THE EFFECTS OF ALIGNED DEVELOPMENTAL FEEDBACK ON THIRD-GRADE STUDENTS’ PERFORMANCE IN OVERHAND THROW FOR FORCE

DISSERTATION

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The Degree of Doctor of Philosophy in the

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By

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* * * *

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This study examined the influence of aligned developmental feedback (ADFB) on student performance of the overhand throw for force in a naturalistic physical education setting, including possible gender differences. The second objective was to determine whether teacher professional development improved content knowledge and pedagogical content knowledge in throwing and the teacher’s ability to deliver ADFB. Participants (n=97) were from four 3rd-grade classes, each randomly assigned to a comparison or experimental group. Both groups received 80 min of throwing practice during seven throwing sessions. Mean body component levels for the step, trunk, humerus and forearm and mean ball velocity scores were calculated from the five throwing trials at the pretest, posttest, and retention test. During Phase 1 the teacher delivered seven sessions of throwing to the comparison group (n=49) using his own feedback but standardized throwing lesson plans. During Phase 2, the teacher was trained to deliver ADFB and teacher feedback was recorded during each session using the ADFB observation system. In Phase 3 the teacher delivered the same seven throwing lesson plans as Phase 1 to the experimental group (n=48), but with the provision of ADFB. An ANOVA revealed significant differences in ADFB between the groups with the experimental group receiving significantly greater ADFB than the comparison group demonstrating the impact of the teacher professional development training. A 2 Group X 2 Gender ANOVA
with repeated measures revealed a non-significant Group effect in pretest ball velocity scores ($p = .374$) but a significant Gender effect ($p < .001$). A 2 Group X 2 Time X 2 Gender ANOVA with repeated measures on ball velocity scores revealed a significant Group X Time interaction ($p = .020$) from pretest to posttest with the experimental group significantly better than the comparison group in ball velocity across the intervention. A 2 Group X 2 Gender multivariate analysis of variance (MANOVA) on body component scores revealed a non-significant Group effect ($p = .361$) revealing no significant differences between the groups in the body components at the pretest. A significant multivariate Group X Time interaction ($p = .001$) was found indicating groups differed over time. Follow-up univariate analyses revealed a significant Group X Time interaction for only the humerus body component. The posthoc paired-sample t-tests revealed that both the experimental and comparison groups improved significantly from pretest to posttest on the step component ($p = .001$) and the humerus component ($p = .002$). However, the experimental group also improved significantly from pretest to posttest in the forearm component ($p = .002$). Separate post-hoc 2 Group X 2 Gender ANOVAs on the posttest scores revealed a significant Group effect for the step ($p < .001$) and humerus components ($p < .001$) with the experimental group better than the comparison group. Gender differences were present in the body components at the pretest regardless of group ($p < .001$), these differences were maintained throughout the posttest and retention test. Effects at the end of the intervention maintained throughout retention for both groups in body components and velocity scores. The findings demonstrate the importance of ADFB in the learning process and how such feedback can enhance a student’s performance on the overhand throw.
Dedicated to My Parents,

SHLOMIT AND ZELLY COHEN
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FIELD OF STUDY

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CHAPTER 1

INTRODUCTION

Children learn and develop through dynamical interaction with their environment and the tasks they experience (Goodway & Savage, 2001; Garcia & Garcia, 2006). School physical education lessons serve as one valuable learning environment in which children experience appropriate tasks and have the opportunity to grow and develop. Fundamental motor skills are important developmental skills that children must learn (Goodway & Savage, 2001; Garcia & Garcia, 2006; Payne & Isaacs, 2007). Therefore, one of the primary goals of physical education is to assist students with motor skill acquisition (Payne & Isaacs, 2007). Physical education teachers play a critical role in the motor learning of children, specifically, they provide the extrinsic information that is essential to student learning (Bilodeau & Bilodeau, 1961; Brophy, 1979; Fishman & Tobey, 1978; Magill, 1993, 1994; Newell & Valvano, 1998; Stroot, 1990; Tan, 1996). This extrinsic information provided by teachers is commonly called feedback. Feedback is a term that represents teacher’s comments, suggestions, and directions in response to students’ specific actions or performance (Fishman & Tobey, 1978; Tan, 1996). Because different children have different errors in performance, the physical education teacher...
needs to provide appropriate feedback for the students in order to correct and improve their performances.

There are many types of feedback identified in the literature such as augmented feedback (Fishman & Tobey, 1978), information feedback (Newell & Valvano, 1998), and congruent feedback (Rink, 2003). The different types of feedback share many commonalities, but there are often subtle differences in the terms (Cohen & Goodway, 2006). Also, different disciplines such as pedagogy and motor learning use different definitions of feedback. In order to develop a clear understanding of the term feedback, this study used the term aligned developmental feedback. Aligned developmental feedback describes the feedback that the teacher delivers to students that is aligned to the developmental levels of the students’ performances (in this study, the skill of overhand throwing for force).

The literature reviewed indicated that teachers who deliver verbal cues and feedback statements that are not aligned to student performance did not improve student outcomes (Fronske, 1997; Stroot, 1990; Oslin, Stroot, & Siedentop, 1997; Yerg, 1981). It was precise feedback that had impact on student performance and improved their movement patterns in contrast to general cues that were delivered during practice (Ramella, 1984; Shapiro, 1977; Silverman et al., 1992; Stroot, 1990; Stroot & Oslin, 1993). In addition, in order to improve student performance, teachers need to consider where the child is developmentally, and prioritize their feedback statements to student ability to process the information delivered as feedback statements (Ramella, 1984; Shapiro, 1977; Stroot, 1990; Oslin, Stroot, & Siedentop, 1997; Tan, 1996; Thomas, Mitchell & Solomon, 1979; Yerg, 1981). Thus, the term aligned developmental feedback
(ADFB) was selected by the researcher to reflect the type of feedback considered the best type of feedback to improve student learning.

Feedback studies have reported that many teachers provide general feedback that is not properly aligned with each student’s developmental level (Rink, 2003; Stroot, 1990; Tan, 1996). A teacher’s ability to provide appropriate feedback to students relies, in part, on the teacher’s ability to observe the skill accurately and evaluate the developmental level of each student. Then the teacher must be able to select an appropriate feedback statement that is aligned to the observed student’s developmental level (Stroot, 1990; Oslin, Stroot, & Siedentop, 1997; Yerg, 1981; Tan, 1996).

The Importance of Feedback

Feedback is considered an important teaching function in physical education pedagogy (Lee et al, 1993, Rink, 2003) because it provides the students with information about their performance as well as supports their effort and build a positive learning climate (Magill, 2004; Siedentop & Tannehille, 2000, Tan, 1996). In general, teachers provide feedback in the form of positive, nonspecific evaluative verbal statements (Rink, 2003; Stroot, 1990; Tan, 1996). For example, when a student practices an overhand throw during a lesson, teachers often use common, general positive feedback such as “well done” or “good job,” which is supportive but does not inform the student about the way he or she performed the skill (Garcia & Garcia, 2006; Lee et al., 1993; Rink, 2003). In both the theoretical and applied literature, feedback that offered more than simple, general feedback, (aligned developmental feedback, as it is called in this study) was found to be a powerful and relevant information variable for skill acquisition (Bilodeau & Bilodeau, 1961, Newell, 1991; Newell & Valvano, 1998, Magill, 1994).
Literature in the area of motor learning and the classroom suggests that feedback is an essential element in learning new skills under certain conditions (Lee et al., 1993; Silverman, et al., 1992; Rink, 2003). According to Bilodeau and Bilodeau (1961), Brophy (1979), and Stroot (1990), one of the most effective teaching strategies is the ability of the teacher to provide specific feedback that is aligned to the movement when the student does not correctly perform the critical features of the skill. Magill (1994) suggested that the critical concern regarding feedback must be to determine two things: (a) what information to give the student (general feedback vs. ADFB), and (b) how to deliver the feedback (to individuals vs. to a group). According to Gangstead and Beveridge (1984), in order for teachers to offer students useful feedback that will help them improve their performances, teachers must have good observation skills and they must help their students understand how to evaluate their own performances and improve using the feedback they are provided.

*The Importance of Teacher Content Knowledge in Providing Feedback*

According to the National Council for Accreditation of Teacher Education (NCATE) Standard 1, teachers should not only make appropriate adjustments to their instruction to help each student learn, but they also need to have an in-depth understanding of the content knowledge they plan to teach (NASPE, 2004).

Having in-depth content knowledge allows teachers to better provide ADFB, because with an extensive understanding of the content teachers are able to provide multiple explanations and instructional strategies to improve the students’ learning processes (NASPE, 2004). There are two kinds of content knowledge: subject content knowledge, and pedagogical content knowledge (PCK) that are essential for effective
teaching (Chen & Ennis, 1995). According to Shulman (1986), subject content knowledge refers to concepts, principles, and skills within a particular subject discipline. Shulman (1986) labeled PCK as the best form of representing the subject matter knowledge, the most powerful examples, analogies, explanations, and the demonstration of the material being taught.

Teachers must have a depth of both subject and PCK to be able to detect errors and provide appropriate ADFB (Armstrong & Hoffman, 1979; Stroot, 1990). Therefore, it is not surprising that more effective teachers provide more feedback than less effective teachers, and that teachers with a limited background in the skill being taught may fail to recognize and correct student errors (Oslin, Stroot, & Siedentop, 1997; Yerg, 1981). Teachers with good subject-matter knowledge are more likely to be able to identify the developmental level of a child’s performance and provide appropriate content-related feedback (Fronske, 2005; Stroot, 1990). The relationships among teachers’ observational skills, their content knowledge, and their ability to deliver ADFB were a secondary propose of this study.

**Theoretical Framework**

The dynamical system theory and constraints models provided the theoretical framework for this study. The constraints model within the dynamical system theory (Newell, 1986) is the predominant theory in motor development that explains the emergence of motor skill development. The constraints model (Newell, 1984, 1986) articulates that constraints on action determine the development of fundamental motor skills and provides a framework to examine the factors influencing motor skill development. The three categories of constraints identified are individual (or organismic),
environmental, and task (Newell, 1986). The three different types of constraints interact with each other to affect the mover’s action (Newell & Valvano, 1998).

*Fundamental Motor Skills and Overhand Throwing for Force*

Fundamental motor skills help children control their bodies, manipulate their environment, and form complex skills and movement patterns involved in sports and other recreational activities (Goodway and Savage, 2001; Graham, Holt/Hale & Parker, 2004). The National Association for Sport and Physical Education (NASPE, 2004) has recommended that children need to demonstrate competency in motor skills, specifically developing skill and proficiency in basic movements such as throwing so they can apply them to game situations. Overhand throwing for force is a critical fundamental motor skill that is an object control skill. It is one of the most important skills in physical education due to its extensive use in a variety of sports (Butterfield & Loovis, 1993). Teaching the throw in the elementary years will give students the capacity for successful and advanced levels of performance (NASPE, 2004), which may increase the likelihood of their participation in games and recreational sports that utilize throwing as a foundational skill.

Overhand throwing for force has been studied by many researchers using both a product and process approach to throwing (Garcia & Garcia, 2002; Langendorfer & Roberton, 2002a; Moore & Reeve, 1987; Roberton & Konczak, 2001; Thomas & French, 1985). One approach to examining how throwing develops is the component approach to throwing (Roberton, 1977). This approach suggests that children progress through a series of developmental levels in each of five different body components: step, trunk, backswing, humerus, and forearm (Roberton, 1977). That is, early attempts at throwing
are immature and primitive, but with practice and feedback, children develop increasingly more efficient patterns of the movement (Goodway & Savage, 2001; Halverson & Roberton, 1979; Halverson et al., 1977).

One product measure that has been used to evaluate the throw is the velocity of the throw (Roberton and Konczak, 2001). This measure does not describe the way in which children throw but instead is interested in the outcome (or speed) of the throw (Roberton and Konczak, 2001). Assessment of the overhand throw performance can be beneficial both to the teacher and to the students (Roberton and Konczak, 2001). The product measure can be used to keep the students motivated and engaged in the activity, while the process measures can be beneficial for the teacher to evaluate the outcomes of the throwing movement patterns (Roberton and Konczak, 2001).

Research in motor development has demonstrated that gender differences in throwing exist and increase with increasing age, with males outperforming females in all aspects of the throw (Greendorfer, 1980; Sherif & Rattray, 1976; Thomas & French, 1985). Males have qualitatively better throws than same-aged females (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002b). Also, males throw with a greater velocity than females at all ages (Halverson et al., 1982; Roberton et al., 1979).

For children to learn throwing they need feedback and opportunities to practice. Research has shown that when children are provided with feedback and opportunities to practice, they improve their performance. There are a number of different approaches to teach the overhand throw such as in the SPARK (Sports, Play, and Activity Recreation for Kids) programs (McKenzie et al., 1998), the biomechanical-
developmental approach (Stodden, 2002), the use of critical cues (Lorson, 2003), and different types of modeling (Adams, 2001). In all cases when children were provided with feedback on their throwing performance and practice they improved their throwing performance from pretest to posttest (Garcia & Garcia, 2002; McKenzie et al., 1998; Oslin, Stroot & Siedentop, 1997).

Statement of the Problem

Feedback is a critical variable in the motor skill learning of children (Bilodeau & Bilodeau, 1961, Newell, 1991; Newell & Valvano, 1998, Magill, 1994). Much of the research in physical education pedagogy on feedback has focused on teacher behavior with little or no examination of the influence that feedback has on individual student learning (Magill, 1994; Rikard, 1992). Pedagogy feedback literature has examined: (a) the amount and the type of feedback episodes that teachers deliver (James, 1971; Masser, 1987; Paese, 1987; Pellett & Harrison, 1995; Rikard, 1991, 1992; Stroot, 1990); (b) the different skill levels (high skilled vs. low skilled students) to which teachers deliver feedback (Pellett & Harrison, 1995; Rikard, 1991, 1992; Silverman, Tyson, & Krampitz, 1992; Silverman, Woods, & Subramaniam, 1999; Wulf et al., 2002), and (c) the different amounts of teacher feedback provided to boys and girls (Erbaugh, 1985; Kerr & Booth, 1978; Shapiro, 1977). Thus far, the research in pedagogy feedback has not examined how the type and amount of teacher feedback influences student performance. Additionally, it is not clear from the literature whether ADFB is better than general feedback with respect to improving student performance.
Significance of the Study

This study provided much-needed data on the effect that ADFB has on student performance in a naturalistic physical education setting. Furthermore, the relationships among the teacher’s content knowledge, ability to observe overhand throwing for force, and ability to deliver ADFB were examined to provide data regarding the importance of these teaching skills to improving student performance.

Purpose of Study

The primary purpose of this study was to examine the influence of ADFB on student performance of the overhand throw for force in a naturalistic physical education setting. A secondary purpose to the main purpose was to examine possible gender differences in throwing performance as a result of teacher feedback. The third purpose of the study was to explore whether teacher professional development would improve content knowledge and pedagogical content knowledge in throwing. Additionally, this study was designed to examine the influence of teacher professional development on the ability to deliver ADFB.

Research Questions

See Table 1.1 for the research questions of this study.
<table>
<thead>
<tr>
<th>No.</th>
<th>Research Question</th>
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<tbody>
<tr>
<td>1</td>
<td>Were there any pre-to-posttest differences in teacher knowledge before and after the professional development?</td>
</tr>
<tr>
<td>2</td>
<td>What type and amount of feedback was delivered to the students in the comparison group and the experimental group?</td>
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<tr>
<td>3</td>
<td>Were there any differences in total amount of feedback delivered to the Experimental and Comparison group?</td>
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<td>4</td>
<td>Were there any differences between the amount of aligned developmental feedback delivered to the Experimental and Comparison group?</td>
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<td>5</td>
<td>Were there any differences between the amount of positive feedback delivered to the Experimental and Comparison group?</td>
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<tr>
<td>6</td>
<td>Were group differences present in pretest throwing velocity between the Comparison and Experimental group?</td>
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<td>7</td>
<td>Were gender differences present in pretest throwing velocity?</td>
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<td>8</td>
<td>Were gender differences present between and within the Comparison and Experimental group pretest throwing velocity scores?</td>
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<td>9</td>
<td>Were there any group differences in pre-to-posttest throwing velocity?</td>
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<td>Were there any gender differences in pre-to-posttest throwing velocity between &amp; within the Experimental and Comparison groups?</td>
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<tr>
<td>11</td>
<td>Were there any post-to-retention test differences in throwing velocity between the Experimental and Comparison groups?</td>
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<td>12</td>
<td>Were there any gender differences in post-to-retention test throwing velocity between &amp; within the Experimental and Comparison groups?</td>
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<td>13</td>
<td>Were group differences present in the body components between the Comparison and Experimental group?</td>
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<td>Were gender differences present in pretest body components between the Comparison and Experimental group?</td>
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<td>16</td>
<td>Were there any pre-to-posttest differences in body components between the Experimental and Comparison groups</td>
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<td>17</td>
<td>Were there any gender differences in pre-to-posttest body components between &amp; within the Experimental and Comparison groups?</td>
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<td>18</td>
<td>Were there any post-to-retention test differences in body components between the Experimental and Comparison groups?</td>
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<td>19</td>
<td>Were there any gender differences in post-to-retention test in body components between the Experimental and Comparison groups?</td>
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<td>20</td>
<td>Were there any gender differences in participation in organized baseball or t-ball?</td>
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<tr>
<td>21</td>
<td>Were there any gender differences in practicing throwing with a family member or friend out side of school?</td>
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<tr>
<td>22</td>
<td>What is the influence of prior throwing experience, and gender on pretest throwing velocity?</td>
</tr>
<tr>
<td>23</td>
<td>What is the influence of prior throwing experience, group, and gender on posttest throwing velocity?</td>
</tr>
</tbody>
</table>

Table 1.1. Research Questions.


Limitations

Limitations, as used in the context of this research, refer to limiting conditions or restrictive weaknesses (Locke, Spirduso, & Silverman, 1987). There are times when all factors cannot be controlled as part of a study design, or when the optimal number of observations simply cannot be made because of problems involving ethics and feasibility. If the investigator has given careful thought to these problems, and has determined that the information to be gained from the compromised aspect of the study is nevertheless valid and useful, then the investigator proceeds but duly notes the limitation (Locke, Spirduso, & Silverman, 1987). The limitations of this study were:

1. Lack of randomization of the participants as a result of the natural setting. The participants were not randomly assigned to one of the independent variables since they were part of an intact class; instead, the classes were randomly assigned to the independent variable.

2. The amount of teacher feedback provided to each participant during practice. It was the intent of the researcher to examine the influence of teacher feedback in a natural environment, in contrast to the motor learning studies conducted in a laboratory setting with maximum control of the independent variable. Teacher feedback was monitored to determine the type and amount of feedback; however, the amount of feedback was not controlled by the researcher.

3. Data on low velocity throws. The radar gun used in this study to record the ball velocity data could only record throwing that was faster than 25 miles per hour.
Changes in velocity for participants who threw slower than 25 miles per hour were not possible to measure, and their results were recorded as a zero.

4. Participants’ prior experience and knowledge of the skill. Overhand throwing for force is a fundamental motor skill that may have been practiced by some or all of the participants outside of class. Therefore, the data is limited because students might have other experiences that affect their performances beside teacher feedback.

5. Students’ prior experience. A child with extensive experience with throwing may have demonstrated a high skill level of overhand throwing during the initial assessment, therefore limiting gains in the posttest and retention test (i.e., possible ceiling effect).

Delimitations of the Study

Delimitations describe the populations to which generalizations may be safely made. The generalizability of the study was a function of the subject sample and the analysis employed. Delimit literally means to define the limits inherent in the use of a particular construct or population (Locke, Spirduso, & Silverman, 1987). The delimitations of this study are:

1. The participants were third-grade students in a suburban Midwestern school. Students in other grades or other geographic or urban school districts might provide different results.

2. The physical education teacher who took part in this study had 7 years of experience and was familiar with teaching the overhand throw. Teachers with a different teaching experience may provide different results.
3. The designated task for the study was overhand throwing for force. Similar studies on other skills might produce different results.

**Definition of Terms**

**Aligned Developmental Feedback (ADFB)**

Feedback statements that match the observed developmental level of the students’ throwing performance.

**Component**

A specific body segment of the throw (Langendorfer & Roberton, 2002).

**Component Approach**

A developmental sequence of the overhand throw describing changes in different body sections during the movement. The component approach for the overhand throw consists of five components: step, trunk, backswing, humerus, and forearm (Roberton, 1978).

**Constraints**

Boundaries or features that interact to limit the form of biological systems searching for optimal states of organization (Newell, 1984, 1986). The three categories of constraints are organismic (or individual), environmental, and task (Newell, 1986).

**Critical Cues**

Short and concise phrases given as verbal key words by the instructor that convey the critical elements of a movement during practice (Fronske, 2005; Landin, 1994).

**Critical Features**

Key elements of a movement that are the most important for optimal performance (Knudson & Morrison, 1997).
Developmental Sequence of the Overhand Throw

The qualitative changes that occur in the individual’s body during performance as he or she practices the same task over time (Roberton & Konczak, 2001).

Environmental Constraints

Constraints pressuring the system components that are shaping the behaviors of the dynamic system (Newell, 1984, 1986). Also referred to *contextual constraints*.

General Positive Feedback

Feedback that supports student effort and builds a positive learning climate Example: Good job, Well done, Very nice, That’s the right idea (Siedentop & Tannehill, 2000).

Individual Constraints

The learner characteristics associated with a student’s body weight, height, and shape (Newell, 1984; 1986). Also referred to *organismic constraints*.

Intervention

A procedure, technique or strategy designed to modify an ongoing process. The particular arrangement of environmental events that the researcher manipulates during experimental study to check for effects on the dependent variable (Cooper, Heron & Heward, 1987). Also called Independent variable.

Knowledge of Performance (KP) Feedback

The information delivered to the learner that refers to the movement while performing the skill and leads to the outcome (Magill, 2004).
Knowledge of Results (KR) Feedback

The information provided about the outcome of the movement (Magill, 2004).

Developmental Level

The description of the different movements within each component; each level is organized in a hierarchical order from least mature to most mature (Roberton, 1978).

Non-Aligned Feedback

Feedback statements that are: (a) not aligned with the observed developmental level of the child’s throwing performance, (b) not drawn from feedback statements that are aligned to the developmental sequence of throwing, and (c) drawn from the developmental sequence feedback statements, but do not align with the observed developmental level of the child’s performance.

Pedagogical Content Knowledge

Pedagogical content knowledge is the most appropriate form of representing the subject matter knowledge, the most powerful examples, analogies, explanations, and the demonstration of the material being taught (Shulman, 1986).

Process Measures of Throwing

The throwing form of body movement which can be assessed using either a component or a total body approach (Payne & Isaacs, 2007). Also referred to the qualitative measures.
Product Measures of Throwing

The ball velocity, throwing distance, and throwing accuracy measures such as the number of times the target was hit (Payne & Isaacs, 2007). Also referred to as outcome measures.

Subject Content Knowledge

The concepts, principles, and skills within a particular subject discipline (Shulman, 1986, 1987).

Task Constraints

The curriculum, goals, methods, teaching strategies, content, and material that teachers’ select to use during lessons for instruction and student learning (Ennis, 1992).
CHAPTER 2

REVIEW OF LITERATURE

Introduction

This chapter is broken down into the theoretical framework of my study, focusing on the dynamical systems theory and the constraints model and how they are applied to feedback as an environmental constraint on students performing the overhand throw. The importance of feedback related to motor skill acquisition, as well as the importance of ADFB in motor learning and pedagogy research (both in laboratory and naturalistic settings) are also covered. The interaction between teacher content knowledge and observation skills are explained, as are age and gender differences in fundamental motor skill development and performance. The fundamental skill of throwing is then focused on, including the skill’s importance, how to assess performance of the skill, and how the constraints model is applied to the skill.

Theoretical Framework

The dynamical system theory and the constraints model (Newell, 1986) provide the theoretical framework for this review. Movement is a product of the cooperation of many subsystems in the body such as muscular strength, neurological status, and skeletal systems (Payne & Isaacs, 2007). These subsystems are frequently interacting and
changing, and each movement pattern requires different subsystems that are important for the specific skill or activity (Payne & Isaacs, 2007).

Dynamical System Theory

The dynamical system theory explains how motor performance, such as the overhand throw for force, can change as a result of many factors. The dynamics of change occurring over time are influenced by a variety of critical factors within the system (such as the task, the individual, and the environment). Common patterns of movement (such as the stages of throwing) seen under specific conditions are referred to as dynamic attractors. These dynamic attractors are influenced by individual, task and environmental constraints that influence performance (Davids et al., 2003; Payne & Isaacs, 2007).

There are three primary principles of the dynamical system theory. The first is complexity. Thelen (2005) explains this principle by stating that all human behavior and actions (mental and physical) are products of different human mental and physical parts that act on and react to each other under any combination of tasks or constraints to create a coherent pattern. Thelen (2005) also explains the interaction of all variables as nonlinear, meaning that there is no one specific and clear order that causes the same outcome every time the variables interact. The second principle of the dynamic system theory is continuity in time. Simply put, this means that the state of the system changes in regard to the states before the present state and that this present state affects any states after it (Thelen, 2005). These changing states are not independent of one another, then, but are intimately bound to one another (Thelen, 2005). The third principle of the dynamical system theory is the concept of dynamic stability. According to Thelen (2005),
it is normal for dynamic systems to change from one stable mode (behavioral attractor) to
the next, for when the states are stable there arise new avenues for creating new stable
states. There are several terms important to understanding the dynamical system theory;
their definitions follow.

**Behavioral attractors.** There are many possible patterns of movement, and
behavioral attractors are common patterns that show under specific conditions (Ennis,
1992). Only powerful, dynamic events will cause system distribution and attractor
change, that is a change in a behavioral attractor (Ennis, 1992). Behavioral attractors are
also referred to as attractor states.

**Phase shift.** The transition from stable attractor state to different attractor state is
called a *phase shift*, where the system shifts as a result of pressure or by a nonlinear
change in the system (Thelen & Ulrich, 1991). The changes causing these shifts can be
from intrinsic as well as extrinsic variables (Southard, 1998). Attractor states are not
preprogrammed, so they are often unstable and result in numerous phase shifts.

**Control parameters.** What moves the system from one attractor state to another
are the *control parameters* (Southard, 1998). Since many parts of a system are free to
assemble in many patterns, many degrees of freedom are present in the movement (e.g.,
there are many ways to throw a ball). Under certain conditions the individual degrees of
freedom stop acting randomly and the subsystems begin to cooperate in a manner that
creates the movement (Magill, 2004). The more skilled the person is and the more time
he/she spends practicing and being proficient in the movement, the more the degree of
freedom decreases (Magill, 2004). Once the control parameters reach a critical point, a
phase shift occurs and new movements emerge. During the phase shift, the previous
stable attractors might be lost and new stable attractors appear in new forms (e.g., throwing with no stepping to throwing with a contralateral step). Each phase shift is considered a level of movement (Magill, 2004; Payne & Isaacs, 2007). Transitioning from one level of movement to the other and creating mature patterns of movement results from internal and external constraints.

A teacher is a powerful environmental constraint and can bring about significant phase shifts by perturbing the system to shift from one stable attractor to another (Ennis, 1992). Thus, good teachers know what variables or constraints most influence a skill and are able to precisely perturb the system into new desirable forms of movement.

The Constraints Model

In 1984 Newell proposed a landmark model to explain how constraints operate in shifting an individual into different patterns of movement. Newell suggested that people should be viewed as systems that are driven to perform skills in a consistent and efficient manner, as new forms of behavior arise out of old forms. The factors that perturb or influence old behaviors are called constraints (Newell, 1984; 1986).

Constraints are defined as boundaries or features that interact to limit the form of the systems searching for optimal states of organization (Newell, 1984; 1986). The three different categories of constraints are organismic constraints (such as balance, motivation, anxiety, and strength), environmental constraints (such as the size of the ball being used, the distance from the target, etc.), and task constraints (such as the performance demands, the movement patterns, and the degrees of freedom allowed) (Gallahue & Ozman, 2002). These three types are discussed in more detail below.
Organismic constraints. Organismic constraints refer to the learner characteristics associated with a student’s body weight, height, and shape (Newell, 1984), which Heywood & Getchell (2005) identified as structural constraints. They are also referred as to functional constraints where the individual’s culture, gender, socioeconomic class, and intellectual and physical abilities influence performance (Ennis, 1992).

Environmental constraints. Environmental constraints include external constraints pressuring the system components that are shaping the behaviors of the dynamic system (Newell, 1984; 1986). This category may include environmental features such as the lighting in the gym, temperature, humidity, and gravity (Newell, 1984; 1986). Environmental constraints also include the context of learning, which the teacher can manipulate in order to improve student performance. Newell and Valvano (1998) identified feedback as environmental information that the learner receives from the teacher and is not naturally available in the learning or performance environment. The teacher’s ability to observe the performance, identify and analyze the movement, and provide feedback that is developmentally aligned to the movement is part of the extrinsic environment promoting successful performance (Newell, 1991; Newell & Valvano, 1998).

Task constraints. Task constraints (or instructional constraints) consist of the curriculum, methods, teaching strategies, content, and material that the teachers select to use during the lessons for instruction and student learning (Ennis, 1992). Newell (1986) related three components to the task constraints: 1) the goal of the task that the teacher set during the lesson, which identifies the desired outcome or the product of the performance
expected; 2) rules during the practice of the task, with the differentiation of opened skills and closed skills; and 3) implementing the task and the student’s response to the task.

*Interaction among constraints.* Each constraint individually affects variability in movement; however, the interactions between the constraints have different impact on the individual movement (Gallahue & Ozman, 2002; Newell 1984, 1986; Payne & Isaacs, 2007). Different individuals/organismic constraints can affect the same task constraints differently, and at the same time a variety of task constraints might produce different outcomes from the same learner (Payne & Isaacs, 2007). For example, the ball size and target distance might lead to success for one student but difficulty for another student, and one student might have different degrees of success with the same task depending on his or her body growth and inherent physical abilities.

*Application of the constraints model to feedback.* Research on feedback has shown that teacher feedback can serve as an effective environmental constraint to facilitate motor performance and bring about desired change by giving the student specific information to correct the movement and to reduce the degrees of freedom (Newell & Valvano, 1998). For example, telling a student to “step with your opposite foot,” or “take your arm way back behind your body” will help constrain the student’s performance and hopefully facilitate a more mature performance of throwing. Teacher feedback, functions as an environmental constraint, and can influence students’ learning and performance by providing feedback (Newell, 1991; Newell & Valvano, 1998). Teachers who have in depth knowledge about the subject matter they teach are more likely to provide content-related feedback (Oslin, Stroot, & Siedentop, 1997; Siedentop & Tannehill, 2000; Stroot, 1990; Stroot & Oslin, 1993); therefore, it is essential that
teachers have adequate knowledge of the skill so that they can provide effective feedback that will improve student performance of the skill. The dynamical systems theory and the constraints model emphasize the importance of the feedback that the students receive during motor skill acquisition; as such feedback can change the student’s performance of the movement (Newell & Valvano, 1998).

*Feedback and Motor Skill Acquisition*

Different types of information can facilitate motor skill acquisition during the learning process. *Instruction* and *demonstration* are two types of such information (Newell, 1991). Another type of information is *feedback*, which is the extrinsic information provided by the teacher to the students in order to correct their motor performance or to reduce their task-related errors, or both (Newell, 1991; Newell, Morris, & Scully, 1985; Newell & Valvano, 1998; Tan, 1996).

There are two different bodies of literature that provide us with valuable information on external feedback. One is from pedagogy and the other is in motor learning. The pedagogy literature and the motor learning literature often describe the same factor as external feedback using different definitions. For example, augmented feedback (Tan, 1996); or congruent or specific feedback are terms used in pedagogy (Rink, 2003, Siedentop & Tannehill, 2000). In contrast, the motor learning literature uses the term information feedback (Newell & Valvano, 1998), and categories of feedback such as Knowledge of Results, and Knowledge of Performance (Magill, 2004). In order to avoid confusion over these different terms, in this study a new term identified as aligned developmental feedback (ADFB) was developed, to represent feedback statements that match the observed developmental level of the student’s performance.
**Definition of Feedback**

Feedback is defined as “a teaching behavior upon motor response of one or more students and intended to provide information related to the acquisition or performance of motor skills” (Fishman & Tobey, 1978, p. 52). While performing a new sport skill, the performer can benefit from two general types of performance-related information (Magill, 2004): a) *task intrinsic feedback*, which gives athletes sensory-perceptual information such as visual, tactile, force, proprioceptive, or auditory task intrinsic information; and b) *augmented (extrinsic) feedback*, which provides learners with information about their performance and is delivered by external sources such as teachers or coaches, adding external information that cannot be detected by the students’ internal sensory systems (Magill, 2004; Schmidt & Wrisberg, 2004).

According to Schmidt and Wrisberg (2004), external feedback adds to students’ intrinsic information, providing information on the outcome of the movement task that the athletes are unable to get from their intrinsic perceptions alone. This external information helps them improve their performance and gives them information about the outcome. The sources of feedback that are related to human movement are information that is available: a) before the learners’ performance; b) during the performance; and c) after the performance (Schmidt & Lee, 2005).

In the learning process, in order for students to learn a new skill and improve their performance, some teaching strategies must occur (Rink, 2003; Rosenshine & Stevens, 1986). In physical education in particular, effective teachers should be clear about their goals; use a step-by-step presentation of the task, including demonstration; and provide students with feedback to enhance the learning and improve the skill performance (Magill,
According to Bilodeau and Bilodeau (1961), feedback is the most important variable controlling performance and learning. ADFB in particular is one of the environmental constraints that provides information to learners about motor learning and performance and is considered to be one of the most important teaching tools in skill acquisition (Newell & Valvano, 1998).

It has been found that in the early stage of learning a new motor skill, teacher feedback in physical education is an important aspect of children learning fundamental motor skills (Magill, 2004; Rink, 2003). Feedback has two important roles in the process of learning a new motor skill: a) as a way to help learners determine whether they performed the skill appropriately (by getting extrinsic feedback they might be able to learn faster than using only their intrinsic feedback), and, b) as a motivation factor for learners that can help them compare the performance goal and their performances during practice (Magill, 2004, Rink, 2003; Siedentop & Tannehill, 2000). The information that the teacher gives the students on their performances helps them improve their performance and can motivate them to work harder and continue their practice trials (Magill, 2004; Rink, 2003; Siedentop & Tannehill, 2000).

The importance of feedback in pedagogy and motor learning is a very common topic of debate. When a teacher provides feedback to a learner, many factors need to be taken into consideration. The most important theoretical and practical question that needs to be answered is “how essential is feedback for skill acquisition when it is provided by the teacher during a physical education lesson?” (Magill, 1994; 2004). Even though much of the data in motor learning and pedagogy supports the notion that feedback enhances
learning new motor skills, it is not clear whether the feedback by itself is the variable that improves the learning or if other factors are the main reason for the improved learning.

The results from both the motor learning research and the pedagogy research regarding feedback effectiveness during physical education practice under certain conditions are still inconclusive (Lee et al., 1993; Magill, 1994). In the pedagogy literature, no significant relationship has been found between the total amount of feedback given and student achievement (Salter & Graham, 1985; Silverman, Tyson, & Krampitz, 1992); however, feedback was identified as a mediating variable that motivated the students to continue practicing and improve their skill performance.

*Feedback in the Motor Learning Literature*

In the *motor learning* literature, feedback is classified into two major categories: *knowledge of results* (KR) feedback, which represents the information provided about the outcome of the movement, and *knowledge of performance* (KP) feedback, which represents the information aspect of the ongoing movement dynamics (Newell, 1991; Magill, 1994, 2004; Schmidt & Wrisberg, 2004; Schmidt & Lee, 2005).

*Knowledge of results (KR).* Many of the textbooks and reviews about feedback claim that without *knowledge of results* (KR) feedback (i.e., feedback regarding the outcome of the performance); learning will not occur (Magill, 1994, 2004; Salmoni et al., 1984; Schmidt & Wrisberg, 2004; Schmidt & Lee, 2005; Winstein & Schmidt, 1990; Wright & Thorpe, 1989). Bilodeau, Bilodeau, & Schumsky’s (1959) research supports this position; however, other research in the field might argue that this claim is overstated (Salmoni et al., 1984). The problem with this claim is that since KR feedback is a form of feedback that can be delivered verbally and terminally (i.e., when the movement has been
completed [Magill, 2004]), there is evidence that some skills are learned without KR feedback or with other conditions of KR feedback (Magill, 2004; Schmidt & Lee, 2005; Schmidt & Wrisberg, 2004; Salomini et al., 1984).

One aspect that seems to impact the effect of feedback is information load (Ramella, 1984; Thomas, Mitchell, & Solomon, 1979). Information load (the amount and precision of KR feedback) affects children of different ages differently (Ramella, 1984; Shapiro, 1977). It was found that high information loads, or more precise KR feedback comments, negatively impact young children (Ramella, 1984; Thomas, Mitchell, & Solomon, 1979). Additionally, older children possess greater cognitive capacity and thus can benefit from a higher information load or more precise KR feedback (Kerr & Booth, 1978; Shapiro, 1977; Thomas, Mitchell, & Solomon, 1979). As KR preciseness and task difficulty increase, younger children have more processing deficits and their performance decrements (Ramella, 1984; Thomas, Mitchell, & Solomon, 1979). Therefore, physical education teachers must take into consideration the age of the student and deliver the information feedback that will be beneficial to that age learner (Cohen & Goodway, 2006; Kerr & Booth, 1978; Shapiro, 1977; Thomas, Mitchell, & Solomon, 1979). To date, there is limited data on children of different ages to guide the teacher about information load and preciseness.

Knowledge of performance (KP). KP feedback is the information delivered to the learner that refers to the movement while performing the skill and leads to the outcome (Magill, 1994, 2004; Salomini et al., 1984; Schmidt & Wrisberg, 2004; Schmidt & Lee, 2005). The information about the process and how the movement was performed is part of KP feedback (Magill, 2004; Salomini et al., 1984; Schmidt & Wrisberg, 2004). Similar
to KR feedback, KP feedback can be delivered verbally by external agents such as teachers; however, this form of feedback can also be provided as nonverbal information, such as a videotape replay of the learner’s performance, computer software information, or biofeedback devices, which are being used in clinical settings (Magill, 2004). Using an example of a student attempting a free throw, in order to provide KP feedback the teacher might talk about the process of the movement, saying "you need to bend your knees a little more to have more force for shooting”.

When teaching new motor skills, it is important for teachers to use modeling or visual demonstration as well as verbal feedback to improve children’s learning (Zetou et al., 2002). It was found that skilled performers tended to benefit more from videotape feedback than novice performers and that novice performers tended to benefit more when the videotape was combined with specific skill-related verbal cues (Zetou et al., 2002). Visual feedback, self-observation, and the teacher's auditory KR feedback were found to be important for the students’ learning and improving their skills (Erbaugh, 1985; James, 1971; Kerr & Booth, 1978; Salter & Graham, 1985; Stroot & Oslin, 1993; Stroot, Oslin, & Siedentop, 1999; Tzetzis et al., 1997; Zetou et al., 2002). Both Tzetzis et al. (1997) and Zetou et al. (2002) have determined that providing KR feedback improves students’ technique and reduces errors in performance.

Information feedback. Another term that is being used in the motor learning literature to define feedback is information feedback (Newell, 1991; Newell, Morris, & Scully, 1985; Newell & Valvano, 1998). Information feedback is defined also as “augmented information is the provision of the information to the learner that is not naturally available in the learning or performance environment” (Newell & Valvano,
Information feedback is a very important tool that teachers can use as change agents of movement to facilitate acquisition of motor skills.

There are several types of information feedback that can be presented to the learner during motor skill acquisition. For example, augmented feedback provides information about the movement dynamics in actions produced by the learner (Newell, 1991; Newell, Morris, & Scully, 1985; Newell & Valvano, 1998). One of the major challenges for the teacher is selecting the specific informational constraints that will reduce errors in the learners’ performance and help them improve the quality and quantity of the output movement (Newell & Valvano, 1998). Several prerequisites are required for a teacher to adequately select and deliver feedback that will assist the student in improving his or her performance. Two such prerequisites are teacher content knowledge and teacher ability to observe and analyze the skill (Barrett, 1983; Gangstead & Beveridge, 1984).

Feedback in Pedagogy Research

Feedback is also considered an important teaching instrument from the pedagogy perspective; however, since most of the motor learning research, in contrast to pedagogy research, was conducted in controlled laboratories with few students and more individual control of the feedback, it is hard to generalize the findings from motor learning research to a natural setting where a teacher in the gymnasium teaches sometimes more than 30 students for 45-minute lessons (Lee et al, 1993; Siedentop, 1991). Siedentop and Tannehill (2000) identified feedback as an important element in the teaching-learning process. From a pedagogical perspective, it is common that teachers provide students with feedback during the lesson that focuses on the skill or the critical elements of the
skill they are learning; and delivering frequent feedback is part of the assessment system that teachers use as a teaching strategy (Siedentop & Tannehill, 2000; Stroot, 1990; Rink, 2003). The teacher directs feedback to the students’ performance, and it serves as an error reduction and/or a means of enhancing correct motor responses from the student (Fishman & Tobey, 1978; Siedentop & Tannehill, 2000; Tan, 1996).

The categories under which the pedagogy literature lists feedback has similarities to motor learning definitions, but the pedagogy literature uses different definitions for the same feedback functions. As a result of the natural physical education setting, where one teacher is responsible for a whole classroom, the teacher may to provide group feedback in addition to individual feedback, which are both considered feedback, under different categories.

Teacher Content Knowledge and Providing Feedback

Teacher content knowledge (CK) is important in the process of providing feedback (Siedentop & Tannehill, 2000; Stroot, 1990; Stroot & Oslin, 1993). Shulman (1986, 1987) identified two categories of CK:

a) **Subject matter content knowledge.** Subject matter content knowledge refers to “the amount and organization of knowledge per se in the mind of the teacher” (p. 9). That is, this category of knowledge includes the depth and scope of the teachers’ understanding of the subject matter. In addition, it includes the knowledge of why the subject is important and how it is related to other subjects both in theory and in practice.

b) **Pedagogical content knowledge.** Pedagogical content knowledge (PCK) refers to the teacher’s ability to transfer and install specific information, i.e., subject
matter, to a specific audience, i.e., classroom students. Hence, by definition, PCK includes an understanding of CK as well as the conceptions of what it means to teach this particular subject matter. Shulman (1986) describes PCK as “ways of representing and formulating the subject that make it comprehensible to others” (p. 9).

According to Shulman (1986), subject matter CK refers to concepts, principles, and skills within a particular subject discipline, and PCK represents the blending of content and pedagogy into the understanding of how particular topics, problems or issues are oriented, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction” (p. 8). For example, teaching the overhand throw to a third grade class through oral explanations and notes would offer the students the content but present it in a way they may find hard to understand. In contrast, presenting the content in a way that the students would better understand it might be achieved by using alternative strategies which can allow students to easily imitate the motion shown. Changing the presentation of the information in this way is an example of a teacher demonstrating good PCK.

The teacher’s control of the two categories of knowledge makes it possible for him or her to combine subject matter CK with PCK to both improve their performance and translate their knowledge to the students. Says Shulman (1986) of what makes a teacher, “The professional holds knowledge, not only of how—the capacity for skilled performance—but of what and why” (p. 13). CK is important in the ability to provide feedback as teachers that lack knowledge of the specific subject they teach might give
incorrect feedback or deliver feedback that is not congruent to the student’s performance (Gangstead & Beveridge, 1984).

*The Teacher’s Ability to Provide Feedback*

In order to provide adequate information about the content they teach, teachers must have the specific subject matter knowledge (Stroot, 1990). Knowing the subject matter can help teachers in the skills of observing student performance, identifying the developmental level of the skill, and delivering ADFB to improve performance.

*Observing and Analyzing Skills*

One skill that is essential for teachers to help them deliver ADFB is *observation*. Barrett (1983) defined observation "as the ability to perceive accurately both the movement response of the learner and the environment in which the response is taking place" (p.22). Skillful teachers observe the student performance, and identify the important components that are aspects of the movement that are critical for optimal performance (Barrett, 1983). Teachers that lack content knowledge in the specific subject they teach or are not skillful enough to identify the developmental level of the student and might give incorrect feedback or deliver feedback which is not congruent to the performance (Barrett, 1983).

The challenge of observing performance in order to give feedback to learners is complex, and many teachers fail in the process of accurately observing students and being able to analyze and diagnose motor performance errors (Gangstead & Beveridge, 1984). Practitioners and scholars have created models for skill analysis to help teachers become more effective in the teaching skill of observation (Gangstead & Beveridge, 1984).
Knudson and Morrison (1996) explained the importance of the approach of qualitative analysis in the overhand throw. The ability of the physical education teacher to analyze the overhand throw appropriately and identify the critical features of the throw, will improve the movement of the performer. They concluded that by knowing the critical features of the overhand throw and integrating the qualitative analysis approach will help the physical education teacher to provide feedback in correcting the major errors and motivate the performer to continue practicing (Knudson & Morrison, 1996).

Walkwitz and Lee (1992) studied eight kindergarten classroom teachers’ ability to observe student performance. Four teachers were in the experimental group and received knowledge training regarding the developmental literature related to the overhand throw. This included a video training package and detailed information about the developmental sequence of the mature pattern of throwing performance. The other four teachers served as a comparison group and received no knowledge training related to the overhand throw. The eight teachers were assessed on their knowledge before and after the throwing unit. The results showed that after the training the experimental group possessed more knowledge than the comparison group on the overhand components. The results of the study also indicated that the trained teachers were able to integrate the knowledge they received in the training with the knowledge they already possessed, and were able to use it to identify the components of the throw and assess their student performance during practice (Walkwitz & Lee, 1992). A limitation of this study was the small number of participants. Placek (1983) noted that a novice teacher might observe students practicing an overhand throw who will appear "busy, happy, and good". An expert teacher, who has a critical eye to observe, will be able to look at the students’ technique and identify the
critical feature such as stepping with opposition, rotation of the trunk, proper release of the ball and other specific features (Placek, 1983).

Stroot and Oslin (1993) investigated the ability of the teacher to deliver feedback to enhance student overhand throwing performance. The teachers in the study were asked to observe the students (ages five through eight years) performing an overhand throw, analyze the skill performance, and provide the students with the necessary instruction and feedback to improve the student performance. During the study the researcher recorded the process measures of the overhand throwing using five components of the overhand throw (foot position, pelvic-spinal rotation, hand position-backswing, elbow-backswing, and arm action-forward swing), as well as the teacher feedback episodes (verbal feedback, verbal corrective feedback, cues, modeling, praise, and manual manipulation). The researchers used the “sport skill process variable assessment instrument” to identify the performance of the throw and the teacher feedback. The results of the study indicated that when the students received an appropriate feedback congruent to their performance, their throwing skills improved from pretest to posttest (Stroot & Oslin, 1993). The teachers were able to analyze and discriminate the obvious component such as stepping with opposition but were not skilled enough to have a critical eye for more advanced movement of the throwing elements. The teachers in the study had the content knowledge of overhand throwing but they did not provide feedback that was aligned to the student performance and therefore did not to improve the student performance (Stroot & Oslin, 1993). When the teachers identified the critical errors during the student performance and delivered appropriate feedback, the students improved their throwing patterns. This study illustrates the importance of subject matter content knowledge, the ability to analyze and
assess the skill, and the importance of the appropriate feedback to enhance student performances.

In summary, the interaction between the teacher content knowledge, their ability to observe the developmental level of the performance, and the type of feedback they deliver are critical to student learning.

Findings Related to Feedback

Feedback is a critical factor in the acquisition of motor skills. There is an extensive body of empirical work to guide the appropriate provision of feedback. However, much of this work has been conducted with adult participants, in laboratory settings (Erbaugh, 1985; James, 1971; Masser, 1987; Salter & Graham, 1985; Thomas, Mitchell, & Solomon, 1979), and using novel tasks (Behets, 1989; James, 1971; Salter & Graham, 1985; Shapiro, 1977) that have little relevance to real world contexts (Cohen & Goodway, 2006). Based on the findings of the literature in the area feedback Cohen & Goodway (2006) found that much of these data are based on adult learners, mostly college, and it is not clear of the generalizability of the findings for children and specifically children in K-12. A comprehensive literature review on feedback yielded of 278 motor learning studies related to feedback. However, only 27 dealt with children in naturalistic settings and with limited implications for teachers (Cohen & Goodway, 2006).

Many studies in the field of physical education pedagogy have examined teacher feedback in conjunction to the amount and type of feedback episodes during instruction (Behets, 1989; Pellet & Harrison, 1995; Rikard, 1991; Rikard, 1992; Silverman, Tyson, & Krampitz, 1992; Silverman, Tyson, & Krampitz, 1993; Stroot, 1990). However, most
of the findings focused on the teacher and did not include information about the influence the feedback had on student learning (Cohen & Goodway, 2006). The findings discussed in this section of the literature review include only studies in which student achievement was identified as a result of the teacher feedback both in motor learning laboratory settings and in physical education lessons in naturalistic settings. These findings were categorized by the following criteria: type and amount of feedback, age-related factors, gender differences, teacher content knowledge, and student skill level.

**Type and Amount of Feedback**

In the many studies on the amount and type of feedback delivered during physical education lessons, it was found that the most common kinds of feedback provided by teachers are auditory, individual, corrective, nonspecific, and positive feedback (Behets, 1989; Pellet & Harrison, 1995; Rikard, 1991; Rikard, 1992; Silverman, Tyson, & Krampitz, 1992; Silverman, Tyson, & Krampitz, 1993; Stroot, 1990). Several studies have correlated student achievement with verbal feedback, and it was indicated that verbal feedback was essential for student learning (James, 1971; Masser, 1987; Paese, 1987; Ramella, 1984).

**Laboratory setting findings.** A number of studies related to feedback have been conducted in experimentally controlled settings (Erbaugh, 1985; James, 1971; Kourdas & Weeks, 1998; Shapiro, 1977; Thomas, Mitchell, & Solomon, 1979). These studies were conducted in non-naturalistic settings examining feedback using mostly novel laboratory-based tasks (Cohen & Goodway, 2006). The studies that fall under these criteria were based on controlling the group assignment as well as the conditions delivered to the participant. Within the laboratory settings, the findings are not clear in terms of these
studies being generalizable for students in physical education lessons (Cohen & Goodway, 2006).

James (1971) compared two groups of students aged 11–12 years. One group (n=8) received visual feedback and an explanation about the trampoline performance (via video tape). The other group (n=10) received verbal feedback only. Each group received equal instruction of one hour, twice a week, for eleven sessions to learn four basic drops and seven bounce routines on the trampoline. Before the study was conducted, the students were tested on their verbal ability. The findings revealed that there was no significant difference in performance between the visual and the non-visual group. Interestingly, the findings indicated that a correlation of $r = 0.6$ was found between the verbal ability of the students and their scores on performance. Boys with high and low verbal ability benefited from visual feedback.

Wulf et al. (2002) studied 48 participants performing volleyball serves based on accuracy to the target. The participants were randomly divided into four groups: (1) novice players—external-focus feedback, (1) novice players—internal-focus feedback, (3) advanced players—external-focus feedback and (4) advanced players—internal-focus feedback. Each participant performed 25 practice trials in two practice sessions. After the two practice sessions, retention tests consisting of 15 trials of volleyball serves were conducted. No feedback was provided during retention. In each of the two-types of conditions (internal-focus feedback and external-focus feedback), one of four feedback statements was given after five trials. The feedback given to the novice and advanced internal-focus groups was similar in content, as was the feedback given to the novice and advanced external-focus groups. The internal-focus feedback referred to the performer’s
own movements, and the external-focus feedback referred to the effects or the output of the movements. The results of the study indicated that during practice all groups increased their accuracy of the serve; however, the advanced groups scored higher than the novice groups, which is to be expected. Both in practice and during retention, the advanced groups showed better movement in terms of quality than the novice groups.

When comparing the types of feedback, the results of the study showed that the external-focus feedback was more effective than the internal-focus feedback in terms of students’ accuracy in performing the serve. After one week of retention in which no feedback was provided, the external-focus feedback groups still performed better in terms of accuracy and movement form. In this study, it is clear that feedback that induced an external focus was more beneficial than feedback that induced an internal focus for both novice players and advanced players (Wulf et al., 2002). As mentioned previously, it is hard to generalize these laboratory-based studies to naturalistic settings when the physical education lessons include 20–30 students and some of the conditions are hard to control during the study.

**Naturalistic setting findings.** Few studies have been conducted in naturalistic environments during physical education lessons while examining the impact that the feedback has on the student performance (Cohen & Goodway, 2006). Pellett and Harrison (1995) examined 68 female seventh and eighth grade students and their teacher. The teacher was trained to deliver specific, congruent, and corrective feedback when the students performed different volleyball skills. Both teacher feedback and student motor-skill responses were coded. Relevant points to be noted from the findings are that all of the students significantly improved from pre-test to post-test for all skills, and both
beginning players and advanced players improved their practice success after teacher feedback in all task presentations (pre-test and post-test). The students in this study improved their performance immediately following teacher feedback. The findings were significantly meaningful for the low-skilled students, who were more influenced by correct practice due to the teacher specific feedback (Pellett & Harrison, 1995).

In another study, 529 students in grades K–6 learned the standing board jump over four weeks. Pre-tests of the standing board jump were used for measurements as well as post-tests following a time span of seven months (Masser, 1987). The students were randomly assigned to three groups. Group C received no instruction or practice in the standing board jump; group E and group E+ both received instruction and practice on the skill being tested, but group E+ in addition received verbal instruction from the teacher during practice. Masser (1987) found that the students improved their performance as a result of 42 instructional lessons; however, there was no significant statistical difference between groups ($p < 0.05$) until verbal feedback was added to the E+ group during the practice. The E+ group who received the feedback from the teacher received the highest score mean in all grades except the second grade. Students who received verbal feedback increased their performance in both the short-term and long-term post-test scores (Masser, 1987). In conclusion, the findings of this study indicated that younger students who received verbal instruction from their teacher improved their performance and were more positively affected by the teacher’s feedback than older students. These findings strengthen the notion of the need for teacher feedback in early childhood when the students are learning new skills.
In some studies, a correlation was found between student practice time and the feedback provided by teachers; that is, the more practice the students were engaged in during their lessons, the more opportunities there were for the teachers to provide feedback and the more learning was influenced (Silverman, Tyson, & Krampitz, 1993; Silverman, Woods, & Subramanian, 1998, 1999; Stroot, 1990; Yerg, 1981; Zetou et al., 2002). Paese (1987) researched the effect of specific teacher feedback on academic learning time (ALT) and on novel motor skill acquisition. He used experimental teaching units (ETUs), which are 20-minute units per lesson, for teaching a novel badminton skill to fifth graders. The students ($N=120$, $F=60$, $M=60$) were tested on badminton shuttle hits before and after one 20-minute unit and the amount of teacher verbal feedback was recorded (Paese, 1987). The results from this study indicated that there was no significant difference on both the pre- and post-test scores of the number of correct hits on the badminton shuttle between the students who received verbal feedback and those who did not ($p > 0.80$). However, the feedback group had a higher ALT (36%) than the non-feedback group (30%) (Paese, 1987). The fact that the students in the feedback group had a higher ALT means that they were allowed to have more practice time, they were given more opportunity to respond, and they were allowed the chance to receive feedback from their teachers that was aligned to their developmental stage. A major criticism of this study was the short duration of the ETUs, giving little time for learning.

Silverman et al. (1992) investigated the relationship between teacher feedback and student achievement in a real-world physical education setting where he did not manipulate any variables. Since other studies showed that practice is strongly related to achievement, the study also examined the relationships of summed feedback variables
with achievement when appropriate student practice was the covariate. Seven physical
education teachers (four male, three female) and 202 students in grades 6, 7, and 8
participated in the study. The feedback that the teachers used varied in type, form, time,
referred, number of students, and quality. All students were pre-tested on the skill to be
learned. The teacher feedback was measured using an adaptation of The Augmented
Feedback Observation Instrument (TAFOI) developed by Fishman and Tobey (1978).
The students practiced volleyball skills for seven class sessions over a two-week period
(30 minutes each lesson) and were observed in each of the seven class sessions. The
results of the study indicated that the typical student received feedback 28.39 times
summed across the seven sessions, 14.55 times for pass and 13.85 times for serve. The
number of instances of feedback directed to individual students ranged from 0 to 237
with all, but 23 students receiving feedback less than 50 times and 6 received feedback
more than 100 times. Most feedback was either positive or prescriptive, was auditory,
occurred at the completion of the skill (terminal), and addressed either part of the skill or
the whole skill. It was also noted that: (a) most students received relatively little skill-
related feedback during instruction, (b) for the summary categories only a few significant
relationships were found with achievement, (c) positive-auditory-concurrent-whole
feedback was positively related to achievement for the pass and serve skills, and (d)
among descriptive, prescriptive, and corrective feedback a number of correlations were
found (Silverman, Tyson, & Krampitz, 1992). This study strengthens the notion that
feedback is essential for student learning as the feedback served as the variable that
motivated the students (Bilodeau & Bilodeau, 1961; Brophy, 1979; Fishman & Tobey,
studies conducted in naturalistic settings all had similarities in the findings related to the most commonly used feedback statement type (i.e., nonspecific, evaluative, positive, verbal statements) (Rikard, 1991, 1992; Rink, 2003; Silverman, Tyson, & Krampitz, 1993; Stroot, 1990; Tan, 1996). This type of feedback as well as the amount of feedback were two variables that were not highly correlated with student achievement during physical education lessons. These findings strongly strengthen the need to identify the type of feedback that eventually will be highly correlated to student success in performing fundamental motor skills and other related skills.

**Age-Related Factors**

Several studies have pointed out that the age of the learner has important meaning in the process of learning when receiving different information loads (James, 1971; Kerr & Booth, 1978; Masser, 1987; Ramella, 1984; Thomas, Mitchell, & Solomon, 1979). Adults are capable of processing information more proficiently than children (Masser, 1987; Thomas, Mitchell, & Solomon, 1979). Children have less information stored in their long-term memory, the processing of information in their short-term memory is slower than in adults, and their control processes and strategies become more efficient with increasing age (Kerr & Booth, 1978; Masser, 1987, Ramella, 1984). As children develop they can handle increasing amounts of information at the same time and more rapidly (Thomas, Mitchell, & Solomon, 1979). A number of studies have been conducted on age and KR feedback, which includes both speed of processing (i.e., post-KR intervals) and information load (preciseness of KR feedback) (Ramella, 1984; Shapiro, 1977; Thomas, Mitchell, & Solomon, 1979). Recent studies have shown that although general KR feedback improves performance as compared to no KR feedback, there are no
significant differences between receiving KR and not receiving KR at a certain age. Most of the studies in this category examined feedback using novel laboratory-based tasks.

In Thomas, Mitchell, and Solomon’s (1979) experiment they evaluated the effect of task complexity and KR preciseness (no KR feedback, general KR feedback, and precise KR feedback) in two age groups of children. Twenty seven second graders and 27 fourth graders (9 students per group) within their group level were asked to grasp a lever and try the first test position, releasing the lever when the target was reached. The basic assumption was that older children would be able to apply more efficient strategies to precise KR information. The lever was returned to starting position after every trial. The control group received no KR feedback, the general KR group was informed of the direction of their error (short or long), and the precise KR group was given both the direction of error and the number of units (each unit = 1 degree) by which the target was missed. The results of both experiments indicated that information load had a different influence on different kinesthetic repositioning performances of children and that it was clearly age related. The fourth graders were more accurate and more consistent than the second graders, as reflected by an unsigned average error score of three trials for each student. It was also indicated that the students who received precise KR feedback and were given both the direction of the errors and the number of units by which the target was missed improved their performance over time. The second graders did not adequately process the precise KR feedback during the learning phase; it was too complicated for them and therefore did not improve their performance. In conclusion, the results of both experiments showed that older children benefited from KR feedback more than younger children in reducing performance errors, as older children can process
information more rapidly and effectively than younger children (Thomas, Mitchell, & Solomon, 1979).

Ramella (1984) also examined the effects of age on the performance of an anticipatory timing task with and without KR feedback. The participants in the study were 18 first graders and 28 third graders. Each child was expected to anticipate the final light on The Basin Anticipation Timer by simply depressing a button. Each child was to demonstrate how many “lightning bugs” he could catch out of 15 trials. Groups 1 and 3 did not receive KR feedback and groups 2 and 4 were expected to learn using the inherent visual feedback of the task. The feedback that was delivered to the students prior to each trial were verbal warning cues (randomly) and verbal KR feedback (as directions and magnitude of errors). The results of the study showed that the groups who received KR feedback made fewer errors than those who did not receive verbal information. The third graders made significantly fewer mistakes ($M = 132.6$ mistakes per second) than the first graders ($M = 151.7$ mistakes per second), and the first graders relied on KR feedback to improve their performance. Differences in anticipatory timing were noted between grades. While the first graders were unable to decrease absolute errors without KR feedback, the third graders made significant improvement without KR. Knowledge of results feedback was found to have little effect on first graders’ reduction of constant errors over 15 trials; however, a significant reduction of variable errors (across three trials) was noted for all subjects without KR feedback.

Oslin, Stroot, and Siedentop (1997) noted that when teaching young children, the teacher needs to simplify the feedback given in order to help the students process the information load and improve their performance with the knowledge they receive from
the teachers. Masser (1987) found that younger students were affected more positively by teacher feedback than older students when performing the standing board jump. After seven months, the post-test scores of the group that practiced the task and received verbal teacher instruction were higher than the scores of the other groups, with the exception of the second graders. This study also strengthens the notion that younger children are affected more than older children by feedback providing specific refinement to the skill. Considering the verbal ability of the children, effective teachers must be aware of the information load and the amount and precision of feedback they deliver to their students. Different feedback should be delivered to different age groups of students.

*Gender and Feedback*

Few motor learning and pedagogical studies have specifically examined gender differences in relation to feedback, and the findings relative to gender were mixed (Erbaugh, 1985; Kerr & Booth, 1978; Shapiro, 1977). In this category, most studies took place in laboratory settings. Erbaugh (1985) examined children’s performance of two motor tasks. The purpose of this research was to examine the temporal spacing of visual feedback during children’s observational motor learning and to examine the effect of selected task and learner characteristics on the motor-reproduction processes of modeling. One hundred and seventeen primary grade students participated in the study (60 boys, $M = 6.5$ years, and 57 girls, $M = 6.6$ years). The students were tested on balancing on a stabilometer and jumping a horizontally rotating bar. Each child performed the two motor tasks during a 30-minute lesson (2 five-trial blocks during learning and one five-trial block during the test) and was randomly assigned to one of the four condition groups: (a) visual feedback—received feedback after each block of trials...
(watched a video of their performance), (b) visual-nonvisual—received feedback only after the first block of trials, (c) nonvisual-visual—received feedback only after the second block of trials, and (d) nonvisual—received no visual feedback (did not see themselves on video performing). The results of the study showed that measuring the stability performance, all children improved from the first block to the third block, while the children in the condition groups that included visual feedback improved more than the others. It was also indicated that the girls, across conditions and trial blocks, performed in the jumping task at a more advanced level than the boys. The girls in the visual-non-visual condition scored the best time. This study showed that visual feedback or self-observation is important later in learning when children need to refine their skills. The children in this study were able to use the visual feedback to make small corrections in their performances (Erbaugh, 1985).

Shapiro (1977) researched a linear positioning task with four-year-old children and found that the boys displayed more variability than the girls at that age. The children in this study were divided into three groups. Each student had 30 trials. The task was moving a slide to the left in search of a target that was 1 inch in width and 10 inches farther from the staring position. Group one received the least precise feedback, statements such as “more” or “less;” group two received feedback of “a little more” or “a little less;” and group three received very specific feedback regarding their performance and how close they were to the target. Considering the influence of feedback in this study, no significant differences were found among the groups, even though the most precise KR conditions helped the students reduce their errors during practice. Another study of the linear positioning task revealed no significant gender differences on an
underhand throwing task after a 12-week program related to feedback (Kerr & Booth, 1978).

The findings relative to gender and feedback were mixed and do not reveal a clear-cut conclusion regarding the influence of feedback on the genders (Cohen & Goodway, 2006). Girls performed better than boys in a variety of feedback conditions with jumping tasks (Erbaugh, 1985), while boys displayed more variability than girls on a linear positioning task (Shapiro, 1977). No significant gender differences related to feedback were found on underhand throwing tasks (Kerr & Booth, 1978).

Feedback and Teacher Content Knowledge

Most studies in this category were conducted in naturalistic settings during physical education lessons. Teacher content knowledge was correlated to the ability of the teacher to provide appropriate feedback as well as promote student learning (Stroot, 1990; Stroot & Oslin, 1993; Oslin, Stroot & Siedentop, 1997; Yerg, 1981). It was also found that effective teachers provide more feedback than less effective teachers and that those teachers with limited content knowledge and background in the skill being taught may fail to recognize and correct student errors (Behets, 1989; Siedentop, 1991).

Although motor learning researchers have viewed feedback effects primarily from the performer’s perspective, sport pedagogy researchers have viewed feedback primarily from the perspective of the teacher with little focus on the impact of the feedback on student learning (Stroot, 1990). Significant correlations were shown between content knowledge and temporal feedback (Stroot, 1990). When teachers could recognize low skill efficiency and target specific components of the skill to change, the students’ performance improved (Stroot & Oslin, 1993). Teachers need more practice time in class
in order to recognize low skill efficiencies in the skills they teach (Silverman, Tyson, & Krampitz, 1993; Silverman & Woods, 1998; Silverman, Woods, & Subramanian, 1999). Hence, the teacher’s ability to structure the class to maximize practice time impacts the opportunities that the teacher has to provide feedback, which in result impacts student learning (Silverman, Tyson, & Krampitz, 1993; Silverman, Woods, & Subramanian, 1999).

Stroot (1990) found significant correlations between students’ learning, teachers’ knowledge of content, adequate practice time for students, and teachers’ ability to provide feedback. The purpose of Stroot’s (1990) study was to determine the relationships among knowledge of content, student-engaged skill learning time, and multidimensional aspects of feedback, as well as to examine how frequency of feedback has changed over the past ten years. Stroot (1990) studied 17 physical education teachers and four students randomly selected from each teacher’s class (n = 68). Two instruments were used to code teacher feedback. The first instrument was the Physical Education Teacher Assessment Instrument (PETAI), which recorded temporal data throughout the class setting, and the second was the TAFOI, which measured a variety of feedback variables. The teachers were tested on their content knowledge in basketball and volleyball concepts, skills, and techniques. The results from the study indicated that of the total class time, the teachers spent 7.6% of that time providing feedback to students. Approximately 5% of the 7.6% of feedback was delivered verbally (auditory), 2% was demonstrations (visual), and 5% involved physical contact with students (tactile). Positive feedback was provided approximately 2% of the time, while negative feedback occurred only 0.07% of the time. Most feedback was individual feedback (6.1%), and
group feedback was 1.2%. Significant correlations were shown between knowledge of content and temporal feedback. Also, high scores in content knowledge were correlated with giving more temporal feedback. The students’ engagement time in the skill was significantly related to total feedback and to 9 of the 13 specific feedback variables: auditory, visual, tactile, terminal, temporal, spatial, sequential, positive, and individual (Stroot, 1990).

Rink (2003) has suggested that refining tasks in which the teacher provides corrective feedback to the class are useful when the teacher has a large group of students because they help the teacher maintain accountability for the students’ performance. However, since students have differences in their abilities, this kind of feedback might not always be useful (Rink, 2003). Stroot and Oslin (1993) noted that teachers who provide feedback must have the ability to observe and analyze skill performance during instruction. In their study, they found that feedback that was appropriate to the performance of overhand throwing helped the students respond correctly and improve their throwing skill (Stroot & Oslin, 1993).

Physical education activities consist of a variety of activities and skills (Lee et al., 1993), and the feedback that the teacher delivers should be related to the complexity of the skill and the students’ abilities. Lee et al. (1993) found that students in some situations, such as when the skill is simple, can identify their own performance errors and do not need teacher feedback to make adjustments. When the task is easy to the learner and the teacher still delivers feedback, the feedback might cause a negative effect on the students’ motivation and interrupt their learning. Thus, the quality of teacher feedback
may be more important than the frequency, and therefore teacher content knowledge related to the task is very important.

From all the examples introduced in this section of the review, it is clear that there are several variables within these studies that have not been addressed and that need to be considered in future research. First, some studies only focused on the teachers’ feedback with little to no examination of the influence this feedback had on student performance. Second, these studies failed to examine the type of feedback being given by teachers, reporting only the rate and not the specificity of the statement. Third, the studies did not take into account individual student differences in terms of the rate and type of feedback needed to increase skill performance (Lee et al., 2003; Rink, 2003; Stroot, 1990; Tan, 1996). Fourth, the majority of the studies occurred in laboratory settings with small numbers of participants and therefore are not generalizable to naturalistic physical education settings (i.e., there is a lack of internal validity in comparison with studies occurring in natural settings) (Ramella, 1984; James, 1971; Oslin, Stroot, & Siedentop, 1997; Wulf et al., 2002). Fifth, the definitions of feedback vary from study to study. Some studies define feedback as augmented (Bilodeau & Bilodeau, 1961; Brophy, 1979; Fishman & Tobey, 1978), while other studies use congruent or specific (Rink, 2003). Thus, there is clear evidence that these issues need to be addressed in further research endeavors.

**Fundamental Motor Skills**

Children do not naturally demonstrate a skilled performance of fundamental motor skills (Goodway & Savage, 2001). They have to learn the skills and pass through different stages of development in order to demonstrate more efficient patterns of
movement before they become skilled in these patterns (Goodway & Savage, 2001). Therefore, fundamental motor skills should be taught during early childhood and elementary school. Fundamental motor skills are divided into three categories: 1) locomotor skills such as galloping, hopping, and running; 2) object control skills such as kicking and throwing; and 3) nonlocomotor skills such as bending and swaying (Goodway & Savage, 2001). Each fundamental motor skill is composed of developmental stages, and there are processes for moving from stage to stage (Haywood & Getchell, 2005; Payne & Isaacs, 2007). In order for children to learn to move from stage to stage, they need help; thus, the teacher’s role is very important in children’s motor development. According to NASPE’s (2004) standard 1 for physical education, it is recommended that children demonstrate competency in motor skills, specifically proficiency in movements such as throwing, so they can apply such skills to game situations. A NASPE benchmark for third, fourth, and fifth grade students is that the students should be able to demonstrate an overhand throw using mature form as well as hitting a target on a wall from a distance of 40 feet (NASPE, 2004). Some age and gender differences among students performing the movement of throwing, however, have been demonstrated (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002b).

**Age and Gender Differences in Fundamental Motor Skills**

A common finding in the motor development literature is the presence of gender differences in the performance of fundamental motor skills, and these differences increase with increasing age (Eaton & Enns, 1986; Garcia, 1994; Greendorfer, 1980; Sherif & Rattray, 1976; Thomas & French, 1985). Since throwing is a critical
fundamental motor skill, teachers must facilitate the learning of this skill and provide information that allows the students to perturb their system toward mature patterns of movement and develop competency in throwing performance (Butterfiend & Loovis, 1993; Easy & Hensley, 1985).

*Performance of Throwing*

*The Importance of Throwing*

Overhand throwing is one of the most important fundamental motor skills (Butterfiend & Loovis, 1993; Easy & Hensley, 1985). Throwing involves imparting force on an external object such as a ball (Barrett, 1995; Langendorfer, 1990). During physical education lessons and other sport activities, the use of the overhand throw varies in many sport skills such as executing the badminton clear pass, spiking during a volleyball game, and pitching a baseball (Butterfiend & Loovis, 1993). In order for students to exhibit competency in such sport skills, they must first learn the fundamental motor skill of the overhand throw. Developing a mature pattern of the skill with progressions will enhance the involvement of the participants in more advanced skills and may increase the probability of them becoming lifelong physically active citizens (Grabbard, 1995; NASPE, 2004).

*Assessment of Throwing Performance*

Overhand throwing is considered one of the most complex fundamental motor skills. Payne and Isaacs (2007) claimed that the throw can be divided into three phases: “(1) the preparation phase, which consists of all the movements directed away from the intended line of projection; (2) the execution phase, which consists of all movements performed in the direction of the throw; and (3) the follow-through phase, which consists
of all the movements performed following the release of the projectile” (p. 342).

Assessment of throwing performance will be discussed with attention to both the
developmental process of the performance and the product of throwing, or movement
outcome, which is the velocity or force of throwing (Payne & Isaacs, 2007).

*Process Measures of Throwing*

The process measures of throwing describe the movement of the body
components during the execution of throwing. Body components vary across time in a
nonlinear relationship with product measures such as velocity and accuracy (Halverson &
Roberton, 1979). “Developmental sequences,” according to Roberton and Konczak
(2001), are verbal descriptions of the qualitative changes that occur in the way the
individuals use their bodies as they perform the same motor task over time” (p. 92). The
changes that occur during the movement are more challenging to describe and are more
challenging to obtain with comparison to the product measures (Roberton & Konczak,
2001). Knowing the changes that occur during movement and being able to identify the
different body components that are related to the movement might help the physical
education teacher improve student performance (Roberton & Konczak, 2001).

Developmental sequences of the overhand throw have been developed from two
perspectives; the total body approach (Wild, 1938), and the component approach

*The total body approach.* Almost seventy years ago, the first study of
developmental throwing stages was conducted by Wild (1938), who observed 32 boys
and girls (Payne & Isaacs, 2007). As a result of this research, Wild (1938) identified four
developmental overhand throwing stages. According to Wild’s (1938) findings, moving
from one stage to the next stage over time proceeds in linear fashion and order (Garcia & Garcia, 2002). “Linearity in a sequence of throwing refers to a hierarchical progress in the sequence without regression to immature forms (invariant order),” stated Garcia & Garcia (2002, p. 63). Furthermore, progression to a more mature pattern of the throw could be changed in the sequence but only to the closest stages (Garcia & Garcia, 2002).

The first stage, stage 1, described a performance involving stationary feet and a dominant arm movement with no trunk rotation. In contrast, the most mature stage, stage 4, showed a mature pattern of throwing with a contralateral step, trunk rotation, and the arm horizontally adducted in the forward swing.

Forty-five years after Wild’s (1938) research, Haubenstricker, Branta, and Seefeldt (1983) developed a five-stage throwing sequence referred to as the total body approach. The total body approach depicted a stage 1 that was very similar to Wild’s, with no step or trunk rotation and a chopping arm motion. By stage 3, children were stepping ipsilaterally (same foot, same arm), and by stage 5 (the most mature stage), children stepped with opposition, had segmental trunk rotation, and showed arm wind-up and follow through. The total body approach was developed under developmental stage theory, which suggested a linear sequence of development that was universal and had an intransitive order (Roberton, 1982; Haubenstricker, Branta, & Seefeldt, 1983).

The component approach. Around the time that the total body approach was being developed, an alternate approach to throwing development was conceptualized. Roberton (1977, 1978) developed a component model of throwing development and suggested that developmental changes occurred at the level of body components rather than the entire body. Roberton’s component approach referred to the changes that occurred at the
component level as steps or levels, in contrast to the term stages (Langendorfer & Roberton, 2001). Table 2.1 summarizes the developmental sequences in the component approach within the five components of the overhand throw for force.

<table>
<thead>
<tr>
<th>Foot (Step) Action Component</th>
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<tbody>
<tr>
<td><strong>S1. No step.</strong> The child throws from the initial foot position.</td>
</tr>
<tr>
<td><strong>S2. Homolateral step.</strong> The child steps with the foot on the same side as throwing hand.</td>
</tr>
<tr>
<td><strong>S3. Contralateral, short step.</strong> The child steps with the foot on the opposite side from the throwing hand.</td>
</tr>
<tr>
<td><strong>S4. Contralateral, long step.</strong> The child steps with the opposite foot a distance of over half the child’s standing height.</td>
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<tr>
<th>Preparatory Arm Backswing Component</th>
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<tr>
<td><strong>B1. No backswing.</strong> The ball in the hand moves directly forward to release from the arm’s original position when the hand first grasped the ball.</td>
</tr>
<tr>
<td><strong>B2. Elbow and humeral flexion.</strong> The ball moves away from the intended line of flight to a position behind or alongside the head by upward flexion of the humerus and concomitant elbow flexion.</td>
</tr>
<tr>
<td><strong>B3. Circular, upward backswing.</strong> The ball moves away from the intended line of flight to a position behind the head via a circular overhead movement with elbow extended, or an oblique swing back, or a vertical lift from the hip.</td>
</tr>
<tr>
<td><strong>B4. Circular, downward backswing</strong> The ball moves away from the intended line of flight to a position behind the head via a circular down-and-back motion, which carries the hand below the waist.</td>
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<tr>
<th>Trunk (Pelvis-Spine) Action</th>
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<tbody>
<tr>
<td><strong>T1. No trunk action or forward-backward movements.</strong> Only the arm is active in force production. Sometimes, the forward thrust of the arm pulls the trunk into a passive left rotation (assuming a right-handed throw), but no twist-up precedes that action. If trunk action occurs, it accompanies the forward thrust of the arm by flexing forward at the hips. Preparatory (trunk) extension sometimes precedes forward hip flexion.</td>
</tr>
<tr>
<td><strong>T2. Upper trunk rotation or total “block” rotation.</strong> The spine and pelvis both rotate away from the intended line of flight and then simultaneously begin forward rotation, acting as a unit or “block.” Occasionally, only the upper spine twists away, then toward the direction of force. The pelvis, then, remains fixed, facing the line of flight, or joins the rotary movement after forward spinal rotation has begun.</td>
</tr>
<tr>
<td><strong>T3. Differentiated rotation.</strong> The pelvis precedes the upper spine in initiating forward rotation. The thrower twists away from the intended line of ball flight and then begins forward rotation with the pelvis while the upper spine is twisting away.</td>
</tr>
</tbody>
</table>

Table 2.1. Developmental Sequences of the overhand throw for force.

Continued
Table 2.1 (continued)

<table>
<thead>
<tr>
<th>Humerus (Upper Arm) Action Component During Forward Swing</th>
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</thead>
<tbody>
<tr>
<td><strong>H1. Humerus oblique.</strong> The humerus moves forward to ball release in a plane that intersects the trunk obliquely above or below the horizontal line of the shoulders. Occasionally, during the backswing, the humerus is placed at a right angle to the trunk, with the elbow pointing toward the target. It maintains this fixed position during the throw.</td>
</tr>
<tr>
<td><strong>H2. Humerus aligned but independent.</strong> The humerus moves forward to ball release in a plane horizontally aligned with the shoulder, forming a right angle between humerus and trunk. By the time the shoulders (upper spine) reach front facing, the humerus (elbow) has moved independently ahead of the outline of the body (as seen from the side) via horizontal adduction at the shoulder.</td>
</tr>
<tr>
<td><strong>H3. Humerus lags.</strong> The humerus moves forward to ball release horizontally aligned, but at the moment the shoulders (upper spine) reach front facing, the humerus remains within the outline of the body (as seen from the side). No horizontal adduction of the humerus occurs before front facing.</td>
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<tr>
<th>Forearm Action Component Forward Swing</th>
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<tr>
<td><strong>F1. No forearm lag.</strong> The forearm and ball move steadily forward to ball release throughout the throwing action.</td>
</tr>
<tr>
<td><strong>F2. Forearm lag.</strong> The forearm and ball appear to “lag,” i.e., to remain stationary behind the thrower or to move downward or backward in relation to her/him. The lagging forearm reaches its furthest point back, deepest point down, or last stationary point before the shoulders (upper spine) reach front facing.</td>
</tr>
<tr>
<td><strong>F3. Delayed forearm lag.</strong> The lagging forearm delays reaching its final point of lag until the moment of front facing.</td>
</tr>
</tbody>
</table>


*Partial validation of the component approach.* Roberton (1977, 1978) conducted a partial validation of the component sequence under the notion of stage theory. Roberton (1977) investigated 73 children performing a forceful overhand throw. Each child practiced 10 throwing trials and each trial was examined independently. The results from this study showed that testing the laws of stability and intransitivity were recognized since all participants had at least 50% of their trials in one category in the arm action.
stages and “all variation across trials was only to adjacent categories in the hypothesized stage ordering (intransitivity)” (Roberton, 1978, p. 167). The pelvis-spine stage did not meet the criteria of universality, and several children had variation in their performance across trials. Only two components of the throw demonstrated stability across stages; therefore, the researcher devised the component approach model, which suggested a progression in part of the throw that did not require change in another part (Roberton, 1977, 1978). A year later, Roberton (1978) studied 76 children over three years and described the action of the humerus and the forearm in a forceful throw. The results from this study supported the previous study (Roberton, 1977) in that at least two components seemed to be predictable; however, the other three did not change progressively over a three-year study. At least half of the students in the study, it was revealed when studying each component separately, did not show development in throwing. It was also found that the development of the throwing components are not similar or do not change in the same relationships from subject to subject (Roberton, 1978). The findings strengthen the validation of the pre-longitudinal study (Roberton, 1977) as well as the findings of this study (Roberton, 1978) and the component approach.

In 2002, however, Garcia and Garcia analyzed 3469 throws of six children aged two to five years over a 2 year period using the total body approach but dynamic systems theory as the theoretical framework. Within the dynamic systems framework, the prescriptive nature of stages was re-conceptualized as being behavioral attractors. Garcia and Garcia (2002) indicated that children’s developmental throwing patterns were nonlinear and varied as a result of individual constraints as well as environmental constraints such as the learning context and the motivation of the child, thus supporting
the dynamic systems theory as an appropriate theoretical framework within which to analyze throwing development (Garcia & Garcia, 2002).

Although the component approach had been developed under the stages theory, it was better explained by the dynamic systems theory (Hamilton & Tate, 2002). The five body components and the different possible configurations of the component levels indicated that there were certain behavioral attractors in throwing that represented common patterns of throwing movements (Langendorfer & Roberton, 2002b). Within this framework, the throwing developmental sequences are considered to be the possibilities of the throwing movement repertoire, and a child phase shifts between these possibilities. Thus, the issue of stability and intransitivity are no longer considered important and the developmental feedback sequence considered valid and reliable (Roberton, 1977; 1978).

*Advantages and disadvantages of the component approach*. The component approach is a good process measurement for assessing the overhand throw since it is much more sensitive than the total body approach to the changes in the body movement patterns during throwing (DiRocco & Roberton, 1981). Even though not all five components have been validated, it was found to be a reliable instrument to detect changes in the throwing pattern and analyze the throwing movement profile of the subjects, especially under a dynamic systems perspective (DiRocco & Roberton, 1981). The primary disadvantage of the component approach is the difficulty of seeing the humerus and forearm action in “real time,” which necessitates the use of videotape analysis.
Product Measures of Throwing

The product measures, or the outcomes of the throwing movement, can be assessed in varied ways, such as speed, distance, or accuracy of the throwing skill. The relationships between the product measures and the process measures are not always linear and the assumption is that poor performance during the process of the movement will produce low results in the outcome measures (Roberton & Konczak, 2001).

Dusenberry (1952) found that students improved their throwing performance looking at the form of the throw and at the same time increased their throwing scores for distance. On the other hand, some studies have demonstrated that changes in movement patterns of throwing can occur without the equivalent changes in the product measures, such as velocity and accuracy (Halverson & Roberton, 1979; Halverson, Et al., 1982). Physical education teachers who wish to assess the product measures as well as the changes in motor development need to know the different components that are involved in the movement and how to measure them (Roberton & Konczak, 2001).

Ball velocity is one of the product measures that has been studied through the years by many researchers (Glassow et al., 1965; Halverson et al., 1982; Roberton et al., 1979). The relationship between process variables of correct movement of the throw and the product measures is still unsure (Halverson et al., 1982; Roberton et al., 1979). However, there has been agreement in the findings that ball velocity increases with age, and gender differences were found within all age groups (Glassow et al., 1965; Halverson et al., 1982; Roberton et al., 1979). Halverson et al. (1982) and Roberton et al. (1979) also reported gender differences for velocity that continued to increase with age. Halverson et al. (1982) studied the horizontal ball velocities of 39 children from
kindergarten to second grade and calculated a yearly rate of change of velocity for both boys and girls. The results of the study indicated that boys increased 5 to 8 ft./sec./year, in contrast to the girls, who only changed 2 to 3 ft/sec/year from kindergarten to second grade and 2 to 4.5 ft/sec/year from third to seventh grades (Halverson et al., 1982).

Roberton et al. (1979) studied horizontal ball velocities of 54 children from kindergarten through second grade. The researcher found that the boys’ ball velocities increased 5.05 ft per sec each year, and the girls’ increased 2 to 3 ft per sec. In the follow-up study a few years later with almost the same participants from the first study, the findings supported the earlier prediction regarding the change in the throwing performance for force in the boys’ ball throwing. Roberton et al. (1979) filmed 67 kindergarten children as both first and second graders. Gender differences in ball velocity were reported, with advantage to the boys, who increased an average of 5.04 ft/sec/year, in contrast to the girls, who increased an average of 2.94 ft/sec/year (Roberton, et al. 1979).

Rippee and Pangrazi (1990) studied right-handed boys and girls from first and fourth grades. They measured velocity, distance, and accuracy as quantitative measures of the throw and also a measured the form of the throw. The results of the study showed that the boys’ throwing performances were more advanced in all variables. The differences between the older boys’ and older girls’ velocity and distance scores were greater than the differences between those of the boys and girls at younger ages. It was also clear that the throwing profiles of the boys in comparison to those of the girls were different. “Boys had a high (positive) correlation (.882) to their velocity/accuracy profile while girls had a low (negative) correlation (−.784)” (Rippee & Pangrazi, 1990, p. 183).
The girls’ throwing competence varied across participants at the fourth grade. Some were high skilled while others had poor performance. The fourth grade girls demonstrated lower profiles in throwing than the younger boys (Rippee & Pangrazi, 1990).

Thomas and French (1985) also found in five velocity studies that boys’ performance was better than girls’ as early as ages 4 to 7 years when they were asked to throw for force and distance. Glassow et al. (1965) studied ball velocities of three grade levels (first, third, and sixth) followed by a second year of specific instructional programs. The same children were recorded in their second, fourth, and seventh grade classes and the authors reported improvement in velocity scores across all ages.

Yan, Payne, and Thomas (2000) claimed that the timing of ball peak velocity should be examined relative to ball release in the throwing skill ability of young girls. The purpose of their study was to evaluate the overhand throw of different age groups of girls (3–6 years old) and to measure ball release velocity and timing of peak ball velocity relative to release, joint angles, and joint angular velocities at ball release using the component approach (Roberton, 1977, 1978). The results of the study indicated age differences in the form of the throwing. When comparing the differences of the girls in ball release velocity and the timing of ball peak velocity related to ball release, significant differences were noted among age groups with advantage to the older girls (Yan, Payne, & Thomas, 2000). The older girls threw the ball faster than the younger girls, but none of the participants released the ball at peak velocity. It was found that younger children released the ball too early or too late and did not reach peak velocity to reach maximum release velocity.
From a physical educator’s perspective, the assessment of throwing performance using product measurements such as velocity scores can be very useful. The product measure can be used as a motivation for the children to practice and improve and at the same time it can be used as both feedback for the child (as knowledge of result) and feedback to the teacher (for the learning process of the students). Velocity is also functional in games like softball and baseball when the performer needs to throw fast.

In conclusion, these studies clearly indicated that gender differences can be found in ball velocity scores, with advantage to the boys, and that velocity scores increase with age (Halverson et al., 1982; Roberton et al., 1979). However, the relationship between the products measures (ball velocity scores) and process measures (the form of the throw) is still incomplete.

**Constraints Model and Throwing**

The component approach to throwing accepts that the developmental levels of motor skill components reflect underlying “attractors” in the dynamic system (Langendorfer & Roberton, 2001). Attractors are considered strong if developmental levels are stable across trials, are qualitatively different from each other, and are presumed to transition to other forms at times to increased intra-individual variability (Payne & Isaacs, 2007; Haywood & Getchell, 2005). A change in the qualitative state of a child’s throw is evidence for a change in constraint. Langendorfer and Roberton’s (2001) study supported Newell’s (1984, 1986) constraints model in that it was found that the movement patterns used to throw a ball emerge from various relationships that constrain the action. When qualitative changes occur in the throw, the model suggests that a shift has also occurred in the person-environment and/or person-task relationship.
Age and gender are two variables that have been studied as important factors that influence throwing development (Butterfield & Loovis, 1993). Gender differences in favor of boys were found both in process measures such as the form of the throw (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002 a, 2002 b; Thomas & Marzke, 1992) and in product measures such as accuracy and velocity (Moore & Reeve, 1987; Moore, Reeve, & Pissanos, 1981; Thomas & French, 1985).

Butterfield and Loovis (1993) supported the findings of Seefeldt and Haubenstricker (1982), indicating that boys tend to achieve mature patterns of throwing performance earlier than girls. Butterfield and Loovis (1993) examined 719 boys and girls aged 4–14 years and assessed their throwing development using the Ohio State University Scale of Intragross Motor Assessment (OSU-SIGMA). The investigators were mostly interested in the percentage of students performing a mature throwing pattern that included sidearm throwing and stepping with opposition. The results of the study indicated that boys demonstrated higher competence in throwing performance of mature throwing patterns than girls, and significant gender differences favoring the boys were found in grades K, 1, 2, 4, and 7.

Thomas, Michael, and Gallagher (1994) examined the impact of different training on throwing for distance in the literature. They conducted a meta-analysis to studies related to throwing for distance with students in the age range of 5–9 years (N=426). The findings from pre-to posttest indicated that both boys and girls improved relative to their pretest, but the gender and training interaction did not have a significant influence on the
gender differences that remained significant. The girls did not “catch up” with the boys, who also improved their performance from pretest to posttest (Thomas, Michael, & Gallagher, 1994). Overall, the findings relative to gender and age indicated that boys perform better than girls in all categories of throwing, including process and product measures (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Seefeldt & Haubenstricker, 1982; Halverson & Roberton, 1979).

*Task Constraints and Throwing*

Task constraints include the external constraints that focus on the goal of the activity that the teacher assigns to the students during the lesson (Barrett & Burton, 2002; Langendorfer, 1990). Different tasks during the physical education lesson can produce different performance of the overhand throw. If the child stands far from the target and needs to use force to hit the target, the throwing performance will be different than the throwing pattern he/she might use to hit a close target. When the task constraints change, the performance of the throw also changes.

Langendorfer (1990) examined the development of throwing patterns when changing the task from accuracy to force. The participants (43 fourth graders aged nine and ten years) improved their performance when they were asked to throw harder. A significant difference was identified in the throwing components under the force conditions (Langendorfer, 1990). Most of the participants used a less mature pattern when throwing for accuracy than when throwing for force. William, Haywood, and VanSant (1993) found that males performed at higher developmental levels than females and also threw faster when asked for forceful throws rather than for accuracy. These findings clearly demonstrate the importance of the task demand and its effect on the
developmental level of the overhand throw. Physical education teachers need to be aware of how and when to change the task demand as well as know their students’ skill levels to match their abilities (Barrett, 1983).

**Environmental Constraints and Throwing**

Common environmental features studied include the size, weight, and mass of the ball, as well as the distance from the target and the amount of feedback delivered by the teacher. However, little research has examined the effect of different instructional strategies and methods on the developmental levels of students’ overhand throwing (Browning and Schack, 1990; Duesenberry, 1952; Halverson & Roberton, 1979; Moore, Reeve, & Pissanos, 1981; Lorson, 2003; Oslin, Stroot, & Siedentop, 1997; Roberton, 1987; Stodden, 2002). Dusenberry (1954) investigated 56 students aged three to seven years to determine their throwing performance for distance. One group received specific throwing instructions twice a week for three weeks, while the other group of students served as a comparison group and only practiced the throw without instruction. The results from this study clearly showed an advantage for the boys in arm and hand movement of the throw. It was also indicated that even though both groups improved during the five weeks of practice, the group of students who received specific instructions had higher throwing scores for distance in comparison to the other group (Dusenberry, 1954).

Moore, Reeve, and Pissanos (1981) studied the effect of different instruction on overhand throwing performance among children. The primary purpose of their study was to determine whether different instruction influenced the distance and accuracy of the throwing performance (Moore, Reeve, & Pissanos, 1981). One hundred and seven
students (m=58, f=49) were divided into three instructional groups; two groups received instruction related to the overhand throw and the third group did not receive any throwing instruction. The students were pre- and posttested on throwing beanbags for distance and accuracy. The results of this study indicated significant differences with advantage to the boys for both measures. No significant differences were found between the two instructional approaches (Moore, Reeve, & Pissanos, 1981). In both studies, differences between the performance of the boys and girls were found, as expected (Halverson et al., 1977; Moore, Reeve, & Pissanos, 1981).

Roberton (1987) studied 22 children (mean age = 5.6) throwing for force with the intent of investigating the changes in the children’s developmental levels with changes in target conditions during throwing. The students were tested on throwing velocity under four conditions: 1) throwing for force without any target, 2) throwing to a stationary target, 3) throwing to a stationary target that changed location across trials, and 4) throwing to a moving target. The results from the study indicated that developmental levels of the throw did not immediately emerge with changes in the task demand. Most participants demonstrated a low-level performance of the throw with the change of environment, and there were no significant differences across conditions. However, the findings revealed the influence of the task constraints on the throwing velocity scores. The throwing velocity scores were higher when the students were tested on throwing for force rather than on the accuracy conditions (Roberton, 1987).

Browning and Schack (1990) studied 42 sixth-grade girls during throwing performance for speed, distance, and accuracy. One group received instruction while the other group did not receive instruction. No differences between the groups were found
related to the throwing patterns (Browning & Schack, 1990). Oslin, Stroot, and Siedentop (1997) studied the use of component-specific instruction (CSI) to promote development of the overhand throw in different age groups of boys and girls. The seven female preschool students who completed the study (aged 3.1 to 5.8 years) were pretested on throwing. The purpose of the study was to examine the effect of CSI on student performance related to the five developmental sequence components of overhand throw in comparison to two other instructional methods. Three students were assigned to a group that received forward-chaining sequence (FCS) instruction during intervention, and the remaining four students received force-production sequence (FPS) instruction. The children in the CSI group received appropriate feedback following each practice trial (Oslin, Stroot, & Siedentop, 1997). The results of the study indicated that all children benefited from CSI regardless of the secondary treatment they received at the same time. During CSI, the level of efficiency was increased to all participants (Oslin, Stroot, & Siedentop, 1997). The data analysis revealed that the elbow and the backswing during the throw were the most important components for executing efficiency in throwing. Oslin, Stroot, & Siedentop (1997) concluded that effective instruction can promote student learning but that further research should be conducted in naturalistic settings where the teacher needs to deliver specific feedback to a large group of students.

Lorson (2003) followed Stodden’s (2002) line of research and investigated first and second grade students performing overhand throwing for force. The students (N=124) were divided into three different instructional approaches. One group received critical cues during instruction, the second group received a typical physical education approach, and the third group received biomechanical instruction. The results from the study
indicated that students in the biomechanical instructional approach showed better improvement in the humerus and forearm components in comparison to the other two instructional approaches. Even through the three instructional approaches improved the throwing performance of all the children involved, the biomechanical approach had an advantage on the more advanced levels within the components (Lorson, 2003).

The research literature reviewed in the previous sections suggests that gender is an important learner constraint that influences the performance of overhand throwing (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002b; Thomas & Marzke, 1992). As indicated, boys outperform girls in both throwing components and throwing velocity (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002b; Thomas & Marzke, 1992). Thus, for the purposes of this study, gender was a variable of interest in the analysis of data. The task constraint of interest in this study was throwing for force, and all tasks associated with this study were focused around the throw for force in order to keep task constraints constant. Roberton et al. (1979) suggested that throwing for force was the most efficient manner in which to promote proficient throwing patterns. Finally, the environmental constraints of instruction and teacher feedback were studied for how they positively impact the performance of throwing (Stroot & Oslin, 1993). However, the data in this area are diverse and limited because of the role of the teacher in providing feedback that matches student performance and is developmentally appropriate to the age group the teacher teaches.
Summary

The findings from an extensive body of research indicate that learning new motor skills needs to be carefully monitored and guided by the physical education teacher. It is the teacher’s responsibility to have sufficient CK and PCK of the subject they teach (Stroot, 1990; Stroot & Oslin, 1993). Good observation skills help teachers’ effectiveness and make it easier for them to identify the developmental levels of the students’ performance, and use ADFB to individualize feedback to the students’ needs (Barrett, 1983; Behets, 1989; Gangstead & Beveridge, 1984; Siedentop, 1991; Stroot, 1990). These teaching skills also help the teacher vary the activities to improve their students’ performance. Teachers also have to take into consideration all three types of constraints (organismic, task, and environmental) for learning to occur (Garcia & Garcia, 2006; Ennis, 1992).

By strengthening the literature base and resolving some of the issues in past research, this inquiry will add to the knowledge base of the relationship between teacher feedback and student performance. In doing so, this study will focus on helping the participant (teacher) acquire a deep understanding of the content (observe student performance, identify the developmental sequences of throwing, and deliver feedback that is aligned to the students’ performance) being taught to students prior to the use of feedback within the classroom setting. ADFB is information that matches student performance and is appropriate for the age and ability of the student so that the performance can be improved upon. This type of feedback is a form of communication between teacher and student and, as such, the teacher needs to know what specific information to deliver and how to deliver this information in order to achieve optimal
impact on the performance of the student in terms of learning and being able to reproduce the skill performance in later attempts (Magill, 1994). Teacher effectiveness should be measured in terms of the appropriateness of the feedback and not necessarily the amount of feedback given (Magill, 1994; Stroot, 2000). Based on the literature (Barrett, 1983; Stroot, 1990; Stroot & Oslin, 1993) and the researchers’ insight, an assumption of this study is that students who receive ADFB will have better throwing performance (body components and ball velocity) than those who receive more general feedback.

The task constraint guiding this entire study is throwing for force. This study takes into consideration the child’s organismic constraint of gender as well as prior experience in throwing outside of school. Finally, this study also considers the primary environmental constraint of teacher feedback (training the teacher to deliver ADFB) in conjunction to the teacher’s content knowledge of the subject being taught and the teacher’s ability to observe student performance and deliver the feedback.
CHAPTER 3

METHOD

The purpose of the study was to examine the influence of ADFB (as part of an intervention package) on student performance of the overhand throw for force. From a dynamical systems perspective this study focused on the interaction of the learner (gender, prior experience) and the environment (different throwing activities and ADFB intervention) on the task of throwing for force.

In this chapter, the pilot study that was conducted as a precursor to the present study is outlined. The research design is explained, followed by the theoretical framework, the setting, participant selection, and description. The following are also explained: instrumentation, research procedures, teacher interventions, and data analysis.

Pilot Study

A pilot study was planned and implemented in order to examine and pretest the instrument used in the present study. The pilot test was conducted following the approval of the Human Subjects Review Board (HSRB) and all procedures were approved (protocol # 2005B0370; see Appendix A). One physical education teacher volunteered to participate in the pilot study.
The participants in this study were first and second grade students. The second grade students served on the comparison group \((n=16)\) and the first graders made up the experimental group \((n=15)\). The researcher created seven lesson plans related to throwing and asked the teacher to follow the lesson plan during her throwing instruction. She was instructed to teach and monitor two throwing stations while the researcher monitored an additional two stations that were not related to throwing. The teacher wore a wireless microphone during the entire study to record the feedback statements she delivered to the students.

Prior to the first lesson of the comparison group the teacher did not receive any specific instructions regarding the way she should teach the throwing unit. The teacher was informed about the study and the general objectives of the study, but was not asked to follow any guidelines except for the lesson plans provided by the researcher, working within the timeline for each station, and monitoring both throwing stations. At the end of the first seven throwing sessions (comparison group), the researcher taught the teacher the developmental sequences of throwing as well as specific feedback related to the student throwing performance. The teacher was asked to deliver this feedback to the student during the next seven throwing sessions (experimental group). The experimental group went through the same process as the comparison group. For both the comparison and experiment groups, all children were tested on the developmental sequence of throwing and throwing velocity was measures via a Jugs radar gun. The evaluation of the throwing performance (developmental sequence and velocity) occurred at the pretest, posttest and retention (two weeks after the intervention) test.
The results from the pilot study indicated that before the intervention the teacher's feedback consisted of general teaching cues such as “point to the target, step and throw” and many positive comments such as “well done” and “good job.” She did not deliver feedback statements that were aligned to the student performance and were developmentally appropriate to their age. After the teacher training the feedback was coded again and the results indicated that the teacher used two to three feedback statements (“good long step” and “turn fast to the target”) and decreased the amount of general feedback. She was still using positive feedback but the majority of the feedback statements were specific feedback related to the student performance.

The pilot study had limitations (listed below) that helped the researcher in the process of developing the current study. One of the major problems of the pilot study was the fact that both the comparison group and the experimental group were very small (comparison group \( n=16 \), experimental group \( n=15 \)). In order to be able to generalize the results or to have the statistical power to analyze the data the number of participants in a group needed to be higher than 30. Further more the participants in the study were first and second grade students. The radar gun that was used to measure the throwing velocity scores could read only throws from 25 mph and higher. Many throws were recorded as “missing data” as the student could not throw hard enough for the radar gun to read their score. Therefore there was not enough data to use for statistical analysis and analyzing the results.

Despite this limitation, the following relevant information was obtained and became applicable to the current study:
a) Based on observations and coding of the teacher feedback, it was determined that the developmental sequence of the overhand throw for force would be a good instrument to assess the student performance in the overhand throw.

b) In the pilot study a set of hierarchy feedback statements were developed that would become part of the ADFB to be provided in the present study. The pilot study allowed piloting of these statements along with content feedback from experts in motor development.

c) Even though the teacher delivered specific feedback related to the student throwing performance, the feedback was not developmentally appropriate or aligned to the throwing sequence (Roberton & Halverson, 1984). These findings helped the researcher define and conceptualize the term ADFB which was used in developing the current study.

d) The pilot study highlighted the need for a new approach to coding feedback. As a result, the term ADFB was conceptualized and an instrument and set of definition was developed to better evaluate the feedback the teacher would provide.

Research Design

A quasi-experimental non-equivalent group design (NEGD) pretest, posttest, retention test, was selected to examine the influence of a feedback intervention on throwing performance. Non-Equivalent Group Designs involve experimental and comparison groups that are designated before the treatment occurs and are not created by random assignment (Ary, Jacobs, & Razavieh, 2002). The NEGD is one of the most commonly used quasi-experimental designs in educational settings. In educational research, children’s assignments to classes cannot be changed due to the complexity of
the school curriculum (Ary, Jacobs, & Razavieh, 2002). It is also very hard to reorganize the classes to accomplish randomization of the students into the different research groups. Therefore, the participants remained in their intact groups and the intervention was randomly assigned to group. (See Figure 3.1 for a graphical representation of the NEGD.)

Note. The line between the groups represents the non-equivalence in the groups.

Figure 3.1. Non-equivalent group design (NEGD) (Campbell & Stanley, 1963).

Ecological Validity

This study was conducted in a natural setting during a physical education unit and thus the social validity of this design and setting was strong (Ary, Jacobs, & Razavieh, 2002). The participants stayed in their intact classes, as the research design allowed this, and the classes were randomly assigned by the researcher to a comparison group or experimental group to reduce threats to internal validity (Ary, Jacobs, & Razavieh, 2002). The NEGD was also chosen by the researcher because of the ability to pretest and posttest all participants. In this design, pretest measures helped to determine whether the groups were equivalent to begin with, since the subjects were not randomly assigned to the groups and provided a way to deal with the threats of internal validity (Ary, Jacobs, &
Razavieh, 2002). An additional advantage of the NEGD was the fact that the intact classes reduced the possibility that the students were aware of the fact that they were in a study since they were not drawn out of their regular classes.

This was a three-phase study. Phase 1 began in a natural setting during physical education lessons for two third grade classes that were randomly assigned to the comparison group and continued for seven throwing lesson plan sessions. Phase 2 began at the end of Phase 1, and included teacher training. Phase 2 ended only when the teacher was considered trained under the criterion identified in the methods section. Phase 3 started when the teacher was ready to implement the intervention and consisted of teaching seven throwing lessons to two third grade classes using ADFB. Figure 3.2 summarizes the three phases of the study. Although this study took place in a natural physical education setting with a public school physical education teacher, the nature of the activities developed in the throwing lesson plans may limit the ecological validity of the study (see development of lesson plans).
Figure 3.2. The three phases of the study.
Setting

The study was conducted in a suburban, mid-sized elementary school in a Midwestern city.

Description of School

The student population at the school was 651 children in grades K-5 (male = 349, female= 302). The student population was comprised of White/others (87%), Black, non-Hispanic (10%), and Asian (3%) (Ohio Department of Education, 2005-2006). The student to teacher ratio in physical education was 22 to 1 (Ohio Department of Education, 2005-2006). Forty one students (6%) were eligible for discounted/free lunch (Ohio Department of Education, 2005-2006). The Ohio Achievement Test Results (2006) indicated that 90% of third grade students passed the math and reading state tests.

Physical education program. The school curriculum plan articulated that the overall physical education curriculum gives each student the opportunity to explore, develop, and refine his/her capabilities in the cognitive, affective, and psychomotor areas emphasizing movement, sensory-motor training, and skill development. The grade selected for this study was the third-grade. Physical education units for the third grade included fitness, fundamental motor skills (e.g., overhand throwing), and lifetime sports and leisure skill development. The participants in the study had previous experience in the overhand throw, as this skill was part of the physical education curriculum for the second grade. In the setting, the students had a 40-minute physical education class once every four days. The physical education lessons were conducted in the gymnasium, which is the size of a standard elementary school basketball court (74 ft by 50 ft) with
only two basketball hoops hanging from the wall. The gym was a safe environment with wide variety of equipment, including basketballs, softballs, footballs, scooters, cones, mattresses, hoops, bats, and varied objects for different activities. The typical routine for the physical education program was to have students enter the gymnasium in one line by their last names and make a big circle. The students completed the warm-up activity, which was written on a white board; then they follow the teacher’s instruction for the next activity of the day.

Participants

Third grade students were selected for this study as the developmental literature suggests that throwing is emerging during this age (Langendorfer & Roberton, 2002). Langendorfer and Roberton (2002) found that by the age of seven the common attractors that describe the overall throwing patterns are more stable and more mature patterns. The participants in this study were 102 students in four third-grade classes with a mean age of 105.4 month ($SD = 4.76$). There were no significant age differences among the four classes. Students remained in their intact classes for the reasons identified in the “research design” section. The four, third-grade classes were randomly assigned to the comparison ($n = 2$ classes) and experimental ($n = 2$ classes) groups. Only students who had parents complete the informed consent procedures were able to participate in the study. Of the 102 possible students, 97 (95%) returned the appropriate consent form and participated in the study. Those who did not complete the consent process still participated in the instructional activities, but their data were not included in the study and they were not videotaped individually in the pre-post and retention test for throwing assessments. All children wore numbered pinnies in order to assist with grouping within
the class and coding from the videotape. Table 3.1 displays the gender and age for each group. All 97 students completed the study. The comparison group included \( n=49 \) students (18 female and 31 male); the experimental group included \( n=48 \) students (21 female and 27 male).

<table>
<thead>
<tr>
<th>Group</th>
<th>Comparison Group (CG)</th>
<th>Experimental Group (EG)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class A</td>
<td>Class B</td>
</tr>
<tr>
<td>( N )</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td><strong>Mean Age</strong></td>
<td>105.73</td>
<td>106.14</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>5.44</td>
<td>5.92</td>
</tr>
<tr>
<td>Male</td>
<td>106.27</td>
<td>104.58</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>5.81</td>
<td>4.18</td>
</tr>
<tr>
<td>Female</td>
<td>105.20</td>
<td>107.71</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>5.07</td>
<td>7.67</td>
</tr>
</tbody>
</table>

*Note.* Mean age is in months.

Table 3.1. Gender and age of participants by group.

**Physical Education Teacher**

The physical education teacher was selected for this study based on prior knowledge of the teacher his willingness to participate, and the fact he had no prior experience or training in the components of throwing (throwing intervention). The teacher has an undergraduate degree in physical education and seven years of teaching experience. He had been working at the school for the past four years. His first teaching experience was as a classroom teacher in high school. He served in the US army for four
years and received his teaching license in health and science. The physical education teacher believed that successful completion of the physical education program encouraged his students to pursue an active lifestyle and to become creative, confident, and independent citizens who will interact within the community.

*Dependent Variables*

Two categories of dependent variables were investigated during this study. The main research questions dealt with the two primary student dependent variables; the developmental level of the component approach to throwing, and throwing velocity during the pretest, posttest, and retention tests. Secondary categories of interest related to this teacher and included the dependent variables of (a) teacher content knowledge as a result of the professional development, and (b) the amount and type of teacher feedback, provided by the teacher during the seven throwing sessions.

*Instrumentation*

Student performance of throwing was analyzed using both process and product measures of throwing. The product measure of throwing performance was throwing velocity as measured by a radar gun. The process measure of throwing performance was assessed using the Developmental Sequence of Throwing Components (Roberton & Halverson, 1984).

*Evaluation of Throwing Performance*

The developmental sequence of throwing components. The Roberton and Halverson (1984) Developmental Sequence of Throwing Components was used to analyze overhand throwing performance. The component developmental sequence for the overhand throwing is a qualitative tool to assess features of the overhand throw
performance for five body components: step, trunk, backswing, humerus, and forearm. Table 3.2 provides a summary of the movement pattern for each of these components. Appendix B describes the developmental level for each component in detail. Each component in the sequence includes different levels or steps of the developmental sequence that range from three to four levels. Level 1 represents an inefficient movement pattern, in contrast to level 3 or 4 which represents the most refined and efficient movement pattern.

Validation of the throwing components. Roberton (1977) provided empirical support for the component approach based on longitudinal studies that were conducted on overhand throwing performance. Even though the developmental validity of the component approach was not established for all the components, it was found to be a reliable tool for assessing the overhand throw and determining the relationships between and within the components (DiRocco & Roberton, 1981). Validation studies supported the trunk sequence (Roberton, 1977; Roberton, 1978; Roberton & Langendorfer, 1980; Roberton & DiRocco, 1981) and the arm sequence (Roberton, 1977; Roberton, 1978; Roberton & Langendorfer, 1980; Roberton & DiRocco, 1981), with the exception of the preparatory arm backswing sequence, which was hypothesized by Roberton (1982) from the work of Langendorfer (1980). The step component was hypothesized by Roberton (1984) from the work of Leme and Shambes (1978) and Seefeldt, Reuschlein, and Vogel (1972). The component approach was recommended as the best qualitative analysis instrument for the body components and movement profiles or body patterns (DiRocco & Roberton, 1981).
**Step (Foot) Action**
- S1. No step.
- S2. Homolateral step.
- S3. Contralateral, short step.

**Trunk (Pelvis-Spine) Action**
- T1. No trunk rotation.
- T2. Upper trunk rotation or total “block” rotation.
- T3. Differentiated rotation.

**Preparatory Arm-Backswing Component**
- B1. No backswing.
- B2. Elbow and humeral flexion.

**Humerus (Upper Arm) Action During Forward Swing**
- H2. Humerus aligned but independent.

**Forearm Action Forward Swing**
- F1. No forearm lag.
- F2. Forearm lag.
- F3. Delayed forearm lag.


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Table 3.2. Developmental sequences within components of the overhand throw for force.

Component procedures. Prior to the beginning of the study, all students completed five throwing trials for force. The participants were placed in a 3 by 5 ft. square that was marked on the gym floor with red tape. The square was 20 ft. from the target, which was 4 by 4 ft. square on the wall. The size of the target meant that student’s throwing performance would not be constrained by the accuracy nature of the task but would provide motivation to throw. Each throw was videotaped and coded for the
developmental sequences. The participants were told to throw the tennis ball "as hard as" they could at the target. Before the camera was turned on to record the five throwing trails of each participant, the participants were allowed five warm-up trials.

Two cameras were used to capture the throwing trials. One camera was positioned in front of the student, in a place where it could not be hit by the tennis balls but had a good view of the participant. The second camera was set to the side of the participant in line with the thrower’s trunk on the side of the dominant throwing arm.

Note.

= Video camera position.
= Throwing target (for pretest, posttest, and retention test).
= Throwing box (20 ft from target).

Figure 3.3. Diagram of gymnasium, throwing box, square target position, and video camera positions.
At a separate time, the developmental level of the throwing components was coded from the videotaped performances. The performance was primarily coded off the side view. However, the front view was also reviewed when the side view did not provide enough evidence of the throwing performance. During the videotape analysis, each throw was assessed individually by the researcher, and a level was given for each of the five components for the five throwing trials. The modal trial at the pretest, posttest and retention test was used for data analysis. All participants demonstrated a modal profile; on no occasion was the profile split. For example, one participant from the comparison group had five throwing trials during the pretest; Trial 1 was coded S2 T1 B2 H1 F1; Trial 2 was coded S2 T1 B2 H1 F1; Trial 3 was coded S1 T1 B1 H1 F1; Trial 4 was coded S2 T1 B2 H2 F1; and Trial 5 was coded S2 T1 B2 H1 F1 (see Table 3.2). Therefore, the model profile of session 1 for the participant was coded as S2 T1 B2 H1 F1. Throwing performance was evaluated in this manner at the pretest, posttest, and retention test.

Only the step, trunk, humerus, and forearm components were used for data analysis, as previous research suggested these body components were most important and involved in the force generation phase of the throw (Roberton, 1979). Additionally, there has been recent debate regarding the importance of the backswing with some researchers suggesting that it is irrelevant how the ball is positioned behind the body in preparation for the force production part of the throw (Lorson, 2003; Stodden, 2002). Also, the backswing has been found to have little relationship with velocity scores (Lorson, 2003; Stodden, 2002).
Training of coders. The assessment of the five body component levels was analyzed by the primary observer who had conducted a pilot study four months prior to this study. The training process before the pilot study followed a standardized training protocol for both the primary researcher and a second observer/coder. Both observers participated in a three-step training process similar to the one used for Academic Learning Time in Physical Education (ALT-PE) (Siedentop et al., 1982). First they studied the definitions of the five levels within each component, then they identified each level and correctly placed it in a description assessment, and, finally, after they had reached scores of 90% or better on that assessment, they correctly identified the body component levels from a training video that was created by a motor development expert in the throwing components. The performances on the training tape were first analyzed by an expert to identify the correct body components of the participants, and then the observers watched the training video and identified the correct body components. The observers had to identify the correct level of each component. Only after the observers identified all of the body components of throwing and reached 90% agreement with the expert on the training tape was inter-observer agreement confirmed. In the final step, the observers coded five students performing overhand throwing for force using the developmental sequence of throwing components. Only after the observers identified all of the body components of throwing and reached 90% agreement with the expert on the training tape was inter-observer agreement checked. Both observers were trained on the five components to a criterion of 90% accuracy.

Inter-observer agreement (IOA). Inter-observer agreement (IOA) was checked throughout the study by the secondary observer (a graduate student), who was trained in
the above protocol. The reliability check compared the results of the two independent observers. Thirty-three percent of the trials from the pretest, posttest, and retention test were compared to ensure there was a 90% agreement on the observations. The level of agreement in the training video was 90%, 93.89% at the pretest, 95.21% at the posttest and 96.20% at the retention test.

*Throwing Velocity*

The researcher used a Jugs radar gun to measure throwing velocity for each of the five practice trials for both the comparison and the experimental groups during the pretest, posttest, and retention tests. The internal accuracy of the Jugs radar gun is +/-0.4 mph, and the display accuracy is +/-1 mph (Jugs, 1999). The radar gun was checked according to the owner’s instructional manual (Jugs, 1999) to maintain a level of accuracy between +/-1 mph.

Throwing velocity was measured by the researcher who stood 25 ft. in front of the participant. The radar gun was positioned directly in the path of the ball (located in the line of the flight of the ball). The researcher recorded throwing velocity for each of the five trials and told the child their velocity score. The radar gun had a minimum velocity of 25 miles per hour; therefore, throws below 25 mph were recorded as “missing data” in the database. The maximum score of the five throwing velocities for each participant was recorded (during pretest, posttest, and retention test) and used in the data analysis. Only the comparison group had two participants out of 49 that had throws below 25 mph during pre-post- and retention test and therefore their score was recorded as “missing data.”
**Teacher Knowledge Test**

The researcher created two types of knowledge tests (see Appendix C) related to the developmental sequence of the overhand throw. The first test was a content knowledge test that included questions about the body components, throwing phases, and feedback statements. The second test aimed to examine the teacher’s ability to: (a) observe and identify the correct developmental level of the throwing body components, (b) identify what was correct and incorrect about the performance, (c) select the appropriate feedback statement to provide to the student, and (d) provide two drills to improve throwing performance (see Appendix C). This test was considered an evaluation of the teacher PCK. There were three PCK tests, one for a more skilled thrower (S4, T2, H3, F2), one for mid-level thrower (S3, T2, H2, F1), and the last one for low skilled thrower (S2, T1, H1, F1). For all tests the researcher created the questions and each draft of the test was sent to three independent scholars who had expertise in the content area of the overhand throw for force. This process repeated itself twice before content validity of the test was determined.

*Test scores.* The tests were graded using a rubric to determine whether the answer was correct or incorrect. A total of 20 points ranging from 0-20 points could be earned for each test separately, and a cumulative score of 80 points represented a maximum score on teacher knowledge.

*Inter-observer agreement.* Inter-observer agreement occurred on a minimum of 33% of all tests to determine reliability of the final score of the tests. The level of agreement in the pretest was 93% for CK test, 92.95% for the PCK 1, 93.54% for PCK 2,
and 93.27% for PCK 3. The level of agreement in the Posttest was 97.23% for CK test, 90.87% for the PCK 1, 96.45% for PCK 2, and 91.23% for PCK 3.

**Teacher Feedback Coding Instrument**

The instrument used to code the teacher feedback was created by the researcher based on the pilot study limitations and problems identified in the literature relative to clear definitions of the feedback statements. The researcher created a table of feedback statements as well as a hierarchy table (see Table 3.3) that explained in detail what feedback statements the teacher needed to deliver and in what order. The feedback statement table that was created was based on the developmental sequence of the throwing components, professional books in physical education pedagogy, and motor development and motor learning articles (Roberton & Halverson, 1984). Based on the definitions of the ADFB, a coding instrument was developed in order to capture the nature of the teacher’s feedback. This instrument was called the Aligned Developmental Feedback Observation System (ADFOS). The feedback statement table, hierarchy, and instrument were sent to five top experts in the field of motor development with expertise in throwing for content analysis and critique. These motor development experts made minor modifications to terminology and supported: (a) the definition of ADFB, (b) the hierarchy of feedback statements, and (c) the ADFOS (see Table 3.3 for hierarchy and feedback statements).
<table>
<thead>
<tr>
<th>PERFORMANCE</th>
<th>ADFB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STEP</strong></td>
<td><strong>STEP</strong></td>
</tr>
<tr>
<td>1. No step</td>
<td>1. Step toward target</td>
</tr>
<tr>
<td>2. Homolateral step</td>
<td>2. Step with your opposite foot</td>
</tr>
<tr>
<td>3. Contralateral short</td>
<td>3. Long step toward target</td>
</tr>
<tr>
<td><strong>TRUNK</strong></td>
<td><strong>TRUNK</strong></td>
</tr>
<tr>
<td><strong>Only when the child steps with opposition do you begin to cue trunk</strong></td>
<td></td>
</tr>
<tr>
<td>1. No trunk</td>
<td>1. Turn your hips/belly button to the target</td>
</tr>
<tr>
<td>2. Block rotation of trunk</td>
<td>2. Turn your hips fast</td>
</tr>
<tr>
<td>2a. Twist your hips and/or</td>
<td>2b. Belly button to the target</td>
</tr>
<tr>
<td>2b. Belly button to the target</td>
<td>And/or Manual manipulation of the hips turning before the shoulders</td>
</tr>
<tr>
<td>3. Differentiated trunk</td>
<td>3. Good hips – maybe cue faster</td>
</tr>
<tr>
<td><strong>BACKSWING</strong></td>
<td><strong>BACKSWING</strong></td>
</tr>
<tr>
<td>1 &amp; 2. No backswing &amp; elbow humeral flexion</td>
<td>1 &amp; 2. Arm far back</td>
</tr>
<tr>
<td>Wings of an eagle</td>
<td></td>
</tr>
<tr>
<td>3. Circular upward</td>
<td></td>
</tr>
<tr>
<td>4. Circular downward</td>
<td></td>
</tr>
<tr>
<td><strong>HUMERUS</strong></td>
<td><strong>HUMERUS</strong></td>
</tr>
<tr>
<td>Until the trunk is at least at level 2 block rotation – you do not cue the humerus. Arm back</td>
<td></td>
</tr>
<tr>
<td>1. Humerus oblique</td>
<td>1. Arm way back</td>
</tr>
<tr>
<td>2. Humerus aligned but independent</td>
<td>2. Elbow back</td>
</tr>
<tr>
<td>3. Humerus lag</td>
<td>Only cue lag if the trunk is rotating quickly</td>
</tr>
<tr>
<td>Manual manipulation of the humerus to a position behind the shoulder showing the child humeral lag</td>
<td></td>
</tr>
<tr>
<td><strong>Humeral lag tends to be a by product of a forceful trunk action not something you can cue specifically</strong></td>
<td></td>
</tr>
<tr>
<td><strong>FOREARM</strong></td>
<td><strong>FOREARM</strong></td>
</tr>
<tr>
<td>We do not cue the forearm – it is a by product of a forceful throw and the other components being properly performed</td>
<td></td>
</tr>
<tr>
<td>1. No forearm lag</td>
<td>When a child is working on level 2 of the humerus provide manual manipulation of the humerus and forearm to show the child what forearm lag would look like</td>
</tr>
<tr>
<td>2. Forearm lag</td>
<td></td>
</tr>
<tr>
<td>3. Delayed forearm lag</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.3. Developmental feedback statements aligned to levels of throwing components.
Categories and Definitions for the Instrument

The ADFOS identified two categories of feedback. The first feedback category was *type of Feedback*. The definition of the type of feedback was carefully chosen based on the mentioned criteria of reliable instrument.

*Aligned developmental feedback*—Feedback statements that match the observed developmental level of the child’s throwing performance are defined as ADFB. Example: The student did not step while throwing and the teacher’s ADFB was “Step toward the target.”

*Non-aligned feedback*—Feedback statements that: (a) are not aligned with the observed developmental level of the child’s throwing performance; or (b) are not drawn from the feedback statements on the list; or (c) drawn from the feedback statements on the list, but does not align with the observed developmental level of the child performance.

Example: The student threw the ball with homolateral step and with no trunk rotation, but the teacher’s feedback was: “Don’t forget to make a step and turn your hip faster.”

*Positive feedback* (P) — feedback that either praises the individual or reinforces a correct movement. Example: “Very good long step, Sandy; tremendous throw, Judy; Good effort, Bill.”

*Negative feedback* (N) — feedback that points out that the individual is doing something incorrectly. Example: “Not good, Tammy; You are stepping with the wrong foot, Dan.”
The second category was *direction of feedback*, which identifies to whom the feedback was provided. An additional clarification was added to this category indicating the gender of the individual receiving feedback.

*Individual* (F/M)—Feedback directed to only one student, although it may be heard by other students in the class. When the teacher delivered individual feedback, the gender of the student receiving feedback was completed.

*Group* (G)—Feedback directed to more than one student in the class.

**Coding procedure.** The teacher wore a wireless microphone that was connected to the video camera during all teaching sessions and recorded everything the teacher said. The night after the lesson was taught the researcher coded the teacher’s feedback by observing the videotape. Coding was conducted for four six-minute rotations of the throwing stations. Figure 3.4 (a) provides an example of the data sheet with a listing of each of the categories being recorded. For example: The teacher said to a student, “Jane, I like the way you make a long step.” The researcher entered this data under the ADFB row for aligned developmental feedback and under positive feedback. Another example the teacher told the group to look at the target, step, and throw. The researcher entered the data in the GFB row for group, marking for general feedback to the group. Figure 3.4 represents the coding sheet of the ADFOS.

After each session, a summary sheet was calculated from the tallies on the ADFOS. At the end of each lesson the totals and percentages of the following categories were recorded for ADFB and non-aligned developmental feedback for the comparison group and the experimental group. The coding record was transferred to a summary sheet at the completion of each observation. The total amount of feedback and the percentage
of feedback occurrence were calculated with comparison of group differences (see Figure 3.4)

The Aligned Developmental Feedback Observation System (ADFBOS)

<table>
<thead>
<tr>
<th>FB</th>
<th>ADF</th>
<th>ADM</th>
<th>NAF</th>
<th>NAM</th>
<th>P F</th>
<th>P M</th>
<th>GNA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td>6min</td>
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<tr>
<td>Total</td>
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<td></td>
</tr>
</tbody>
</table>

Direction Type Of Feedback (T)

<table>
<thead>
<tr>
<th>Group</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
<td>Female</td>
</tr>
<tr>
<td>Female</td>
<td>Non-Aligned Female</td>
</tr>
<tr>
<td></td>
<td>Non-Aligned Male</td>
</tr>
<tr>
<td></td>
<td>Positive Female</td>
</tr>
<tr>
<td></td>
<td>Positive Male</td>
</tr>
<tr>
<td></td>
<td>Group Non-Aligned</td>
</tr>
</tbody>
</table>

Note. Six minutes were coded separately for each station.

Figure 3.4. The Aligned Developmental Feedback Observation System (ADFOS).

Coding system. The total amount of feedback was calculated by tallying each feedback statement from the coding sheet. The same procedure was conducted for the amount of feedback per minute (by dividing the number of feedback statements during
the lesson into the 24 minutes that was designated for throwing practice). The total amount of feedback for each category was tallied and summarized, and the percentages of each category from the total amount of feedback of each teaching session were calculated. From the total amount of feedback, the percentages of ADFB and non-aligned developmental feedback were calculated. The total amount of feedback by gender difference was calculated and percentages for each gender were identified from the total amount of feedback. For the purpose of this study, teacher feedback statements related to gender differences were not calculated or reported in the results section.

*Training and inter-observer agreement.* The ADFOS was used by two observers, the researcher and a trained graduate student, to code the feedback statements. The observers had both been trained to use the ADFOS to 90% accuracy in a three-step training process similar to that used for Academic Learning Time in Physical Education (ALT-PE) (Siedentop et al., 1982). The three steps of the process were: (a) studying the ADFOS definitions, (b) completing a written test on those definitions—a test on which they were required to score 90% before they were allowed to move to the next step, and, (c) coding a 10-minute lesson using the ADFOS. Observers met the required agreement level of 90% scoring 93% agreement on the ADFOS training tape. Inter observer-agreement was then assessed for a total of 33% of all videotaped lessons. Inter Observer Agreement was 92% at Session 1, 95% at Session 2, and 96% at Session 3 (before the intervention). Following the teacher training, when the intervention was implemented 100% of the sessions were checked for IOA and IOA was 92% at Session 1, 95% at Session 2, 94% at Session 3, 93% at Session 4, 96% at Session 5, 94% at Session 6, and 96% at Session 7.
Procedures

Figure 3.5 shows an overview of the study procedures. The study procedures included human consent approval, developing the throwing lesson plans, randomly assigning the classes to comparison and experimental groups, and the implementation of three phases of the study.

Figure 3.5. Research procedures.

Human Consent Procedures

Institutional IRB approval was secured prior to the onset of the study (protocol # 2005B0370—refer to Appendix A). Approval to conduct the study at the school was obtained from the principal (see Appendix D) and the physical educator of the school signed a consent form (see Appendix E) to participate in the study. Parental consent forms were sent home to the students before the study began (see Appendix F). Only
students whose signed permission forms were returned were assessed in the study. Ninety seven participants (95%) of the 102 possible participants returned consent forms.

*Development of the Throwing Lesson Plan*

The lesson plans were developed by the researcher, a 10-year veteran physical education teacher. Seven lessons of 40 minutes were part of the overhand throw for force unit. Each student practiced overhand throwing for force for 12 minutes of a 40 minute lesson during the seven sessions, a total of 84 minutes in two stations. Prior research has suggested in order to learn a new fundamental motor skill, at least 80 minutes of practice need to be implemented (Goodway, Crowe & Ward, 2003). The researcher used references from professional journals and personal experience to guide this process. Two lesson plans were developed prior to the start of the study (see Appendix G for lesson plan and activities) and the remaining of the lessons were developed as Phase 1 of the study progressed based on observations of the children’s throwing patterns. The primary objective of the lesson plan was to instruct a forceful overhand throw. The guidelines that informed the researcher in writing the seven lesson plans for this study were: (a) the teacher must teach the overhand throw for force and allow each individual to practice the overhand throw at least 12 minutes during the lesson; (b) the lessons should be organized in a manner that allows the teacher to spend time observing the student throwing performance and provide them with ADFB, if needed, or other feedback; (c) the activities should be varied and integrate different throwing activities to increase the students’ interest and participation, and (d) the physical education teacher should be the only instructor in the throwing station, therefore the two stations (see Figure 3.8) should be close to each other in the gymnasium. The lesson plans were sent to two experts for
content validity. The two experts concurred that the throwing lesson plans consisted of developmentally appropriate throwing activities. The activities in the lesson plans had also been previously tested in motor skills programs for elementary aged children. These activities had been empirically validated as being an effective means to promoting the development of throwing components (Lorson, 2003).

These lesson plans (see Appendix G for lesson plan example) were used in phases 1 and 3 of the study. Thus, the nature of the lesson plans developed by the researcher were high quality lessons with developmentally appropriate activities that would promote throwing development. Both the comparison group in Phase 1 and the experimental group in Phase 3 were instructed from these lesson plans. From an ecological validity point of view, the comparison group in Phase 1 did not represent a typical physical education program in public schools due to the quality of the throwing intervention they received.

Student Practice Trials

In addition to the exact amount of academic learning time that was devoted to each group (12 minutes total of throwing activities) for learning and practicing the overhand throwing for force, the researcher purposefully controlled in each lesson the number of practice trials each student should have at each station. The students practiced the throwing activities with a partner. Each student had five throwing trials and then his partner had the same number of throwing trials. The entire group in the station had thrown all five balls, they retrieved the balls and started again the same throwing activity. These procedures allowed the teacher to control for the number of throwing trials each participant practiced during the lesson (see Appendix G for throwing activities).
Treatment integrity for throwing trials. When the researcher coded the teacher feedback she also coded the number of practice trials that the students were practicing. In each lesson two female and two male students were chosen randomly from the class. The researcher and the second observer counted the number of throwing trials each student had during the activity to make sure that they all had similar practice opportunities to throw. The typical child received an average of 20 throws per six minute station.

Treatment Integrity

The teacher received the lesson plans from the researcher before the study started. The researcher asked the teacher to read the lesson plans to verify that the activities were clear and would be easier implemented during the lesson. The researcher informed the teacher that at the end of the first week of teaching, the next two lesson plans would be created according to the student progression of learning. The lesson plans for both the comparison groups and the experimental groups were identical. The lesson plans and the throwing intervention were the treatment for the comparison group before the teacher was trained. It was important for the internal validity of the study that the teacher implement the lesson plans as given by the researcher and follow the timeline for each station to make sure that all students received the same throwing intervention from an activities standpoint. A reliability checklist was checked and the feedback statements were coded by the researcher each day. The researcher also assessed treatment integrity, which checks whether the independent variable was implemented as intended, via a checklist, which was completed for each lesson using video observation and coding. According to the analysis of these data, the teacher completed all lessons as intended.
IOA for lesson plans treatment integrity. At the end of the day when the researcher analyzed the lesson plans and coded the teacher feedback, the graduate student who did the IOA for the feedback episodes also did IOA for treatment integrity (see Figure 3.6 for lesson plans reliability checklist). Only when the researcher and the graduate student reached 90% agreement was the treatment integrity accepted as reliable. During Phase 1 the level of agreement for treatment integrity was 91.34% for lesson 1, 94.32% for lesson 2, 95.44% for lesson 3, 93.52% for lesson 4, 93.60% for lesson 5, 95.51% for lesson 6, and 94.03% for lesson 7. During Phase 3 the level of agreement for treatment integrity was 96.74% for lesson 1, 94.53% for lesson 2, 91.66% for lesson 4, 94.65% for lesson 5, 90.56% for lesson 6, and 90.64% for lesson 7.

<table>
<thead>
<tr>
<th>Procedural Reliability Check</th>
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</thead>
<tbody>
<tr>
<td>Date________________________</td>
</tr>
<tr>
<td>IOA____________</td>
</tr>
<tr>
<td>1. Introduction of the stations.</td>
</tr>
<tr>
<td>2. Monitoring both throwing stations and delivering feedback.</td>
</tr>
<tr>
<td>3. Activities completed as described in the lesson plan.</td>
</tr>
</tbody>
</table>

Figure 3.6. Procedural reliability checklist.

Data Collection Procedures

The body components and throwing velocity scores were collected at the pretest, posttest, and retention test in accordance with the guidelines identified above. Data
collection regarding the teacher feedback was collected for each of the seven sessions of the study. All data were collected by the researcher. See Table 3.4 for an overview of the dependent variable data collected and the time period when they were collected. Data regarding the independent variable was collected during the study at the end of each teaching session.

<table>
<thead>
<tr>
<th>Session</th>
<th>Variable</th>
<th>Pretest</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Posttest</th>
<th>Retention</th>
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<td>X</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>Observation System</td>
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<tr>
<td><strong>Independent Variable</strong></td>
<td>Teacher Feedback</td>
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<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
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<td>Student throwing</td>
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<td>X</td>
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</tr>
</tbody>
</table>

Table 3.4. Summary of data collected across the study.

*Implementation of the Intervention*

The four third-grade classes were randomly assigned to a comparison ($n = 2$ classes; $n = 51$ children) or experimental ($n = 2$ classes; $n = 51$ children) group. There were three phases to the intervention. Phase 1 was considered the *comparison phase* of the intervention, where the physical education teacher implemented the throwing intervention to two randomly assigned classes using the researcher’s lesson plans, but his
own pedagogy and feedback. Phase 2 of the intervention consisted of teacher training increasing the teacher’s content knowledge about throwing through training on the developmental sequences components of the overhand throw for force. Finally, Phase 3 of the intervention consisted of the experimental phase of the study where the physical educator implemented the throwing intervention using specific feedback based on the developmental sequences. (See Figure 3.7 for the three-phase scheme.)
Figure 3.7. Summary of the three phases of the research procedures.
Phase 1 (Comparison Phase)

Pretest procedures. The participants in the comparison phase of the study consisted of 51 students from two-third-grade classes. All children in the comparison group (classes A and B) were pretested on five trials of throwing performance in the week before the study started in accordance with the procedures outlined in the throwing procedures. The pretest took place during the regular physical education lesson. The researcher pre-tested each participant individually following the class name list while the other students participated in the activities that their teacher planned. The videotape was reviewed and the students’ modal level of throwing was recorded in accordance with the procedures outlined above.

At the start of the pretest the students were asked to answer two questions considering their previous experience with throwing. They were yes (1) or no (0) questions and the answers were recorded for later data analysis. The two questions were: (a) do you participate in organized baseball or t-ball practice team outside of school? (b) do you practice throwing regularly at home with a parent, sibling or friend? If the answer to the question was “yes”, a “1” was recorded for the participant. If the answer to the questions was “no” a “0” was recorded for each question. The data were recorded and were later analyzed by the researcher related to the student throwing experience.

Prior to Phase 1, the teacher did not receive any specific instructions regarding the way he should teach the throwing unit. The teacher was informed that the researcher was interested in learning more about how students best learned the overhand throw for force. The teacher agreed to teach the lesson plans that the researcher had created and work within the timeline for each station.
Within Class A and Class B, students were randomly assigned a number and wore the pinnies with their numbers for the entire intervention period in order to assist tracking the child over the intervention and coding their data by observing the videotape. For each of the seven instructional sessions, the students were randomly assigned to four groups in order to control for the possibility of group effects. That is, for each lesson, a child was in a different group, but stayed in this group for the entire lesson.

Daily procedures. The students entered the gym every day, following their regular routine of entering lined up by last name then forming a circle. When the teacher gave the sign, the students started a typical warm-up routine of eight activities that lasted approximately eight minutes. When the warm-up activities ended, the teacher divided the students into four groups of approximately five to six students per group that had been previously designated by the investigator.

The gymnasium was organized into four areas where the four groups would work. In one half of the gymnasium two stations were set up (#1 and #2) that consisted of activities for practicing the overhand throw. In the other half of the gymnasium two other stations were set up (#3 and #4) that consisted of different activities that were not related to throwing or the intervention. The four groups were assigned to one of the four stations in no particular order as each group would rotate to each station.

Upon the start command, all students participated for six minutes in their station. Upon the freeze command, stations #1 and #2 switched with each other and stations #3 and #4 switched with each other. After 12 minutes, station #1 switched with station #3 and station #2 switched with station #4. In this manner, the students completed the stations in the other half of the gymnasium, resulting in completion of all four stations of
the lesson plan. Figure 3.8 demonstrates the organization of the gymnasium for the intervention.

![Diagram of gymnasium, station positions, and video camera positions.](image)

Figure 3.8. Diagram of gymnasium, station positions, and video camera positions.

The students practiced a total of 12 minutes of overhand throwing in two different stations (6 minutes each station) according to the guidelines of the lesson plan (see Appendix G). The physical education teacher was responsible for monitoring and providing feedback at both of the two throwing stations. At each throwing station a video camera was set up to capture the students’ practice. The teacher wore a wireless...
microphone and his feedback was recorded onto the video camera. Those students \( n = 5 \) who had not consented to participate in the study were located further down the throwing line so that they would not be captured on the videotape, but they did engage in the throwing activities of their regular physical education class.

The two groups of students at the non-throwing stations practiced different activities, and the researcher monitored them while the teacher was teaching in the throwing stations. The activities that the students practiced were part of a basketball unit that the teacher was implementing during this time of the year to the entire school. The basketball activities were given to the researcher by the teacher according to his planning and were not related to the study procedures.

**Posttest.** At the end of the seven throwing lessons, the researcher posttested the students following the same procedures as the pretest. All students were asked to throw a ball as hard as they could five times toward the wall. Every throw of each participating student was captured on videotape.

**Retention test.** Ten days after the first seven lessons of the overhand throw unit, the researcher conducted a retention test with the comparison groups during the physical education lesson. The exact same procedure used for the pretest and the posttest were used for the retention test.

**Phase 2 (Teacher Training Phase)**

Two days after the posttest was completed for the comparison group, the researcher started the process of training the teacher to develop the teacher’s content knowledge on the developmental sequences of throwing and the provision of ADFB.
During the training week, the teacher taught two juggling lessons for both groups until the experimental groups started the study.

Pre-assessment of teacher knowledge. Prior to Phase 2, teacher training, the CK test was orally administrated to the teacher on day one of the training and took approximately 25 minutes to administer. The three video-observation PCK tests were also orally administrated and took 20 minutes per test. These procedures were repeated at the end of Phase 2.

Teacher training. At the end of Phase 1, the researcher provided four workshop sessions to train the physical education teacher. The workshops were conducted in school during four different meetings, each lasted two hours. The training was introduced in eight steps. The training steps for the teacher were as followed:

Step I (Session I, One Hour)

Description of components and levels. The researcher met the teacher in school and provided copies of the long and short versions of the developmental sequence of throwing from Robertson and Halverson (1984) (see Appendix B and Table 3.2). Both the researcher and the teacher had a copy of this information in front of them during the training. The researcher then: (a) read the steps to the teacher; (b) demonstrated to the teacher each step and each level within the steps; (c) had the teacher perform each step, and (d) manipulated the teacher’s body through each step (only if the teacher did not perform the step correctly the first time).

Step II (Session I, One Hour)

Describing the levels. The researcher asked the teacher to read the list in Table 3.2 (the short version of the developmental sequence of throwing). Then the teacher was
asked by the researcher to verbalize each level within the components as well as
demonstrating the level as identified in Appendix B. In the first attempt at this task the
teacher used the list to assist him. In the second attempt at the task, during the
verbalization of the components, the teacher did not use any list and did not receive help
from the researcher. The researcher coded correct and incorrect performance of the
levels. If he was below 90% correct identification he repeated the process until he
reached a criterion of 90% correct identification, at which time he would be considered
trained for this step of the training process. The teacher reached the 93% correct
identification of the performance on the first attempt.

_Step III (Session II, One hour)_

_DVD training_. The researcher provided a DVD to the teacher as part of
independent training. The researcher created the training DVD that included three parts.
The first part of the DVD included a video clip of an expert performing an overhand
throw with high proficiency at the high levels of all of the five body components. The
expert was a graduate student and a veteran physical education teacher who was trained
in the developmental sequence of throwing. The expert was videotaped with a digital
camera from the side. The throwing modeling was followed by a verbal explanation of
each component individually. A full demonstration of the overhand throw was captured
from the side view. The DVD of the expert was used to help the teacher identify the
correct performance of the overhand throwing. The DVD consisted of five vignettes. The
researcher asked the teacher to look at the DVD, while he looked at the developmental
sequence of throwing list (Table 3.2) and verbalized the levels within each step. This step
of the process was completed by the physical education teacher during the first part of the
second training session. At this point in the teacher training, there was no specific requirement for accuracy. Attention was focused on looking at the vignettes and verbalizing the levels within the throwing components.

*Step IV (Session II, One Hour)*

*Learning the feedback statements and hierarchy.* Before the study started, the researcher created a table with a list of all the body components and the developmental sequence of overhand throwing for force from Roberton and Halverson (1984). The teacher received a table (see Table 3.3) that summarized the hierarchy of the teacher feedback statements that he was expected to use when he observed his students performing an overhand throwing as well as the feedback statements.

In Table 3.3, the left column consists of the steps of the components and the right column consists of the matching ADFB statements to correct the error if it appeared during the performance. These feedback statements were based on the hierarchy above (see Table 3.3).

The teacher received the table (see Table 3.3) and was asked by the researcher to read the feedback statements aligned with the level in each component that matched the error. The teacher read and studied the feedback statements for 30 minutes.

Along with the feedback list (see Table 3.3), the researcher provided the teacher with the second part of the DVD, which involved vignettes of children at different levels of performance. The vignettes were taped during the researcher’s pilot study (DVD training for students). The training DVD of the children’s performances was 3 minutes long with five vignettes. The researcher watched the vignettes with the teacher, they observed each child separately, using a full description of the developmental level of the
student performances shown in the vignettes, identified and listed the common mistakes, and chose the best feedback statements that matched the performances. The researcher clarified unclear points to the teacher if needed and went over the hierarchy of the feedback statement.

**Step V (Session III, One Hour)**

*Identify the levels and errors of performance with support.* At this step the teacher and the researcher observed the same DVD that was provided to the teacher and the teacher was asked to verbalize the levels in each body component of the children in the video. The teacher was allowed to use the list of components. If the teacher did not identify the component or the levels correctly, the researcher helped him and he was asked to look again at the list. If the teacher correctly identified the levels, he was asked to verbally choose the best feedback statement to correct the error (using Table 3.3). The teacher identified correctly 95% of all the level components of the five vignettes and provided the correct performance (without assistance from the researcher) and moved on to the final step of the training.

**Step VI (Session III, One Hour)**

*Identify the levels and errors of performance with no support.* During the second part of session III, the researcher showed the teacher five vignettes of different children that the teacher had not seen before. At this point the teacher was asked without any help to identify: (a) the components of each student’s throwing performance, (b) the mistakes in the observed performance, and (c) the best feedback statement that matched the error. The teacher reached a criterion of 93% correct identification of the vignette.
Post-assessment of teacher knowledge. The same procedures that were used at the pretest were conducted as the posttest. The teacher reached the criterion score of 90% or above and he was considered trained and ready for live coding of the forth graders.

Step VII (Session IV, One Hour)

Live coding of forth graders. In order to be sure that the teacher could deliver the experimental intervention in a real setting, he was coded delivering the ADFB to forth graders. The physical education teacher taught the overhand throw during the first 15 minutes of a forth-grade physical education lesson. The researcher videotaped the lesson, using the wireless microphone, and live coded the teacher’s feedback statements. The researcher videotaped 10 students during the lesson. These students received feedback from the teacher. When the lesson ended the researcher watched four randomly selected children, who were videotaped, and analyzed the data, coding the teacher feedback statements. The teacher delivered 93% of ADFB statements out of the total amount of feedback during the 15 minutes session and he was considered trained. The rational for choosing forth-grade students was due to the fact that third and forth grade students are similar in their ability to understand and perceive information load.

Step VII (Session IV, One Hour)

One throwing lesson delivered to fourth graders. The researcher asked the teacher to practice the intervention package that included his ability to observe students performing overhand throwing for force, identifying errors during student performance according to the developmental sequence, and delivering ADFB statements that matched the errors. The teacher taught one lesson of forth-graders teaching the overhand throw while the researcher followed all the procedures that were planned for the study. The
researcher live coded the teacher feedback statements at that point but also coded the video at the end of the day for treatment integrity. At this point, the researcher used the trained graduate student for the IOA for the vignettes. The same procedures that were implemented during Phase 1 for treatment integrity were applicable for this session. The teacher upon reaching 90% correct identification of the errors and delivery of the matching feedback statements, was considered to be trained.

Phase 3 (Experimental Phase)

*Pretest.* During the week of teacher training the 49 third graders who had consented to participate in the study in the experimental groups (classes C and D) were pretested following the same procedures mentioned above.

*Implementing the intervention (ADFB).* After the teacher was trained and ready to start the intervention and deliver ADFB, the experimental groups (classes C and D) participated in the study. The same lesson plans as those used with the comparison groups were used for the seven lesson throwing unit, however, with the experimental groups the teacher was required to deliver ADFB chosen by the researcher (see Table 3.3 for feedback statements and hierarchy). All of the other procedures for Phase 3 mirrored Phase 1 other than the teacher provided ADFB. During the lesson the teacher observed student performance and provided ADFB to the student’s performance. For example, the teacher observed one of the students performing the overhand throw, with a homolateral step. The teacher provided the student with feedback “step with your opposite foot” and at the same time assisted the child by putting his body in the correct position.

*Treatment integrity.* The same procedures that were used in Phase 1 to make sure that the teacher followed the lesson plans that were used during Phase 3. However, at this
point, another variable was integrated into the study, the ADFB that was part of the intervention treatment was coded by the researcher at the end of every lesson and was checked by the graduate student, who maintained IOA with the researcher at 90% accuracy. The teacher maintained treatment integrity of both the lesson plan and ADFB for the seven lessons of throwing.

Posttest. At the end of the seven throwing lessons, the researcher posttested the students following the same procedures for the pretest.

Retention test. Ten days after the seven lessons of the overhand throwing intervention, the researcher conducted a retention test with the experimental group. The exact same procedures used for the pretest and the posttest were used for the retention test.

Timeline of the Study

This study was conducted over the course of ten weeks. It started in the beginning of January and ended at the end of March 2007.

Data Analysis

Table 3.5 illustrates the research questions, type of data used, and method of analysis.
### Teacher Knowledge

<table>
<thead>
<tr>
<th>RQ 1. Were there any pre-to-posttest differences in teacher knowledge before and after the professional development?</th>
<th>Teacher Knowledge test range from 0-80 points</th>
<th>Teacher training/ professional development</th>
<th>Independent samples t-test</th>
</tr>
</thead>
</table>

### Teacher Feedback

<table>
<thead>
<tr>
<th>RQ 2. What type and amount of feedback was delivered to the students in the comparison group and the experimental group?</th>
<th>Talley &amp; percentage of all type and amount of feedback</th>
<th>Group</th>
<th>Descriptive Statistics (mean, and SD,)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 3. Were there any differences in total amount of feedback delivered to the Experimental and Comparison group?</td>
<td>Total count of all feedback categories</td>
<td>Group</td>
<td>univariate ANOVA - examine the Group main effect</td>
</tr>
<tr>
<td>RQ 4. Were there any differences between the amount of aligned developmental feedback delivered to the Experimental and Comparison group?</td>
<td>Total ADFB</td>
<td>Group</td>
<td>univariate ANOVA - examine the Group main effect</td>
</tr>
<tr>
<td>RQ 5. Were there any differences between the amount of positive feedback delivered to the Experimental and Comparison group?</td>
<td>Total positive feedback</td>
<td>Group</td>
<td>univariate ANOVA - examine the Group main effect</td>
</tr>
</tbody>
</table>

Table 3.5. Research questions, type of data used, and methods of analysis.
Table 3.5 (continued)

**Student Performance Data Analysis**

**Velocity Scores**

<table>
<thead>
<tr>
<th>RQ</th>
<th>Description</th>
<th>Mean Test</th>
<th>Group</th>
<th>Time</th>
<th>Gender</th>
<th>ANOVA Type</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 6</td>
<td>Were group differences present in pretest throwing velocity between the Comparison and Experimental group?</td>
<td>Mean pretest throwing velocity</td>
<td>Group</td>
<td>2 Group X 2 Gender ANOVA</td>
<td>(examine main effect for Group)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ 7</td>
<td>Were gender differences present in pretest throwing velocity?</td>
<td>Mean pretest Throwing velocity</td>
<td>Group</td>
<td>2 Group X 2 Gender ANOVA</td>
<td>(examine main effect for Gender).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ 8</td>
<td>Were gender differences present between &amp; within the Comparison and Experimental group pretest throwing velocity scores?</td>
<td>Mean pretest Throwing velocity</td>
<td>Gender</td>
<td>2 Group X 2 Gender ANOVA</td>
<td>(examine the Group X Gender interaction). If significant Post-hoc follow up analyses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ 9</td>
<td>Were there any group differences in pre-to-posttest throwing velocity?</td>
<td>Mean pretest and posttest throwing velocity</td>
<td>Group</td>
<td>2 Group X 2 Time X 2 Gender ANOVA with repeated measures (examined the Group X Time interaction)</td>
<td>If significant Post-hoc tests included: 1) paired sample t-tests on pre-to-post scores for each group 2) ANOVA on posttest velocity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ 10</td>
<td>Were there any gender differences in pre-to-posttest throwing velocity between &amp; within the Experimental and Comparison groups?</td>
<td>Mean pretest and posttest throwing velocity</td>
<td>Gender</td>
<td>2 Group X 2 Time X 2 Gender ANOVA with repeated measure (examined the Group X Time X Gender interaction). If significant: 1)paired sample t-tests on pre-to-post scores for each group by gender 2) ANOVA on posttest velocity by group and gender</td>
<td>Continued</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3.5 (continued)

<table>
<thead>
<tr>
<th>RQ 11. Were there any post-to-retention test differences in throwing velocity between the Experimental and Comparison groups?</th>
<th>Mean posttest and retention test throwing velocity</th>
<th>Group Time Gender</th>
<th>2 Group X 2 Time X 2 Gender ANOVA with repeated measures (examined Group X Time interaction) If significant Post-hoc tests included:- 1) paired sample t-tests on post-to retention for each group by gender 2) ANOVA on retention test velocity mean scores</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>RQ 12. Were there any gender differences in post-to-retention test throwing velocity between &amp; within the Experimental and Comparison groups?</th>
<th>Mean posttest and retention test throwing velocity</th>
<th>Gender Time Group</th>
<th>2 Group X 2 Time X 2 Gender ANOVA with repeated measures (examined the Group X Time X Gender interaction) If significant post-hoc tests included:- 1) paired sample t-tests on post-to retention for each group by gender 2) ANOVA on retention test velocity mean scores by group and gender</th>
</tr>
</thead>
</table>

**Student Performance Data Analysis**

**Body Components**

<table>
<thead>
<tr>
<th>RQ 13. Were group differences present in the body components between the Comparison and Experimental group?</th>
<th>Mean pretest body components- step, trunk, humerus, forearm</th>
<th>Group Gender</th>
<th>2 Groups X 2 Gender MANOVA examine Group main effect If significant examine the univariate tests. If univariate test significant examine the means table.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>RQ 14. Were gender differences present in pretest body components between the Comparison and Experimental group?</th>
<th>Mean pretest body components- step, trunk, humerus, forearm</th>
<th>Gender Group</th>
<th>2 Groups X 2 Gender MANOVA examine Gender main effect If significant examine the univariate tests. If univariate test significant examine the means table.</th>
</tr>
</thead>
</table>

Continued
Table 3.5 (continued)

<table>
<thead>
<tr>
<th>RQ 15. Were gender differences present within the Comparison and Experimental group pretest body components?</th>
<th>Mean pretest body components- step, trunk, humerus, forearm</th>
<th>Gender Group</th>
<th>2 Groups X 2 Gender MANOVA examine Group X Gender Interaction. If significant examine the univariate tests. If univariate test significant examine the means table.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 16. Were there any pre-to-posttest differences in body components between the Experimental and Comparison groups</td>
<td>Mean pre and posttest body components- step, trunk, humerus, forearm</td>
<td>Group Time Gender</td>
<td>2 Group X 2 Time X 2 Gender MANOVA with repeated measures examine Time effect. If significant examine Group X Time multivariate interaction. If significant examine the univariate Group X Time interaction. If univariate test is significant conduct post-hoc tests: 1) paired sample $t$-test on pre-to-post for each group. 2) ANOVA on posttest body component between groups, Bonferroni adjustment at $p &lt; .006$ ($p = .05/8$)</td>
</tr>
<tr>
<td>RQ 17. Were there any gender differences in pre-to-posttest body components between &amp; within the Experimental and Comparison groups?</td>
<td>Mean pre and posttest body components- step, trunk, humerus, forearm</td>
<td>Gender Time Group</td>
<td>2 Group X 2 Time X 2 Gender MANOVA with repeated measures examine Gender X Time multivariate interaction. Then examine Group X Time X Gender multivariate interaction. If significant post-hoc analyses</td>
</tr>
</tbody>
</table>

Continued
<table>
<thead>
<tr>
<th>RQ 18. Were there any post-to-retention test differences in body components between the Experimental and Comparison groups</th>
<th>Mean post-to-retention body components- step, trunk, humerus, forearm</th>
<th>Group X 2 Time X 2 Gender MANOVA with repeated measures examine Group X Time multivariate interaction. If significant examine the univariate effects. If univariate test is significant conduct post-hoc tests: 1) paired sample ( t )-test on pre-to-post for each group. 2) ANOVA on retention body component between groups, Bonferroni adjustment at ( p &lt; 0.006 ) ( (p = 0.05/8) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 19. Were there any gender differences in post-to-retention test in body components between the Experimental and Comparison groups?</td>
<td>Mean post-to-retention body components- step, trunk, humerus, forearm</td>
<td>Gender X Time X Group MANOVA with repeated measures examine Gender X Time X Group multivariate interaction. If significant examine the univariate effects. If univariate test is significant conduct post-hoc tests: 1) paired sample ( t )-test on pre-to-post for each group by gender. 2) ANOVA on retention body component between groups and gender, Bonferroni adjustment at ( p &lt; 0.006 ) ( (p = 0.05/8) )</td>
</tr>
</tbody>
</table>

**Student Prior Experience in Throwing**

| RQ 20. Were there any gender differences in participation in organized baseball or t-ball? | Throwing experience percentage male & female indicating yes | Gender | Chi-square |

Continued

118
<table>
<thead>
<tr>
<th>RQ 21. Were there any gender differences in practicing throwing with a family member or friend outside of school?</th>
<th>Throwing experience percentage male &amp; female indicating yes</th>
<th>Gender</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 22. What is the influence of prior throwing experience, and gender on pretest throwing velocity?</td>
<td>Pretest throwing velocity</td>
<td>Gender and Prior Throwing experience</td>
<td>Stepwise Multiple Regression</td>
</tr>
<tr>
<td>RQ 23. What is the influence of prior throwing experience, group, and gender on posttest throwing velocity?</td>
<td>Posttest throwing velocity</td>
<td>Gender, Group and Prior Throwing experience</td>
<td>Stepwise Multiple Regression</td>
</tr>
</tbody>
</table>
CHAPTER 4

RESULTS

This chapter provides the results relative to the research questions. The first portion of the chapter addresses the teacher knowledge test data followed by the questions relative to the ADFB to provide a context for the results of the primary purpose of the study. The second portion of the chapter presents the research questions associated with the influence of the feedback on the throwing performance and throwing velocity of comparison group and the experimental group, including gender differences. Each section examines the influence of the feedback on velocity mean scores before and after the intervention, the influence of the feedback on the body components, and the relationship between body components and velocity mean scores with prior experience on the participants in throwing for force.

Teacher Knowledge

Phase 2 of the study examined the teacher’s knowledge relative to the developmental sequences and instruction for overhand throw for force. The development of the teachers throwing knowledge and ability to observe, analyze, and provide aligned ADFB was a foundation for Phase 3 of the study. Research question 1 examined whether pretest to posttest differences in teacher knowledge existed as a result of the professional
development sessions. The teacher took four tests, one was related to content knowledge (CK) and the other three related to pedagogical content knowledge (PCK), each worth 20 points. A total range of possible points for teacher knowledge was 0 to 80 points. The teacher’s test result scores are presented in Table 4.1. These data are presented in a summary of the CK and the PCK test scores before and after the teacher professional development.

<table>
<thead>
<tr>
<th>Knowledge Test</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>PCK 1</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>PCK 2</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>PCK 3</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>Total Score</td>
<td>37</td>
<td>77</td>
</tr>
</tbody>
</table>

*Note.* CK = content knowledge, PCK = pedagogical content knowledge

Table 4.1. Teacher knowledge test scores.

An Independent Samples *t*-test on the total test score revealed that there were significant differences (*t* [6] = -14.77, *p* < .001 [2-tailed]) in teacher throwing knowledge from pretest to posttest. The teacher’s knowledge of throwing significantly improved as a result of the professional development sessions.

*Teacher Feedback*

Follow-up research questions to the one on teacher knowledge were related to the teacher’s ability to provide aligned developmental feedback during the experimental
condition. As total feedback and positive feedback were potential confounding variables, the differences in the amount of these types of feedback between the comparison and experimental conditions were also examined. The teacher feedback data are presented in Table 4.2 as a summary of the number of feedback statements delivered to the comparison group and the experimental group during the throwing unit. The feedback statements are provided in terms of (a) a total number of statements across the seven lesson throwing intervention and (b) a percentage of the intervention. These data in Table 4.2 answer research question 2.

<table>
<thead>
<tr>
<th>Type of Feedback</th>
<th>Comparison Group</th>
<th>Percentage</th>
<th>Experimental Group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total FB</td>
<td>1370</td>
<td>100</td>
<td>1303</td>
<td>100</td>
</tr>
<tr>
<td>Total ADFB</td>
<td>160</td>
<td>11.67</td>
<td>706</td>
<td>54.18</td>
</tr>
<tr>
<td>Total NADFB</td>
<td>471</td>
<td>34.37</td>
<td>82</td>
<td>6.29</td>
</tr>
<tr>
<td>Positive FB</td>
<td>373</td>
<td>27.22</td>
<td>354</td>
<td>27.16</td>
</tr>
<tr>
<td>Other</td>
<td>366</td>
<td>26.71</td>
<td>161</td>
<td>12.35</td>
</tr>
</tbody>
</table>

*Note.* Data represent numbers of feedback statements and percentage of total feedback statements for each group. FB = feedback, ADFB = aligned developmental feedback, NADFB = non-aligned developmental feedback.

Table 4.2. Teacher feedback statements by group.
Total Amount of Feedback

Research question 3 examined whether there were any group differences in total amount of feedback. A univariate ANOVA revealed a non-significant Group main effect \( (F[1, 26] = .246, p = .624, \eta^2 = .009) \), indicating that there were no significant differences between groups in the total amount of feedback delivered to the students.

Aligned Developmental Feedback (ADFB)

Research question 4 examined whether there were any differences in ADFB between the comparison and experimental groups. A univariate ANOVA revealed a significant Group main effect \( (F[1, 26] = 41.584, p = .001, \eta^2 = .615) \), indicating significant differences between the two groups. Table 4.2 revealed that the experimental group had significantly greater ADFB than the Comparison group.

Positive Feedback

Research question 5 examined whether there were any differences in total amount of positive feedback delivered to the comparison group and the experimental group. A univariate ANOVA revealed a non-significant Group main effect \( (F[1, 26] = .084, p = .775, \eta^2 = .003) \), indicating no significant differences between groups in positive feedback.

Throwing—Ball Velocity

Pretest Differences in Throwing Velocity

Research question 6 examined whether group differences existed in mean recorded throwing velocity scores during the pretest. Table 4.3 reports the mean pretest, posttest, and retention test recorded velocity scores for each group by gender. A 2 Group
X 2 Gender ANOVA on pretest velocity scores revealed a non-significant Group main effect ($F[1, 91] = .799, p=.374, \eta^2=.009$), indicating that groups were statistically similar in their mean recorded velocity at the pretest.

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Velocity Pretest</strong></td>
<td><strong>Comparison Group</strong></td>
<td>Female</td>
<td>31.18</td>
<td>4.57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>38.40</td>
<td>6.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>35.89</td>
<td>7.00</td>
</tr>
<tr>
<td></td>
<td><strong>Experimental Group</strong></td>
<td>Female</td>
<td>30.57</td>
<td>3.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>41.37</td>
<td>8.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>36.64</td>
<td>8.62</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>Female</td>
<td>30.83</td>
<td>3.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>39.80</td>
<td>7.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>36.27</td>
<td>7.84</td>
</tr>
</tbody>
</table>

| Velocity Posttest    | **Comparison Group** | Female | 33.00 | 5.29 | 16 |
|                      |         | Male  | 39.76 | 6.96 | 30 |
|                      |         | Total | 37.41 | 7.15 | 46 |
|                      | **Experimental Group** | Female | 33.33 | 3.83 | 21 |
|                      |         | Male  | 44.00 | 8.36 | 27 |
|                      |         | Total | 39.33 | 8.57 | 48 |
|                      | **Total** | Female | 33.18 | 4.45 | 37 |
|                      |         | Male  | 41.77 | 7.88 | 57 |
|                      |         | Total | 38.39 | 7.92 | 94 |

| Velocity Retention test | **Comparison Group** | Female | 32.62 | 5.12 | 16 |
|                         |         | Male  | 39.63 | 6.40 | 30 |
|                         |         | Total | 37.19 | 6.82 | 46 |
|                         | **Experimental Group** | Female | 32.85 | 3.36 | 21 |
|                         |         | Male  | 44.18 | 7.95 | 27 |
|                         |         | Total | 39.22 | 8.49 | 48 |
|                         | **Total** | Female | 32.75 | 4.15 | 37 |
|                         |         | Male  | 41.78 | 7.47 | 57 |
|                         |         | Total | 38.23 | 7.74 | 94 |

Table 4.3. Mean velocity scores for each group by gender at pretest, posttest, and retention test.

Research question 7 examined whether there were gender differences present in pretest throwing velocity mean scores. A 2 Group X 2 Gender ANOVA revealed a
significant Gender effect at the pretest \( F[1, 91] = 44.46, p<.001, \eta^2 = .328 \). Boys (39.80 mph) had significantly higher throwing velocities than girls (30.83 mph).

Research question 8 examined whether there were differences gender in pretest throwing velocity mean scores between the comparison and experimental groups. The 2 Group X 2 Gender ANOVA revealed a non-significant Group X Gender interaction \( F[1, 91] = 1.68, p=.198, \eta^2 = .018 \), indicating that gender differences were similar among the groups.

**Pretest to Posttest Differences in Throwing Velocity**

Research question 9 examined whether there were any group differences in ball velocity scores from pretest to posttest. A 2 Group X 2 Time X 2 Gender ANOVA with repeated measures on the last factor yielded a significant Time effect \( F[1, 93] = 84.10, p<.001, \eta^2 = .483 \), indicating significant improvement in velocity from pretest to posttest. A significant Group X Time interaction \( F[1, 93] = 5.60, p=.020, \eta^2 = .059 \) was also found, indicating that one group was significantly better than another group from pretest to posttest. Since a significant Group X Time interaction was found, post-hoc paired sample \( t \)-tests were used to determine if differences in ball velocity existed from pretest to posttest for each of the experimental and comparison groups. The post-hoc paired samples \( t \)-tests revealed that both the comparison group \( t[45] = -4.202, p<.001 \) [2-tailed]) and the experimental group \( t[47] = -9.898, p<.001 \) [2-tailed]) improved significantly from pretest to posttest in ball velocity. Additionally, a post-hoc ANOVA on posttest velocity scores was used to determine if differences between groups existed at the posttest. The ANOVA revealed a non-significant Group effect \( F[1, 92] = 1.384, p=.245 \).
$p=.243, \eta^2=.015$), indicating no significant differences between groups in mean recorded velocities at the posttest.

Research question 10 examined whether there were any gender differences in ball velocity scores from pretest to posttest for the experimental and comparison groups. A 2 Group X 2 Time X 2 Gender ANOVA with repeated measures on the last factor yielded a non-significant Gender X Time interaction ($F[1, 93] = .383, p=.538, \eta^2=.004$), indicating that was gender was similar over time. In addition, this question examined whether there were any group by gender differences present in pretest to posttest throwing velocity mean scores. A non-significant Group X Time X Gender interaction ($F[1, 91] = .113, p=.738, \eta^2=.001$) was found. Thus, gender differences were similar between the groups across time. Figure 4.1 represents the mean velocity scores by group for pretest, posttest and retention test.

![Figure 4.1. Changes in ball velocity scores from pretest, to posttest, to retention test by group.](image-url)
Posttest to Retention Test Differences in Throwing Velocity

Research question 11 examined whether there were any group differences in ball velocity from posttest to retention test. A 2 Group X 2 Time X 2 Gender ANOVA with repeated measures on the last factor revealed a non-significant Time effect ($F[1, 90] = 1.252, p = .266, \eta^2 = .014$), indicating that there were no significant changes from posttest to retention test. A non-significant Group X Time interaction was reported ($F[1, 90] = .093, p = .762, \eta^2 = .001$), indicating that groups did not differ in mean throwing velocity from posttest to retention test. These results indicated that both groups maintained the improvement in their throwing velocity from posttest to retention test.

Research question 12 examined whether there were any group by gender differences in posttest to retention test throwing velocity mean scores. A non-significant Group X Time X Gender interaction ($F[1, 90] = .345, p = .558, \eta^2 = .004$) indicated that genders did not differ by group across time.

Summary

Mean ball velocity score summary. Prior to the intervention there were no significant differences in ball velocity between groups. Over the course of the intervention, groups differed from pretest to posttest. The experimental group had significantly higher ball velocities from pretest to posttest. Follow up analyses revealed that both groups significantly improved pre-to-posttest ball mean velocity scores. There were no significant differences found between groups for ball velocity at the posttest. For both groups, from posttest to retention test there were no significant changes in ball velocity indicating that both groups maintained their performance over this period of time.
Summary of the gender differences. Prior to the intervention significant gender differences existed at the pretest, with males having greater mean recorded velocities than females. These gender differences were present within both the experimental and comparison group. Each gender improved significantly in ball velocity from pretest to posttest. However, males continued to significantly outperform females throughout the intervention at the posttest and retention test. Both genders maintained their performance gains from the posttest to the retention test.

Body Components Differences

This section addresses the results of the research questions considering the influence of ADFB on the body components. Table 4.4 represent the means score and standard deviation of body component levels at the pretest, posttest, and retention test for the step, trunk, humerus, and forearm components by group.

Pretest Differences

Research question 13 examined whether group differences were present in the body components at the pretest. A 2 Group X 2 Gender multivariate analysis of variance (MANOVA) revealed a non-significant Group effect \( F[1, 93] = 1.109, p=.361, \eta^2=.057 \), revealing there were no significant differences between the groups in the body components at the pretest.

Research question 14 examined whether gender differences were present in the body components at the pretest regardless of group. A 2 Group X 2 Gender MANOVA revealed a significant Gender effect \( F[1, 93] = 8.558, p<.001, \eta^2=.0271 \), at the pretest indicating there were gender differences in body components. Follow-up univariate tests showed there were significant differences between gender for the step \( F[1, 93] = \).
24.525, \( p < .001, \eta^2 = .209 \), trunk \( (F[1, 93] = 9.775, p = .002, \eta^2 = .095) \), humerus \( (F[1, 93] = 22.203, p < .001, \eta^2 = .193) \), and forearm \( (F[1, 93] = 15.965, p < .001, \eta^2 = .147) \) components at the pretest. Table 4.5 shows the mean component scores by gender for step, trunk, humerus, and forearm. Examination of the means table revealed males had more advanced components than females for each of the four components.

Research question 15 examined whether gender differences were present in the body components between groups at the pretest. A non-significant Group X Gender interaction was found \( (F[1, 93] = 1.993, p = .102, \eta^2 = .081) \). There were no significant differences found between groups for gender in pretest body components.
<table>
<thead>
<tr>
<th>Component</th>
<th>Comparison (n=49)</th>
<th>Experimental (n=48)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>3.20</td>
<td>0.53</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.87</td>
<td>0.33</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.51</td>
<td>0.58</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.26</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>Posttest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>3.51</td>
<td>0.50</td>
</tr>
<tr>
<td>Trunk</td>
<td>2.02</td>
<td>0.14</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.73</td>
<td>0.53</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.36</td>
<td>0.48</td>
</tr>
<tr>
<td><strong>Retention Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>3.57</td>
<td>0.50</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.97</td>
<td>0.14</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.71</td>
<td>0.54</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.32</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Table 4.4. Mean component levels for each group for the step, trunk, humerus, and forearm.
Table 4.5. Mean component levels for each group by gender for the step, trunk, humerus, and forearm.
Pretest to Posttest Differences in Body Components

Research question 16 examined whether differences were present in the body components from pretest to posttest test between the comparison group and the experimental group. A 2 Group X 2 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted and revealed a significant Time effect \( (F[1, 93] = 27.428, p<.001, \eta^2=.549) \), indicating body components improved. A significant Group X Time interaction \( (F[1, 93] = 4.881, p=.001, \eta^2=.178) \) was also found, indicating groups differed over time. Follow-up univariate analyses revealed a significant Group X Time interaction for the humerus \( (F[1, 93] = 17.369, p<.001, \eta^2=.157) \) components, and non significant differences for the step \( (F[1, 93] = 1.285, p=.260, \eta^2=.014) \), trunk \( (F[1, 93] = .734, p=.394, \eta^2=.008) \), and the forearm \( (F[1, 93] = 2.997, p=.087, \eta^2=.031) \) components.

Each group was then selected and analyzed separately using a post-hoc paired-sample \( t \)-test to determine if differences in mean component levels were present from pretest to posttest. A Boneferoni adjustment of the alpha was calculated and the level of significance was established at \( p<.006 \) \( (p=.05/8) \). The post-hoc paired-sample \( t \)-tests revealed significant differences from pretest to posttest for each group in the following body components. The comparison group improved significantly from pretest to posttest on the step component \( (t[48] = -3.665, p=.001 [2-tailed]) \) and the humerus component \( (t[48] = -3.355, p=.002 [2-tailed]) \). The experimental group improved significantly from pretest to posttest in the step \( (t[47] = -4.497, p<.001 [2-tailed]) \), humerus \( (t[47] = -8.851, p<.001 [2-tailed]) \), and forearm \( (t[47] = -3.293, p=.002 [2-tailed]) \).

Separate post-hoc 2 Group X 2 Gender ANOVAs on the posttest scores revealed a significant Group effect for the step component \( (F[1, 93] = 13.317, p<.001, \eta^2=.125) \) and
the humerus component ($F [1, 93] = 15.254, p<.001, \eta^2=.141$). The comparison group had a mean step component level of 3.51 compared to the experimental group’s mean step component level of 3.77, and the comparison group had mean humerus component level of 1.73 compared to the experimental group’s mean humerus component level of 2.04. The other components of trunk ($p = .448$) and forearm ($p = .052$) did not reveal significant differences between groups at the posttest.

Research question 17 examined whether any gender differences were present in the body components from pre-to-posttest between the groups. A 2 Group X 2 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted and revealed a non-significant multivariate Gender X Time interaction ($F [1, 93] = 2.076, p=.091, \eta^2=.084$), indicating that genders did not differ over time. A non-significant multivariate Group X Time X Gender interaction ($F [1, 93] = 1.585, p=.185, \eta^2=.066$) was also found, showing that gender and group did not differ over time.

Posttest to Retention Test Differences

Research question 18 examined whether posttest to retention test intervention differences existed between the groups in the body components. A 2 Group X 2 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted and revealed a non-significant multivariate Time effect ($F [1, 93] = 1.390, p=.244, \eta^2=.058$) from posttest to retention test, indicating that body components did not differ from posttest to retention test. A non-significant multivariate Group X Time interaction ($F [1, 93] = .834, p=.507, \eta^2=.036$) from posttest to retention test was revealed. No significant changes were found from post-to-retention test in the body components between groups.
Research question 19 examined whether there were any gender differences present in posttest to retention test intervention between the groups in the body components. Table 4.6 represents the mean component levels by gender for the step, trunk, humerus, and forearm body components. A 2 Group X 2 Time X 2 Gender MANOVA with repeated measures on the last factor was conducted and revealed a non-significant multivariate Group X Time X Gender interaction ($F [1, 93] = 529, p=.714, \eta^2=.023$), indicating that groups did not differ by gender from post-to-retention test.
<table>
<thead>
<tr>
<th>Component</th>
<th>Female (n=39)</th>
<th>Male (n=58)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Pretest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>2.97</td>
<td>0.48</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.76</td>
<td>0.42</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.15</td>
<td>0.36</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.05</td>
<td>0.22</td>
</tr>
<tr>
<td>Posttest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>3.35</td>
<td>0.48</td>
</tr>
<tr>
<td>Trunk</td>
<td>2.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.58</td>
<td>0.49</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.15</td>
<td>0.36</td>
</tr>
<tr>
<td>Retention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>3.48</td>
<td>0.50</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.97</td>
<td>0.16</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.58</td>
<td>0.49</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.17</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Table 4.6. Mean component levels by gender for the step, trunk, humerus, and forearm.
Summary of the Differences in Body Components by Group

Prior to the intervention, no significant group differences in the four body components (step, trunk, humerus, and forearm) were found at the pretest. Overall, groups differed across the intervention from pretest to posttest for the combined multivariate body components. When each component was examined separately, only the humerus component was significantly different across time, the intervention between groups with the experimental group having a more advanced humerus. However, when each group was examined individually, both experimental group and comparison group improved significantly from pretest to posttest. The comparison group improved significantly in the step component and the humerus component, while the experimental group significantly improved in the step, the humerus, and the forearm components. For both experimental and comparison group, there were no significant differences from posttest to retention test in the body components, indicating that both groups maintained their performance gains from posttest to retention test.

Summary of Differences in Body Components by Gender

Prior to the intervention, there was a significant gender effect with males outperforming females. This was true for overall gender differences and gender differences within each group. The males’ step, trunk, humerus, and forearm body components were significantly higher than the females at the pretest. Each gender improved significantly from pretest to posttest. However, males continued to significantly outperform females throughout the intervention at the posttest and retention test. Both genders maintained their performance gains from the posttest to the retention test.
Students’ Prior Experience

Research Question 20 examined gender differences in participation in organized baseball or t-ball. Table 4.7 represents the summary of the student self report regarding their prior experience on overhand throw. For the sample of 97 participants, a chi-square analysis revealed the percentage of participants who replied yes for question # 1 differed by gender, $\chi^2 (1, N = 97) = .007, p < .05$. More males replied yes to being engaged in organized t-/baseball than females.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Participate in organized t-/baseball (Qs#1)</th>
<th>Practice Throwing with others (Qs#2)</th>
<th>Participate in organized t-/baseball (Qs#1)</th>
<th>Practice Throwing with others (Qs#2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>Yes</td>
<td>12</td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>30.8</td>
<td>33.3</td>
<td>58.6</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>27</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>69.2</td>
<td>66.7</td>
<td>41.4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>39</td>
<td>39</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Note.

*Question 1:* do you participate in organized baseball or t-ball practice team outside of school?

*Question 2:* do you practice throwing regularly at home with a parent, sibling or friend?

Table 4.7. Student prior experience in throwing by gender.
Research Question 21 examined gender differences in practicing throwing with a family member or a friend outside of school. For the sample of 97 participants, a chi-square analysis showed the percentage of participants that replied yes to practicing throwing with others outside of school differed by gender, $\chi^2 (1, N = 97) = .000, p < .05$. Significantly more males than females replied yes to this question.

Research question 22 explored the influence of prior throwing experience, and gender on pretest throwing velocity scores. A stepwise multiple regression tested a three variable model: prior experience in throwing during team practice, prior experience in throwing with family member or other, and gender.

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.739(a)</td>
<td>.545</td>
<td>.530</td>
<td>5.36207</td>
</tr>
</tbody>
</table>

Predictors: (Constant), Que2, Que1, Gender

Table 4.8. Model summary of the influence of throwing experience and gender on pretest velocity scores.

<table>
<thead>
<tr>
<th>Model</th>
<th>Beta</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>.327</td>
</tr>
<tr>
<td></td>
<td>Practice in organized t-/baseball team</td>
<td>.263</td>
</tr>
<tr>
<td></td>
<td>Practice with family member or others</td>
<td>.401</td>
</tr>
</tbody>
</table>

Table 4.9. Beta and significance of the predictor variables for pretest velocity scores.
The $R^2$ indicated that 54% of the variance in the pretest velocity score was explained by the three predictor variables. The $B$ value indicated that participation with others outside of school had the greatest influence on the pretest velocity scores, followed by Gender, and then practicing in an organized team.

Research question 23 explored the influence of prior throwing experience, group and gender on posttest throwing velocity scores. A stepwise multiple regression tested a four variable model: prior experience in throwing during team practice, prior experience in throwing with family member or other, group, and gender. All were significantly predictive of pretest velocity scores.

The $R^2$ indicated that 53% of the variance in the posttest velocity score was explained by the four predictor variables. The $B$ value indicated that participation with others outside of school had the greatest influence on the posttest velocity scores, followed by Gender, practicing in organized team, and then the Group. All were significantly predictive of posttest velocity scores.

<table>
<thead>
<tr>
<th>Model</th>
<th>$R$</th>
<th>$R$ Square</th>
<th>Adjusted $R$ Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.727(a)</td>
<td>.529</td>
<td>.508</td>
<td>5.56307</td>
</tr>
</tbody>
</table>

Predictors: (Constant), Group, Gender, Que1, Que2

Table 4.10. Model summary of the influence of throwing experience, gender, and group on posttest velocity scores.
<table>
<thead>
<tr>
<th>Model</th>
<th>Predictor Variable</th>
<th>Beta</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>.313</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Practice in organized t-/baseball team (Que1)</td>
<td>.277</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>Practice with family member or others (Que2)</td>
<td>.374</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Group</td>
<td>.158</td>
<td>.038</td>
</tr>
</tbody>
</table>

Table 4.11. Beta and significance of the predictor variables for pretest velocity scores.
CHAPTER 5

DISCUSSION

The purpose of this study was to examine the effect of aligned developmental feedback (ADFB) on third-grade student performance of the overhand throw for force in a naturalistic physical education class setting. Possible gender differences in the students’ throwing performance as a result of teacher feedback were also explored. In addition, the study examined whether professional development was found to improve the teacher’s content knowledge (CK) and pedagogical content knowledge (PCK) in throwing and what the influence of the teacher’s professional development was on the teacher’s ability to deliver ADFB to the students.

The study contained three phases. The first phase included the throwing sessions of the comparison group before the teacher professional development. Phase 2 included training the teacher on the developmental components of throwing and professional development of his knowledge related to the ability to observe student performance and deliver feedback that matched the developmental level of the throwing components. Once “trained,” the teacher entered Phase 3 which consisted of implementing the treatment (ADFB) during the throwing lessons to the experimental group.
This chapter discusses the three phases of the study. The first section focuses on Phase 2 of the study, which included the teacher’s professional development and his knowledge of the content he was teaching—the overhand throw for force. The data from the teacher knowledge test is discussed as related to his ability to deliver ADFB. The second section of the discussion focuses on the type and amount of feedback the teacher used in Phase 1 and Phase 3. The total amount of feedback, the total number of ADFB statements, and the total number of positive feedback statements are discussed in relation to the effect of the feedback and the importance of the feedback on student performances. Finally, the third section of the discussion focuses on the dependent variables of student throwing performance (velocity mean scores and throwing components) as well as the gender differences in throwing performance. Finally, the implications of the results of this study to physical education teachers and physical education teacher educators are discussed and recommendations for future research are provided.

Teacher Knowledge

Previous research related to teacher knowledge suggested that teachers with better CK in the subject they teach will be better able to observe student performance, identify the critical errors during student practice, and deliver feedback that will be valuable for the learning process (Siedentop & Tannehill, 2000; Stroot, 1990; Stroot & Oslin, 1993). Furthermore, teachers that lack CK in the specific subject they teach often give incorrect feedback or deliver feedback that is not developmentally appropriate to the student performance (Gangstead & Beveridge, 1984). Prior to Phase 2 of the study the teacher was tested on his knowledge related to overhand throw for force. His test scores in the CK part of the test was 8 out of 20 (40%). When he was asked to observe video clips of
students throwing, and to identify correct and incorrect performance, his lack of CK and PCK, prevented him from accurately analyzing and diagnosing the student movement patterns and therefore his feedback statements were incorrect and did not align to the performance being observed. In the PCK part of the test he scored 29 out of 60 (45%). Overall, prior to the professional development intervention the teacher demonstrated poor CK and PCK with a total knowledge score of 37 out of 80 (46%). The findings from the current study are in line with Placek’s (1983) study on novice teachers who observed students performing overhand throw for force and analyzed their performance. The novice teachers in Placek’s study did not have the knowledge to look critically at the students’ performance and therefore did not have the ability to improve student throwing performance. It was clear from the present study that prior to the professional development intervention this teacher lacked the ability to critically evaluate the overarm throw for force in a developmental manner.

The literature on teacher training suggests that when teachers are provided with training they benefit from the experience (Barrett, 1983; Walkwitz & Lee, 1992). In addition, the literature suggested (Knudson & Morrison, 1996; Walkwitz & Lee, 1992) that teachers who received knowledge related to the content they teach during training, possessed more knowledge and were better able to integrate the knowledge they received in identifying the developmental sequence of the overhand throw. In the literature, teacher training helped in better assessing the student performance during practice and provide feedback that was developmentally aligned to the student level of performance (Walkwitz & Lee, 1992).
In the current study, teacher training consisted of: (a) learning the developmental sequence of the body components, (b) observing student practicing throwing and being able to identify correct and incorrect performance, and (c) delivering ADFB following the specific hierarchy. The teacher in this study clearly benefited from the teacher professional development on throwing improving all four parts of his scores (one related to CK and three related to PCK). Overall, the teacher significantly improved his knowledge score from the pretest (37 out of 80) to posttest (79 out of 80), suggesting that both CK and PCK improved over the teacher professional development sessions. The teacher PCK was improved as a result of improvement in the CK. He translated the knowledge that he obtained during the professional development into PCK and demonstrated this knowledge by (a) better observation skills and identifying correct and incorrect performances, and (b) by delivering feedback that was developmentally appropriate and aligned to the students’ performance.

From a practical sense, following the professional development and training, the teacher was better able to: (a) identify the correct developmental level of the student’s throwing performance, (b) identify the critical mistakes in the students’ performance, and, (c) deliver feedback that was aligned to the student’s performance and that was developmentally appropriate (ADFB). These skills are critical to being an effective teacher (Barrett, 1983; Rink, 2003; Siedentop & Tannehill, 2000; Stroot, 1990). The teacher knowledge findings in the current study supported the findings from the literature (Barrett, 1993; Knudson & Morrison, 1996; Stroot & Osln, 1993; Walkwitz & Lee, 1992) that teachers with more CK and PCK are able to provide feedback that matches the
developmental level of the student’s performance and are valuable to the learner (Shulman, 1986; 1987)

Some anecdotal comments recorded during the study provide some interesting context for the study’s findings. During Phase 1 of the study the teacher reported basing his knowledge of throwing on his baseball coaching experience rather than teacher professional development or CK. A good example was teaching the third grade students the term “snap the wrist,” a phrase often used with advanced throwing performance such as pitchers in baseball. However, after the professional development in Phase 2, the teacher commented that feedback statements such as “snap the wrist” were not developmentally appropriate to the third graders he taught and that he would not use these comments again in his teaching.

The teacher also mentioned during his training that the knowledge he learned was very beneficial for him and that in his career as a teacher he had little opportunity to learn and expand his physical education CK. With the current educational focus on classroom-based achievement tests, it seems that many physical education teachers often do not receive professional development training in their content area (Ward & O’Sullivan, 2006). The present findings on teacher knowledge suggest that inservice teacher’s need to continue to be provided with opportunities to engage in professional development training and that when they do receive such training they benefit from it. The knowledge that the teacher gained during the four professional development training sessions allowed him to successfully observe the student performance and to accurately deliver feedback statements as will be discussed in the section below.
Research questions 2–5 explored the type and amount of feedback the teacher
delivered before and after the teacher professional development. The teacher professional
development results above showed that the teacher was able to learn when provided with
professional development. However, a much more critical question was whether the
teacher could translate this learning into practical pedagogy in his lessons. In other
words, could the teacher provide ADFB in the real world context of the gymnasium? A
critical assumption of this study was that children who received ADFB would be more
likely to better learn the overhand throw than children who did not receive such feedback.
Thus, a necessary step of the study was to demonstrate that there was a difference in the
provision of ADFB prior to and following the teacher training.

Previous studies have found that most feedback delivered during physical education
lessons was auditory, individual, corrective, nonspecific, and positive (Behets, 1989;
Pellet & Harrison, 1995; Rikard, 1991; Rikard, 1992; Silverman, Tyson, & Krampitz,
1992; Silverman, Tyson, & Krampitz, 1993; Stroot, 1990). However, these studies failed
to look at the type of feedback in relation to student performance and only reported the
rate and amount of feedback statements being delivered by the teacher. Research
questions 2 to 5 focused on the extent to which ADFB was provided prior to teacher
training (Phase 1 - Comparison) and after teacher training (Phase 3 – Experimental).
However, in addition to ADFB, total feedback and positive feedback were also examined
as they were potentially confounding variables to the findings of the study (Magill,
2004).
During Phase 1 (comparison phase) the teacher’s knowledge test score indicated that he had little knowledge relative to the developmental sequence of the overhand throw for force. Thus, one might infer from the literature (Rikard, 1991, 1992; Rink, 2003; Silverman, Tyson, & Krampitz, 1993; Stroot, 1990; Tan, 1996) that his feedback would be general in nature. The feedback summary from Phase 1 supports this view and shows that more than 85% of his total feedback statements were general statements to individuals or to a group (see Table 4.2). Only a small percentage of his feedback statements that were aligned to performance (11.67% of ADFB). In addition, the teacher provided feedback to the students’ throwing performance in a sequence that was not developmentally appropriate. For example, a child might be stepping ipsilaterally, and the teacher would provide feedback on the trunk or arm action. In reality, this feedback is developmentally inappropriate as trunk rotation cannot occur until the step is contralateral.

It seemed that the teacher’s knowledge during Phase 1 was not accurate to student performance. During the lesson, he observed individual students; but resorted to a lot of generic group feedback such as “step and throw” and positive statements such as “well done” or “good job” to reinforce performance that he considered a correct movement. The findings from this study support the findings in the literature (Rikard, 1991, 1992; Rink, 2003; Silverman, Tyson, & Krampitz, 1993; Stroot, 1990) relative to the importance of CK and PCK as foundational knowledge in order to better observe the performance, identify the errors, and deliver feedback that is specific to the level of the performance.
The section on teacher knowledge above documented that the teacher improved in his CK and PCK of throwing as a result of the professional development training. Research suggests that teachers with sufficient CK and PCK are better able to analyze and discriminate correct and incorrect performances and therefore were able to deliver appropriate feedback (Stroot, 1990; Stroot & Oslin, 1993; Oslin, Stroot, & Siedentop, 1997). Research also suggests that effective teachers with proficient CK and PCK deliver less general feedback and more feedback that is developmentally aligned to a student performance. However, one study with preservice teachers by Stroot and Oslin (1993) found that although the preservice teachers had the CK in the subject they taught, they could not deliver feedback statements that were aligned to the students’ performances. In other words, the preservice teachers could not translate their knowledge into practice and therefore only when their students received an appropriate feedback statement that matched the level of throwing performance, did throwing skills improve (Stroot & Oslin, 1993). The Stroot and Oslin (1993) study findings illustrate an important point that teachers need to be able to translate their CK and PCK into effective teaching in order to enhance student performance.

In Phase 2 of the study the researcher intervened on the teacher’s CK as it related to throwing developmental sequences. The teacher in this study clearly showed his ability to translate his improved CK into improved PCK and then into effective teaching. From a theoretical perspective, this researcher believed that the teacher’s ability to provide ADFB was a demonstration of the teacher’s improved PCK. The teacher was able to: (a) better observe skills and discriminate performance, (b) identify the level of the students’ performance, and (c) deliver feedback that was aligned to the observed performances.
Prior to the teacher training he provided 11.67% of ADFB. However, after the teaching training he provided 54.18% of ADFB over the seven lessons of throwing. There were statistically significant differences between his feedback statements in Phase 1 and Phase 3. Most importantly, the ADFB provided in Phase 3 was developmentally appropriate, provided to an individual, and individualized to the student’s performance, thus enhancing the student’s ability to learn the overhand throw. Overall, the findings from this section documented that the intended intervention in Phase 3 was appropriately enforced.

One other purpose of the feedback part of the study was to examine the potentially confounding variables of total amount of feedback and positive feedback. It may be suggested that total feedback and positive feedback could be positively correlated with student throwing performance (Schmidt & Lee, 2005). Thus it was important to examine if there were differences in these feedback categories between Phase 1 and Phase 3. The statistical analysis reported that there were no significant differences in total feedback \( (p=.624) \) and positive feedback \( (p=.775) \) between Phase 1, the comparison phase and Phase 3, the experimental phase. These findings lend strength to the study as they enable the investigator to better understand the direct impact of ADFB on the throwing performance of third grade children.

Overall, the findings from teacher knowledge and teacher feedback demonstrate that without CK and PCK the teacher provided general feedback. However, once CK and PCK improved, the teacher was able to provide feedback that was precise, developmental, and aligned to performance. However, the major focus of this study centers on the relationship between what teachers say and what children do. In other
words, if the teacher provided ADFB, would the children learn to throw for force more effectively than a group who did not receive such specific feedback?

The next two sections a discussion of the impact of ADBF on throwing performance will be undertaken, specifically body component scores and ball velocity. The first part of this discussion will focus on body components as this relates to the process of throwing. It is important to understand the pattern with which the participants threw the ball in order to interpret the findings from ball velocity. From a biomechanical perspective, more advanced throwing patterns are associated with higher ball velocities and thus a discussion of velocity findings in light of body components is most beneficial (Lorson, 2003; Stodden, 2002; Langendorfer & Roberton, 2002a, 2002b).

Quality of the Comparison Group

The comparison group received well validated and empirically tested lesson plans and activities during Phase 1. The high quality nature of these lesson plans and instruction in the comparison phase was not typical to a regular physical education lesson. This fact may be a delimiting factor in considering the results of this study. The quality of the instruction that the comparison group received is evident by the results reported for body components and velocity scores. This researcher would suggest that the comparison group improved significantly over time as a result of the high quality of the instructional activities in the lesson plans in Phase 1. The high quality of the instruction in Phase 1 is both a strength and weakness. It is a weakness in that the comparison group did not really reflect the activities in a typical physical education class. The quality of the comparison group also made it harder to show significant differences in velocity and body components over time (pre to post) and also at the posttest between the comparison
and experimental groups. The quality of the comparison group however is a significant strength of the study in that it lends credence to the impact of ADFB on body components and velocity scores. Any differences that were found between the experimental and comparison groups can be strongly associated with the provision of ADFB due to the high quality nature of the comparison group.

Body Components

Research questions 16–24 explored the influence of ADFB on body component levels of overhand throw for force and possible gender differences in performance. Analyzing the throwing components as a process measure during physical education lessons requires the teacher’s knowledge of the developmental sequence of the overhand throw.

Pretest Body Components

The results of the multivariate data analysis revealed that there were no significant differences between the groups on the four body components (step, trunk, humerus, forearm) at the pretest. The comparison group had a mean pretest component profile of 3.20 for the step, 1.87 for the trunk, 1.51 for the humerus, and 1.26 for the forearm. Similarly, the experimental group had a mean pretest component profile of 3.37 for the step, 1.89 for the trunk, 1.41 for the humerus, and 1.27 for the forearm. The findings from the pretest body components indicated that the comparison group was a good match for the experimental group and lend strength to the study’s findings.

To examine a proficient throw from a process measures point of view, the movement pattern of the throw was evaluated. Langendorfer and Roberton (2002) described the characteristics of a proficient thrower as throwing with a long contralateral
step (S4); segmental rotation of the trunk, where the hips rotate first, flowed by the spine, shoulder, humerus, and forearm (T3); humerus lagging behind the trunk (H3); forearm lagging behind the humerus (F3); and, finally, the throwing arm follow-through across the body. The third grade throwers in this study were not able to demonstrate this efficient throwing pattern. Prior to the intervention the third-grade students in this study stepped with a contralateral short step (S3) and had block rotation of the trunk (T2). With respect to the arm, the humerus was in front of the body, known as humerus oblique (H1), and there was no forearm lag (F1). Thus, the third graders in the present study needed to lengthen their step, segment their trunk, and lag their humerus and forearm in order to be at the most proficient levels.

Gender Differences in Body Components before Intervention

Studies have shown that gender differences exist at early ages and expand over time in varied fundamental motor skills (Lorson, 2003; Nelson, Thomas, & Nelson, 1991; Stodden, 2002; Thomas & French, 1985; Williams, 1996). Gender differences, related to the body components, in favor of boys were found in the performance (form) of the overhand throw (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002; Thomas & Marzke, 1992).

Examination of the pretest body components showed gender differences for all four components (step, trunk, humerus, and forearm). These findings are similar to those in the literature where gender differences for body components were reported (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson et al., 1991; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002; Nelson et al., 1991; Thomas & Marzke, 1992). In this current study, females demonstrated a pretest mean throwing component profile of
2.97 for the step, 1.76 for the trunk, 1.15 for the humerus, and 1.05 for the forearm. Males demonstrated a more advanced profile of 3.50 for the step, 1.96 for the trunk, 1.67 for the humerus, and 1.41 for the forearm. In practical terms, more males than females showed a long contralateral step (S4) and block rotation of the trunk (T2). Additionally, more males than females were closer to positioning their humerus aligned to the body (H2) and some forearm lag (F2). Male patterns of performance in throwing were more mechanically efficient to produce forceful throws than females which may account, in part, for the gender differences found in throwing velocity that will be discussed in the next section.

Even though this study did not attempt to experimentally answer the question of why there were significant differences between males and females in pretest performances, the findings from this study did report that more boys than girls participate in organized sports outside of school and practice throwing more often. This is similar to reports in the throwing literature that suggest prior experience may be one factor accounting for gender differences in throwing (Butterfield & Loovis, 1993; Halverson et al., 1982; Thomas & Marzke, 1992). Future research should examine these relationships.

**Influence of the Intervention on Body Components by Group**

Overall the results of the study indicated that both groups were statistically similar at the pretest. Over the course of the intervention there was a significant multivariate Time effect, indicating that groups improved over time in the performance of throwing. Univariate analysis of these data revealed that all four body components improved from pretest to posttest. The effect size for Time was moderate (.55), indicating that the 7 throwing lessons accounted for 55% of the variance in throwing scores. These results
supported similar findings from the literature relative to different instruction and improvement in performance (McKenzie et al., 1998; Lorson, 2003; Oslin, Stroot, & Siedentop, 1997; Stodden, 2002). Both the comparison and experimental groups in this study received 80 minutes of throwing practice and were instructed by the same teacher using the same tasks and lesson plans. Additionally, practice trials for both groups were similar and were controlled by the researcher. Thus, the findings of this study support similar studies related to the effect practice and instruction has on overhand throwing for force (Halverson & Robertson, 1979; Halverson et al., 1977; Lorson, 2003; Stodden, 2002). In this study, both groups received practice and instruction on how to perform the overhand throw and thus it is not surprising that the effect size for Time was moderate. From these results it may be suggested that the opportunity to practice throwing for 80 minutes resulted in improvements to throwing irregardless of the type of feedback the students received.

There was also a significant multivariate Group X Time interaction for body components showing that groups differed across time in the performance of the overhand throw. The effect size for the Group X Time interaction was small (.18) indicating that ADFB accounted for 18% of the variance in throwing scores. In Phase 1 the teacher used generic feedback such as “stand sideways,” “L-shape,” “snap your wrist,” and “bend your back forward and step” during his instruction. Additionally, many of these feedback statements were provided at a group level showing that the teacher was unaware or unresponsive to individual differences in performance. However, after the teacher professional development training, the experimental group received mostly individual instruction with 54.18% of ADFB related to the four body components and the sequence
of the body components as they occurred (Roberton & Halverson, 1984). The experimental participants received ADFB that was presented in a hierarchy of what was considered most important and used feedback such as “stand sideways,” “make a long step with the opposite foot,” “turn your hips fast,” and “follow through.” As intended, these feedback statements were both developmentally appropriate and aligned to performance.

The post-hoc univariate Group X Time interaction for body components revealed that groups differed across time in only one of the four body components. The step, trunk, and forearm components did not differ between groups over time. However, the experimental group had a significantly more advanced humerus action than the comparison group from pretest to posttest. This is discussed below.

It was reported that significant differences were found in the pre-to posttest results for both the comparison and experimental groups. The comparison group improved from pre- to posttest on the step ($M=3.20$ in pretest & $M= 3.51$ in posttest) and humerus ($M=1.51$ in pretest & $M= 1.73$ in posttest) components but not on the trunk and the forearm. The experimental group improved significantly from pretest to posttest in the step ($M=3.37$ in pretest & $M= 3.77$ in posttest), humerus ($M=1.41$ in pretest & $M= 2.04$ in posttest), and forearm ($M=1.27$ in pretest & $M= 1.52$ in posttest). These findings might be related to the fact that the teacher improved his CK and PCK during Phase 2 that helped him with his observation skills and his ability to deliver feedback that matched the student performance in Phase 3. Post-hoc analyses also revealed that the experimental group had a significantly better step and humerus component than the comparison group at the posttest.
Both groups improved the step component over the course of the seven lesson plans. It may be that the nature of the instructional activities developed and implemented in the lesson plans in Phases 1 and 3 resulted in this change. For example, stepping from the back end of a tape box to the front end of the box was one of the activities in the lesson plans that promoted a long step. Thus, from a constraints perspective, the task itself promoted improvement in the step component. The experimental group was better than the comparison group at the posttest as a result of the feedback statements that were both developmentally appropriate and aligned to performance. During Phase 3 the teacher delivered feedback that was related directly to the observed performance using the appropriate hierarchy, which resulted in significant differences between the experimental group and the comparison group in the step and the humerus at the posttest. Using the box activity example, in Phase 1 the teacher did not provide any feedback relative to the length of the step, he just instructed the students to “step forward and throw,” while in Phase 3, he often used “long contralateral step” that was first listed in his feedback statements. This statement was developmentally appropriate and aligned to the performance of short step to the target.

Both groups also improved in the humerus component over the course of the seven lesson plans. Again, the nature of the activities provided in the seven lesson plans may have brought about this change. For example, one activity required the thrower to reach back and get the ball from a partner who was standing behind the thrower necessitating the thrower to pull the humerus backwards rather than in front of the body. Again, from a constraints perspective, the task itself may have promoted improvement in the humerus component. Thus, the significantly better humerus at the posttest for the
experimental group can be related to the specific feedback statement that the teacher used after the professional development. In addition to the feedback statement, “arm way back,” the teacher manually manipulated the humerus to a position behind the shoulder showing the child humeral lag.

The ancillary effects from the changes in the step and the humerus might have affected the forearm component for the experimental group from pre-to posttest. Since the experimental group exhibited significant differences in mean score for the humerus, the forearm movement may have been affected and moved from no forearm lag (F1) to forearm lag (F2). Similar to the present study’s findings, Stodden (2002) found significant changes in both humerus and forearm components from pretest to posttest when he used the biomechanical intervention strategy.

As the forearm and the humerus components are more difficult to instruct (Lorson, 2003, Oslin et. al., 1997), the ADFB allowed the teacher to provide the students with accurate feedback on the step and humerus. In contrast to the comparison group, during Phase 3, the experimental group received ADFB in a hierarchy that reinforced the movement of the humerus to position behind the shoulder, and when needed the teacher addressed the forearm positioning. The focus of ADFB on humerus positioning may have resulted in the ancillary effects of promoting forearm lag. The experimental group therefore demonstrated improvement over time in the forearm in addition to the step and humerus, whereas the comparison group, which did not receive accurate feedback on the humerus or forearm, did not show forearm improvement.

Interestingly, neither group significantly changed in the trunk component from pretest to posttest. The third grade students in both groups of this study exhibited block
rotation of the trunk (T2) at the pre-and posttest and therefore did not demonstrate any improvement in this particular body component. These findings are supported in a previous study by Langendorfer and Roberton (2002) related to the body component profiles. Langendorfer and Roberton (2002) indicated that block rotation of the trunk (T2) is considered to be a strong attractor and moving from level 2 (block rotation) to level 3 (segment rotation of the trunk) may be very difficult at the age of eight years (Langendorfer & Roberton 2002, Lorson, 2003; Stodden, 2002). Demonstration of segmented rotation is a complex movement pattern and may not come until later in the developmental time frame (Langendorfer & Roberton 2002, Lorson, 2003; Stodden, 2002). Lorson (2003) found similar findings in his study on second grade students, who exhibited deeper attractors on the trunk component than in the step component.

Overall, the findings relative to the group differences clearly demonstrate the importance of ADFB in the learning process and how such type of feedback can enhance a student’s performance on the overhand throw. The participants in the experimental group who received significantly more ADFB statements demonstrated an overall higher level of performance relative to the comparison group who only received 11.67% of ADFB.

*Influence of the Intervention on Body Components by Gender*

The findings for gender across the intervention were non-significant. As indicated above, significant gender differences were found at the pretest favoring boys in all body components. There was a non-significant Gender X Time interaction showing that changes from pretest to posttest were not different by gender. Given that gender differences were present at the pretest, this means that the gender differences remained
across the intervention to the posttest. Regardless of the type of feedback they received during practice, significant differences remained between the genders, with males doing better than the females throughout the study. There was also a non-significant Gender X Group X Time interaction showing that there were no group differences in how genders changed from pre-to posttest. In other words, for both groups, the gender differences that were there at the pretest remained at the posttest and stayed the same within group. These findings are similar to previous findings in the literature related to the persistence of gender differences across time (Dusenberry, 1954; Garcia & Garcia, 2002; Lorson, 2003; Thomas et al., 1994).

Overall, the findings from this study on body components shed light on the importance of ADFB. The teacher’s improved CK and PCK allowed the teacher to better analyze the students’ performance and deliver feedback that was aligned to the developmental levels of their performance. The experimental group received 54.18% of their feedback statements in the form of ADFB in contrast to the comparison who group who only received 11.67% of their feedback statements as ADFB. At the posttest the experimental group had a better step and humerus performance than the comparison group and the experimental group’s forearm improved significantly from pre-to posttest whereas the comparison’s group did not. The findings clearly demonstrate the importance of ADFB in the learning process and how such type of feedback can enhance a student’s performance on the overhand throw.

Maintenance of Intervention Effects for Body Components

The multivariate analysis from posttest to retention test revealed no significant effects. There was a non-significant Time effect, Group X Time interaction, and Group X
Time X Gender interaction. Essentially nothing statistically changed from the end of the intervention to the retention test 12 days later. Thus, the gains acquired from the intervention were maintained to the retention test. The findings indicated that regardless of group or gender, both comparison group and experimental group, males and females, maintained their performances in all four body components from posttest to retention test. The important finding from these data is that one can attribute that the participants truly "learned" the overhand throw and that the changes that occurred over the course of the 7 lesson plans was relatively permanent and maintained until the retention test (Schmidt & Lee 2005). These findings again demonstrate the importance of ADFB statements during the learning process. They also attest to the quality of the learning activities in the throwing lesson plans as both the comparison and experimental groups maintained their performance. Physical education teacher education programs need to make sure that they equip their graduates with adequate CK and PCK and uncover the process of analyzing and delivering feedback that matches the developmental level of the students’ performance so that the teachers from these programs deliver aligned feedback statements to their students.

Previous literature in throwing has suggested a strong relationship between the pattern of throwing performance (such as body components) and the product of throwing such as velocity (Stodden, 2002; Southard, 2002). In this study, ADFB brought about changes in the process or body components of throwing. What remains to be discussed are the changes in velocity scores as a result of ADFB and the possible link to body component levels. The following section discusses the results of the product measures of
the students’ performance and ties the findings of this section to show the relationship between the two variables.

**Mean Ball Velocity Scores**

Teachers and scholars use ball velocity scores as a product measure to evaluate student performance. Measuring ball velocity scores can help teachers identify their students’ progression and determine whether learning has occurred. Also from a functional perspective, if children are to apply throwing in games like baseball or softball, they must be able to throw hard and fast. At the same time, researchers can use ball velocity as a dependent variable in intervention studies and in examining the relationship between throwing and other constraints (Lorson, 2003; Stodden, 2002). This study used ball velocity as one student measure of the ability to throw a ball and as a primary dependent variable in examining the impact of ADFB on throwing performance. It was believed that ADFB would act as an environmental constraint to promote throwing efficiency and improve the speed at which students receiving ADFB threw the ball compared to students who did not receive ADFB.

**Pretest Measures of Ball Velocity**

Research question 6 examined whether group differences were present in pretest velocity scores. Prior to the intervention, no significant differences were found in pretest velocity mean scores between the comparison group and the experimental group. The comparison group’s mean velocity score was 35.76 mph, while the experimental group’s was 36.64 mph. The fact that no statistical differences were found between the groups prior to the study, supported the findings of body components, indicated that the comparison group used was an appropriate comparison group. Lorson (2003) found in his
study that second grade students’ mean scores at the pretest were: CUE group (24.34 mph), BP group (23.04 mph), and TPE group (23.25). The participants in Lorson (2003) were a year younger from the participant in the current study (third graders), and therefore they exhibit a lower mean velocity score than the third grade students.

Gender Differences in Pretest Ball Velocity

There has been agreement in the literature that ball velocity increases with age, and gender differences have been found within all age groups (Halverson et al., 1982; Roberton et al., 1979). Gender differences exist in almost all categories of throwing, including process and product measures of throwing (Lorson, 2003; Roberton & Konczak, 2001; Thomas & Marzke, 1992). Roberton et al. (1979) reported that boys’ ball velocities were significantly better that of girls. Lorson (2003) reported that second grade males had a mean velocity of 30.45 mph, while females had a mean of 14.87 mph. This current study found that there were significant differences between males (39.83) and females (30.80) pretest velocity scores (see Table 4.4 for mean recorded velocity summary by gender). Also, these gender differences were the same within each group. The effect size for gender was moderate (.33) indicating that 33% of the variance in ball velocity scores could be accounted for by gender. Thus, this work supports the body of literature on throwing.

While examining individual constraints, this study reported that there were significant differences in prior throwing experience between genders with more boys reporting more experience than girls. The results from the self-report questionnaire in this study indicated that 72.4% of the boys practiced throwing with a family member, while only 33.3% of the girls responded positively to this question. In addition, the self-report
questionnaire indicated that 58.6% of the boys participate in organized t-/baseball, while only 30.8% of the girls responded positively to this question. These results suggest that boys get more practice opportunities, modeling and reinforcement than girls. It may be that the gender differences reported in velocity can be partially accounted for by prior throwing experience. This is similar to other literature that has found gender differences were related to students’ experiences in the overhand throw outside of school (Greendorfer, 1980; Halverson, Roberton, & Langendorfer, 1982), and that these differences might have affected velocity scores as well as body components. Halverson, Roberton, and Langendorfer (1982) found that boys practiced the overhand throw in organized teams and outside of school activities more than girls, and this may have accounted for the significant differences between the genders. The results of this study support that conclusion.

Regression analysis data also support this contention that prior experience in baseball or t-ball and experiences in throwing with others significantly contributing to the variance in pretest velocity scores. Practicing with others outside of school had the greatest influence on the pretest velocity scores, then gender, followed by practicing in organized team sports. These three predictor variables accounted for 54% of the variance in pretest throwing velocity. These findings are similar to Halverson et al. (1982) in explaining the gender differences in the pretest velocity scores. The findings in this study related to gender differences in prior experience need to be viewed with caution as these data were self-reported by the students. However, they do provide an interesting context to the study’s main findings and suggest an avenue for further research.
Influence of the Intervention on Ball Velocity Scores by Group

There were no significant differences between groups at the pretest. However, there was a significant Time effect with an effect size of .48. This effect size was small to moderate indicating that 48% of the variance in posttest scores was accounted for by the seven lesson plan throwing unit. Clearly, the lesson plans were well constructed and included developmentally appropriate tasks that provided an opportunity to practice throwing and improve overall throwing ball velocity.

There was also a significant Group X Time interaction reporting that the experimental group had faster velocity scores than the comparison group over time. The comparison group’s pretest velocity scores were 35.89 and their posttest mean velocity score was 37.41 mph. The experimental group’s pretest velocity score was 36.64 and their posttest mean velocity score was 39.33 mph.

In examining the results of the significant Group X Time interaction for velocity, a number of issues are pertinent to consider. Both groups received the same lesson plan, the same 80 minutes of practice time, as well as the same number of practice trials for each participant. Additionally, potentially confounding variables in the form of the total amount of feedback and positive feedback statements being delivered to the participants in both groups were controlled for (statistically the same). The only measured difference between the groups was ADFB. Thus, the findings relative to the experimental group greater throwing speed over time may be attributed with some confidence to the delivery of ADFB to that group.

Several studies examined the effect of instruction on throwing performance (Browning & Shack, 1990; Dusenberry, 1952; Garcia & Garcia, 2002; Lorson, 2003;
McKenzie et al., 1998; Stodden, 2002; Thomas et al., 1994) and found that proper instruction positively affected the students’ throwing performance. The results of this study strengthen the notion that effective instruction improves student performance.

Lorson (2003) found that two groups of second-grade students who received 120 minutes of a biomechanical approach or critical cue approach to throwing improved their velocity scores from pretest to posttest. However, in contrast to the present study, Lorson (2003) did not find significant differences between his groups over time. Stodden (2002) also reported that the kindergarten children improved from pretest to posttest, but no significant differences were found between the groups (biomechanical versus traditional) over time. Roberton and Konczak (2001) reported the mean velocity score of eight year old students at 43.07 mph, which was higher than the mean score for both experimental group (35.89 mph) and comparison group (35.89 mph) after 80 minutes of practice and instruction in the current study. The current study supports the existing literature that suggests that sufficient instruction results in improvements in ball velocity scores. However, it also adds new information to the literature suggesting that ADFB will result in significantly better velocity scores than a group of children receiving good instructional activities but more general feedback.

Despite there being a significant Group X Time interaction, post-hoc analysis revealed that experimental and comparison groups were not statistically different in their posttest velocity scores. A reasonable explanation for the non-significant differences in posttest mean ball velocity scores can be the timeframe of the study. This study identified 80 minutes as an appropriate amount of time to bring about changes in throwing patterns based upon prior literature (Goodway, Crowe, & Ward, 2003); however, it might be
suggested from the findings that this may not be enough time to see significant
differences in posttest velocity scores between the groups. The 80 minute instructional
timeframe was enough though to bring about changes in throwing performance (both
body components and velocity) for both groups. Further research should be conducted
over a more extensive period of time to examine this issue and expose any significant
posttest differences between groups.

The findings from the regression showed that 53% of the variance in posttest
velocity scores could be accounted for by the four component model. The beta weights
showed that participation with others outside of school had the greatest influence on the
posttest velocity scores, followed by gender, practicing in an organized team, and then
the group. All parts of the model significantly contributed to the variance in posttest
velocity scores. The significant regression finding for Group provided further support that
ADFB positively influences throwing velocity. These findings strengthen the notion that
the time spent in school practicing and learning the throw was important and that the
instruction had an influence on the students’ posttest results. Future research needs to
focus on longer units of effective instruction using ADFB to identify the effect of ADFB
in comparison to the gender predictor and other environmental and individual constraints
that might act as confounding variables in this study.

Influence of the Intervention on Ball Velocity Scores by Gender

Males had better ball velocity scores (39.80 mph) than females (30.81 mph) at the
pretest. However, when one examines the findings relative to gender across the
intervention there was a non-significant Gender X Time interaction and a non-significant
Gender X Group X Time interaction. Essentially, the gender differences that were
present at the pretest persisted across the intervention and into the retention test. These findings are similar to those by Lorson (2003) and Stodden (2002) who also found that gender differences persisted across their throwing interventions.

It might be that the intervention was not powerful enough for the girls to catch up with the boys, as the differences between them from the start were too big to bridge the gap and allow the girls to improve their performances in such a short period of time. The regression findings also suggest strong environmental factors such as practice of throwing outside of school are a factor in gender differences. Although gender was a strong predictor in the regression model, it is not clear what it is about “gender” that accounts for these differences. Future research should examine this topic considering these findings.

*Maintenance of Intervention Effects in Throwing Velocity*

It is important in intervention studies to examine the extent to which participants retain their performance after the intervention is completed. Thus, a retention test lends power to an intervention study’s findings. As with the body components, 12 days after the posttest was completed participants engaged in a retention test. The results from the posttest to retention test were all non-significant for ball velocity. There was a non-significant Time effect, Group X Time interaction, and Group X Time X Gender interaction. What this tells us is that the participants did not statistically change their throwing performance from posttest to retention test.

These findings illustrated that even though each group received only 80 minutes of instruction, learning occurred, and both groups maintained their posttest scores 12 days after the study was over. From this data, however, it is clear that teachers and
practitioners need to take into consideration that 80 minutes of intense practice cannot close that performance gap between the boys and the girls, and further steps should be made to help the girls improve their velocity scores. As to differences in throwing, product and process measures appear to exist in early childhood (Butterfield & Loovis, 1993; Garcia & Garcia, 2002; Halverson & Roberton, 1979; Langendorfer & Roberton, 2002b) and might be related to environmental constraints (instruction, social acceptance for differences in activities for males vs. females). This study strongly supports the need for ADFB as an additional environmental constraint that will help students improve their throwing performance.

The Relationship between Throwing Body Component and Ball Velocity

From the above results it may be suggested that the children in the experimental group benefited from the ADFB; it helped them produce the kinds of throwing patterns that enabled them to throw faster than the comparison group from pre- to posttest. It is valuable at this point to consider the relationship between the body components and velocity scores. In other words, what kinds of changes occurred in body components that may be linked to the improvements in throwing velocity?

The relationship between the product measures and the process measures is not always linear. Some studies (Halverson & Roberton, 1979; Halverson et al., 1982) have demonstrated that the change in the form of a throw did not directly influence or change the product measures, or the speed of the throw. In this study, a change in the process measures of the throw for the experimental group, such as improvement of the forearm action, may have lead to significant change in velocity scores over time, a fact that is further discussed in the following sections.
The findings revealed that although both groups improved their velocity scores over time, the experimental group demonstrated better humerus action than the comparison group from pre-to posttest and a significantly better posttest step and humerus components than the comparison group. In addition, the experimental group showed greater improvement than the comparison group in their velocity scores from pretest to posttest. These velocity results may be related to the superior process measures of the experimental group. Each body component that changed from pretest to posttest will be discussed below in light of the nature of the process changes that occurred and the potential impact on velocity scores.

Step Component. Transferring the body weight over a long step is a necessary part of an efficient throw that enables the thrower to impart greater velocity to the ball (Langendorfer, 1990). Both groups significantly improved the step from pretest to posttest; However, the students in the experimental group had a significantly better posttest step (more had a long step) than the comparison group. In Phase 1, the teacher provided generic comments like “step and throw.” After the professional development training, the teacher delivered 54.18% ADFB that continually encouraged the students to make a “long contralateral step.” The longer step may have accounted, in part, for the better ball velocity scores of the experimental group over time.

Humerus Component. Another critical feature to an efficient throwing pattern that results in faster ball velocity is humeral lag. Humeral lag is where the humerus lags behind the shoulder. The intent of humeral lag is to create a “power chain” effect where the trunk rotates first, followed by the shoulders, followed by the humerus and, as each component enters the power chain, the body accelerates resulting in imparting greater
velocity to the ball. The experimental group had a significantly better posttest humerus action than the comparison group. The ADFB provided in Phase 3 assist the experimental students in positioning their humerus aligned to their body (H2). Although the experimental group findings did not reach humeral lag (H3), the changes that occurred across the seven lesson plans may have, in part, accounted for the findings for velocity. Similar findings were found in Dusenberry (1952) and Roberton and Halverson (1979) in the linear relationship between the process and product measures of the throw.

*Forearm Component.* The final part of the power train in an efficient thrower is “delayed forearm lag,” and this too is associated with force production and ball velocity scores (Stodden, 2002; Langendorfer, 1990). Only the experimental group significantly improved from pretest to posttest in the mean forearm body component scores. It might be that the comparison group did not improve on the forearm component because the teacher did not give them feedback that was developmentally appropriate, and, conversely, that the experimental group did improve on the forearm component because they received specific, aligned feedback related to this aspect of the throw. Additionally, the ancillary effects from the change in the humerus component may have influenced the forearm component, which caused significant improvement in the forearm action only for the experimental group. This advanced performance allowed the students in the experimental group to use the correct forearm action what may have increased their velocity scores.

*Trunk Component.* Both groups exhibited block rotation of the trunk (level 2) and no changes occurred across the intervention. It may be suggested that block rotation of
the trunk was efficient enough to generate forceful throws and allowed the students to improve their speed from pretest to posttest.

Relationship of this Study to Dynamic Systems Theory

This study used the dynamic system theory and the constraints model to explain the changes in the students’ overhand throwing performance. The three categories of constraints—individual, environmental, and task—interact one another and result in changes in the throwing movement patterns. Garcia and Garcia (2006) explained that movement changes constantly depending on the task’s demands, the individual’s interactions with others, the individual’s previous experience and maturation, and changes in environmental constraints. All three categories of constraints were part of this study. Task constraints were held constant with both the comparison and experimental group receiving the same seven throwing lesson plans and activities. Thus, it appeared that the environmental constraint of ADFB provided by the teacher positively affected student mean ball velocity scores and changes in the humerus body component. Garcia and Garcia (2006) state that teachers are a form of environmental constraint for students and therefore should provide extrinsic feedback to assist students in improving their performances. This seemed to happen in the current study. Also, learner constraints were part of the present study. Learner constraints in the form of students’ prior experiences and gender were significantly related to pretest and posttest ball velocity scores and show the impact of learner factors on performance.

In conclusion, this study adds to the previous body of research in two major elements. The first one is the fact that the study was conducted in a natural setting during a physical education lesson for third grade students. One of the problems with previous
research related to feedback was that most studies were conducted in laboratory settings with college students. Thus, the results from prior studies were hard to generalize to real-life settings in physical education lessons. In addition, most other studies focused on the type and amount of feedback delivered by the teacher but did not study the effect of that feedback on student performance. In contrast to other research, this study examined the effect of specific ADFB on student performance directly related to student achievement.

This study also adds to the body of literature by demonstrating a strong link between CK, PCK, provision of ADFB, and improved student performance in throwing. The ADFB statements delivered by the teacher during Phase 3 were a demonstration of his improvement in CK and his ability to translate this CK into PCK and further into the provision of ADFB as a result of the professional development in Phase 2. The differences in percentage of ADFB varied between Phase 1 and Phase 3 and are further evidence that the teacher’s PCK improved from Phase 1 to Phase 3. This improvement in PCK, as demonstrated by the provision of ADFB resulted in changes to the student’s throwing performances both in process and product measures.

Implications for Teachers and Practitioners

The following implications represent the summation of findings relative to P-12 teachers:

1. Many teachers deliver general feedback statements that are not aligned with the skill level of the student, and do not individualize the feedback. The findings demonstrate that ADFB is more effective than general feedback in student learning.

2. Teachers need to have a deep understanding of the subject they teach in order to deliver ADFB. They need CK (i.e., observation skills and critical eye to identify
mistakes) and PCK (i.e., the ability to transfer this knowledge to their students that will result in performance improvement). Teachers need to take the time to become knowledgeable about new units of instruction.

3. Professional development for the teacher was important in extending the teachers’ knowledge of the subject matter taught.

4. When provided with professional development training the teacher could deliver more ADFB than prior to training. Thus, professional development training is critical to continue to develop teachers professionally and enhance student learning.

5. When delivering ADFB it is important to use a logical hierarchy and focus on the developmental sequence of the performance in order to bring about change in performance.

6. Instructional time of 80 minutes can bring about significant skill learning in throwing (process and product) that is retained.

7. Do not overwhelm students with too much information. Focus on one or two critical elements of a movement and reinforce correct performance. Only when a student is able to demonstrate proficiency of a skill should the teacher move, to the next level in the sequence.

8. Physical education teachers need to encourage children, specifically girls, to take part in and out of school activities. Both genders should have equal opportunities during school time to practice the skill.
9. Physical education teachers should encourage parents to engage in throwing activities with their children at home, and they could send physical education homework home with the children in order to promote throwing.

10. Teachers need to allocate enough time to: (a) practice, (b) increase proficiency in performance, (c) increase repetition, (d) allow teachers more time to observe students performances, and (e) deliver ADFB. Short units might not be a sufficient teaching strategy if teachers want students to improve performances and demonstrate high skill proficiency.

The following implications represent the summation of findings relative to Physical Education Teacher Education (PETE) programs:

11. Physical Education Teacher Education (PETE) programs need to make sure their programs include a variety of classes and experiences that teach CK and PCK in depth. Programming for PETE teacher candidates should include mandatory classes in several sports that help them to develop a critical eye to observe and analyze skills and deliver ADFB that improves student performance.

12. Initial teacher preparation programs should focus on preparing teacher candidates who understand the process of skill analysis and the provision of appropriate feedback. The hierarchical method used in providing ADFB appeared to be effective and could have some value in other sport and skill areas.

13. PETE programs should choose different school environments that give their candidates opportunities that occur early and often to practice clinical and field sequence analysis of teaching and allow frequent feedback to help them improve their CK and PCK.
14. PETE programs should ensure that their candidates use different types of feedback and recognize the importance in ADFB for learning to occur. Teacher candidates should be given opportunities to apply different kinds of feedback in different situations.

15. University supervisors and mentor teachers should be required to code teacher candidates regularly in their use of feedback.

16. Systematic qualitative skill analysis (developmental sequence of the throw, observation skills, and delivering ADFB) can significantly improve teacher candidate performance and teaching skills, and therefore, PETE programs are highly encouraged to include this training in their programs.

17. PETE programs should use instructional technology to enhance their teacher candidate expertise in developing their skill analysis skills and improve their observational abilities to deliver accurate feedback that is aligned with student performance.

Suggestions for Future Research

There is much to learn about the relationship between teacher feedback and student learning. The following are suggestions for future research:

1. Examine the effect of the amount and type of feedback provided to each gender and the impact it has on performance. Examining the type of feedback related to gender may give more insight into the type of feedback females receive and need in comparison to males.
2. Investigate the role of teacher feedback related to the students’ skill level. Examine the type and amount of feedback beneficial to low skilled performers versus high skilled performers.

3. Explore the influence of the verbal ability of a student in benefiting from teacher feedback. This work would examine both the age of a child and also English as a Second Language learners and how feedback influences student learning. The fact that ESL students may not understand all the information that is delivered to them may serve as an obstacle for benefiting from ADFB. Even though the teacher delivers specific feedback that is aligned to students’ performance, they may not use it appropriately to change the movement pattern of the throw or any other activity.

4. Examine the relationship between information load, teacher feedback and student learning. This would include looking at the role of the amount, precision, rate, and content of feedback delivered to different age groups of students.

5. Examine the influence of other environmental variables such as prior experience that are tied to student learning and may act as a confounding variable in the child’s ability to benefit from teacher feedback.

6. Investigate the inter-relationship among practice time, feedback, and student learning. The interaction effect between practice and feedback and the examination of time on task, opportunities to respond, and the time the students are engaged in practice. These variables influence the opportunities to provide effective feedback to children and perhaps influence learning.
7. Investigate the relationship between other types of feedback (general, behavioral, positive) and students’ performance to delineate between the motivational effects and the informational effect when learning new skills.

8. Develop ADFB hierarchy for other fundamental motor skills, and examine the influence of this ADFB on motor skill development.

9. Replicate this study with other grade level, examining the effect of ADFB on children’s’ performances in other grades.

10. Conduct more research in naturalistic settings, where the teacher needs to deliver ADFB to a large group of students.

11. Investigate the use of instructional technology (such as video camera and computer programs to analyze motor performance), and examine the relationship between the instructional technology and feedback.
LIST OF REFERENCES


APPENDIX A

HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD
APPROVAL TO CONDUCT RESEARCH
October 25, 2006

Protocol Number: 200580370
Protocol Title: THE EFFECTS OF DEVELOPMENTAL CONGRUENT FEEDBACK ON STUDENT PERFORMANCE IN THROWING, Jacqueline Goodway-Schiebler, Robin Dunn, Ilmaik Hurmeric, Rona Cohen, Sport & Exercise Sciences

Request to amend the protocol dated 10/06/06—add Dunn & Hurmeric as co-investigators, delete Barrett & Gross, add data collection sites, retention test, measurement instrument, addition of 180 subjects.

Type of Review: Amendment—expedited
Date of Approval: October 25, 2006
IRB Staff Contact: Cheri Petney
(614) 292-0526
Petney.62@osu.edu

Dear Dr. Goodway-Schiebler,

The Behavioral and Social Sciences IRB APPROVED the above referenced amendment BY EXPEDITED REVIEW.

Note that if applicable, informed consent (and HIPAA research authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. The IRB-approved consent form and process must be used. Changes in the research (e.g., recruitment procedures, advertisements, enrollment numbers, etc.) or informed consent process must be approved by the IRB before they are implemented (except where necessary to eliminate apparent immediate hazards to subjects).

It is the responsibility of the investigator to promptly report to the IRB any serious, unexpected and related adverse events or potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University’s OHRP Federalwide Assurance #00006378.

All forms and procedures can be found on the ORRP website – www.orrp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Thomas Nygren, PhD, Chair
Behavioral and Social Sciences Institutional Review Board
APPENDIX B

DEVELOPMENTAL SEQUENCES FOR COMPONENTS OF THE OVERHAND THROW FOR FORCE
Foot (Step) Action
S1. No step. The child throws from the initial foot position.
S2. Homolateral step. The child steps with the foot on the same side as the throwing hand.
S3. Contralateral, short step. The child steps with the foot on the opposite side from the throwing hand.
S4. Contralateral, long step. The child steps with the opposite foot a distance of over half the child’s standing height.

Trunk (Pelvis-Spine) Action
T1. No trunk action or forward-backward movements. Only the arm is active in force production. Sometimes, the forward thrust of the arm pulls the trunk into a passive left rotation (assuming a right-handed throw), but no twist-up precedes that action. If trunk action occurs, it accompanies the forward thrust of the arm by flexing forward at the hips. Preparatory (trunk) extension sometimes precedes forward hip flexion.
T2. Upper trunk rotation or total “block” rotation. The spine and pelvis both rotate away from the intended line of flight and then simultaneously begin forward rotation, acting as a unit or “block.” Occasionally, only the upper spine twists away, then toward the direction of force. The pelvis, then, remains fixed, facing the line of flight, or joins the rotary movement after forward spinal rotation has begun.
T3. Differentiated rotation. The pelvis precedes the upper spine in initiating forward rotation. The thrower twists away from the intended line of ball flight and, then, begins forward rotation with the pelvis while the upper spine is twisting away.

Humerus (upper arm) action during forward swing.
H1. Humerus oblique. The humerus moves forward to ball release in a plane that intersects the trunk obliquely above or below the horizontal line of the shoulders. Occasionally, during the backswing, the humerus is placed at a right angle to the trunk, with the elbow pointing toward the target. It maintains this fixed position during the throw.
H2. Humerus aligned but independent. The humerus moves forward to ball release in a plane horizontally aligned with the shoulder, forming a right angle between humerus and trunk. By the time the shoulders (upper spine) reach front facing, the humerus (elbow) has moved independently ahead of the outline of the body (as seen from the side) via horizontal adduction at the shoulder.
H3. Humerus lags. The humerus moves forward to ball release horizontally aligned, but at the moment the shoulders (upper spine) reach front facing, the humerus remains within the outline of the body (as seen from the side). No horizontal adduction of the humerus occurs before front facing.

Forearm action forward swing.
F1. No forearm lag. The forearm and ball move steadily forward to ball release throughout the throwing action.
**F2. Forearm lag.** The forearm and ball appear to ‘lag’, i.e., to remain stationary behind the thrower or to move downward or backward in relation to her/him. The lagging forearm reaches its furthest point back, deepest point down, or last stationary point before the shoulders (upper spine) reach front facing.

**F3. Delayed forearm lag.** The lagging forearm delays reaching its final point of lag until the moment of front facing.

APPENDIX C

TEACHER CONTENT KNOWLEDGE AND PEDAGOGICAL CONTENT KNOWLEDGE TEST
Questions about the vignettes (Total of 20 points)

- List the developmental level of the observed throwing performance (5 points)
  1. ________________________________________________________________
  2. ________________________________________________________________
  3. ________________________________________________________________
  4. ________________________________________________________________
  5. ________________________________________________________________

- What is correct and incorrect in the performance? (5 points)
  Correct
  1. ________________________________________________________________
  2. ________________________________________________________________
  3. ________________________________________________________________
  4. ________________________________________________________________
  5. ________________________________________________________________

  Incorrect
  1. ________________________________________________________________
  2. ________________________________________________________________
  3. ________________________________________________________________
  4. ________________________________________________________________
  5. ________________________________________________________________

- What feedback should you provide to the student based upon the observed performance? (5 points)
  1. ________________________________________________________________
  2. ________________________________________________________________
  3. ________________________________________________________________
  4. ________________________________________________________________
  5. ________________________________________________________________

- Provide two drills to improve the throwing performance (5 points)
  1. ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________
  2. ___________________________________________________________________
   ___________________________________________________________________
The overhand throw can be broken down into 3 parts, what are they? (3 points)
1. ________________________________________________________________
2. ________________________________________________________________
3. ________________________________________________________________

What teaching cues/feedback do you use to teach overhand throw? (4 points)
1. ________________________________________________________________
2. ________________________________________________________________
3. ________________________________________________________________
4. ________________________________________________________________

There are many possible feedback statements you can provide for throw. What decisions do you use in deciding which pieces of feedback you give? (4 points)
1. ________________________________________________________________
2. ________________________________________________________________
3. ________________________________________________________________
4. ________________________________________________________________

Describe a proficient step for the throw (3 points)
_____________________________________________________________________
_____________________________________________________________________
Describe a proficient trunk action (3 points)
_____________________________________________________________________
_____________________________________________________________________

Describe a proficient arm action during the throw? (3 points)
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

_____________________________________________________________________

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APPENDIX D

PRINCIPAL APPROVAL LETTER
To Members of the IRB Committee,

I am writing this letter to indicate support of the study by Dr. Jackie Goodway and Ms. Rona Cohen entitled:

*The effects of developmental congruent feedback on student performance in throwing*

The focus of this study is of value to Mr. and the students of our school. Please accept this letter as an indication of our support of the project. If you require further information I may be reached at

Sincerely,

Principal
Elementary School
APPENDIX E

TEACHER CONSENT FORM

Protocol number: 2005B0370
Principal Investigator: Jackie Goodway

I consent to participate in research being conducted by Dr. Jackie Goodway and Rona Cohen of The Ohio State University and his/her assistants and associates. The investigator(s) has explained the purpose of the study, the procedures that will be followed, and the amount of time it will take. I understand the possible benefits, if any, of my participation.
I know I choose not to participate without penalty. If I agree to participate, I can withdraw from the study at any time, and there will be no penalty.

Please check YES or NO to each of the following statements:
I consent to participate in this study: YES ☒ NO □
I consent to videotaping me during this study: YES ☒ NO □
I consent to the investigator keeping the videotapes after the study is completed for use in classes for training other teachers: YES ☒ NO □
I consent to the investigator keeping the videotapes after the study is completed for presentations to other researchers and teachers: YES ☒ NO □

I have had a chance to ask questions and to obtain answers to my questions. I can contact the investigators at (614) 292-8393. If I have questions about my rights as a research participant, I can call the Office of Research Risks Protection at (614) 688-4792. I have read this form or I have had it read to me. I sign it freely and voluntarily. A copy has been given to me.

Print the name of the participant: Mr.

Date: 11. 8. 06

Signed:

(Principal Investigator or his/her authorized representative)

Signed: (Participant)

(Person authorized to consent for participant, if required)
APPENDIX F

SAMPLE PARENT PERMISSION TEMPLATE
Signing the parental permission form

I have read (or someone has read to me) this form and I am aware that I am being asked to provide permission for my child to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to permit my child to participate in this study.

Please check YES or NO to each of the following statements:
I consent to my child’s participation in this study: YES ☐ NO ☐
I consent to videotaping of my child during this study: YES ☐ NO ☐
I consent to the investigator keeping the videotapes after the study is completed for use in classes for training other teachers: YES ☐ NO ☐
I consent to the investigator keeping the videotapes after the study is completed for presentations to other researchers and teachers: YES ☐ NO ☐

I am not giving up any legal rights by signing this form. I will be given a copy of this signed Form.

Printed name of subject

Printed name of person authorized to provide permission for subject

Signature of person authorized to provide permission for subject

Relationship to the subject

Date and time

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A signed copy of this form has been given to the participant or his/her representative.

Printed name of person obtaining consent

Signature of person obtaining consent

Date and time

Witness(es) - May be left blank if not required by the IRB

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APPENDIX G

LESSON PLANS AND ACTIVITIES
<table>
<thead>
<tr>
<th>Time</th>
<th>Activity Development</th>
<th>Organization</th>
<th>Teaching Cues/Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00- 0:05</td>
<td>Warm-up Activities</td>
<td>8 warm-up routine activities</td>
<td></td>
</tr>
<tr>
<td>0:05- 0:10</td>
<td>Teacher Introduction to throwing Demonstration of the overhand throw for force</td>
<td>Students sit on floor within their groups.</td>
<td>No specific guideline was given to the teacher other than the lesson plans and the activities.</td>
</tr>
<tr>
<td>0:10- 0:15</td>
<td>Explain 4 stations: 2 throwing stations (tennis ball station, bean bag station) 2 basketball stations</td>
<td>Students receive pinnies with numbers. The students will wear the same number every lesson. The students will be randomly assigned to a different group every lesson.</td>
<td></td>
</tr>
<tr>
<td>0:15- 0:16</td>
<td>Transition</td>
<td>Students will go to four satiations in the groups.</td>
<td></td>
</tr>
<tr>
<td>0:16- 0:40</td>
<td>Throwing stations Station I—Tennis Balls Students will throw tennis balls to target using the overhand throwing motion standing at least 15 ft from the wall. As they hit the marked target they can move away. Station II—Bean Bags Students will throw to hula hoops and try to throw as many bean bags as they can out of 15 trials.</td>
<td>Tennis ball station: Students take turns in throwing; each throws 5 tennis balls and switches with his or her partner. Students step back if they hit the wall 3 times. Duck tape on the wall.</td>
<td>Teacher cues or instructions In each station, each student has 5 trials and then switches with his or her partner. (A total of 15-20 trails for each student during each station.)</td>
</tr>
<tr>
<td>0:40- 0:45</td>
<td>Closure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lesson No.</td>
<td>Throwing Activity #1 6min</td>
<td>Throwing Activity #2 6min</td>
<td></td>
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<td>------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Session # 1</strong></td>
<td>Students will throw tennis balls to target using the overhand throwing motion standing at least 15 ft from the wall. After they hit the marked target 3 times with oppositions, they can move away. Each student throws 5 balls and switches with his or her partner.</td>
<td>The students will throw bean bags to hula hoops that are stationed at different heights and are different sizes and try to hit the target. Each student throws 5 bean bags and switches with his or her partner.</td>
<td></td>
</tr>
<tr>
<td><strong>Session # 2</strong></td>
<td>Students will throw tennis balls trying to knock out cones (the cones are placed on chairs to make the target higher) 12 feet a way from students. Each student throws 5 balls and switches with his or her partner.</td>
<td>The students will throw bean bags toward Snoopy targets that are stationed at different heights and are different sizes. Each student throws 5 bean bags and switches with his or her partner.</td>
<td></td>
</tr>
<tr>
<td><strong>Session # 3</strong></td>
<td>Students will throw tennis balls toward 3 red squares of different sizes. Their partners hand them balls from behind. Students must reach their arms way back to get the balls.</td>
<td>Students will throw bean bags toward 4 helium balloons of different shapes stationed at different distances. If students hit the balloon 3 times with opposition and long step, they can move a way from the target.</td>
<td></td>
</tr>
<tr>
<td><strong>Session # 4</strong></td>
<td>Students will throw bean bags toward balloons of different colors and sizes and try to hit them stepping with opposition. Each time a student hits the ball, he or she gets 2 points and can step away from the target.</td>
<td>Students will throw bean bags toward bowling pins that are stationed on two tables. Students need to pass with their step over a line that is marked on the floor to help them improve their long step.</td>
<td></td>
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<tr>
<td><strong>Session # 5</strong></td>
<td>Students will throw bean bags from different distances to 3 big garbage cans. Their partners will “feed” them with bean bags as the students reach back to get them and give them feedback on their performance.</td>
<td>Students will throw tennis balls toward the monkey target on the wall. They get 3 points each time they hit the monkey’s big ears, 4 points for his nose, and 5 for his mouth.</td>
<td></td>
</tr>
<tr>
<td><strong>Session # 6</strong></td>
<td>Students will throw tennis balls toward square wall targets of different sizes.</td>
<td>Students will throw yard balls to hoops that are hung with their tops at different heights.</td>
<td></td>
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<tr>
<td><strong>Session # 7</strong></td>
<td>Students will practice throwing for force as presented in the pretest. They will stand 20 ft away from the target and throw as hard as</td>
<td>Students will throw to a stationary target created from self-tie plastic kitchen trash bags filled with empty aluminum cans. The target</td>
<td></td>
</tr>
</tbody>
</table>
they can. is drawn on the outside of the bag. Each time students hit the target they receive a point. The targets are hung in different places in the gym.

**Total allocated throwing time = 12 minutes for each student**