy at the top of the swing on the other side. The amount of potential
and kinetic energy involved may be gauged by measuring the height that the bob achieves at each side of the swing.

Inhelder and Piaget (1958) provided children of various ages with a small wooden frame, a string attached to the top horizontal bar of the frame, and weights of various sizes that could be attached to the string. They invited children to experiment with the materials provided and then questioned the children as they worked. Inhelder and Piaget described three stages of children's understanding of pendulum phenomena. Stage I begins during the preoperational period of development. In this stage physical actions dominate children's mental operations. Children are unable to distinguish between their own physical actions and the motion of the pendulum itself. In Stage II children are able to seriate the lengths and elevations of the pendulum, and they can observe the differences between the frequencies objectively. Stage II children, however, are still unable to separate the variables (length, weight, amplitude, and force) involved in the movement of the pendulum. In the first part of Stage III, children are able to separate the variables if they are given combinations in which one of those variables changes while the others remain constant. In the latter part of Stage III, the children are able to isolate all of the variables by excluding the inoperant links in the experiment.
Kamii and DeVries (1978) also experimented with three- and four-year-old children's understanding of pendulum phenomena. They encouraged children to participate in constructing a pendulum in their classroom and then allowed them to play freely with it. The teacher in the classroom provided a doll for the children to use as a target when swinging the pendulum. Kamii and DeVries concluded that play with the pendulum was a very appealing activity for children of this age. They asserted that there are some age differences in children's understanding of pendulum phenomena. The three-year-old in this study believed that her push caused the pendulum to move. The four-year-olds in the study, however, understood that the pendulum moved by itself if they released it away from the point of equilibrium and that its trajectory depended on where the pendulum was released. All of the children focused primarily on the movement of the bob rather than on what was happening at the top of the string.

**Play and the construction of physical-knowledge**

Play activities provide an appropriate context for children's construction of physical-knowledge. According to DeVries (1973), Piagetian theory emphasizes that neither physical nor logico-mathematical knowledge can be transmitted through social interactions. These types of knowledge must be constructed by children through their own mental actions on objects. Frost (1992) stated that Piaget's studies of both cognitive development and of play
"have shown that intellectual competence is achieved through intense interaction (play) with the environment" (p. 26). Kamii and DeVries (1978) also supported children's construction of physical-knowledge through play. They stated that the outdoor play environment provides an ideal location for children to construct such knowledge.

According to Kamii and DeVries (1978), the equipment in the outdoor play environment encourages children to act upon it and then to observe the reactions of the equipment. Research by Frost and Strickland (1978) compared the outdoor equipment choices of 138 kindergarten through second-grade children. Their findings indicated that children prefer equipment that moves and that can be adapted to their play scenarios. Taylor (1989) asserted that toys and equipment that incorporate motion help children to investigate physics principles.

Using equipment in the outdoor play environment to teach physics principles to children of all ages has been suggested by experts from several fields. Reitz (1975) recommended that high school physics teachers take their students to an elementary school playground because "there are science principles to be noted, apparatus to be manipulated, and even data to be collected!" (p. 55). Ruchlis (1974) believed that the playground provides the most appropriate laboratory for elementary children to observe the effects of energy and motion in their own immediate environment. In the outdoor play environment,
children may experience different combinations of science principles in the context of events familiar in their own lives. Kamii and DeVries (1978) stated "on playgrounds, preschool children learn an enormous amount of elementary physics at the level of practical intelligence" (p. 247). Dreyer and Bryte (1990) agreed that school playgrounds may provide young children with excellent opportunities for experimenting with science concepts. They asserted that equipment such as parachutes, slides, swings, teeter-totters, playground balls, and balance beams can introduce children to the dynamics of pendulums, levers, air pressure, and motion.

Ruchlis (1974) believed that "certain activities, particularly those with the swing and seesaw, are especially useful because of the interplay of forces and motions and their relationship to concepts involving energy" (p. 21). Swings, in particular, are discussed in the physics literature dealing both with the instruction of adults and with the knowledge construction of young children. Swings are basically life-size pendulums (Rawlins, personal communication, May 20, 1993; Dreyer and Bryte, 1990; Reitz, 1975; Ruchlis, 1974) and can provide children with opportunities to observe and experience the physics principles associated with pendulums. These principles include balance, force, gravity, resistance, and resonance.
Vygotsky's Theory

In contrast to the facilitator roles of play and language in Piaget's theory of cognitive development, Vygotskian theory describes a much more causative relationship. "The major cognitive consequence of play is an increase in the cognitive alternatives available to the player, as well as the flexible management of these" (Sutton-Smith, 1979, p. 316). This statement captured the essence of the relationship between play and cognitive development in Vygotskian theory. Vygotsky (1962) believed that this relationship was fundamental. "The most spontaneous form of thinking is play, or wishful imaginings that make the desired seem obtainable" (p. 18). During the preschool years, play serves as an adaptive mechanism that promotes cognitive growth. Through play activities, children discover new concepts and gain new information. New cognitive structures are built. In discussing Vygotsky's theory, Vandenberg (1986) stated that "play not so much reflects thought (as Piaget suggests) as it creates thought" (p. 21). Vygotsky held that play is a means of aiding a child's construction of symbolic thinking so that it is no longer dominated by the context of current events and concrete objects (Johnsen & Christie, 1986).

Several researchers have found in their work support for Vygotsky's theory. Smilansky (1968) found that participation in sociodramatic play stimulated children's language development, enhanced symbolic capabilities,
broadened concepts, and led to the acquisition of new knowledge. Fein (1979) asserted that role reversals in dramatic play cause children to use old information to pose new problems. These new problems encourage children to utilize abilities such as inference, transformability, reversibility, and substitutability, that may have been previously unused. Reifel and Yeatman (1991) found that, in the block play of four- and five-year-olds, Vygotsky's social and material bases for learning were clearly apparent. Some children in their study required an object or person in the environment to trigger or to express new ideas. Other children had already "internalized those preoccupying ideas" (p. 156) and needed no external help in expressing them.

Caplan and Caplan (1974) observed that young children are intrinsically motivated toward discovery and exploration during play. "They are almost continuously involved in the process of concept formation and in clarifying and extending their understandings of the world" (p. 89). The work of these researchers supports Vygotsky's supposition that play provides young children with opportunities to build new cognitive structures and understandings.

In Vygotsky's theory cognitive development is dependent on the individual's participation in and mastery of social interactions (Kohlberg, 1987). Although Vygotsky believed that thought and language begin as separate, unconnected functions, he asserted that the formal and informal
education that children receive "through the medium of language strongly influences the level of conceptual thinking they reach" (Thomas, 1992, p. 331). Language in social context is a primary determinant of cognitive development in Vygotsky's theory.

Both Piaget and Vygotsky recognize a close relationship between play and cognitive development. The differences in their theories are in the roles they ascribe to play in the developmental process. Piaget sees play as a method for refining previously existing cognitive structures. Language helps children to internalize and conceptualize their actions during play, but it is not necessarily an essential element in cognitive development. Children's levels of cognitive development may significantly exceed their levels of speech development. Vygotsky, however, views play as a vehicle for developing new cognitive structures. Language plays an essential role in cognitive development because it is the means through which much new information is acquired. While cognitive and language development are not identical in Vygotsky's theory, they are reflective and mutually supportive of each another.

Summary

Play is an activity that is common to all people. It is especially beneficial to young children because it facilitates their development of knowledge and capabilities in the physical, affective, and cognitive domains. Piaget's theory of cognitive development describes three types of
knowledge that children construct in play activities: social knowledge, logico-mathematical knowledge, and physical-knowledge. Physical-knowledge may be particularly important because it is the first type of knowledge that children construct, and because it is the basis for children's understanding of many principles typically found in elementary science curricula. Equipment in the outdoor play environment provides young children with opportunities for experimenting with physical-knowledge construction. Swings offer life-size examples of pendulums for young children to explore and experience many physics principles. While Piaget's theory suggests that language may facilitate cognitive development, Vygotskian theory describes language as an essential element in young children's cognitive development. Studying the language and behaviors of young children on the swings may yield information on their cognitive development, their construction of physics principles, and the relationship of the outdoor play environment and equipment to children's construction of physical knowledge.
CHAPTER 3

METHODOLOGY

This study was conducted in two corporate child care centers in the North Texas Area. Permission to test subjects was obtained by means of a letter to the subjects' parents (Appendix A). The study was conducted during June, July, and August of 1993.

Subjects

The subjects involved in this investigation were children enrolled in the two corporate child care centers. There were two primary concerns in selecting the age groups of children to be included in the study. First, during the pilot study the researchers noted that children younger than age three did not play on the swings without direct and sustained adult assistance. Second, Inhelder and Piaget (1958) described a shift in children's understanding of physical knowledge concepts that occurs at the end of the preoperational period. As this study focused primarily on children's independent behaviors on swings during the preoperational period, three-, four-, five-, and six-year-old children were included in the investigation.

Since summer enrollments were not complete at the time of this proposal, the exact number of children involved in the study was not yet established. Information on gender
and ethnicity was also unavailable at this time. Initial interviews were conducted with the directors of both centers to determine the presence of any special needs children within the classes.

Observation Schedules

Observations at both centers were conducted in the outdoor play environments, focusing specifically on the swings. At Center A the children were divided by ages into four classes. These classes consisted of the three-year-olds, the four-year-olds, the five-year-olds who had not yet attended kindergarten, and the five- and six-year-olds who had just completed kindergarten in May. Each class had a morning and afternoon outdoor play time scheduled. Although the three-year-old class did not leave the center for special activities, the other classes were gone at least one-half day each week during the observation period for field trips.

At Center B the children were divided by ages into three classes. These classes consisted of the three-year-olds, the four-year-olds, and the five- through twelve-year-olds. This last group was referred to as the "older kids" by the director and the teachers at the center. Each of these classes also had a scheduled morning and afternoon play time. The four-year-olds and the "older kids" at Center B also took half-day field trips each week. The three-year-olds did not leave the center.
The observation period at both centers lasted for six weeks. Since the outdoor play periods of the individual classes were scheduled consecutively, all age groups were included in each observation. Daily observations lasted from one and one-half to two hours. Observations were conducted three times per week at Center A during Weeks 1, 3, and 5, and two times per week during Weeks 2, 4, and 6. At Center B observations were conducted two times per week during Weeks 1, 3, and 5, and three times per week during Weeks 2, 4, and 6. Morning and afternoon observations were alternated at each center to minimize the effects of time of day on the children’s play activities. Appendix C outlines the observation schedules at both child care centers.

Site Description

In May the Frost Playground Rating System (Ages 3-8) was used in the outdoor play environments of both child care centers to provide a basis for describing their similarities and differences (See Appendix D).

The differences between the two outdoor play environments, as indicated by the Frost Playground Rating System (Ages 3-8), were minimal. Play Environment A had a slide attached to its large playscape structure. Play Environment B did not have a slide. Play Environment A provided the children with a large grassy area for games with rules or unorganized gross motor play. Although the area was not immediately adjacent to the area where the play equipment was located, it was accessible to the children and
observable to teachers supervising the playscape area. Play Environment B did not provide such an area. Play Environment A also provided the children with a horizontal swing as well as two vertical swings. Play Environment B had only two vertical swings. Play Environment A was adjacent to the parking lot of a nearby grocery store. Litter and debris from the parking lot had blown up against the fence of Play Environment A. Although the trash remained on the outside of the fence, it was clearly visible from inside the play environment. Play Environment B was clean and clear of debris. Play Environment B had a portable table for water and bubble play that was not evident in Play Environment A. Play Environment B provided shade for the children's activities with several medium-sized trees. Play Environment A had no trees.

Each play environment had two vertical swings. On Play Environment A, the structure from which the swings were suspended was approximately 86 inches tall. The suspending chains were 48 inches long. At their lowest points, both swings were 23 inches above the ground. On Play Environment B, the structure from which the swings were suspended was approximately 92 inches tall. The suspending chains were 60 inches long, and both swings hung 16 inches above the ground. The seats of the swings in both play environments were U-shaped and made of flexible rubber. Each seat was six inches wide and 26 inches long. On Play Environment A
the seats were blue and on Play Environment B they were yellow.

Methods of Data Collection

The primary method of data collection in this investigation was participant observation. Glesne and Peshkin (1992) defined participant observation as a method in which "the researcher carefully, systematically experiences and consciously records in detail the many aspects of a situation" (p. 43). Glesne and Peshkin further stated that a participant observer must constantly analyze observations for meaning and for evidence of personal bias. The observer engages in these activities because they are instrumental to the goals of the research.

These observations took place in the outdoor play environments of the two child care centers previously described. Data was recorded by video-taping, audio-taping, and field notes.

Glesne and Peshkin (1992) stated that videotaping is an invaluable tool for "focusing on one aspect of everyday interaction" (p. 51). Musatti and Mayer (1993) employed video-taping as the primary method of data collection in their study of pretend play in an outdoor play environment. DeVries (personal communication, May 12, 1993) recommended the use of video-taping as the primary method of data collection in the investigation described in this paper. In this investigation, the video camera was directed specifically at the children playing on the swings in the
outdoor environments. Videotaping permitted the replay of specific behaviors that the children exhibit on the swings in the outdoor play environment. This replay helped to clarify the researcher's understanding of those activities. Further, the videotapes were shown to two early childhood educators to triangulate the data collected by the primary researcher.

Bogdan and Biklen (1992) recommended using a tape recorder when the study relies upon extensive interviewing. In this investigation, audio-taping was used to accurately record children's verbalizations during their outdoor play activities on the swings. Transcriptions of these audio-tapes were prepared daily.

Finally, the independent observations of the researcher were recorded in anecdotal field notes. Agar (1980) stated that field notes are a record of the researcher's "observations, conversations, interpretations, and suggestions for future information to be gathered" (p. 112). In this study field notes were used to record events in the outdoor play environment, descriptions of the environment, and interactions involving the children and/or the teachers. Glesne and Peshkin (1992) stated that field notes should be both descriptive and analytic. "In recording details, strive for accuracy, but avoid being judgmental" (p. 47). Subjective opinions or personal observations of the researcher were recorded separately in a research diary.
Transcriptions of both the field notes and the research diary were prepared daily.

Another method of data collection in this investigation was informal interviews of the subjects. Agar (1980) stated that the goal of interviewing is to ascertain the significant details of an event and to learn how those details are connected. In this study, key informants were interviewed individually and in groups immediately after they had finished their activities on the swings. The researcher attempted to include as many children as possible from the age and ability range represented in the informal interviews. Children were shown a model of the swings in their play environment and were asked to describe their own activities and the movements of the swing during their play.

Dreyer and Bryte (1990) suggested interviewing children after their play on swings to introduce them to pendulum phenomena. During a pilot study specifically to formulate interview questions, the researcher used several of the questions employed by Dreyer and Bryte to initiate discussions with children who had just finished swinging in an outdoor play environment. Although the interviews in this investigation were open-ended, the following questions developed in the pilot study formed the basis of the informal interviews:

What does it feel like when you are swinging?

Which swing were you on? Why did you choose that one?
How did you make the swing go faster?
How did you make the swing go slower? How did you make it stop?
What parts of your body do you use when you swing? What do you do with your ___(body part)___?
If you were going to teach somebody else how to swing, what would you say?
You are such a good swinger! How did you learn to swing? Do you remember what ______ told you about swinging?
The children's responses were recorded on video and audio tapes.

Guttman Scaling

The most recent investigation of children's construction of physical-knowledge is DeVries' (1988) study of children's conceptions of shadow phenomena. The present study is based on two of the assumptions made in that study and employed methodology similar to that used by DeVries. The first assumption is that children's construction of the physics principles involved in swinging emerges in stages similar to their understanding of shadow phenomena. The second assumption is that a Guttman scale can be used to accurately portray those stages of understanding.

A Guttman scale provides a hierarchical sequence of content-related elements in which all aspects of the first elements are incorporated into the later elements. The
acceptability of a Guttman scale is reflected in the scale's reproducibility (Guttman, 1954). Reproducibility is measured by the percentage of scale-type behaviors which reflect individual scale items among the total number of behaviors observed. According to Guttman, for a scale to be considered acceptable 90% of the instances observed must reflect the scale items.

Guttman scales have been employed frequently in research dealing with Piagetian stage theory. Trepanier and Hofmann (1973) developed a Guttman scale in their study of Piaget's sequential development of number conservation in young children. Kohlberg (1987) used a Guttman scale to in his study of sorting and inclusion tasks as cognitive variables. The major objective of Kohlberg's research was to determine if "the various attributes of concept formation dealt with by Inhelder and Piaget formed a Guttman scale" (p. 147). Likewise, DeVries (1986) used a Guttman scale in her study of young children's conceptions of shadow phenomena.

In this investigation, the Guttman scale was developed in a pilot study conducted with the assistance of Mrs. Virginia Rawlins, a former adjunct professor in elementary physics at the University of North Texas. Mrs. Rawlins and the primary researcher observed young children's behaviors on the swings in an elementary school outdoor play environment. The observed behaviors were sequenced into eight hierarchical stages—a Guttman scale. Subsequent
observations of young children on the swings in various play environments helped to refine the scale to its present form and to document the progression of behaviors observed. The content validity of the scale was established through review by a panel of three early childhood educators. These experts agreed that the stages described in the scale were typical of young children's behaviors on the swings and that the scale's sequence followed a realistic progression. The Guttman scale developed in the pilot study is as follows:

STAGE I
-- sits in swing
-- balances in swing seat
-- ready for motion to begin
-- requires a push from another person to begin motion

STAGE II
-- applies feet to ground
-- begins to put feet at angle for application of force meted for motion of swing
-- requires a push from another person to begin motion

STAGE III
-- applies force through hand and body alignment for good control of motion
-- requires a push to start motion or uses a running start
-- asks for higher amplitude
-- begins to pump at appropriate location of swing

STAGE IV
-- achieves a relatively small amplitude through pumping
-- demonstrates an undeveloped back kick (foot flex is absent, legs are apart)
-- body, feet, and hands not fully coordinated
-- demonstrates nonstandard start and stop methods
-- plays with swing in other ways
-- swings independently (no expectation of outside push)

STAGE V
-- height of swing is a goal of activity
-- starts swing activity easily
-- inconsistent hand, foot, and body coordination while pumping

STAGE VI
-- stops swing motion with difficulty
-- swing motion is generally jerky
-- obtains a large amplitude
-- incomplete follow through in leg movements
STAGE VII
-- swings in standard form
-- stops and starts smoothly
-- obtains and maintains a large amplitude
-- experiments with dismount

STAGE VIII
-- experiments with chain lengths
-- experiments with circular motions
-- intentionally achieves a bumping effect at point C
-- secure in personal and swing movements

This Guttman scale was used in the form of a checklist (Appendix E) to organize the children's video-taped behaviors in a developmental sequence. A copy of the checklist was completed daily for each child who played on the swings.

Data Analysis

Data analysis was conducted by the primary researcher. Triangulation was achieved with the assistance of two early childhood educators. Videotapes of the children's behaviors on the swings were analyzed with the goal of identifying behaviors that consistently gave evidence of the children's construction of the physics principles related to pendulums. Checklists based on the Guttman scale described previously were completed by the primary and secondary researchers. The completed checklists were analyzed to determine the
minimal .90 coefficient of reproducibility required for an acceptable Guttman scale.

Transcriptions of the audio-tapes were analyzed by the primary researcher and by two early childhood educators. The goal of the analysis was to identify elements in the children's language which demonstrated their abilities to verbalize their understanding of the physics principles related to pendulum phenomena. Those elements were compared to behaviors the same children exhibited during play on the swings. The researchers sought to determine the relationship between their language capabilities and the understandings they demonstrated in their physical activities on the swings.

Summary

This study used three components to investigate young children's language and behaviors during play on swings in the outdoor environment. The first component focused on the children's coordination of actions in experimenting with physics principles during their play. This component was studied through participant observation. Data was collected by video-tape and field notes.

The second component of this investigation was to compare the children's observed behaviors on the swings to a Guttman scale constructed from similar observations during a pilot study. A checklist was used to document and establish a hierarchy of children's behaviors on the swings and to determine the acceptability of the Guttman scale.
The third component of this investigation was to demonstrate children's ability to verbalize their understanding of pendulum phenomena as compared to their behaviors on the swings. The children were interviewed and asked to explain their actions and the swing's movements using a model. The children's verbal responses were compared to video-tapes of their behaviors on the swings.
CHAPTER 4

ANALYSIS OF DATA AND FINDINGS

This study investigated three-, four-, five-, and six-year-old children's construction of physics principles on swings in the outdoor play environment. This chapter is organized to present the analysis of data and findings according to the three purposes of the study. In addition, a description of the physics principles of swinging is included as background for a comparison of student behavior and language. A summary is provided at the end of the chapter.

Observations and informal interviews of the children were completed during a five-week period in July and August of 1993. Twenty-five observations were conducted, each lasting approximately two hours. During these observations 213 swinging episodes occurred involving 91 different children. Eighty-eight of these episodes occurred at Center A, and 125 occurred at Center B. The tables in Appendix E depict the number of episodes each child participated in at each center.

Description of the Swing's Movements

In this study the movements of the swing are described as ranging between three points. Point A is the furthest point reached on the back swing. Point B is the point at
which the swing rests at equilibrium, when gravity is the only force acting upon the swing. Point C is the furthest point reached on the forward swing. Points A and C vary depending upon the amplitude of the individual swinger. Figure 1 depicts the three points of the swing's movements.

Amplitude in this study was described as either high, medium, or small. Children were judged to be swinging at a high amplitude when the seat of the swing was between approximately five and seven feet above the ground at Point C, at a medium amplitude when the seat was between approximately three and five feet above the ground at Point C, and at a small amplitude between approximately 18 inches and three feet above the ground. Amplitudes were estimated by the researcher during direct and videotaped observations. Figure 2 depicts the three levels of amplitude achieved by swingers in this investigation.

Development of Children's Behaviors on Swings

The first purpose of this study was to describe children’s observed behaviors on swings in the outdoor play environment with a Guttman scale that provided a hierarchical measure organizing children’s swinging behaviors into stages. Formulated as a research question, this purpose was redefined: Do the observable behaviors of young children on swings in the outdoor play environment correspond to the hierarchical Guttman scale established in the pilot study? Direct and videotaped observations of
Figure 1. Three points of movement for the swing.

Figure 2. Range of amplitude for the swing.
children on swings were employed to build a description of children's swinging behaviors.

**Guttman Scale on Swinging**

The Guttman scale developed in the pilot study of this investigation identified basic behaviors and movements that three-, four-, five-, and six-year-old children exhibited while swinging. Subsequent observations of young children involved in swinging activities over a six-week period of time provided additional information on the development of these behaviors and the order in which they occurred. Based on the preliminary eight-level Guttman scale, the behaviors involved in swinging were reinterpreted into a descriptive stage model. These stages retained the hierarchical nature of the Guttman, meaning that each one built upon behaviors acquired in the preceding stage.

During the data collection period, 98 Guttman scales were completed on 55 different children. The tables in Appendix F depict the number of Guttman scales completed on each child and the final stages achieved by those children. The number of Guttman scales completed and the total number of children observed in this investigation vary considerably. Guttman scales were completed by the researcher while reviewing the videotaped observations. Only 57 parents at both centers gave permission for their children to be videotaped. Children for whom the researcher did not have permission to videotape, however, were still included in field observations and notes.
During the data collection period, the Guttman scale developed in the pilot study (see Appendix D) underwent three significant revisions. The first revision recognized the importance of observation and imitation for beginning swingers and fully described early pumping behaviors. The second revision acknowledged the importance of upper body control in the early stages and focused on the refinement of pumping behaviors in Stages V, VI, and VII. The final revision rearranged clusters of behaviors in Stages V, VI, and VII as follows:

Stage I
-- sits and balances on swing seat
-- ready for motion to begin
-- requires a push from another person to begin motion
-- holds on to chains
-- moves legs in a bicycling motion in attempt to pump

Stage II
-- mimics body movements of other swingers
-- moves legs together in attempt to pump
-- leans with body in attempt to pump
-- stomachs swing to achieve swing movement independently

Stage III
-- uses a running start or a jump start to begin swing movement
-- asks/strives for higher amplitude
-- demonstrates nonstandard start and/or stop methods
-- applies feet to ground at angle for application of force meted for motion
-- achieves a small to medium amplitude through pumping

Stage IV
-- demonstrates an undeveloped back kick and forward stretch (foot flex is absent, legs are apart)
-- body, feet, and hands not fully coordinated
-- stops swing with difficulty
-- swings independently (no expectation of outside push)
-- swing movement is jerky at Points A and C

Stage V
-- height of swing is goal of activity
-- compares own amplitude to that of other swingers
-- starts swing motion easily
-- incomplete follow through in leg movements
-- plays with swing in other ways

Stage VI
-- obtains large amplitude
-- swings in standard form
-- stops and starts smoothly
-- secure in personal and swing movements

Stage VII
-- obtains and maintains large amplitude
-- experiments with dismount
-- stretches feet to "touch" high objects at Point C

Stage VIII
-- experiments with chain length
-- experiments with circular movement of swing
-- intentionally achieves bumping effect at Point C

Establishing Reproducibility of the Guttman Scale

The reproducibility of the revised Guttman scale was established with the assistance of two secondary researchers. Both secondary researchers are doctoral candidates in Early Childhood Education at the University of North Texas and have daily contact with young children through their professional responsibilities in early childhood programs. Training for the secondary researchers included direct experiences on swings, observations of children playing on swings, and an explanation of the behaviors listed on the Guttman scale. The secondary researchers viewed videotaped episodes of children playing on swings and completed Guttman scales on the children's behaviors. Using the primary researcher's scale as a
standard (Towstopiat, 1984), the number of observer agreements and disagreements were compared to calculate the percentage of agreement index. The percentage of agreement index for the revised Guttman scale was established at 92.11%. This figure falls well above the minimal .90 coefficient of reproducibility required for an acceptable Guttman scale (Guttman, 1954).

Observation With the Guttman Scale

Individual differences in physical ability, height, interest, and previous experiences with swinging may have determined children’s placement in and passage through these stages. At each age level a wide range of swinging behaviors was observed. Some of the three-year-olds observed in this study functioned comfortably in Stages V and VI, while several of the older children were as yet in the second and third stages of the scale. Table 1 depicts the ages of the children and the stage behaviors exhibited. Although a general trend toward older children functioning in higher stages was observable, age did not appear to be the sole determinant of children’s placement on the Guttman scale.

Although multiple behaviors emerged, an overall trend was observable in each stage. In Stage I children concentrated on maintaining their balance as they became familiar with the movements of the swing. Stage II swingers observed other children on the swings and attempted to mimic their movements. Children in Stage III focused on adapting
the behaviors they had observed in others to fit their own capabilities, while children in Stage IV worked to perfect the timing between their own body movements and the movements of the swing. In Stage V children were eager to show off their abilities on the swings and often compared themselves to others on the swings. Stage VI swingers had mastered basic movements on the swings and attempted to refine and expand their skills. Children in Stage VII were secure in their own abilities and knew what to expect from the swing’s movements, while children in Stage VIII began to experiment to make deliberate changes in those movements.

**Stage I -- balance.** Children in the earliest stage of swinging appeared to focus on two primary areas. First, they had to be able to maintain their balance while seated on the swing. The behaviors that contributed to maintaining balance included sitting upright on the seat of the swing, holding on to the chains with both hands, and maintaining balance without back support. In Stage I children were able to demonstrate these behaviors both when the swing was in motion and when it was resting at the point of equilibrium.

Kristin, a three-year-old at Center B, exhibited Stage I behaviors during the first three weeks of data collection. In the first observations Kristin was able to seat herself on the swing and to hold on to both of the chains. While seated, however, Kristin made no efforts to move any part of her body and would remain motionless for long periods of time.
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Mdn = Median Stage Placement  X = Child

The second focus for Stage I swingers was to construct an understanding of the cause and effect events involved in swinging. Although children in this stage were ready for and expected the swing's motion to begin, they were not able to initiate or perpetuate that motion themselves. Stage I swingers required a push from another person to begin or
sustain their swing's movement. Kristin, the three-year-old described above, waited patiently for long periods of time for an adult or another child to push her in the swing. After the pushes she would ride the swing without moving any part of her body until the swing slowed and stopped. When the swing's motion ended, Kristin would either exit the swing or wait again for someone else to push her. In the early weeks of data collection, Kristin's belief that pushes from another individual were necessary for the swing to move was clearly demonstrated. First, her own passivity on the swing indicated that she had not associated pumping with the potential for moving the swing. Second, Kristin frequently attempted to push other children on the swings, even if those children had already pumped themselves to a substantial amplitude and even if they indicated that they did not want to be pushed.

If Stage I swingers attempted to move the swing themselves, this was usually in response to an adult's or an older child's prompting to "Pump!" or "Move your legs!". Stage I swingers may have responded by moving their legs in a bicycling motion in an attempt to pump. Ming, a three-year-old at Center A, also exhibited passive behavior on the swing. In an early observation, however, as her teacher was pushing her, Ming turned to look at Jane, a Stage IV swinger beside her.

Jane has pumped herself to a medium amplitude. Jane looks at Ming.
Jane: "Pump your legs like me! Ming, pump your legs!"

Ming looks at her own legs. She bends and straightens them three times in a bicycling motion. Ming relaxes her legs and looks back at Jane.

Stage II -- observation and trial & error. In Stage II children became aware that they had the potential to move the swing themselves. This awareness generally came about through the individual's observations of other children on the swings, but may also have arisen through the individual's repetition of random movements while sitting on a swing.

While observing more advanced swingers, some children noticed the swinger's body movements and the effects of those movements on the swing. The preoperational children on which this investigation focused centered on the movements of one particular part of the body and attempted to mimic that movement. Although the body parts most often involved in this imitation were the legs, several children focused on the leaning motion of the swinger's trunk and copied this motion in an attempt to move the swing. When the children in this stage chose to mimic leg movements, their attempts at pumping were to bend and extend their legs repeatedly, but not necessarily at the appropriate time in the swing's period. This pumping motion usually had little effect on the swing's movement.
Victor, a three-year-old Stage II swinger at Center B, attempted to mimic the pumping of Michael, a Stage VI swinger:

Victor is seated on the swing. He watches as Michael backs up his swing and begins to pump. Michael quickly pumps to a medium amplitude. Victor backs up his swing and lifts his feet as he saw Michael do. As the swing moves, Victor extends his legs and bends them twice. He relaxes his legs and leans back in the swing with his arms extended. He leans forward abruptly and the swing tips. Victor puts his feet down and stops the swing.

Although Stage II swingers experimented with their own bodies to make their swings move, they still required a push from another individual to swing in standard form. They often began to experiment, however, with other ways to achieve movement on the swings. Most frequently, this experimentation took the form of "stomaching" the swing. While laying across the swing on their stomachs, the children would hold on to both chains or to the seat of the swing and kick off on the ground to propel the swing. This behavior was often seen in more advanced stages as well. Theodore, a three-year-old at Center B, demonstrated this behavior as he waited for his teacher to push him.
Theodore’s teacher helps him to sit on the swing. She pushes him four times to a medium amplitude and then leaves to attend another child. Theodore sits passively as the swing moves, slows, and then stops. The teacher returns to push him again to a medium amplitude, and then leaves. The swing stops and Theodore slides out. He turns to face the swing and, grasping both chains at the level of his head, Theodore lays across the swing seat on his stomach. Theodore moves his hands to grasp the seat and takes three running steps forward, moving the swing to Point A. He lifts his feet and allows the swing to move to Point C and then back to Point B, where he puts his feet down and repeats this maneuver.

**Stage III -- adaptation.** In Stage III children began to adapt the behaviors they had observed in others to their own abilities and limitations. Because their legs were not long enough or strong enough to kick off from the ground while seated in the swing, many children used a running start to begin the swing’s motion. In a running start the child stands in front of the swing, grasping both chains with hands slightly above the head. The child runs forward, pulling the swing behind until reaching Point C. As the swing begins to return to Point B, the child jumps backward
to sit in the seat. The swing is then in motion and the child begins to pump or kick off from the ground. Other children attempted a jumping start where they stood behind the swing at Point B and grasped both chains above their heads. The children lifted themselves up and through the swing to sit down. The momentum of their bodies carried the swing forward to Point C where the children began to pump. Still other children in this stage employed a leaning start where they sat in the swing seat at Point B and leaned their bodies forcefully forward and back to begin the swing's movement. As the swing started to move the children added pumping motions with their legs.

Children in Stage III worked to achieve a higher amplitude by either asking for repeated pushes from another person or by attempting to pump themselves. Tyler, a four-year-old at Center A, functioned at the Stage III level as he interacted with Duke one afternoon.

Tyler and Duke are sitting on the swings.

Tyler (to Duke): "Will you push me? I'll save your swing if you'll push me."

Duke: "Alright." He gets off his swing and goes around to begin pushing Tyler on his back. Tyler swings at a small amplitude.

Duke stops pushing and goes back to his own swing.

Tyler: "Wait! It's not high."

Duke comes back and pushes Tyler three times.
Duke: "See, it's high. Keep your feet up."
Duke goes back to his swing. He kicks off and begins to pump.
Tyler: "See, I'm going higher."

Although the idea of pumping to achieve a high amplitude was firmly fixed Stage III, pumping was often ineffective because the children had not timed it properly with the period of the swing. The inefficient pumping of Stage III typically did not take the swingers past a medium amplitude. Many children supplemented their pumping efforts by kicking the ground forcefully each time their swing passed through Point B. Although this extra kick was helpful, it still did not propel Stage III swingers past a medium amplitude. Conrad, a four-year-old at Center B, demonstrated Stage III pumping throughout the investigation.

Conrad begins his swing by backing up slightly behind Point B and lifting his legs. As the swing approaches Point C, Conrad extends his legs slightly in front of him. As the swing moves back past Point B, Conrad kicks the ground again. He repeats this kick each time his swing passes Point B. His legs remain extended in the kicking position as the swing moves to Point A. Conrad's swing remains at a medium amplitude.

Stage III swingers generally stopped the motion of their swings by exiting the swing. They waited until the
swing was moving at what they judged to be a safe amplitude, and then they jumped from the seat as the swing passed Point B. Most often, Stage III swingers retained their grasp on the swing's chains when they jumped. This may have caused them to be off-balance when they landed or to be dragged a few steps by the swing's momentum. Jason, a four-year-old at Center A, demonstrated this type of dismount:

Jason is pumping at a medium amplitude. He stops pumping and the swing slows. As the swing approaches Point B Jason grasps both chains above his head, lifts his body out of the seat, and tries to put both feet on the ground.

Jason: "Ouch!"

The swing drags Jason for a few feet. He stumbles, and then lets go of the chains.

Jason rubs his hands together, and then rubs them on his pant legs.

Stage IV -- timing. In Stage IV children continued to practice the behaviors they had developed in earlier stages. They no longer required or expected an outside push to begin or sustain their swing's movement. Timing became a major focus in this stage as the swingers worked to fully coordinate the movements of their bodies and those of the swing. The actions of their hands, feet, and trunk did not appear to be fully synchronized, although each part was doing what was necessary to achieve the desired goal. Stage
IV swingers pumped with their legs apart and without a total foot flex on their back kick at Point A or without a total foot stretch at Point C. The swing's movements may have appeared to be a little jerky at Points A and C as the seat pivoted slightly with the children's unsynchronized leaning of their trunks. Crissy, a five-year-old at Center A, pumped consistently at a Stage IV level. Although she extended her legs each time the swing approached Point C, she did not straighten them past a 120 degree angle. Each time the swing approached Point A, Crissy bent her legs, but never past an 80 degree angle. During this particular observation, Crissy remained on her swing for about seven minutes, pumping in the described manner. Her swing did not exceed a medium amplitude.

Stopping the swing's movements was still challenging for Stage IV swingers. To stop the swing, Stage IV swingers may have exited the swings as in Stage III, although they typically let go of the chains when they jumped, or they may have attempted to stop the swing by scooting to the edge of the seat and dragging their feet repeatedly on the ground. Jenny, a Stage V swinger in the five-year-old class at Center A, consistently used this method to stop her swing.

Jenny is swinging at a medium amplitude. She stops pumping and scoots forward to the edge of her swing. The swing slows. As the swing approaches Point B on its forward movement,
Jenny lets go of both chains and puts her feet on the ground.

Stage V -- demonstrating prowess. Achieving a high amplitude was the primary goal of Stage V swingers. In this stage children appeared to be very eager to demonstrate their abilities on the swings to their peers and to adults in the outdoor play environment. Competition was evident at times as children compared themselves to others on the swings. Troy and Nicolette, both five-year-olds at Center A, demonstrated a Stage V competition:

Nicolette and Heather are on the swings.
Heather is swinging at a high amplitude.
Nicolette is idling on her swing.
Troy (to Heather): "Can you touch the sky?"
Heather: "I don’t want to go that high."
Nicolette begins to swing. She pumps to a high amplitude.
Nicolette: "These swings don’t go that high."
Troy: "I can make ‘em go that high. Keep kickin’ your feet until they do. That’s how."
Heather stops pumping. Her swing slows. She gets up and leaves.
Troy: "I’ll show you how." He sits on the swing and begins to pump. He achieves a high amplitude.
Troy: "See, look!! Ohhhhhhh!"
Nicolette stops pumping and looks at Troy. She begins to pump again.
Troy: "I can beat you all. I'm passin' you."
Nicolette: "I'm goin' higher."

Stage V swingers were generally able to begin their swing's motion easily by backing up to Point A and then lifting their feet off the ground. Swingers in this stage, however, still had not mastered either the total foot flex or stretch needed to achieve the maximum amplitude possible. Johnna, a six-year-old at Center B, pumped on a Stage V level:

Johnna sits in a swing. Both feet are on the ground. She backs the swing up to Point A and then lifts her feet off the ground. As the swing moves to Point C, Johnna extends and straightens her legs. Her feet, however, are relaxed and pointing inward. As the swing returns to Point A, Johnna bends her knees. Again her feet are relaxed, her toes touching. She continues to pump in this manner and remains consistently at a medium amplitude.

Stage V swingers often played with their swings to achieve other types of movement. The most frequently seen form of play was twisting the swing's chains vertically and then letting them unwind. Children engaged in this type of play while they were sitting upright on the swing's seat or
while they were stomaching the swing. A second form of play seen during this investigation was that of swinging in a standing position. Although this form seldom lasted for more than a minute or two, on several occasions children attempted to use it as a means of increasing their speed or amplitude:

Chardet has challenged the researcher to a "race". They each sit in a swing. Chardet backs his swing up to Point A. The researcher backs up even with Chardet.

Chardet: "Okay, when I say 'GO'. Ready, set, GO!"

Chardet and the researcher begin to swing and pump.

Chardet: "I'm going to stand up."

Chardet stands in the seat of his swing, first with his right foot, then on both feet.

Researcher: "Will that help you go faster?"

Chardet: "Yeah, you can't beat me!"

Chardet accidentally slips out of the swing. His feet land square on the ground and he retains his balance. Chardet climbs up to stand on the seat again, his hands grasping the chains at shoulder level. He leans to pump three times. Chardet sits on the seat and begins to pump his legs.
A third form of play frequently seen on the swings was that of flipping backward from a seated position. A small amplitude was needed to accomplish this maneuver. At varying points during the swing's period, the swingers scooted forward in the seat and then flipped their legs over their heads while still holding on to both of the chains. Most often the swingers would land with their feet on the ground, or sometimes on their knees, step backward, and then stand upright. Swingers in more advanced stages often experimented with back flips at high amplitudes.

A fourth form of play for Stage V swingers was to straddle the seat like a saddle and then to use their feet to propel the swing perpendicular to its standard motion. Rebecca, a five-year-old Stage V swinger, and Crissy, a five-year-old Stage III swinger, played on the swings in this manner. Although Rebecca was adept at straddling the seat and propelling the swing, Crissy did not yet have the balance and coordination needed:

Rebecca and Crissy are sitting on the swings.
Rebecca: "Let's do a horsey ride."
Rebecca stands and swings one leg over the seat of the swing and sits down, using both hands to grasp the chain that is now in front of her face. Crissy stands and tries to swing one leg over her seat. She loses her balance and wobbles. She sits on the seat
and tries to get her leg over on the other side.

Rebecca: "You put one leg like this--one leg over it and then put your bottom on."

Crissy gets her leg over, but she is off balance. The seat wobbles. She gets off quickly and sits the standard way.

The final type of play observed in Stage V children was that of making the swing's movements crooked. Most frequently, children engaged in this type of play while they were idling on the swing, but occasionally a child would experiment with a lean to one side or the other when the swing was at a medium amplitude. Most often the lean that caused the swing to go crooked was initiated accidentally, and then repeated and exaggerated. During the repetitions, swingers might attempt to synchronize their swing's movements to either bump into or narrowly miss the other swinger. Brittney and Jason were six-year-olds at Center A. They experimented with making their swings go crooked during a morning observation:

Brittney and Jason are swinging at a small amplitude. They talk about visits to the zoo. They clasp their inside hands and the swings begin to go crooked.

Jason: "This is fun!"

Brittney: "This ain't fun at all."
Brittney shakes her hand free of Jason's. She stops her swing by putting both feet on the ground. She backs up to Point A, lifts her feet, and begins to pump. Jason sits in his swing and watches Brittney.

**Stage VI -- refinement.** In Stage VI children refined and strengthened the skills acquired in previous stages. They were able to obtain a large amplitude during swinging, but may not have been able to sustain that amplitude for long periods of time. Stage VI children swung smoothly in standard form without the small jerks that were evident in earlier stages. Stage VI swingers were able to both stop and start the swing's motion easily. Virginia, a six-year-old at Center A, demonstrated Stage VI behaviors during an afternoon observation:

Virginia has been waiting by Crissy's swing. As Crissy leaves to line up, Virginia grabs her swing with one hand and sits down. She backs the swing up to Point A, lifts her feet, and begins to pump. She quickly achieves a high amplitude. The swing's movements are smooth and controlled. Virginia stops pumping and rides in the swing. She holds onto one chain and puts her other hand in her lap. The swing slows to a medium amplitude. Virginia grasps both chains and begins to pump. Again she
achieves a high amplitude. The teacher calls her to line up. Virginia drags her feet to slow the swing. She jumps from the seat at a medium amplitude and runs to line up.

Stage VI swingers were confident of their own abilities and they knew what to expect in the swing’s movements. They felt very secure at high amplitudes. Whereas in earlier stages, the swing’s bumping effect at Point C at high amplitudes might have startled the swingers and caused them to cry out or stop pumping, Stage VI swingers took little notice and continued swinging. Suzanne, a four-year-old at Center A, demonstrated her ease with unexpected movements in her swing:

Suzanne is swinging at a small amplitude. She begins to pump and achieves a high amplitude. At Point C Suzanne suddenly extends her legs upward and the swing seat tips back abruptly. Suzanne’s face registers surprise. She repeats this movement three times. On the next seven pumps Suzanne extends her legs out. The swing “bumps” at Point C. Suzanne swings back to Point A. On her next approach to Point C she extends her legs up and the seat tips. She repeats this movement four times, then pumps with her legs extended out seven times, and then with them extended up four times. Suzanne stops
pumping. Her swing slows. She drags her feet and the swing stops.

**Stage VII -- security.** By Stage VII children were secure in their control of the swing's motion. The follow-through on their leg movements during pumping was complete and the children may have stretched their feet to visually "touch" a high object at Point C. Jane, a six-year-old at Center A, stretched her feet to "touch" a tree about twenty yards from the swings:

Jane has pumped to a high amplitude. Her legs are fully extended and her toes are pointed at Point C. She talks to Rebecca on the swing beside her.

Jane: "Look, Rebecca, I'm real high. I'm touchin' the tree!"

Jane continues pumping and stretching.

Jane: "I'm gonna touch the roof."

Stage VII swingers not only had the ability to achieve a high amplitude, but they could also maintain it for long periods of time. During this stage children experimented with various methods of leaving the swing, such as jumping out at increasing heights at Point C. Titus, a six-year-old at Center B, experimented with jumping from the swing during a morning observation:

Titus is swinging at a high amplitude.

Titus: "I'm going to jump! Here I go! Five, four, two, one. Wait!"
Titus stands in the swing.

Titus: "Here's how I do this! Five, four, three, two, one--is that how you count backwards? Here I go!"

Titus jumps, landing crouched on both feet. He stands, goes back to his swing, and lifts himself to squat on the seat.

Titus: "I'm gonna go real high."

Nicolette is watching by the other swing.

Titus: "Nicolette, would you push me?"

Nicolette pushes him to a medium amplitude, then leaves. Titus leans with his body and increases his amplitude somewhat.

Titus: "I'm goin' real high! Look at me!"

He jumps from the swing, landing on his hands and feet.

Stage VIII -- further experimentation. In the final stage, children continued to experiment with previously acquired behaviors. The focus in this stage, however, was not merely to acquire a high amplitude, but to investigate methods of altering the swing's movements. Stage VIII swingers tried to shorten the chains to see what effect that had on the swing’s period, and they experimented with circular movements of the swing’s period. Because they were secure in their control of the swing, Stage VIII swingers may have intentionally worked to achieve the "bumping effect" that occurs at Point C when the swing has a very
high amplitude. John, a six-year-old at Center A, was the only Stage VIII swingers observed in this investigation. He was very aware of the bumping effect at Point C when he was swinging at a high amplitude:

John has backed his swing to Point A. He is leaning back with the small of his back on the swing seat and his hands loosely grasping the chains.

John: "When I go high it gives me the bumps. Like this."

John grasps the edges of the seat and pulls them out and down.

Researcher: "Can you show me?"

John: "Yeah, like this."

John sits in the seat and begins to pump. He quickly achieves a high amplitude.

John: "Here it comes! Like this!"

The swing bumps at Point C. John pulls the chains back abruptly to exaggerate the bump. He repeats this for the next three swings.

John: "Here's another one!"

John stops pumping and drags his feet in the gravel to stop the swing.

Conclusions

Although significant revisions to the original Guttman scale were necessary, this investigation has outlined a hierarchical stage model for young children's development of
swinging behaviors. Each of the eight stages describes a qualitative focal point for children as they acquire new behaviors and construct an understanding of swings and pendulum phenomena.

Children's Construction of Physics Principles on Swings

The second purpose of this study was to identify young children's behaviors during play on swings that may be consistently observed as evidence of their construction of the physics principles related to pendulums. Early observations of children at play on swings and discussion of pendulum phenomena with three physicists led to the development of the following research question: What is the nature of children's understanding of the physics principles related to pendulums as evidenced by their play on swings in the outdoor play environment? Methodology used to investigate this question included observations of children playing on swings in the outdoor play environment and open-ended interviews of children after their play episodes on swings based on the questions given in Chapter 3.

Physics Principles Related to Swings and Pendulums

An analysis of the physics principles related to swings and pendulums focused attention on five primary concepts: balance, force, gravity, resonance, and resistance.

Balance

For children to maintain their balance on a swing, they must first align their own center of gravity to that of the swing (Marble, personal communication, August 17, 1993). In
this study, the children worked to maintain their balance from three basic positions on the seat of the swing. The first and most frequently assumed position was sitting in standard form on the seat. For beginning swingers, balance was achieved with little body movement regardless of whether the swing was moving or stationary. Children just familiarizing themselves with the movements of swings sometimes found it challenging to maintain their balance while sitting on the seat:

The teacher has pushed Kristin to a small amplitude. Kristin straightens her legs at Point B. As the swing approaches Point C, Kristin slides out of the seat. She lands on both feet, her hands still holding the chains. Her expression shows that she is startled. She smiles and laughs, then sits in the seat again.

Children with more experience on swings began to experiment with maintaining their balance in various positions. Misty, a Stage IV swinger, tried letting go of one chain while maintaining a small amplitude:

Misty lets go of one chain with her hand. She keeps her arm flexed around the chain and her hand poised to grasp the chain again. Misty: "I can hold on with one hand, see?" After one full swing she grasps the chain again quickly.
Rebecca, another Stage IV swinger, was more comfortable with swinging one-handed:

Rebecca swings at a medium amplitude. She holds to one chain with her left hand and uses the other to first fix her skirt and then to remove a strand of hair from her mouth. Rebecca pumps with her legs to maintain her amplitude.

Rhonda, a six-year-old at Center B, found a way to swing comfortably with no hands:

Rhonda puts the seat of the swing at the small of her back. She backs up to Point A and swings forward, putting a foot up around each chain over her head. She clasps her hands under her back. Rhonda swings in this position.

Children also experimented with maintaining their balance while pumping the swing. Typically during pumping children extend their legs outward as the swing approaches Point C. If, however, the legs are extended upward, the swinger’s center of gravity is altered and the swing tips backward abruptly. Beginning swingers may find this movement frightening, as did Spencer, a four-year-old at Center B who was just learning to pump:

Spencer pumps himself to a medium amplitude.

As he approaches Point C Spencer extends his legs outward and upward. The swing tips back
and begins to move crookedly. Spencer’s face looks startled. He drags his feet, stops the swing and stands up. He moves away from the swing and watches Conrad on the swing next to him.

Children who are more secure in the swing’s movements may deliberately seek to achieve the tipping effect. Suzanne, a five-year-old who was able to achieve a high amplitude through pumping, experimented with tipping her swing:

Suzanne is swinging at a high amplitude. She extends her legs up at Point C and the swing tips. She repeats this movement four times. She pumps with her legs extended outward ten times, then with them up four times. The swing tips each time. Suzanne stops pumping and calls to Rebecca. Her swing slows and then stops. Suzanne stands and leaves.

The second position children assumed on the swings was to lay across it on their stomachs. The children held on to the chains or the seat, or they trailed their hands along the ground while in this position. Swingers maintained their balance by keeping their feet on the ground. On one occasion the researcher observed Curtis, a six-year-old at Center B, deliberately tipping the swing to lose his balance from this position:

Curtis stands up and dives into the seat of the swing. He lands with his stomach on the seat, his hands on the ground and his feet in
the air. The swing tips and Curtis falls forward out of the swing on his hands and head. Curtis stands and repeats his dive and tip in the opposite direction. Curtis stands and sits in the seat of the swing.

The third position children assumed on the swings was to stand on the seat. This position was typically assumed by older children who had no difficulty maintaining their balance while holding on to the chains.

**Force**

The second physics concept children experimented with while swinging was force. Force must be applied to move the swing. Force results from one of two types of energy, kinetic or potential, as they are applied to the swing. The force involved in these two types of energy must be applied in the same direction as the children intend for the swing to move in order for that movement to occur. Force applied in other directions will result in the children being "out of resonance with the swing" (Marble, personal communication, August 17, 1993) and the swing’s movements will become crooked. Force applied in the opposite direction of the swing’s movement will stop the swing.

Thirty-one children responded to the interview question on how to slow and then stop their swings’ movements. Eleven of those children responded that they used force to stop the swing by either dragging or stomping their feet on
the ground. Rebecca, a five-year-old Stage V swinger, discussed the use of force as follows:

Researcher: "How do you make the swing go slower?"
Rebecca: "You, you, what, if you, when you get real high, and then you, then you stop pumpin' your legs and you'll start going low."
Researcher: "Okay. How do you stop?"
Rebecca: "What you do, umm, you, umm, if you're goin' high, you stop pumping and when you get real, real low, you just put your feet down."

Mark recognized the use of force in stopping the swing's movements in the following interaction with Noelle:

Noelle is swinging at a high amplitude. Mark has been arguing with Noelle and Jane over whose turn it is to swing. The three have agreed that it is Mark's turn first, and then Noelle will have a turn.
Mark: "Kick the rocks, Noelle, so I can get on. Kick the rocks."
Noelle drags her feet and the swing slows. She drags them forward and then backward and Mark grabs hold of one chain of the swing and stops its movements completely.
Potential energy. The first type of energy used to apply force to the swing was potential energy. Potential energy is energy associated with position (Lough, personal communication, September 2, 1993). Potential energy was evident in the swing's period at both Points A and C when the swing stopped moving in one direction in preparation to begin movement in the opposite direction (Lough, personal communication, September 2, 1993).

Children used potential energy when they backed their swings up to Point A in preparation for a standard start. In a standard start children functioning at or above Stage IV would walk the swing backward as far as the length of their legs and the height of the swing allowed. This action stored potential energy in the swing which was released when the children lifted their feet and allowed the swing to move forward. As the swing approached Point C, the children extended their legs to begin pumping.

Potential energy was also used to move the swing in the form of pushes from another person. Beginning swingers frequently asked for pushes to begin and sustain their swing's motion. These children relied solely on pushes from another person and did not attempt to move the swing themselves. Other children requested pushes to help them begin, but then were able to pump and lean themselves to maintain their swing's motion:

Whitney and Lannie sit in the swings.
Whitney's feet do not touch the ground.
Whitney: "We need somebody to push us." (To the researcher) "Will you push us?"
Researcher: "Sure."
The researcher pushes Whitney to a small amplitude.
Whitney: "That's enough. I can pump myself now."
Researcher: "You can?"
Whitney: "Yeah. See?"
Whitney begins pumping. His legs are not fully extended at Point C and not fully bent at Point A. He leans forward with his body. Whitney achieves a medium amplitude.

Occasionally, experienced swingers who had previously demonstrated their ability to pump themselves asked adults in the play environment to push them. When questioned, teachers suggested that these children were attempting to gain adult or peer attention in a manner that had been previously successful for them or for other children.

Many times children pushed their peers on the swings to either begin or sustain movement. Three-year-old Allison's attempts at pushing were typical of those of very young children:

Allison goes behind Theodore and grabs the swing's chains. She walks the swing forward and then shifts her hold to the swing's seat.
to pull Theodore back. She shifts back to the chains and walks Theodore forward again and then pulls him back without letting go. She repeats this six times. Theodore curls his legs up and smiles. Allison stops pushing, and then starts again in the same manner, this time running instead of walking.

Some children attempted to push their peers by standing between the two swings at Point B and pushing or pulling on the chains as the swing went by. This type of pushing caused the swing’s movements to be crooked and the swinger usually requested the pusher to stop. Older or more experienced children typically pushed their peers by standing behind them and pushing on the swingers’ backs.

**Kinetic energy.** The second form of energy used to apply force to the swing is kinetic energy. Kinetic energy is the energy of motion (Lough, personal communication, September 2, 1993). During this investigation children applied kinetic energy to their swings in seven ways. The first was in using a jumping or running start. Many children would use the momentum gained from running or jumping with their own bodies to begin their swings’ movements. Running or jumping starts were most frequently used by children whose legs were not long enough to start the swing by backing it up and kicking off.
The second way children applied kinetic energy to their swings was by kicking off on the ground to increase their amplitude. Kicking off in this manner was an early form of pumping the swing to a higher amplitude. Genetta, a Stage III swinger at Center B, used kicking off to propel her swing throughout the study:

Genetta swings, kicking off at Point B. Her legs are not completely straight at Point C and do not bend at Point A. She kicks off at Point B and leans forward as she approaches Point C. She does not lean backward at Point A. Genetta maintains a medium amplitude.

Kicking off did not allow children to achieve more than a medium amplitude on their swings.

The third method children used to apply kinetic energy to their swings was walking the swing. When walking the swing the children would sit on the seat, hold on to both chains and walk their feet along the ground, either forward or backward, to Point A or Point C. Typically, children walked the swing backward in preparation for beginning the swing's movement. Corinne used this method to begin swinging in the following vignette:

Corinne is sitting in the swing. She is holding on to both chains and her feet are flat on the ground. She takes three steps backward until she is standing on her tiptoes.
at Point C. She lifts her feet and the swing moves forward. Corinne begins to pump and achieves a medium amplitude.

On other occasions children walked the swing to bump into another swinger or to deliberately make their swing's movements crooked.

The fourth application of kinetic energy was when children "idled" on the swing. Idling occurred when children were seated on the swing with their feet on the ground. Instead of walking the swing with their feet, the children bent and straightened their legs to move the swing in a circular pattern without lifting their feet off the ground. Idling the swing usually occurred when children were engrossed in watching others in the play environment or when they were involved in conversation with other children on or around the swings.

The fifth and sixth methods that children used to apply kinetic energy to their swings were pumping and leaning. Children experimented with pumping and leaning separately and in combination to move their swings. Some inexperienced swingers attempted to begin their swings' movements solely by leaning their trunks. Other children focused on leg movements and attempted to pump without moving any other body parts. As these children gained experience with swings they experimented with adding leaning movements at various points in the swing's period:
The teacher has pushed Bruce to a medium amplitude. She leaves. Bruce bends and straightens his legs to pump. He leans his head and chest forward each time the swing moves forward. His pumping does not maintain the amplitude of the swing and it begins to slow.

On occasion, more experienced swingers used pumping and leaning to achieve a high amplitude, and then relied solely on leaning to sustain that amplitude. James, Stage V swinger, employed this strategy most frequently:

James sits in the swing. He walks the swing back to Point A. He lifts his feet and begins to pump. James quickly achieves a high amplitude. His leg movements become minimal. He maintains his amplitude mostly by leaning with his trunk. He swings in this manner through nine completions of the swing's period. James stops leaning and rides in the swing. The swing slows.

Leaning was also the activity used to move the swing when children chose to stand on the seat. Pierre, a Stage III swinger at Center A, demonstrated leaning to apply force to his swing:

Pierre walks behind his swing. He grasps both chains with his hands and steps into the
seat with his right foot, and then his
left. He begins to lean back and forth.
Pierre: "See, this is how I make myself go."
He leans a few more times to pump the swing.
Pierre jumps off the swing and leaves.

Finally, children used kinetic energy to apply force to
the chains of the swings with their arms and hands. Force
was applied to the chains to keep the children's center of
gavity in line with that of the swing. Force was also
applied to the chains through arm movements when the
children were pumping. During informal interviews conducted
immediately after children had finished swinging, they were
questioned about the parts of their bodies used during
swinging and how those body parts were used. Of the 24
children responding to this question, one-third of them
recognized the use of their arms and hands during swinging,
but only two children discussed applying force to the chains
with these body parts. Brittney, a Stage VI swinger at
Center A, described the use of force on the chains:

Brittney is sitting on the ground with the
researcher.
Researcher: "What parts of your body do you
use when you swing?"
Brittney: "Your elbows and your feet."
Researcher: "What do you do with your elbows?"
Brittney: "You push back with 'em. On the chains."
Gravity

The third concept considered in this study was that of gravity. Gravity maintains the swing's equilibrium at Point B when no additional forces are applied. Gravity also maintains the tautness of the swing's chains during all points of the swing's period.

Gravity causes the bumping effect that children experience at Points A and C when swinging at very high amplitudes. As the swing travels between Points A and C it moves with kinetic energy. At Point C, as the forward movement of the swing stops and the backward movement of the swing is about to begin, there is no kinetic energy in the swing. The same is true at Point A as the swing stops its backward movement and the forward movement is about to begin. "When the kinetic energy goes to zero...the tension in the chain is reduced. The only tension in the chain at that point is gravity" (Lough, personal communication, September 2, 1993). The reduction of tension in the chain causes it to slack for a moment until kinetic energy restores that tension as the swing reverses its movements. At this moment the swinger experiences a bump or a jerk.

During data collection 15 children were observed swinging at amplitudes high enough to achieve this bumping effect. Only two of the children verbalized their thoughts on the causes. John, a six-year-old Stage VIII swinger, asserted that the bumps happened because "...sometimes when you get too high, the swing widens out like that and it makes
the bumps." Nicolette, a Stage VI swinger, observed the
difference between her bumps and those of the researcher
during an informal interview conducted when they were
swinging together:

Nicolette sits in the swing and watches the
other children in her class play a ball game.
She idles in her swing.
Nicolette (to the researcher): "Will you swing
with me?"
Researcher: "Sure!"
The researcher goes to sit in the empty swing.
Nicolette and the researcher back their swings
up to Point A and lift their feet to swing
forward. They begin to pump.
Nicolette: "How high can you go?"
Researcher: "I don't know. Let's see!"
Nicolette kicks off on the ground during the
first four swings. Both achieve a high
amplitude through pumping. The researcher
bumps at Point C.
Researcher: "Whoa! I'm bumping! You're bumping, too!"
The researcher slows and then stops her
swing. Nicolette does likewise.
Researcher: "That was pretty high!"
Nicolette: "Yeah, that was pretty high!"
Researcher: "You know what, I tried to get real high so I could bump it, but I couldn't bump it as big as you could bump it. Why do you think I can't bump it as big as you can?"
Nicolette: "'Cause you're bigger."
Researcher: "Oh, you think that has something to do with it?"
Nicolette nods.
Researcher: "What makes it bump like that?"
Nicolette: "I don't know."
Researcher: "I don't know either. I wish I did."

Resistance

The fourth concept considered in this study was resistance. Resistance to the swing's movements comes from several sources. Friction between the chain and the overhead supporting bar provides resistance to the swing's movements. Air resistance from the wind may slow or accelerate the swing's movements. Children overcome the resistance offered by the friction in the air and in the bearings of the swing by putting kinetic or potential energy into the swing (Lough, personal communication, September 2, 1993). On only one occasion did a child acknowledge the effects of resistance on the swing's movements. Robert, a Stage IV swinger, is swinging with Michael, a five-year-old. Both are swinging at a medium amplitude:
Robert (to Michael): "The wind's blowin' me and it helps."

Michael: "Huh?"

Robert: "The wind's blowin' me. I'm goin' higher."

Resonance

The final physics concept that children experimented with during activities on swings was that of resonance. Swings and pendulums vibrate at a natural rate under the property of resonance (Lough, personal communication, September 2, 1993). Angular displacement from equilibrium does not vary this natural rate of vibration. The amplitude of a swing or pendulum can be increased only by coupling the application of force with a rate that corresponds to the rate of vibration. As described earlier, applications of force through pushing, pumping, and leaning increase the amplitude of swings if they are applied at the appropriate time in the swing's period. On five occasions, children noticed that through the application of force the resonance of their own swing had become synchronized with that of the child on the next swing. In the following vignette, Patrick and Jane have noticed the synchronized movements of their swings:

Jane and Patrick have pumped their swings to a high amplitude. Their swings are moving at the same amplitude and frequency.
Patrick: "I'll never go higher than you, Jane. Never."

Jane: "I'm gonna stay goin' big like you, too."

The period and the frequency of the swing are determined by the length of the supporting chains. Children may increase the frequency of their swings' movements by shortening the length of the chains. Likewise, they may decrease the frequency by lengthening the chains. During this investigation children were observed experimenting with chain length on three occasions. Although the children were able to shorten the chains by twisting the seat and kinking the chains, they were often too short to sit down in the seat or to kick off on the ground to begin their swings' movements. Phillipa, a five-year-old at Center B, appeared to understand the effect shortening the chains would have on the swing's frequency, but she was unable to take advantage of it:

An older boy has twisted the swing seat to shorten the chains. Phillipa comes to investigate. She untwists the seat and sits down. An older girl is on the other swing, which also has shortened chains.

Phillipa: "Will you help me get this?"

Girl: "What?"
Phillipa: "Will you help me get this? I wanna get it up real short and then go real, real fast and jump out."
Phillipa begins to twist the seat of her swing.
Phillipa: "Is this how you do this?"
Girl: "No, go the other way."
Phillipa twists the seat in the other direction. It is approximately four feet above the ground. Phillipa grasps both of the chains.
Phillipa: "Now how do I get in it?"
Phillipa stomachs the swing with a jump.
Girl: "No, that’s not how."
Girl gets out of her swing. She stands with her back to the swing seat, grasps both chains at the level of her head and lifts herself to sit in the seat.
Girl: "Like this. Put your feet together and jump like this."
Phillipa tries this method three times but is unable to lift herself. She goes around her swing.
Phillipa: "I got it."
Phillipa stomachs her swing and lifts one knee in the seat. She tries to pull the rest of her body in.
Phillipa: "I can't do this!"

Phillipa laughs and watches the older girl.

The teacher calls and Phillipa turns to look at the door.

Phillipa (to the Girl): "My mom's here. See, I told you I couldn't get in!"

Phillipa runs to the door.

Conclusions

Children have an operational understanding of the physics principles related to pendulums and swings. Although they may demonstrate a tacit awareness of these principles, their primary concentration is on motion and their behaviors and language almost always deal directly with their desire to move the swing. The use of physics principles as categories for children's behaviors in this section is a heuristic to assist adult understanding of children's behaviors on the swings.

Although children do not apply the terminology used by physicists, their activities on the swings demonstrate their interest in experimenting with balance, force, gravity, resistance, and resonance. Examples of experimentation with these concepts are evident in both experienced and novice swingers. Many children use the understanding of these concepts that they have constructed to enhance their activities on the swings. By far, the majority of children's behaviors on swings deal with the application and effects of force. Very early in their experiences with
swings children recognize that force of some type must be applied to the swing to achieve the desired results. Early experiences on swings involve children's development of the ability to apply this force efficiently. Later experiences focus on creative uses of force and the use of the swing as a medium for children's own goals.

Children's Language and Their Understanding of Physics Principles

The third purpose of this study was to identify elements in young children's language and interactions which demonstrate their understanding of the physics principles related to pendulums. During data collection this purpose was formulated into the following research question: Are there elements in young children's language and interactions which demonstrate their understanding of the physics principles related to pendulums? Samples of children's spontaneous language and interactions with peers and adults in the outdoor play environment were collected through video-taping and field notes. Open-ended informal interviews based on the questions discussed in Chapter 3 were conducted with children immediately after their swinging episodes. These interviews were recorded on audiotapes.

Children's Spontaneous Language and Interactions

Language interactions occurred frequently and spontaneously for children on the swings. Children talked to themselves, to other children, and to the adults in the
outdoor play environment. Analysis of the children's verbalizations on the swings identified twelve categories of conversation. Four of these categories are not pertinent to the research question to be discussed in this section. These categories will be mentioned only briefly while the remaining eight will be discussed in more detail.

**Social Interactions**

Social interaction played a large role in the first four categories of language identified during children's play on swings. The first category dealt with situation management or "whose turn is it?" Children waiting for a turn on the swings asked their teachers or the current swingers when or if they could swing. The children seated on the swings typically responded that they had just sat down, or that their turn was not up yet. The second category dealt with pride in accomplishment or "look what I can do!". This category was particularly evident in Stage V swingers who were interested in demonstrating their prowess to their peers or to the teachers. Verbalizations in this category included comments such as "I can swing with one hand!" and "Look how high I'm swinging!". The third category of language interactions was that of safety and rules. Children repeated safety rules relevant to play on the swings such as "You should never walk in front of a swing 'cause if you do you might get hit" to peers they judged to be in imminent danger. The final category of social interaction language to be identified in this study was that
of socio-dramatic play. Socio-dramatic play did not figure largely in children's activities on the swings in this study. The researcher observed only three instances in which children were involved in fantasy play. On two occasions children played cowboys, straddling the seats of their swings for horses. Each occasion involved a different pair of children and neither lasted for more than a few minutes. On the third occasion, two children used their swings as airplanes during a game of Super Mario Brothers. This scenario lasted for almost 20 minutes and involved much starting and stopping of the swings as the children landed and took off.

Language and Knowledge of Physics Principles

Eight categories of language interaction that gave evidence of children's understanding of physics principles were identified in this study. These categories emerged from analysis of 181 samples of children's language during play on the swings and may be grouped according to three of the physics concepts outlined in the second section of this chapter: force, resonance, and gravity. Table 2 indicates the number of language samples on each of these topics.

Force. Children talked about applying force to their swings through three actions. The first of these actions was pushing. Pushing was the topic of 97 verbalizations by the children. Sixty-six of these verbalizations were requests by the children for someone else to push them. Children addressed 45.5% of these requests to other
Table 2

Language Samples on Related Physics Principles

<table>
<thead>
<tr>
<th>Physics Principles</th>
<th>Number of Language Samples</th>
</tr>
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<tbody>
<tr>
<td><strong>Force</strong></td>
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</tr>
<tr>
<td>Pushing</td>
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<td><strong>Gravity</strong></td>
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<tr>
<td><strong>Resonance</strong></td>
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</tr>
<tr>
<td>Speed</td>
<td>42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>55</strong></td>
</tr>
</tbody>
</table>

children. Victor, a Stage I swinger, frequently requested pushes from his peers:

Victor runs to the swing. He stomachs the swing, then stands upright and turns to sit in the seat. He looks around himself. Victor: "Could someone push me? Samuel, could you push me?"
Samuel walks to Victor's swing. He is holding a rake from the sandbox.

Samuel: "Sure."

Victor: "Put that stick down."

Samuel bends down with the rake. He is distracted by something in the gravel. Victor watches him for a moment, then looks around again.

Victor: "Randolph, could you come push me?"

Randolph runs over from the playhouse. He goes behind Victor and begins to push him on his back.

Children addressed 54.5% of their requests for pushes to adults in the play environment. Most of these requests were from children who legitimately needed assistance to begin their swings' movements. On occasion, however, children who were competent in pumping requested assistance from an adult:

- Randy is swinging at a medium amplitude.
- Kristin goes behind Randy and begins to push him.
- Randy: "You're makin' me go high, Kristin. I'm goin' high."
- The teacher walks over to watch. She stands approximately 15 feet away from the swings.
- Randy: "Stop pushin' me, Kristin. Stop
pushin' me, Kristin. Stop. Stop pushin' me, Kristin."

Kristin continues to push Randy. He drags his feet to slow his swing. He stops. Kristin hits Randy in the eye. Randy cries. Teacher takes Kristin away.

Randy (calls to teacher): "Will you push me? Will you push me?"

Teacher: "Please?"

Randy: "Please."

Teacher turns to talk to Conrad. Randy backs his swing to Point C, lifts his feet, and begins pumping when the swing moves forward. He achieves a medium amplitude. Teacher walks behind Randy and pushes him on his back.

Teacher: "Well, look at you! You don't need me!"

Randy smiles and continues pumping.

Other verbalizations about pushing included children offering to push their peers when they perceived a need for outside assistance and seven occasions when children responded that they could push themselves when such offers were made. The emphasis in these responses was on the children pushing, rather than pumping, themselves to achieve movement on their swings:
Rebecca pushes Jane twice and then moves to push Tabitha in the next swing.
Tabitha: "Don't push me. I can push myself."
Rebecca steps back and watches Tabitha.
Tabitha (as her swing moves toward Point C: "Pump, pump, pump, pump."
Tabitha bends and straightens her legs as she says this. After the swing completes its period four times, Tabitha begins to pump using her legs and trunk at the appropriate points in her swing's period.

All of the seven children who rejected outside assistance by stating that they could push themselves had demonstrated pumping behaviors at Stage III or higher on the Guttman scale.

The second action that children focused on when discussing the use of force on the swings was pumping. Pumping was the topic of 19 of the children's verbalizations during this investigation. Although five of these verbalizations were merely statements of the children's ability to pump, the majority dealt with one child attempting to teach another how to pump. Mary had evidently attempted to teach Scarlett how to pump on at least one previous occasion:

Scarlett is swinging at a small amplitude.
Mary goes behind Scarlett to push her.
Scarlett leans back with her legs extended in front of her. She maintains this position throughout the swing’s period.

Mary: "You have to move your legs. Remember how I showed you? When you go back, make your legs go back. When you go forward, make ’em go straight."

Mary watches Scarlett swing for a moment.

Mary: "Scarlett, you’re not doin’ like I showed you! I’m gonna teach you how to do it someday!"

Jumping was the third activity children dealt with in their conversations on force. Although jumping was a frequently used method for exiting the swing, only nine verbalizations occurred on the subject. Five of these verbalizations were simply statements of a child’s intention to jump from a swing. Four centered on one or more of the children’s fear of making the jump. The following discussion between Jake and Kimmy was typical of those four conversations:

Jake and Kimmy are swinging at medium amplitudes.

Jake: "We don’t want to jump out ’cause we’re scared."

Kimmy: "I’m not scared."

Holding on to both chains, Kimmy slides out of her seat. She lands on both feet,
the swing drags her a few steps before
she stops it.

Kimmy: "See, I’m not scared. I jumped out!"

**Gravity.** The concept of gravity entered into the
children’s spontaneous language and interactions only
indirectly and only in two conversations. Twice John, a
Stage VIII swinger, initiated a conversation with the
researcher on the "bumps" that occur at Points A and C when
swinging at high amplitudes. John attributed the bumps to a
force that "widened" the flexible seat of his swing when he
was swinging very high. John did not recognize the role of
gravity in the bumping effect, but he experimented with
trying to achieve the "bumps" from both a sitting and a
standing position.

Although John was the only child to discuss bumping at
Point C when swinging at high amplitudes, other children
responded verbally when they experienced the bump. Swingers
exhibiting behaviors at Stage VI or higher generally
verbalized a "Whoa!" or an excited scream when they bumped.
These children were not frightened by the bump and appeared
to enjoy it. Children who were less secure in the swing’s
movement or less sure of their abilities to control the
swing reacted differently to the bump. Jeremy, a Stage IV
swinger, reacted in the following manner:

Jeremy and John are playing Super Mario
Brothers on the swings. They have both
pumped to a high amplitude.
John: "Dump da dum!"

John’s swing bumps at Point C. He continues to pump and swing.

Jeremy: "Look how high I’m goin’!"

Jeremy’s swing bumps at Point C. His face looks startled.

Jeremy: "OH!"

As the swing moves back toward Point B, Jeremy drags his feet on the ground to slow his swing. He drags his feet again as the swing moves forward. When his swing has slowed to a medium amplitude, Jeremy begins to pump again.

Resonance. The concept of resonance was addressed 55 times in children’s spontaneous language interactions on the swings. The categories of language dealing with resonance included "We’re Goin’ the Same", "Shortening the Chains", "Height", and "Speed". On five occasions children observed the synchronized frequencies and amplitudes of their swings with comments such as "We’re goin’ the same." Although Phillipa mentioned that the swing would move "real, real fast" because the chains had been shortened, all three conversations on that topic centered primarily on the difficulties of climbing into the swing at its new height rather than on the changes in the swings’ frequencies that would occur.
While discussing the application of additional force, five children commented that their swings' movements would become faster. These children demonstrated behaviors at Stage V or lower on the Guttman scale. In contrast, 42 children indicated that a change in the amplitudes of their swings would occur with the application of additional force. Troy and Nicolette, both Stage VI swingers, discussed the relationship of force and amplitude:

Nicolette is sitting on a swing. She bends over to fix her shoe. Troy stands beside the other swing.

Troy: "Can you touch the sky?"

Nicolette begins to swing. She pumps to a high amplitude.

Nicolette: "These swings don’t go that high."

Troy: "I can make ‘em go that high. Keep kickin’ your feet until they do. That’s how. I’ll show you how."

Troy sits on the swing and begins to pump. He achieves a high amplitude.

Troy: "See, look! Ohhhhhhh!"

Nicolette stops her swing, then starts it again.

Troy: "I can beat you all. I’m passing you."

Nicolette: "I’m going higher."
Children's Language During Informal Interviews

Informal interviews based on the questions listed in Chapter 3 were conducted with the children immediately after they finished their play on the swings. A total of 23 interviews were conducted with 39 children. Fourteen of the interviews involved a single child, five involved a pair of children, one involved three children, and three interviews were conducted with groups of four children. None of the interview questions received responses from all 39 children. The lack of responses from some children was due to the rapid pace of the group interviews. All of the children interviewed in group settings may not have had an opportunity to respond before the group's discussions moved on to a different topic. During three individual interviews, however, the children involved simply lost interest in the activity and left before the interview was completed.

Question 1 -- What Does It Feel Like When You're Swinging?

Thirty-one children responded to the first question. Most responses dealt with the physical sensations the children experienced when swinging and fell into five categories. Seven children said they felt like they were "high" or "in the sky" when they were swinging. All of these children had exhibited swinging behaviors at or below Stage V. Another seven children said that swinging felt "fun". These children exhibited behaviors at all stages of the Guttman scale. Three children described the air
movement they felt during swinging. Grace, a Stage III swinger, answered "It feels like you get some fresh air on you". Brent, a Stage IV swinger, said, "Well, it feels like it, it, it just feels like when it's soft." Chardet, Robert, and Jason answered the first question by describing their body movements while swinging. Jason, a Stage VI swinger, said "It feels like, you're, you're legs are goin' -like you're legs are kickin' a soccer ball." The most animated answers came from four children who compared swinging to flying. All four of these children exhibited swinging behaviors at or above Stage VI. Brittney, a Stage VI swinger said "It feeled like I was a bird, flying in the sky." Three children answered "I don't know" to the first question and the remaining children gave answers that appeared to have little association with the question or with swinging. Kileigh, for example, responded "Like I'm hitting my head with my ball."

Question 2 -- Which Swing Were You On? Why Did You Choose That One?

This question received responses from 16 of the 39 children interviewed. All of these children correctly identified the swing they had been on. Nine of the children responded by simply turning and pointing to their swing. Five children identified their swing by naming the person who was currently sitting there, as in Abby's answer, "that one Randolph's on."
The second part of this question received responses from only 14 of the children interviewed. Most of the children who responded indicated that they had chosen a particular swing because it was in some way the best. Four children described the swings they had chosen as the "highest" even though the pairs of swings at each center were the same distance above the ground. Titus's answer was typical of those responses. Titus was a Stage VII swinger.

"Because it's the high one. It's kinda special. Because it's more higher than the other swing. And when you're on it you can swing and go more higher than on the one with it low down."

Four children said they had chosen a particular swing "because I wanted that one." Finally, two children responded that theirs had been a forced choice because, as Jason said, "I had to 'cause Bruce was on the other one."

Question 3 -- How Do You Make Your Swing Go Faster?

Twenty-nine of the 39 children interviewed responded to this question. The question focused on increasing the speed of the swing rather than the amplitude. Because in their spontaneous language most children recognized that increased amplitude rather than frequency was the result of applying force to the swing, this question was phrased to probe children's understanding of resonance. A majority of the children answered this question about speed by describing an application of force that would make their swings go
"faster". Titus, a Stage VII swinger, gave a typical response:

"'Cause when you're on the swing and you swing your feet and you just wait and you just wait and so you kick your feet more faster and you wait and um, you'll go more faster."

Five children, however, appeared to recognize that increased amplitude would actually be the result of an application of force and spoke of making the swing go higher rather than faster. These five children exhibited swinging behaviors in Stages II, IV and VI. Troy, a Stage VI swinger, focused on amplitude in his response:

"I push my own self. Keep on kickin' my feet up and down. Keep on kickin' my feet up in the sky. That's how I make it go high."

Seventeen children answered that pumping was the way they made their swings go faster. All but two of these children exhibited swinging behaviors at Stage IV or higher. Leon's answer was typical of these responses:

"You pump. You swing your feet back and forth because when you swing your feet back and forth it makes you go faster because when you--because I think when you swing you get more lower when you start, when you put your feet back and forth like this it gets more higher and that's how you
make it, swing it higher. Because that’s how you do it."

Three children responded to the third question by demonstrating a leaning motion with their trunks. Brent’s answer combined language and a demonstration:

"Ummm, you just swing yourself like this."

Brent stands and rapidly leans backward and forward, bending at his waist three times.

Troy and Samuel answered that pushing would make the swing go faster. Troy, a Stage VI swinger, indicated that he pushed himself while Samuel, a Stage I swinger, said "Somebody else has to push you." Kristin, a Stage II swinger, stated that holding on to the chains would make her swing faster, and Nicolette, a Stage VI swinger, said, "I start kickin’ backwards and forwards on the rocks".

**Question 4 -- How Do You Make Your Swing Go Slower? How Do You Make Your Swing Stop?**

Thirty-one of the children interviewed responded to this question. In the responses of only two of these children was there evidence of the understanding that the amplitude, not the frequency, of the swings would change when the force was moderated. Rebecca, a Stage IV swinger responded to the first part of the question by saying:

"You, you, what, if you, when you get real high, and then you, then you, stop pumpin’ your legs and you’ll start going low."
Rebecca also included amplitude in her method for stopping her swing:

"What you do, umm, you, umm, if you're goin' high, you stop pumping and when you get real, real low, you just put your feet down."

Three categories were evident in the responses of the children to the fourth interview question. Fourteen children responded that they could slow their swings' movements by stopping their pumping activities. All but two of these children had exhibited swinging behaviors at or above Stage IV. Titus, a Stage VII swinger, described the process of slowing the swing as follows:

"Umm, when you are swingin' and you swing slow, then you don't let your feet go no more and you start slowin' down."

Four children said that they slowed their swings by dragging their feet in the gravel underneath. All of these children represented higher stages on the Guttman scale. Their responses included demonstrations as well as verbal explanations. Jane, a Stage VII swinger, provided this response:

"You do like this. Like this. Like when you get low. Like this."

Jane stands and makes skating motions in the gravel with her feet.

"But not like a dog."
Several of the children's responses made a connection between making the swing go fast and making the swing go slow. Four-year-old Russ explained very logically that "the swing don't go faster when it goes slower." Kristin, a Stage II swinger who was very proud of her emerging pumping skills, indicated that she didn't go slow on her swing--she just went higher. Likewise, Spencer, a Stage IV swinger, stated that his swing "was slow when I didn't swing faster."

The second part of this question required children to explain their methods for stopping the swing's movements. Overwhelmingly, the children's responses involved putting their feet on the ground. Three of the children described dragging their feet in the gravel. Robert, a Stage IV swinger, demonstrated dragging his feet, but he verbalized this action as "scrounging your feet on the rocks." Nicolette, a Stage VI swinger, also reported that she stopped her swing by putting her feet down on the rocks but added, "sometimes I just jump off."

**Question 5 -- What Parts of Your Body Do You Use When You Swing? How Do You Use That Part?**

Twenty-four children responded to this question. In all, the children identified six different body parts used in swinging. Responses from ten children included the feet with pumping and/or kicking given as their primary function. Legs were the second most commonly identified body part, and they were usually assigned the same functions of pumping and kicking. Phillipa described the use of her feet and legs by
saying "When I sit down, I kick my feet, um my legs. Swing 'em back and forth. Yeah." Two children, however, compared their leg movements during swinging to walking and running. Jane, a Stage VII swinger, answered the fifth question with this comment:

"I use my legs and shoes and feet. And socks. You run with them. You can just run here." Jane points to the swings.

Although five children mentioned using their arms during swinging, only two of them described pushing or applying force on the chains with them. Instead, the use of the arms was more often grouped with the use of the hands for holding on to the chains. As Crissy explained, "You just hold on and you start swingin'."

Two of the children identified the trunk as a body part they used in swinging. Bruce, a Stage II swinger, patted his chest, calling it "this body", and said that he used it to pump. Emily responded that she used her back to swing and described the motion in the following manner: "I do with my back like, I always, I do, I always lay on my back on beds."

Ten children identified more than one body part when they answered this question, with the feet and arms being the most frequent combination. Leon's answer was typical of the combination responses: "My hands and my feet. I hold on to the bars and I put my feet backwards and forwards every time I get on the swing."
Question 6 -- If You Were Going to Teach Someone Else How to Swing, What Would You Tell Them?

The sixth question attempted to discover what children considered most important in swinging and in learning to swing. Twenty-three children responded to this question. The most frequent response, given by sixteen children, was to tell novice swingers to pump or swing their legs. Jason, a Stage IV swinger, gave an answer typical of this category:

"I would tell 'em to push your feet up and back. And if they wanted to stop, I'd stop 'em. If they're too little."

Four of these same children also included leaning in the instructions they would give to novice swingers. John, a Stage VIII swinger, indicated that he would include both pumping and leaning in his instructions:

"I would say 'I'll teach you.' When we would get on the swings I would tell them to do the back thing. I would tell them to just push off and curl up. Push off and curl up."

In combination with the instructions to pump their legs, three children indicated that they would also tell novice swingers to hold on to the chains. Titus, a Stage VII swinger, stated:

"Uh, I'd tell 'em hold on to the swing tight and swing their legs if they want to go fast, swing it fast. Then if they want to go slow, swing their feet slow."
Although pumping played an important role in all of the responses, five children indicated that they would demonstrate pumping behaviors rather than just telling the novice swingers what to do. Brent suggested the most direct route to demonstrating swinging behaviors: "I would tell them to swing like this," and he ran to a swing, sat down, and started pumping. Two of the children felt that pumping could only be mastered through extensive practice. Troy, a Stage VI swinger, said "Well, I'd tell them to start off slow and then--you can put somebody on the swings and let them swing." Leon used all of the above categories in his complex set of instructions:

"I would tell them to hold on real tight to the--if they hold on real tight, I'll push them and I'll tell them how to swing. I'll tell them how to swing and I'll tell them to-I'll tell them how to swing their feet and I'll get in my swing and I'll swing and I'll let them copy me and I'll ask the person if they want to copy me and I'll ask the person 'Do you wanna swing more faster?' and if the person says yes then I'll tell them to swing your feet more faster a long time past a minute and then you'll go faster."

**Question 7 -- How Did You Learn to Swing?**

Twenty-six children responded to this question. Their responses fell into four categories. Most of the children
stated that they had been taught to swing by an older family member. Fathers were given the credit most frequently, but mothers, grandparents, and older siblings were also mentioned. Titus, a Stage VII swinger, described how his father taught him to swing:

“Well, see, a long time ago we--I was only four years old. I mean, five years old. I didn’t know how to swing and so I have to--somebody--I mean, my daddy, each time I was little, my daddy taught me how to swing. He told me to push my feet up and down, up and down. Then one day we went to the park and we stayed there gold. Then we went to see the snakes. We went to see the snakes. Then one day when it was night, I learned how to swim--swing. And I didn’t need nobody to push me anymore.”

Six of the children indicated that they had learned to swing through extensive practice and two stated that they had watched and then modeled a friend’s behaviors on the swing. Age played an important role in five of the children’s descriptions of how they had learned to swing. Three children stated that they had learned to swing as babies. Jane, a Stage VII swinger, described how she learned to swing in the following manner:

“Uh, I just keep on practicing. My big brother, Aaron, who lives in California,
uh, he pushed me when I was a little baby.
That's what he did for me. When I was
going on the swings, if they were too
high, I would try and get my hands up
there. And I did it. That's what I did."

Frequency and Type of Language Related to Physics Principles

In this investigation, forty-eight of the children who
had been evaluated with the Guttman scale were also involved
in informal interviews. The language of forty of these
children revealed an understanding of the physics principles
related to swinging. Language samples were drawn from
informal interviews and spontaneous interactions during
observations. Table 3 compares the stage level behaviors
exhibited by each child and the number of verbalizations
involving resistance, resonance, balance, gravity, and
force. Force and resonance were the topic of most of the
children's verbalizations. Out of 186 language samples, 111
dealt with the application of force and 66 dealt with
resonance. Five children, all exhibiting behaviors at Stage
III or higher, made references to balance. Gravity was
referred to only by three children, all of them evaluated at
Stage VI or higher. Resistance was mentioned only once, by
Robert, a Stage IV swinger.

As in the comparison of ages and stages, a general
trend appears to be evident with more relevant
verbalizations by higher level swingers. The mean number of
utterances at each stage also supports an overall increase
in the number of relevant verbalizations from the lower to the upper stages. There are, however, notable exceptions. Kristin, a Stage II swinger, had 19 verbalizations dealing with the physics concepts discussed in this investigation. Kristin spent much time on the swings and talked continuously to the researcher, the teachers, and her peers. She recognized the use of force in making the swing move and understood that the application of force changed the amplitude rather than the frequency. Virginia and Joel, both Stage VI swingers, did not refer to physics principles at all in their conversations, even though their developed behaviors on the swings gave evidence of a tacit understanding.

Conclusions

Many of the children's responses to the interview questions gave evidence of an understanding of the physics principles related to swinging. Leon's instructions for teaching someone to swing, for example, were surprisingly complex and included all of the physical movements needed for pumping. Likewise, Rebecca's explanation of slowing and stopping the swing's movements provided a concise description of a standard stop for a higher level swinger, as well as demonstrating her understanding that the swing would go lower rather than slower. Other comments made by children indicated a lack of understanding of swings and physics. B.K.'s statement that to make the swing go faster "You turn around and make your belly come out--and you turn
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G = Gravity  R = Resonance  Re = Resistance
B = Balance  F = Force
this way" and Jane's identification of shoes and socks as body parts used in swinging suggested that the children were not thinking through the questions or their answers.

An analysis of the responses given by children at each stage of the Guttman scale revealed general connections between stage level and the complexity and articulation of the children's responses. John, the sole Stage VIII swinger in this investigation, responded to only five of the seven interview questions. His responses were vague and his meaning was difficult to discern. John spoke of "spreading his feet in" to stop the swing and of telling novice swingers to "do the back thing".

The most articulate interviews were given by Rebecca, a Stage V swinger, Nicolette, a Stage VI swinger, and Titus, a Stage VII swinger. Rebecca and Nicolette were very serious during the interviews and paused to consider before answering each question. Their responses always included more than one element relevant to the question and they presented information in a very concise and organized manner. In contrast, Titus was very quick to answer questions. His responses were direct, but included many descriptive elements. Allison, another Stage VI swinger, however, limited herself to two responses during the interview. She answered either "I don't know" or "'Cause I like to do that" to each interview question.
Summary

Swinging behaviors develop in a hierarchical fashion. In early behaviors, children focus on maintaining their balance, adapting the behaviors they observe in others to their own needs, and perfecting their timing. In these early stages children are developing the abilities they need for swinging. With the security of the later stages, children begin to compare themselves to others, to refine their abilities, and to experiment with the swing. Children demonstrate developed swinging behaviors in these stages. Behaviors in all stages give evidence of children’s understanding of the physics concepts of balance, gravity, resonance, resistance, and force. Although some children appear to be able to use language to talk about these principles, others at all stages depend on actions to demonstrate their tacit knowledge.
CHAPTER 5

CONCLUSIONS AND IMPLICATIONS

Summary

The purpose of this study was to investigate three-, four-, five-, and six-year-old children’s understanding of the physics principles related to pendulums and swings. An analysis was made of the children’s behaviors and language to identify elements that would give evidence of their understanding of these principles.

The children were observed at play on the swings during 25 two-hour observations. Their behaviors on the swings were compared to an eight-level Guttman scale developed in a pilot study. The Guttman scale was significantly revised during the study to more accurately describe the development of young children’s swinging behaviors. The children’s behaviors on the swings were categorized according to the related physics principles of balance, gravity, force, resistance, and resonance. Also, language samples were drawn from the children’s play on the swings and from informal interviews. These samples were analyzed for elements related to the physics principles to provide information on children’s understanding of their own role in making the swing move.
Conclusions

Three primary conclusions may be drawn from the data collected in this investigation. First, the behaviors that children exhibited on swings developed in a hierarchical fashion based upon their opportunities to practice these behaviors in a social context. Second, children's activities on the swings provided them early opportunities to collect information about related physics principles. These early opportunities are essential to the children's ultimate construction and understanding of pendulum phenomena. Third, children's language interactions on the swings were essential to their development of swinging behaviors and to their understanding of the related physics principles.

Developmental Stages of Swinging

Children's behaviors on the swings developed in a hierarchical fashion. Although individuals varied considerably in their demonstration of specific actions or strategies, children progressed through a sequence of behaviors as they learned to swing. The Guttman scale developed in this study outlined the hierarchical progression of swinging behaviors as they emerged in the children observed. As in the Guttman scale developed by DeVries (1986) in her study of children's conceptions of shadow phenomena, each stage incorporated what was achieved in the preceding stage and represented what was new in the
children's behaviors. Each stage further demonstrated a qualitatively different focus in the children's activities and experiences.

Cratty's Theory of Perceptual-Motor Behavior

The focus of each stage in the Guttman scale on swinging had certain similarities to stages in Cratty's (1969) three-level theory of perceptual-motor behaviors described in Appendix G. Cratty's first level described general supports for perceptual-motor behaviors. Similarly, the Guttman scale on swinging developed in the present study described the emergence of the children's expectations of the swing's movement patterns in Stage I. In Stage II of the Guttman scale, the children began to observe the behaviors of peers and how those behaviors affected the swing's movement.

The second level of Cratty's theory described ability traits. Likewise, Stages III, IV, and V of the Guttman scale on swinging also focused on children's physical abilities as they related to a specific behavior, that of pumping the swing. Children worked to personalize physical movements according to their individual size, strength, and speed, and to coordinate the movements of individual body parts. Finally, children enjoyed demonstrating the abilities they had developed to others in the outdoor play environment.
The third level of Cratty's theory described factors that were specific to a particular behavior and the situation in which it occurred. In Stage VI of the Guttman scale on swinging practice was key to the refinement of the newly developed behaviors. Practice was also essential to the ability of Stage VII swingers to maintain a high amplitude for long periods of time. Stage VIII swingers experimented with varying amounts of force and with spatial components to achieve different types of movement on the swing. Table 4 depicts the similarities between the Guttman scale on swinging and Cratty's theory of perceptual-motor development.

Harrow's Taxonomy of the Psychomotor Domain

Harrow's (1972) taxonomy of the psychomotor domain also provided some parallels for evaluating the Guttman scale on swinging developed in this study. In the first level of Harrow's taxonomy were those reflex movements which are involuntary in nature. In Stage I of the Guttman scale on swinging, children's primary focus was on maintaining balance while sitting upright on the seat both when the swing was resting at the point of equilibrium and when it was in motion.

In the second level of Harrow's taxonomy, children focused on basic-fundamental movements. Similarly, in Stage II of the Guttman scale on swinging, children began their initial efforts in pumping, the locomotor behavior involved
### Table 4

**Comparison of Guttman Scale on Swinging and Cratty’s Theory of Perceptual-Motor Development**

<table>
<thead>
<tr>
<th>Guttman Scale on Swinging</th>
<th>Perceptual-Motor Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I -- Balance</td>
<td>Level I -- General</td>
</tr>
<tr>
<td>Stage II -- Observation</td>
<td>Supports of</td>
</tr>
<tr>
<td>and Trial-and-Error</td>
<td>Behavior</td>
</tr>
<tr>
<td>Stage III -- Adaptation</td>
<td>Level II --</td>
</tr>
<tr>
<td>Stage IV -- Timing</td>
<td>Perceptual-Motor</td>
</tr>
<tr>
<td>Stage V -- Demonstrating</td>
<td>Ability Traits</td>
</tr>
<tr>
<td>Prowess</td>
<td></td>
</tr>
<tr>
<td>Stage VI -- Refinement</td>
<td>Level III -- Task</td>
</tr>
<tr>
<td>Stage VII -- Security</td>
<td>Specifics</td>
</tr>
<tr>
<td>Stage VIII -- Experimentation</td>
<td></td>
</tr>
</tbody>
</table>

in moving the swing from one point to another, and in applying force to the chains of the swing through the non-locomotor movements of pushing and pulling.

The third level of Harrow’s psychomotor domain dealt with perceptual abilities. Likewise, children exhibiting behaviors at Stages III and IV of the Guttman scale on swinging had already acquired the basic behaviors involved in moving the swing through observing other children. Their tasks during these stages were to adapt the observed
behaviors to their own abilities and then to practice and
perfect the adapted behaviors.

Level 4 in Harrow's taxonomy described the physical
abilities developed for use in making skilled body
movements. In Stage V of the Guttman scale on swinging,
children enjoyed demonstrating their abilities in these
areas to others in the outdoor play environment as they
worked to refine their movements on the swings.

The degree of proficiency children achieved for each
specific movement was a focus in Level 5 of Harrow's
taxonomy. Stages VI and VII of the Guttman scale on
swinging also focus on integrated behaviors. In these
stages children combined various behaviors to achieve motion
on their swing. They continued to practice these behaviors
to refine their performance and enhance their skills.

The sixth and final level of Harrow's taxonomy of the
psychomotor domain focused on individual communication
through movement. Similarly, the final stages of the
Guttman scale on swinging dealt with the children's
personalized use of the integrated behaviors developed in
previous stages. The goal of these stages, however, was
experimentation rather than communication. Table 5 depicts
the parallels between the Guttman scale on swinging
developed in this study and Harrow's taxonomy of the
psychomotor domain.
Harrow (1972) provided an appropriate summary of her taxonomy by stating:

Success in any skilled movement is determined by past learnings and experiences, efficient development in the two lower levels of this taxonomy, perceptual abilities, and physical abilities; it is also dependent upon intensive practice in the particular skill and also in a wide range of other skilled movement especially in early childhood, continuous motivation, and the meaningfulness of the activity to the learner (p. 88).

An evaluation of the Guttman scale on swinging leads to a similar conclusion. Children's ultimate development of the behaviors needed to move the swing depends on the basic skills developed in the earliest stages. Refinement of those early skills occurs through extensive practice, and children will engage in extensive practice only if they are motivated to do so.

Social Influences of Motor Development

Both Cratty and Harrow, however, omit an important element in children's development of swinging behaviors. Social influences are key motivators for children. Vygotsky (1978) asserted that children demonstrate their emerging abilities first in a social context and later independently. The desire to join or emulate their peers in swinging
Table 5

Comparison of the Guttman Scale on Swinging and Harrow's Taxonomy of the Psychomotor Domain

<table>
<thead>
<tr>
<th>Guttman Scale on Swinging</th>
<th>Taxonomy of the Psychomotor Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I -- Balance</td>
<td>Level I -- Reflex Movements</td>
</tr>
<tr>
<td>Stage II -- Observation</td>
<td>Level II -- Basic Fundamental Movements</td>
</tr>
<tr>
<td>and Trial-and-Error</td>
<td></td>
</tr>
<tr>
<td>Stage III -- Adaptation</td>
<td>Level III -- Perceptual Abilities</td>
</tr>
<tr>
<td>Stage IV -- Timing</td>
<td></td>
</tr>
<tr>
<td>Stage V -- Demonstrating</td>
<td>Level IV -- Physical Abilities</td>
</tr>
<tr>
<td>Prowess</td>
<td></td>
</tr>
<tr>
<td>Stage VI -- Refinement</td>
<td>Level V -- Skilled Movements</td>
</tr>
<tr>
<td>Stage VII -- Security</td>
<td>Level VI -- Non-Discursive Moves</td>
</tr>
<tr>
<td>Stage VIII -- Further Experimentation</td>
<td></td>
</tr>
</tbody>
</table>
activities heavily influences children's decisions to practice their developing skills. In this investigation, children rarely interacted with the swings independently. Typically, children approached the swings as a group, racing to see who would get there first and win one of the two swings available. Once two children were engaged in swinging, they continued to interact both physically and verbally with each other and with others in the immediate environment. On those occasions when children found themselves alone on the swings, they focused more on inviting others to join them than on actually swinging. Jason's behaviors were typical of children interacting independently with the swing:

Jason and Brittney are swinging. Brittney stops pumping. Her swing slows and stops, and Brittney leaves. Jason stops pumping. His swing slows. Jason idles on his swing. He grasps the closest chain of Brittney's swing.

Jason: "Who wants on this swing? Who wants on this swing?"

No one answers Jason. Jason leaves the swings.

Social interactions with more experienced swingers also provide valuable instruction to novice swingers. Vygotsky's (1978) zone of proximal development provides a model for
understanding the relationships between novice and experienced swingers. The zone of proximal development begins where the child is functioning independently and continues to where the child can function with the assistance of a supportive environment. Adults and more experienced children provided this supportive environment for children developing swinging behaviors. Through demonstration and direct instruction from individuals in the environment, novice swingers acquire behaviors more efficiently than if they continued to experiment independently.

Novice swingers in this investigation relied upon more experienced swingers to model pumping and play behaviors on the swings. Children exhibiting behaviors at Stage II of the Guttman scale on swinging focused specifically on observing others on the swings and then attempted to imitate the observed behaviors. Likewise, more experienced swingers provided novice swingers with direct instruction in pumping, play, and experimentation. This direct instruction came predominantly from children who had very recently acquired the behavior being taught. Children exhibiting behaviors in Stages III, IV, V, and VI more frequently engaged in teaching behaviors than did those children in Stages VII and VIII.
Stages and Phases

Although the levels of psychomotor development outlined by Cratty and Harrow parallel the stages described in the Guttman scale developed in this study, the idea of fixed or even flexible stages in development continues to be a point of controversy. Specifically, Forman (personal communication, August 6, 1993) questioned the idea of multiple stages in children's development of swinging behaviors as suggested by DeVries. He suggested that a Guttman scale may not provide the most appropriate format for organizing the development of children's behaviors on the swings because it presupposes the existence of distinct, abrupt stages. Forman and Kuschner (1983) proposed that the development of young children occurs in continuous rather than abrupt stages. "The whole process is an integrated one, because the gains of one stage are used in subsequent stages, not outgrown" (p. 8).

Instead of looking at eight hierarchical stages for the Guttman scale, developing swing behaviors may be seen in two broad phases. During the first phase children acquired and developed the skills and behaviors needed to swing in standard form. They focused on understanding the movement of the swing, developing the body movements necessary to achieve the movement of the swing, and coordinating these body movements to the movement of the swing. The behaviors exhibited during the first phase may be described as
developing behaviors on the swings. The first four stages of the Guttman scale on swinging may be collapsed into this developing phase. During the second phase, children had already developed basic behaviors and were able to turn their attention to comparisons with their friends and exploring their own potential and that of the swing. The refinement, extension, and elaboration of the children's swinging behaviors was evident in the phase two swingers. These behaviors may be broadly described as developed behaviors on the swings. Table 6 depicts the division of these phases and stages.

By dividing the stages of the Guttman scale into phases of developing and developed behaviors additional support is provided for the general trend in age and stage relationships that was identified in Chapter 4. As was previously stated, this study identified a general trend of older children exhibiting more developed behaviors Guttman scale. Replacing the eight Guttman stages with a developing and a developed phase illustrates this trend clearly. Table 7 depicts the percentages of children in each age group that would be evaluated as either developing or developed swingers. The percentage of developed swingers increases significantly at each age level.

**Children’s Behaviors and Physics Concepts**

In their study of children's understanding of pendulum phenomena, Inhelder and Piaget (1958) asserted that the
Table 6

Comparison of Phases and Guttman Stages of Swinging

<table>
<thead>
<tr>
<th>Phase A</th>
<th>Phase B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing Behaviors</td>
<td>Developed Behaviors</td>
</tr>
<tr>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>III</td>
<td>III</td>
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<td>IV</td>
<td>IV</td>
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<td>VI</td>
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<tr>
<td>VII</td>
<td>VII</td>
</tr>
<tr>
<td>VIII</td>
<td>VIII</td>
</tr>
</tbody>
</table>

Table 7

Percentages of Developing and Developed Swingers at Each Age Level

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Developing Swingers</th>
<th>Developed Swingers</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 year olds</td>
<td>86.67 %</td>
<td>13.33 %</td>
</tr>
<tr>
<td>4 year olds</td>
<td>60.00 %</td>
<td>40.00 %</td>
</tr>
<tr>
<td>5 year olds</td>
<td>47.06 %</td>
<td>52.94 %</td>
</tr>
<tr>
<td>6 year olds</td>
<td>12.50 %</td>
<td>87.50 %</td>
</tr>
</tbody>
</table>

first stage of understanding began during the preoperational period of development. In this period, physical actions dominated children's mental operations and children were unable to distinguish between their own physical actions and the motion of the pendulum itself. This period was essential to the eventual construction of the physics principles pertaining to pendulums because in it children
collected information about the properties of pendulums. During the concrete operations period of development, children organized this information into schemes and began to make generalizations in formulating the laws of physics pertaining to pendulums.

The behaviors of the preoperational children in this study were consistent with the findings of Inhelder and Piaget (1958). Physical actions dominated the children’s interactions with the swings. In their efforts to move the swing, the children engaged in active experimentation with pushing, pumping, and leaning. Although children watched their peers on the swings to identify the behaviors used to move the swing, these observations were not passive. Children copied the actions of successful swingers in an effort to receive similar results. Little time was spent in passive observation or reflection. Additionally, children identified their own movements completely with those of the swing. Descriptions of the swing’s movements or requests for an application of force to the swing were typically related with the child, rather than the swing, at the center of the action. The only notable exception to this observation was the comment made by John, a Stage VIII swinger, when he attempted to explain what made his swing bump at Point C. John stated that the bumps happened when "the seat of the swing widens out", indicating that the
swing, and not John himself, was responsible for what he felt.

Through active experimentation with making the swing move, the preoperational children in this study gathered information about swings and pendulums. In their early activities on the swings, children engaged in accommodating behaviors. Piaget and Inhelder (1969) defined accommodation as "the modification of internal schemes to fit reality" (p. 6). Accommodating behaviors were present in the children's activities as they worked to acquire and adapt the basic behaviors they needed to move the swing. Children accommodated their basic body movements and the related physical principles into a well-defined and operational physical knowledge of swinging. Once this physical knowledge had been constructed, children began to practice swinging just for the pleasure of seeing what they could do on the swings. At that point, children's activities on the swing became assimilation. Piaget and Inhelder (1969) defined assimilation as "the filtering or modification of input" (p. 6). As Piaget (1962) stated, almost all behaviors related to intelligence "are susceptible of becoming play as soon as they are repeated for mere assimilation, i.e., purely for functional pleasure" (p. 89). Children's play on the swings during the later Guttman stages was basically assimilation. The information they gathered was stored and organized according to the
children's existing cognitive structures. Given an environment that continues to encourage experimentation and opportunities for reflection, an equilibrium between assimilation and accommodation will occur. The children will organize their information into schemes and begin to make generalizations in formulating the laws of physics pertaining to swings and pendulums.

Children's Language and Cognition

Piaget's theory of cognitive development described play as assimilation. During play activities children refine existing cognitive structures and practice previously learned behaviors. Although language helps children to internalize and conceptualize their actions during play, Piaget did not see language as an essential element in cognitive development; children's levels of cognitive development may significantly exceed their levels of language development.

Vygotsky described play as the means through which children develop new cognitive structures. Language is essential to cognitive development because it is one of the means through which children acquire new information. While cognitive and language development are not identical in Vygotsky's theory, they are reflective and mutually supportive of each other.

Social interactions provide the context for language and cognitive development in Vygotsky's theory. As Luria
(1977), a student of Vygotsky, stated, social interactions are "the genuine source of the most complex forms of conscious activity in man" (p. 72). In this investigation, children developed their swinging behaviors in a social context, i.e., imitating the actions of their peers and direct instruction from their peers. Language, as the medium through which direct instruction occurred, played a key role in children's acquisition of swinging behaviors. Through language interactions children established new levels of independent functioning within their zones of proximal development. Wertsch (1979) stated, "...the progression from one level to the next in the zone of proximal development is largely the result of the child's effort to establish and maintain coherence between his/her own action and the adult's speech" (p. 20). In this investigation, more experienced peers provided the language for direct instruction rather than adults.

Children's play behaviors on the swings gave evidence of their construction of physical knowledge in this study. Many children appeared to be practicing and refining previously learned behaviors. Conrad, Spencer, and Genetta, for example, repeatedly practiced the same Stage IV behaviors throughout the five weeks of investigation. They did not add to or significantly change their method of repeatedly kicking off at Point B to move the swing. This pumping behavior had been established previously and now the
children practiced to perfect it before moving on to Stage V behaviors.

Other children appeared to be building new cognitive structures based on their active experimentation with the swings. Kristin and Robert, both Stage I swingers at the beginning of the study, worked to learn new pumping behaviors. Kristin developed her initial pumping skills by watching peers and attempting to mimic their behaviors. Robert developed his pumping behaviors by following the direct instruction of an older child. Both children learned to pump through social interactions on the swings. Language played a key role in Robert's initial experiences on the swings. By the end of this five-week investigation, Kristin and Robert had developed these initial pumping attempts to Stage III behaviors. A description of Kristin's progression through Stages I, II, and III is presented as a case study in Appendix I.

With few exceptions, younger children functioning at lower Guttman stage levels did not have the language to explain their behaviors or the swing's movements in either their spontaneous conversations or in informal interviews. Four-year-old Spencer consistently demonstrated Stage IV behaviors throughout the five weeks of observations. His language, however, did not reflect his physical knowledge. Spencer responded "I don't know" when asked how he made his swing go faster, even though he had pumped his swing to a
medium amplitude just moments before. When questioned about slowing and stopping his swing, Spencer explained, "It's way fun, 'cause I love swingin'" even though he had stopped pumping and dragged his feet on the ground to exit his swing for the interview. Spencer's language production, like that of many other children in the developing phase of swinging behaviors, did not reflect the understanding of physics principles evidenced by his activities on the swings.

The spontaneous language of older children, particularly those functioning at higher Guttman stage levels, accompanied their interactions with the swings. These children discussed their actions and plans with others involved in the activity. Although the children did not use technical vocabulary in their discussions, their language was descriptive and frequently contained newly coined words and phrases to describe their activities. John described the swing as it "wides out" and Robert talked about "scrounging" his feet on the rocks to stop the swing. Likewise, the children's structured language during informal interviews was descriptive of their activities though it did not feature technical vocabulary. Although Nicolette, a Stage VI swinger, did not use the word "pumping", she was able to describe her pumping behaviors very eloquently by saying "with my feet I kick backwards and forwards and with my arms I move them backwards and forwards, too--holding on
the bar." David, a Stage VII swinger, used similarly complex language to describe stomaching the swing:

David: "Um, um, my dad showed me how to jump on the swing and then to land on your tummy and kick your feet on the ground and you'll turn around. Then you lift your feet up and, and you don't kick and you start spinning real fast."

These children and others were able to use language to describe their activities. The level of their language development was comparable to that of their cognitive development.

The interaction of children's language and cognition in this investigation provides support for both the Piagetian and Vygotskian theories of cognitive development. Children added to and refined their existing cognitive structures through play on the swings. The development of their swinging behaviors was not dependent upon their abilities to use language to describe their activities. Three of the children exhibiting swinging behaviors in Stages V and VI, for example, did not refer to physics principles at all in their language interactions. Language and social interactions, however, provided many children with introductions to basic skills, with information on refining their behaviors, and with assistance when it was needed. Through social interactions children gained instruction on
initiating new behaviors and motivation for practicing and refining these behaviors.

Kinneavy's Purposes of Language

Kinneavy (1971) provided an additional framework with which to organize the children's language interactions in this investigation. He proposed a theory of discourse in which the aims or purposes of language were the central feature of communication between individuals and groups. The purposes and forms of language outlined in Kinneavy's theory of discourse provided the basis for the English Language Arts Curriculum Framework--K-12 (1980) developed by the Texas Education Agency.

Kinneavy outlined four purposes of language use in his theory. He emphasized, however, that these purposes almost never appear in isolation. While one purpose may be primary, other purposes usually operate at the same time in subordinant roles. Examples of each of these purposes can be found in the children's language interactions on the swings. The first purpose of language use was to provide information. Informative language is centered in reality. It is used to provide information and to answer questions with verifiable evidence. Children in this investigation used informative language in making general statements about their own abilities, such as Rebecca's statement "I can push big!" and in discussing their play environment. Tabitha and
Jane used informative language in the following discussion about the weather:

Tabitha and Jane sit down in the swings and begin to pump.

Tabitha: "It looks kinda like its going to rain today. See over there. Over there."

Tabitha gestures with her head to some clouds in the sky.

Jane: "Yes, but it's sunny over us."

The second purpose of language use described by Kinneavy was that of persuasion. Persuasive language is centered on the receiver. It is used in attempts to change the thinking of individuals or of groups. On the swings, children used persuasive language to encourage others to join in their activities or to imitate their behaviors. This was the type of language used in peer teaching strategies. Genetta used persuasive language with Randy when she attempted to teach him to pump:

Genetta and Randy are on the swings.

Genetta is kicking off to pump at a medium amplitude. Randy is idling on the swing.

Genetta (to Randy): "Do your legs like this. You want me to push you?"

Randy: "Yeah."

Genetta: "Then do your legs like this."
Randy kicks off a Point B. He leans and pumps to a small amplitude.

The third purpose of language use in Kinneavy's theory of discourse was literary. This purpose included language that is intended to give pleasure to both the speaker and the listener. The children's language during the two episodes of dramatic play on the swings observed in this study could be categorized as literary language. John frequently sang "Dump da dum!" to announce that he was doing something special on the swings that he wanted others to notice. Songs and rhymes verbalized by the children while swinging were also included in this category.

The fourth purpose of language use in Kinneavy's theory was expressive language. Expressive language is used to clarify the speaker's thoughts and feelings. On the swings, children used expressive language to share their joy or excitement in their own accomplishments as they acquired new behaviors. They also used expressive language to complain when other children were interfering in their activities. Spencer used expressive language to tell his teacher about Conrad's behavior on the swings:

Conrad and Spencer are swinging. Conrad spreads his legs and the swing tips back and begins to go crooked. Spencer stops his swing and watches Conrad.
Spencer: "Miss Patti, he’s not swinging right! He’s going crooked and it’s in my way. He better move right now."

During their play on swings in the outdoor environment, children use language for all four of the purposes outlined in Kinneavy’s theory. The inclusion of these purposes in the framework for language arts curriculum in programs for all age levels indicates their importance in children’s overall language development. Interactions on swings in the outdoor play environment provide an appropriate environment for practicing the four purposes of language use described in the framework for language arts curricula developed by the Texas Education Agency.

Implications

The analysis of data in this investigation holds implications for several areas of early childhood education. First, implications for child development theory can be drawn from the use of the Guttman scale model in this study. Second, implications for physical knowledge curriculum for children of all ages can be drawn from the analysis of children’s behaviors on the swing. Third, suggestions for further research on the study of young children’s construction of physical knowledge can be based on the findings of this study.
Theories of development provide constructs for viewing the behaviors that children exhibit in a given context. Two constructs that currently dominate research in child development are theories of stage development and theories of continuous development. Stage development theories propose that development occurs in a series of shifts, with abrupt changes occurring from one stage to the next. Continuous development theories, however, hold that development proceeds at a fairly stable and steady rate and that each new development is built upon the developments that precede it (Dworetzky, 1990). Both of these constructs can be supported with research on child development and both provide a valid perspective for viewing the development of children’s behaviors in this investigation.

Theories of continuous development acknowledge to a greater extent the role of environmental and social influences in children’s development. Although development is closely tied to genetics and biological maturation, learning and individual experiences play a significant role in children’s cognitive processing. The appearance of new behaviors, such as kicking off on the ground or pumping, is the result of an accumulation of learning and experience rather than abrupt occurrences in children’s development. These new behaviors have developed along a continuum and are built upon behaviors acquired by the children at earlier
points on that continuum. Table 8 provides a heuristic for viewing the continuous development of swinging behaviors in this investigation along side the stage development models previously discussed.

Although continuous development theories provide a valuable perspective for viewing children's development of swinging behaviors, the current investigation is based primarily on a stage development model. The developmental theories of Piaget and Vygotsky, which provide the basic assumptions for this investigation, support the use of a stage development model in researching young children's development. According to Forman and Kuschner (1983), Piagetian theory holds that child development occurs both in continuous stages because "the child knows an increasing amount" (p. 8), and in discontinuous stages because "the child's basic approach to the world undergoes qualitative changes" (p. 8). Vygotskian theory also describes children's development in terms of stages or periods. Vygotsky (1972) stated that the criteria for outlining the boundaries of developmental periods are not found in children's psychological development or in the growth of intellectual functions. Instead, such criteria may be found in the way one primary activity replaces another in children's behaviors and interactions.
Table 8
Comparison of the Four Constructs Used to View Children's Swinging Behaviors

<table>
<thead>
<tr>
<th>Guttman Scale on Swinging</th>
<th>Harrow's Taxonomy of the Psycho-Motor Domain</th>
<th>Cratty's Theory of Perceptual-Motor Behaviors</th>
<th>Phases of Swinging the Psycho-Motor Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I - Balance</td>
<td>Level I - Reflex</td>
<td>Level I - General</td>
<td>Phase A - Developing Supports of Behavior</td>
</tr>
<tr>
<td></td>
<td>Movements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage II - Observation</td>
<td>Level II - Basic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Trial-and-Error</td>
<td>Fundamental Movements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage III - Adaptation</td>
<td>Level III - Perceptual Abilities</td>
<td>Level II - Perceptual-Motor Ability</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Traits</td>
</tr>
</tbody>
</table>
Table 8 -- (continued)

<table>
<thead>
<tr>
<th>Guttman Scale on Swinging Taxonomy of the Psycho-Motor Domain</th>
<th>Theory of Perceptual-Motor Behavior</th>
<th>Phases of Swinging Behaviors</th>
</tr>
</thead>
</table>

Stage IV - Timing

Stage V - Level IV -
Demonstrating Physical Prowess Abilities

Stage VI - Level V -
Refinement Skilled Movements Level III - Task Specifics Movements

Stage VII - Level VI -
Security Non-Discursive Movements

Stage VIII -
Further Experimentation Phase B - Developed Behaviors
Fischer (1987) asserted that although adults and older children may develop cognitively in a continuous rather than a stage-like manner, the development of infants and young children is more stage-like because of their neurological immaturity. In his study of meaningful links between specific brain and cognitive developments, Fischer describes a relationship between the formation of synapses, the links by which neurons in the brain communicate, and sensorimotor development. Fischer states that when synapses are formed "new cognitive capacities appear" (p. 264). Although the formation of new synapses in the visual cortex peaks when the child is between eight and twelve months of age, in the frontal cortex the formation of new synapses does not peak until one to two years of age and does not decrease substantially until after the child reaches seven years of age. New cognitive capacities develop in a stage-like fashion throughout the sensorimotor and preoperational years.

In this investigation, the use of the Guttman scale to organize the development of children's swinging behaviors in a hierarchical stage model is based on DeVries' (1986) similar use of Guttman scale stages in her research on physical knowledge construction. As stated in Chapter 3, DeVries drew her rationale for using a Guttman scale from Piaget's assertion that "cognitive stages are qualitatively different structures that are sequential in an invariant
order and hierarchical in the sense that a later stage incorporates the preceding one" (p. 491).

Although the data analysis in this investigation supported the existence of hierarchical stages in children's development of swinging behaviors, Forman (personal communication, August 6, 1993) cautioned against the use of a Guttman scale model. Using such a model might obligate the researcher to create a greater number of stages than the data actually supports.

Forman's (personal communication, August 6, 1993) observations encouraged the researcher to return to the field to re-examine the number of stages outlined in the Guttman scale on swinging developed in this study. At this time, the final revision of the Guttman scale occurred, rearranging certain clusters of behaviors in Stages V, VI, and VII. These observations, however, supported a sequence of qualitative differences in both the children's physical behaviors and the goals for their interactions with the swings and with others in the play environment in eight hierarchical stages. The high rate of reproducibility on the Guttman scale (92.11%) established with the assistance of secondary researchers also supported the researcher's outline of hierarchical stages. As will be discussed in a later section of this chapter, the researcher did ascertain a need in these observations to replicate the current study on a sample of concrete operational children, focusing on
the development of behaviors in higher stages of the Guttman scale.

Although continuous stage development theories provide a useful and interesting perspective from which to view swinging behaviors, a stage development theory offers a more appropriate format in this investigation. Organized in a hierarchical sequence of development, the research may be discussed in the context of its theoretical bases and related to the findings of similar research efforts.

**Piagetian and Vygotskian Theories of Development**

The developmental theories of both Piaget and Vygotsky have been used to provide a theoretical basis for this investigation. Both theories provide appropriate constructs for analyzing the data collected. Piagetian theory explains the nature of young children's activities on the swings and how those early activities will contribute to the children's ultimate construction of physical knowledge. Vygotskian theory, however, explains the rich context in which early behaviors occur and the social environment necessary for their development. Further, Vygotskian theory recognizes the changing role of language in children's development of swinging behaviors. The nature of children's language while swinging changes over time. Initially, children's language is geared toward acquiring assistance and instruction and there is little evidence of self-reflection. At some point, though, the nature of language changes. It begins to
reflect children's knowledge of swinging and pride in their accomplishments. A social context is necessary for both the initial and later language interactions.

To summarize the role of Piagetian and Vygotskian theories in this investigation, both are essential for describing children's construction of physical knowledge on swings in the outdoor play environment. Piagetian theory explains the cognitive development that occurs in children's early interactions with swings and foretells how that development will continue given further opportunities for experimentation and reflection. Vygotskian theory describes the social context necessary for development to occur and the changing role of language throughout the developmental process.

**Implications for Educational Programs**

The findings of this investigation hold implications for instructional strategies and topics for learners of all ages. Although the most direct implications involve programs for young children and the purpose of play on swings in early childhood education, the findings also have ramifications for science programs for older children and for teacher education programs.

**Implications for Early Childhood Programs**

The study of physics principles related to pendulums begins with young children's earliest experiences on swings. Time is a key factor in these early experiences. Early
childhood programs should include sufficient time in their scheduling for young children to explore and practice swinging behaviors. These early explorations lay the foundation for constructing a formal understanding of the physics principles related to swings and pendulums. Social interactions during the early experiences should also be encouraged since they provide the primary means through which young children acquire swinging behaviors and the children's primary motivation for practicing those behaviors. Likewise, spontaneous language interactions should be encouraged and noted by the teacher as children use the four purposes of language.

**Implications for Teachers of Older Children**

Curriculum for older children that includes a study of pendulums should begin on swings in the outdoor play environment and build upon the information collected by children in their early experiences. Additional experiences on swings will assist older children in organizing existing information into schemes that can then be generalized in constructing an understanding of related physics principles. Meaningful social interaction from adults or more advanced peers will provide children with the technical vocabulary needed to build accurate verbal descriptions of these principles. Science curriculum for learners of all ages should incorporate direct experiences and meaningful language interactions to assist learners in constructing
their own understanding of physical knowledge within a meaningful context.

**Implications for Early Childhood Teacher Education Programs**

The results of this study indicate that it is important for teachers to understand not only how cognitive and physical development occur in young children, but also how teachers can facilitate that development by providing a supportive environment for experimentation and exploration. An understanding of play as the vehicle for children's development and learning is also essential for early childhood teachers. Teacher education programs must address these needs by providing beginning teachers with a broad knowledge base in child development and related issues and with field experiences for direct observation. Further, teacher education programs must emphasize the role of teachers in supporting children's development through positive interactions within each child's zone of proximal development. Observational assessment of children's development of behaviors and construction of knowledge is also an important activity for teachers of young children. Teacher education programs should train beginning teachers in observational skills and should provide practical experiences in using the information gained through observation in developing curriculum and planning instruction.
Implications for Further Research

The researcher suggests several changes for replicating the present study. First, interview questions should be developed only after initial observations reveal the physics principles on which the children are focusing. In the present study, the interview questions were developed prior to the delineation of the physics principles on which the children’s behaviors were centering. Therefore, the interviews were not as revealing as they might have been. Based on the behaviors of the children in this study, the researcher recommends the following questions for informal interviews.

1. How high can you swing? What does it feel like?
2. How do you make the swing go higher?
3. How do you make the swing go lower?
4. How do you stop the swing?
5. What parts of your body do you use when you swing? What do you do with your ______?
6. What would you say to teach somebody else how to swing?

Informal interviews should be open-ended and conducted immediately after children exit the swings. Individual questions should address each child’s experiences on the swings (e.g., What happened when you started swinging very
high? Why did you decide to stop the swing when you did? Can you explain what you did?)

A second suggestion for replicating the present study would focus on the language component. The researcher recommends that language be viewed in terms of its purposes for children in learning to swing. Kinneavy's (1971) purposes of language could be used to categorize the language interactions of the children on the swings and in informal interviews. These functions could then be compared to the stages of the Guttman scale.

The time of year at which this study was conducted may have affected the number of children who chose to play on the swings. Summer temperatures in northern Texas do not encourage physical exertion in outdoor play. A third suggestion for replicating the present study would be to conduct it in mid-spring or mid-fall when outdoor temperatures are more comfortable for the children's play. Also, the types of clothes worn by children during other times of the year may provide examples of resistance for children to explore.

Several suggestions for further research have developed in this investigation. First, replicating the present study on a population of older children would provide information on the behaviors of concrete operational thinkers and their strategies for organizing the information they have collected to develop schemes. Second, replicating the
present study in both preoperational and concrete operational children on other pieces of equipment in the outdoor play environment, such as slides, would provide a basis for generalizing the present findings to the construction of other areas of physical knowledge. Such a study would also refine by supporting or rejecting the use of a Guttman scale for organizing children's developing behaviors. Third, replicating the present study among children of divergent cultures would follow the criteria suggested by DeVries (1986) and Kohlberg (1987) for demonstrating the presence of stages in a given domain of thought, namely physical knowledge construction. Fourth, a study focusing specifically on novice swingers and their social interactions might provide a clearer picture of the role of language in children's development of swinging behaviors. Fifth, research on the neurological development of young children and its relationship to swinging behaviors would provide information for Fischer's (1987) hypothesis on continuous and discontinuous development in children of all ages.

Conclusions

Play on swings has been a part of the early childhood experience for generations of children across many cultures. The findings of this investigation indicate that swinging provides valuable experiences for children and their development in the cognitive, physical, social, language and
emotional domains. Further study of children's behaviors on swings in the outdoor play environment will assist researchers in understanding the complex nature of child development and the relationships between play and knowledge construction.
Dear Parents,

I am a doctoral candidate in early childhood education at the University of North Texas. As part of my dissertation I am interested in observing children's cognitive development in their outdoor play activities, particularly on the swings.

I request permission for your child to participate in this research study. I have received permission from the director of the Children's World Child Care Center to observe the children in the three-, four-, five-, and six-year-old classes during my research study. I will observe the children as they play on the swings during their normally scheduled outdoor time. I will record my observations on video tape, audio tape, and in written notes. These recordings will be made only with parental permission. The results of these observations will be presented to the committee of UNT professors who are supervising my studies. The video and audio tapes will be retained by me at the conclusion of the study. Portions of these tapes may be presented to students and teachers at professional conferences. To preserve confidentiality, pseudonyms will be used for the children, the center, and the teachers.

Your decision whether or not to allow your child to participate will in no way affect your child's standing in the child care center. At the conclusion of the study, a summary of the information gathered will be made available to all interested parents and teachers. Should you have any questions or desire further information, please call me at (817) 387-7039. Thank you in advance for your cooperation and support.

Sincerely,

Jill Englebright Fox
THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS.

Please fill out the form below. Then return it to the center director as quickly as possible.

I give permission for my child, ____________________________, to participate in this project.

I do not give permission for my child, ____________________________, to participate in this project.

________________________________________
Parent/Guardian signature
APPENDIX B

OBSERVATION SCHEDULE
# Observation Schedules

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<th>Thurs.</th>
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A = Center A  
B = Center B
APPENDIX C

FROST PLAYGROUND RATING SCALES
FROST PLAYGROUND RATING SYSTEM (AGES 3-8)
As Administered in Play Environment A

Instructions:
Rate each item on a scale from 0-5. High score possible on
Section I is 100 points, Section II is 50 points and Section III
is 50 points, for a possible grand total of 200 points. Divide
the grand total score by 2 to obtain a final rating.

Section I. What does the playground contain?
Rate each item for degree of existence and function on a scale of
0-5 (0 = not existent; 1 = some elements exist but not
functional; 2 = poor; 3 = average; 4 = good; 5 = all elements
exist, excellent (function).

_4_ 1. A hard-surfaced area with space for games and a
network of paths for wheeled toys.
_4_ 2. Sand and sand play equipment.
_4_ 3. Dramatic play structures (playhouse, car or boat
with complementary equipment, such as
adjacent sand and water and housekeeping
equipment).
_5_ 4. A superstructure with room for many children at
a time and with a variety of challenges and
exercise options (entries, exits, and
levels).
_0_ 5. Mound(s) of earth for climbing and digging.
_0_ 6. Trees and natural areas for shade, nature study
and play.
_1_ 7. Zoning to provide continuous challenge; linkage
of areas, functional physical boundaries,
vertical and horizontal treatment (hills and
valleys).
_0_ 8. Water play areas, with fountains, pools and
sprinklers.
_0_ 9. Construction area with junk materials such as
tires, crates, planks, boards, bricks and
nails; tools should be provided and
demolition and construction allowed.
_0_ 10. An old (or built) vehicle, airplane, boat, car
that has been made safe, but not stripped of
its play value (should be changed or
relocated after a period of time to renew
interest).
_3_ 11. Equipment for active play: a slide with a large
platform at the top (slide may be built into
side of a hill); swings that can be used
safely in a variety of ways (soft material
for seats); climbing trees (mature dead trees
that are horizontally positioned); climbing
nets.
12. A large soft area (grass, bark mulch, etc.) for organized games.


14. Fences, gates, walls and windows that provide security for young children and are adaptable for learning/play.

15. A garden and flowers located so that they are protected from play, but with easy access for children to tend them. Gardening tools are available.


17. A transitional space from outdoors to indoors. This could be a covered play area immediately adjoining the playroom which will protect the children from the sun and rain and extend indoor activities to the outside.

18. Adequate protected storage for outdoor play equipment, tools for construction and garden areas, and maintenance tools. Storage can be separate: wheeled toys stored near the wheeled vehicle track; sand equipment near the sand enclosure; tools near the construction area. Storage can be in separate structures next to the building or fence. Storage should aid in children’s picking-up and putting equipment away at the end of each play period.

19. Easy access from outdoor play areas to coats, toilets and drinking fountains. Shaded areas and benches for adults and children to sit within the outdoor play area.

20. Tables and support materials for group activities (art, reading, etc.)

Section II. Is the playground in good repair and relatively safe?

Rate each item for condition and safety on a scale of 0-5 (0 = not existent; 1 = exists but extremely hazardous; 2 = poor; 3 = fair; 4 = good; 5 = excellent condition and relatively safe yet presents challenge).

1. A protective fence (with lockable gates) next to hazardous areas (streets, deep ditches, water, etc.).

2. Eight to ten inches of noncompacted sand, wood mulch (or equivalent) under all climbing and moving equipment, extending through fall zones and secured by retaining wall.
3. Size of equipment appropriate to age group served. Climbing heights limited to 6-7 feet.

4. Area free of litter (e.g., broken glass, rocks), electrical hazards, high voltage power lines, sanitary hazards.

5. Moving parts free of defects (e.g., no pinch and crush points, bearings not excessively worn).

6. Equipment free of sharp edges, protruding elements, broken parts, toxic substances, bare metal exposed to sun.

7. Swing seats constructed of soft or lightweight material (e.g., rubber, canvas).

8. All safety equipment in good repair (e.g., guard rails, signs, padded areas, protective covers).

9. No openings that can entrap a child's head (approximately 3 1/2 - 9 inches). Adequate space between equipment.

10. Equipment structurally sound. No bending, warping, breaking, sinking, etc. Heavy fixed and moving equipment secured in ground and concrete footings recessed in ground. Check for underground rotting, rusting, termites, in support members.

Section III. What should the playground do?
Rate each item for degree and quality on a scale of 0-5 (0 = not existent; 1 = some evidence but virtually nonexistent; 2 = poor; 3 = fair; 4 = good; 5 = excellent). Use the space provided for comments.

1. Encourages Play:
   - Inviting, easy access
   - Open, flowing and relaxed space
   - Clear movement from indoors to outdoors
   - Appropriate equipment for the age group(s)

2. Stimulates the Child's Senses:
   - Change and contrasts in scale, light, texture and color
   - Flexible equipment
   - Diverse experiences

3. Nurtures the Child's Curiosity:
   - Equipment that the child can change
   - Materials for experiments and construction
   - Plants and animals

4. Supports the Child's Basic Social and Physical Needs:
   - Comfortable to the child
   - Scaled to the child
   - Physically challenging
5. Allows Interaction Between the Child and the Resources:
   Systematic storage that defines routines
   Semi-enclosed spaces to read, work a puzzle, or be alone

6. Allows Interaction Between the Child and the Other Children:
   Variety of spaces
   Adequate space to avoid conflicts
   Equipment that invites socialization

7. Allows Interaction Between the Child and Adults:
   Easy maintenance
   Adequate and convenient storage
   Organization of spaces to allow general supervision
   Rest areas for adults and children

8. Complements the Cognitive Forms of Play Engaged in by the Child:
   Functional, exercise, gross-motor, active
   Constructive, building, creating
   Dramatic, pretend, make-believe
   Organized games, games with rules

9. Complements the Social forms of Play Engaged in by the Child:
   Solitary, private, meditative
   Parallel, side-by-side
   Cooperative interrelationships

10. Promotes Social and Intellectual Development:
    Provides graduated challenge
    Integrates indoor/outdoor activities
    Involves adults in children's play
    Regular adult-child planning
    The play environment is dynamic--continuously changing.

Comments:

No loose parts evident.

FROST PLAYGROUND RATING SYSTEM (AGES 3-8)
As Administered in Play Environment B

Instructions:
Rate each item on a scale from 0-5. High score possible on Section I is 100 points, Section II is 50 points and Section III is 50 points, for a possible grand total of 200 points. Divide the grand total score by 2 to obtain a final rating.

Section I. What does the playground contain?
Rate each item for degree of existence and function on a scale of 0-5 (0 = not existent; 1 = some elements exist but not functional; 2 = poor; 3 = average; 4 = good; 5 = all elements exist, excellent (function).

___4___ 1. A hard-surfaced area with space for games and a network of paths for wheeled toys.
___3___ 2. Sand and sand play equipment.
___4___ 3. Dramatic play structures (playhouse, car or boat with complementary equipment, such as adjacent sand and water and housekeeping equipment).
___5___ 4. A superstructure with room for many children at a time and with a variety of challenges and exercise options (entries, exits, and levels).
___0___ 5. Mound(s) of earth for climbing and digging.
___3___ 6. Trees and natural areas for shade, nature study and play.
___3___ 7. Zoning to provide continuous challenge; linkage of areas, functional physical boundaries, vertical and horizontal treatment (hills and valleys).
___2___ 8. Water play areas, with fountains, pools and sprinklers.
___0___ 9. Construction area with junk materials such as tires, crates, planks, boards, bricks and nails; tools should be provided and demolition and construction allowed.
___0___ 10. An old (or built) vehicle, airplane, boat, car that has been made safe, but not stripped of its play value (should be changed or relocated after a period of time to renew interest).
___5___ 11. Equipment for active play: a slide with a large platform at the top (slide may be built into side of a hill); swings that can be used safely in a variety of ways (soft material for seats); climbing trees (mature dead trees that are horizontally positioned); climbing nets.
Section II. Is the playground in good repair and relatively safe?

Rate each item for condition and safety on a scale of 0-5 (0 = not existent; 1 = exists but extremely hazardous; 2 = poor; 3 = fair; 4 = good; 5 = excellent condition and relatively safe yet presents challenge).

__5__ 1. A protective fence (with lockable gates) next to hazardous areas (streets, deep ditches, water, etc.).

__5__ 2. Eight to ten inches of noncompacted sand, wood mulch (or equivalent) under all climbing and moving equipment, extending through fall zones and secured by retaining wall.
3. Size of equipment appropriate to age group served. Climbing heights limited to 6-7 feet.

4. Area free of litter (e.g., broken glass, rocks), electrical hazards, high voltage power lines, sanitary hazards.

5. Moving parts free of defects (e.g., no pinch and crush points, bearings not excessively worn).

6. Equipment free of sharp edges, protruding elements, broken parts, toxic substances, bare metal exposed to sun.

7. Swing seats constructed of soft or lightweight material (e.g., rubber, canvas).

8. All safety equipment in good repair (e.g., guard rails, signs, padded areas, protective covers).

9. No openings that can entrap a child’s head (approximately 3 1/2 - 9 inches). Adequate space between equipment.

10. Equipment structurally sound. No bending, warping, breaking, sinking, etc. Heavy fixed and moving equipment secured in ground and concrete footings recessed in ground. Check for underground rotting, rusting, termites, in support members.

Section III. What should the playground do?
Rate each item for degree and quality on a scale of 0-5 (0 = not existent; 1 = some evidence but virtually nonexistent; 2 = poor; 3 = fair; 4 = good; 5 = excellent). Use the space provided for comments.

1. Encourages Play:
   Inviting, easy access
   Open, flowing and relaxed space
   Clear movement from indoors to outdoors
   Appropriate equipment for the age group(s)

2. Stimulates the Child’s Senses:
   Change and contrasts in scale, light, texture and color
   Flexible equipment
   Diverse experiences

3. Nurtures the Child’s Curiosity:
   Equipment that the child can change
   Materials for experiments and construction
   Plants and animals

4. Supports the Child’s Basic Social and Physical Needs:
   Comfortable to the child
   Scaled to the child
   Physically challenging
5. Allows Interaction Between the Child and the Resources:
   Systematic storage that defines routines
   Semi-enclosed spaces to read, work a puzzle, or be alone

6. Allows Interaction Between the Child and the Other Children:
   Variety of spaces
   Adequate space to avoid conflicts
   Equipment that invites socialization

7. Allows Interaction Between the Child and Adults:
   Easy maintenance
   Adequate and convenient storage
   Organization of spaces to allow general supervision
   Rest areas for adults and children

8. Complements the Cognitive Forms of Play Engaged in by the Child:
   Functional, exercise, gross-motor, active
   Constructive, building, creating
   Dramatic, pretend, make-believe
   Organized games, games with rules

9. Complements the Social forms of Play Engaged in by the Child:
   Solitary, private, meditative
   Parallel, side-by-side
   Cooperative interrelationships

10. Promotes Social and Intellectual Development:
    Provides graduated challenge
    Integrates indoor/outdoor activities
    Involves adults in children's play
    Regular adult-child planning
    The play environment is dynamic--continuously changing.

Comments:
   Few loose parts evident.

APPENDIX D

GUTTMAN SCALE CHECKLIST OF SWING BEHAVIORS
GUTTMAN SCALE CHECKLIST OF SWING BEHAVIORS

Child’s First Name

Age

Date

Play Period

STAGE I

sits in swing

balances in swing seat

ready for motion to begin

requires a push from another person to begin motion

STAGE II

applies feet to ground

begins to put feet at angle for application of force meted for motion of swing

requires a push to begin motion

(Look for how long the foot is in contact with the ground and at what angle the foot is at contact)

STAGE III

applies force through hand and body alignment for good control of motion

requires a push to start motion or uses a running start

asks/strives for higher amplitude

begins to pump at appropriate location of swing

(Look for the angle of the body at points A & C)
### STAGE IV

- achieves a relatively small amplitude through pumping
- demonstrates an undeveloped back kick (foot flex is absent, legs apart)
- body, feet, and hands not fully coordinated
- demonstrates nonstandard start and stop methods
- plays with swing in other ways
- swings independently (no expectation of outside push)

### STAGE V

- height of swing is a goal of activity
- starts swing activity easily
- inconsistent in hand, foot, and body coordination while pumping

### STAGE VI

- stops swing motion with difficulty
- swing motion is generally jerky
- obtains a large amplitude
- incomplete follow through in leg movements

### STAGE VII

- swings in standard form
- stops and starts smoothly
- obtains and maintains a large amplitude
- experiments with dismount
STAGE VIII

_________ experiments with chain length

_________ experiments with circular motions

_________ intentionally achieves bumping effect at point C

_________ secure in personal and swing movements
APPENDIX E

FREQUENCY OF OBSERVATION EPISODES
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Total Number of Children at Center B -- 47

Total Number of Episodes at Center B -- 125

Total Number of Children at Centers A and B -- 91

Total Number of Episodes at Centers A and B -- 213
APPENDIX F

NUMBER OF GUTTMAN SCALES COMPLETED ON EACH CHILD,
AND FINAL STAGE EVALUATION
Number of Guttman Scales Completed on Each Child and Final Stage Evaluation

Center A

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Cratty's Theory of Perceptual-Motor Behaviors

Cratty (1969) developed a three-level theory of perceptual-motor behaviors to describe the role of movement tasks in an educational setting. In the first level, Cratty described general supports of perceptual-motor behaviors. These supports included children's initial interest in a specific behavior, persistence in practicing the behavior, ability to analyze the mechanics of the behavior, and the levels of expertise children hoped to attain. Cratty stated that in the initial stages of acquiring a perceptual-motor behavior, "the ability to analyze the mechanics and spatial dimensions of tasks influences learning and performance" (p. 26).

The second level of Cratty's theory described ability traits. These traits were related to the physical abilities children bring to specific tasks. The speed, strength, and accuracy of various body parts and combinations of body parts were included in this level. Cratty asserted that "ability traits...are changed if the individual continues to practice activities which enhance these attributes" (p. 29).

The third level of Cratty's theory described factors that were specific to a particular behavior and the situation in which it occurred. Past experience with that behavior were included in this level, as were the social conditions in which the behavior was practiced.
APPENDIX H

HARROW'S TAXONOMY OF THE PSYCHOMOTOR DOMAIN
Harrow’s Taxonomy of the Psychomotor Domain

Harrow’s (1972) taxonomy of the psychomotor domain described six levels of movement "as a way of viewing, explaining, and categorizing" (p. 1) children’s movement behaviors for educators. In the first level of Harrow’s taxonomy were those reflex movements which are voluntary in nature. Included in this level were segmental reflexes which maintain tension in certain muscles to facilitate adjustments in the child’s balance, and postural reflexes utilized by the body to maintain support in an upright position.

In the second level of Harrow’s taxonomy, children focused on basic-fundamental movements. Basic-fundamental movements included locomotor activities which "get the learner from one place to another" (p. 52), and non-locomotor movements such as pushing and pulling.

The third level of Harrow’s psychomotor domain dealt with perceptual abilities. Behaviors in this level included eye-hand and eye-foot coordination, children’s awareness of directional concepts, and their body awareness within a specific context. These and other perceptual abilities assisted children in interpreting stimuli so that they could make adjustments to the environment when needed.

Level 4 in Harrow’s taxonomy described the physical abilities developed for use in making skilled body movements. Endurance, strength, flexibility, and agility
were components of this level. These qualities played an important role within the taxonomy because of their contribution to efficient movement.

Efficient movement was also a focus in Level 5 of Harrow's taxonomy. In this level, however, the degree of proficiency the child obtains was key. This proficiency was described in terms of integrated behaviors.

The sixth and final level of Harrow's taxonomy of the psychomotor domain focused on communication through movement. "Each learner develops a style of moving which communicates his feelings about his affective self to the perceptive observer" (p. 90). Communication behaviors were developed after extensive practice of the behavior and were highly individualized.
APPENDIX I

A CASE STUDY OF THE STAGE DEVELOPMENT OF SWINGING BEHAVIORS DURING THE OBSERVATION PERIOD
A Case Study of the Development of Swinging Behaviors During the Observation Period

Kristin is a three-year-old at Center B. During the five weeks of data collection, Kristin demonstrated a developmental progression of swinging behaviors. Table 9 depicts a timeline of this progression. Kristin was observed at play on the swings frequently during observations at Center B, and a total of eleven Guttman scales were completed on her swinging behaviors. Her teacher reported that prior to data collection Kristin's participation in swinging activities had been minimal. The teacher suggested that the presence of the video camera and the researcher's specific focus on the swings encouraged Kristin's interest in swinging.

During the first observation on July 13 Kristin's primary focus was on pushing others in the swings. She attempted to push her peers on three occasions, even when they indicated that they did not need or desire her assistance. Kristin's behaviors at this time illustrated her understanding that outside pushes were essential for moving the swing. When Kristin was seated on the swing she exhibited Stage I behaviors and waited patiently for the teacher or other children to push her. These behaviors were consistent during the next three observations. Kristin made no attempt to move her swing through her own efforts and frequently tried to push her peers.
On July 23, Kristin first demonstrated a Stage II behavior when she stomached the swing to achieve movement independently. While seated in the swing, however, she continued to request outside pushes and made no effort to pump herself. On July 27, Ebony, a Stage VII swinger, offered Kristin direct instruction on pumping. Seated on the swing next to Kristin, Ebony urged "Kristin, move yur legs back. Kristin, move your legs back. Kristin, do like this! Kristin, do like this! Kristin, do like this!"

Kristin watched Ebony and then bent and straightened her legs three times. Her movements had little effect on the swing's amplitude and she continued to request pushes from others in the play environment.

On July 29, when Kristin requested a push from her teacher, the teacher responded, "You got to learn to pump, child!" Kristin did not attempt to move her legs and requested a push from the researcher instead.

Kristin's first successful efforts in pumping occurred on August 2. She seated herself on the swing and watched Spencer, a Stage III swinger, for a few moments. She requested and received a push from the researcher, and as her swing slowed, Kristin began to imitate Spencer's trunk and leg movements. She was able to sustain a small amplitude through her pumping movements. Again, Kristin requested a push from the researcher, but before the researcher could respond, Kristin kicked off on the ground.
and applied considerable force to her swing. She announced "Hey! I pushed my own self!" and repeated her kick off. She continued to practice this movement throughout the observation.

Two days later, on August 4, Kristin started her swing's motion independently with a leaning start and achieved a medium amplitude through her own pumping efforts. She refused two offers of outside pushes and told her teacher proudly "I can do it my own self now."

On August 6 Kristin again demonstrated independent swinging behaviors and worked to sustain a medium amplitude through pumping. She exited her swing on two occasions by jumping from the seat at Point B while still retaining her grasp on the chains.

Although Kristin's final evaluation on August 10 placed her firmly in Stage III of the Guttman scale, she had begun to demonstrate some higher stage behaviors. She was able to begin her swing's motion easily with a leaning start and, though her back kick was still undeveloped, her pumping behaviors had matured. Kristin focused on obtaining a high amplitude and she had begun to compare her amplitude with that of other swingers.

Kristin's behaviors on the swings during the first five weeks of data collection clearly illustrate a developmental progression. They also provide a description of the role of language and social interactions in the development of
swinging behaviors. Through modeling, instruction and repeated practice, Kristin acquired basic behaviors on the swings. Given further opportunities for practice and interaction Kristin will continue to refine her swinging behaviors and will construct an understanding of the related physics principles.
Table 9

Timeline of Kristin’s Development of Swinging Behaviors

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<td>- Moves legs in attempt to pump</td>
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<td>told to pump</td>
<td>imitates body</td>
<td>uses a leaning</td>
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<td>but did not attempt</td>
<td>movements of others;</td>
<td>start;</td>
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<td>asks for higher amplitude;</td>
<td>achieves a medium amplitude through pumping;</td>
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<tr>
<td></td>
<td>kicks off on the ground;</td>
<td>refuses outside push</td>
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<tr>
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<td>&quot;Hey, I pushed my own self!&quot;</td>
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<td>demonstrates a nonstandard stop</td>
<td>strives for higher amplitude;</td>
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<td>undeveloped back kick;</td>
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<td>compares self to others;</td>
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<tr>
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<td>starts swing motion easily</td>
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REFERENCE LIST


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