The Effects of a Professional Development Workshop on Teachers’ Pedagogical Content Knowledge and Student Learning in a Lower Elementary Throwing Unit

DISSERTATION

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By

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Abstract

The purpose of this study was to: (a) examine the influence of a teacher professional development workshop on a teacher’s PCK of throwing unit and (b) to determine the effects of teachers’ instruction of a four day throwing unit on student throwing performance prior to and following the professional development workshop. A randomized control-group pretest-posttest with a retention test design was utilized to examine the change of the teacher’s PCK and students learning in the teacher’s intact classes. The following variables were measured: (a) task representation; (b) task demonstration; (c) feedback; and (d) task modification alignment for teachers, and throwing performance (body component levels for the step, trunk, humerus, and forearm, and the ball velocity) for students. Descriptive statistics (i.e., means and frequencies) and inferential statistics (i.e., non-parametric tests) were used to analyze dependent variables in both the comparison and the experimental classes. The results of the teachers’ data showed that teachers’ PCK variables including task representation, task demonstration, feedback, and task modification alignment can be changed as a function of teachers’ knowledge bases. Furthermore, the improved teachers’ PCK can influence the increase of students’ throwing performance. The findings of the study suggest that the teacher education programs should provide content courses to improve the teacher’s knowledge bases and many opportunities to improve PCK that influence student learning.
Dedication

I would like to dedicate this work to my advisor: Jacqueline Goodway, to my beloved wife and son: Jihyun Lee and Liam Chang as well as to all other friends and family members who helped me get to this point.
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Completion of this doctoral dissertation represents one of my most significant achievements. I would like to acknowledge the people who helped make it possible.

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Chapter 1: Introduction

What makes an effective physical educator? Being enthusiastic and passionate about teaching and working with children is certainly important but may not be sufficient to become an effective physical education teacher. Researchers suggested that becoming an effective physical education teacher an individual should be able to manage the classroom, organize and design effective lessons, implement instructions, and monitor student progressions (Rink, 2010; Siedentop & Tannehill, 2000). Another important element of being an effective physical educator is building sufficient knowledge of physical education content (Content Knowledge or CK) (Capel & Katene, 2000; Siedentop & Tannehill, 2000; Ward, 2009a; Ward, Li, Kim, & Lee, 2012). Furthermore, finding a variety of ways to effectively deliver CK to students (General Pedagogical Knowledge or GPK) is important to be an effective teacher in physical education (Ayvazo, Ward, & Stuhr, 2010). The combination of CK and GPK is called pedagogical content knowledge (PCK) which has been diversely defined in the literature (Ayvazo, 2007; Ball, Thames, & Phelps, 2008; Grossman, 1990; Grossman, Schoenfeld, & Lee, 2005; Gudmundsdottir & Shulman, 1987; Shulman, 1987, Ward, 2009b).

Shulman (1987) initially conceptualized PCK as the blend of CK and GPK in general education and stated that PCK is one of the three knowledge bases required for teaching (the three being CK, PCK, and curricula knowledge). Shulman (1986) emphasized two components of PCK, how teachers represent the particular content to
learners (e.g., analogies, illustrations, examples, and demonstrations); and what or how much students know about the content (e.g., their background, their understanding and misunderstanding of some concept about the content).

Even though CK is considered as a core factor that influences development of a teacher’s PCK, other knowledge bases have also been suggested as potential components of PCK (Ball et al., 2008; Grossman, 1990; Grossman et al., 2005; Gudmundsdottir & Shulman, 1987). The conceptual view of PCK has been variously defined, modified and refined by these researchers. For example, Gudmundsdottir and Shulman (1987) divided PCK into three distinct areas: (a) subject matter knowledge; (b) pedagogical knowledge; and (c) knowledge of learners. Furthermore, Grossman (1990) proposed four knowledge domains: (a) conceptions and purposes of teaching; (b) knowledge of students’ understanding; (c) curricular knowledge; and (d) knowledge of instructional strategies that affect PCK.

Grossman et al. (2005) made an attempt to re-conceptualize PCK. The researchers emphasized a teacher’s understanding of subject matter and knowledge of students as the primary components of PCK rather than curricular knowledge and knowledge of instructional strategies highlighted in Grossman’s (1990) initial view. Most recently, Ball et al. (2008) empirically examined Shulman’s definition of PCK in mathematics. They proposed two sub-domains of PCK including: (a) knowledge of content and students (KCS); and (b) knowledge of content and teaching (KCT).

In physical education, Ayvazo (2007) defined PCK as “the act of selecting content from one’s knowledge base for the purpose of teaching in a specific context” (p. 77). Most recently PCK was described by Ward (2009b) as “a focal point, a locus, or an
event in time (and therefore specific contextually) where teachers make decisions in
terms of pedagogy and content based on their understandings of a number of knowledge
bases (e.g., of understanding students, of curriculum, of context, of content, and of
pedagogy).” Ward (2009b) further argued that PCK is influenced by the following four
knowledge bases: context, curriculum, students, and other knowledge bases.

Based on the aforementioned various views of knowledge domains needed to
build a teacher’s PCK, four knowledge bases that affect the teacher’s PCK in physical
education can be postulated: (a) content knowledge; (b) knowledge of students; (c)
knowledge of instructional strategies (pedagogical knowledge); and (d) knowledge of
context.

Content knowledge refers to the teacher’s understanding of physical education
content and the organization of its structures to effectively teach students. Physical
education teachers should also know how to perform an activity or skill and what to teach
for improving student’s learning outcomes (Ward, 2009a). Thus, having a strong CK
should be considered as a prerequisite (Kleickmann et al., 2013; Shulman, 1987) to
effectively teach students because it sets a knowledge base as the foundation for effective
teaching (Chen & Ennis, 1995; Shulman, 1986).

Teachers should be aware of the knowledge their students already possess or if
they are being introduced to new concepts (Grossman, 1990). This background
information on their students also includes understanding the developmental level of
individual students’ ability to perform a task and their ability to perform sports or more
advanced activities. Teachers must know developmental principles that affect skill
acquisition (Gallahue, Ozmanm, & Goodway, 2012) and be aware of the common errors
that students frequently make in performing a task (Ball et al, 2008). In addition, the teacher knowledge of students includes the student’s previous learning experiences in a given task (Marks, 1990). This knowledge is important since previous experiences may influence the student’s motivation to learn the content and actual ability to execute the movement task.

Physical education teachers also need to build knowledge of instructional strategies—pedagogical knowledge. Pedagogical knowledge refers to a teacher’s ability to represent the physical education content using a variety of approaches including descriptions, illustrations, metaphors, and examples (Grossman, 1990; Shulman, 1986). Using appropriate instructional strategies should help students understand the content well and improve students’ learning (Rink, 2010). Selection of appropriate instructional strategies such as demonstrations, feedback, and cues and application of those strategies to either groups or individual students would be essential in this knowledge domain.

Lastly, physical education teachers should have sufficient knowledge of contextual factors that might impact the quality of teaching. This knowledge domain includes an understanding of school culture and expectations, understanding of parents’ expectations for the quality of physical education (Grossman, 1990), and how to effectively use instructional materials (e.g., visual resources, equipment) and facilities. Building knowledge of context can improve the physical education teacher’s ability to set appropriate annual goals, create lesson plans, and select appropriate equipment to maximize student learning.

Consideration of the aforementioned four knowledge bases raises a fundamental but important question, “How do inservice physical education teachers improve these
knowledge bases?” Professional development might be the best answer to the question. Stanescu, Ciolca, Vasiliu Ana, and Stoicescu (2012) defined professional development as a comprehensive, sustained, and intensive way to help teachers improve their effectiveness of teaching in physical education. Researchers suggested that teachers can learn new skills or diversify instructional strategies through professional development (Day, 1999; Till, Ferkins, & Handcock, 2011). Therefore, professional development is considered as a meaningful learning opportunity for inservice teachers to build their knowledge bases (Stanescu et al., 2012). In the physical education field, researchers have conducted studies to demonstrate that physical education teachers can improve PCK through professional development workshops (CK workshop) (Kim, 2011; Lee, 2011).

Based on the notion that all four knowledge bases are important (CK, knowledge of students, instructional strategies, and context) to improve PCK, it may be suggested that additional components should be added to the CK workshops conducted in previous studies (e.g., Kim, 2011; Lee, 2011). Designing and planning a quality workshop that can practically assist inservice teachers in building knowledge bases and PCK could result in enhancing students’ successful learning.

Need for the Study

Inconsistent conceptualizations and definitions of PCK and lack of consistency in the measurement of PCK have presented issues in drawing conclusions from the PCK literature (Loughran, Berry, & Mulhall, 2006; Marks, 1990). In physical education research, PCK has also lacked functional definition (Ayvazo, 2007). The absence of a functional definition of PCK is a barrier to observing, measuring, and analyzing PCK,
because it is difficult to know what PCK is, how to measure PCK, how to develop PCK, or how to use and discuss PCK in research and practice without a clearly defined functional definition.

Researchers at The Ohio State University have developed a functional definition of PCK (Ayvazo, 2007; Kim, 2011; Lee, 2011; Ward, 2009b). Furthermore, Kim (2011) and Lee (2011) proposed specific variables of PCK and observed and measured these PCK variables in secondary physical education. Kim (2011) and Lee’s (2011) work has contributed to research on PCK allowing the researcher to be able to identify levels of PCK before intervention and changes in levels of PCK after the intervention. The results of this work have reported that improved PCK positively influenced student learning. However, it is difficult to apply the functional definition and variables of PCK that Kim (2011) and Lee (2011) used with secondary physical education to the elementary school level because such definitions and variables are not developmentally relevant to the elementary aged child. The environment of elementary physical education is different from that of secondary physical education. In elementary school children are learning important fundamental motor skills and will progress through different developmental levels of these skills in order to attain proficient performance (Gallahue et al., 2012). An individualized developmentally-appropriate instructional approach is frequently used in elementary school to teach content based on a student’s developmental level (Graham, Holt/Hale, & Parker, 2012). Thus, the teacher’s knowledge to discriminate the developmental level of a child’s performance is an important PCK variable in elementary physical education. Furthermore, knowledge of students’ developmental skill level is a cornerstone to provide developmentally appropriate tasks by using a variety of
pedagogical knowledge such as demonstrations, feedback, and cues appropriate to students’ developmental level (Goodway, Derienger, & Lee, 2013). There is a need in the literature to define PCK and operationalize PCK variables considering the unique context of the elementary physical education environment. Further, PCK research should be conducted that centers on elementary physical education using valid observations, measurement, and analysis in order to lead to a better understanding of PCK.

Historically, the methodology used to investigate PCK in physical education was similar to that of general education, being mostly qualitative and descriptive in nature (e.g., Doutis, 1997; Jenkins, Garn, & Jenkins, 2005; Jenkins & Veal, 2002; Kutame, 2002; Rovegno, Chen, & Todorovich, 2003; Sebren, 1995; Tsangaridou, 2002). Qualitative studies allowed in-depth insights into changes in a teacher’s PCK and showed that teacher education and professional development programs can influence the development of a teacher’s knowledge bases and PCK (Hunuk, Ince, & Tannehill, 2012; Kutame, 2002; Rovegno et al., 2003). However, such qualitative studies do not claim to generalize findings because the development of each teacher’s knowledge bases and PCK may be influenced by their different educational backgrounds, sports experiences, or the environment of the school district (Krauss et al., 2008). Even though Rovegno (1992) recommended the need to study PCK experimentally, the majority of the studies conducted since that time were qualitative in nature due to the lack of operational definitions of PCK and the difficulty of measuring PCK as a variable (Ayvazo, 2007). Only a few studies have used an experimental approach (Kim, 2011; Lee, 2011). An experimental approach can allow the researcher to see a relationship between the
teachers’ PCK and student learning outcomes by manipulating the teachers’ levels of knowledge bases.

The research literature on CK and PCK has consistently demonstrated that improved teacher CK results in the development of teacher PCK (Creasy, Whipp & Jakson, 2012; Doutis, 1997; Jenkins et al., 2005; Jenkins & Veal, 2002; Kutame, 2002; Rovegno et al., 2003; Sebren, 1995; Tsangaridou, 2002; Walkwitz & Lee, 1992). In particular, Kim (2011) and Lee (2011) reported that improving the CK of the teacher through a professional development workshop resulted in an immediate impact on teacher behavior and on student learning. However, just developing the teacher’s CK does not guarantee improving the teacher’s PCK because there are other knowledge based factors such as the teacher’s knowledge of students (Ball et al., 2008; Grossman, 1990; Grossman, et al., 2005; Gudmundsdottir & Shulman, 1987; Shulman, 1987). To date, there is no research that has experimentally manipulated teachers’ other knowledge bases such as knowledge of instructional strategies or context to see changes in PCK and student learning in an elementary physical education setting.

Finally, there is little research exploring the relationship between PCK and student learning in an individual fundamental motor skill-based elementary physical education setting. Studies focusing on this relationship have only occurred at the secondary level in a sport context (Kim, 2011; Lee, 2011). There is scant information about how manipulating components of PCK affect a teacher’s PCK and how this change results in student learning outcomes. Conducting this kind of investigation can help researchers explore what variables of PCK may influence student learning and how teachers change their teaching for future classes. Therefore, there is a need to explore the
relationship between improving teacher’s knowledge bases and the demonstration of improved PCK, as well as between PCK and student learning.

To address these deficiencies, there are two purposes to this study. The primary focus of this study is to examine the influence of a teacher professional development workshop on a teacher’s PCK of throwing unit. A secondary focus of this study is to determine the effects of teachers’ instruction of a four day throwing unit on student throwing performance prior to and following a professional development workshop.

**Research Questions and Hypothesis**

**Research Question 1**

How does a teacher’s PCK in teaching a throwing unit differ as a role of their knowledge bases prior to (comparison condition) and following (experimental condition) a teacher professional development workshop?

**Research sub-questions**

1. How does the teachers’ task representation differ between the comparison and experimental classes?

   *Hypothesis 1*- Teachers in the experimental classes will demonstrate a higher % of correct task representations than in the comparison classes.

2. How does the teachers’ task demonstration differ between the comparison and experimental classes?
Hypothesis 1-Teachers in the experimental classes will show a higher percentage of correct demonstrations than in the comparison classes.

Hypothesis 2-Teachers in the experimental classes will show greater a frequency of correct demonstrations than in the comparison classes.

3. How does the teachers’ feedback differ between the comparison and experimental classes?

Hypothesis 1-Teachers will deliver more feedback statements to individual students in the experimental classes than in the comparison classes.

Hypothesis 2-Teachers in the experimental classes will deliver a higher % of developmentally appropriate feedback to individual students than in the comparison classes.

4. How does the alignment in the teachers’ task modification differ between the comparison and experimental group classes?

Hypothesis 1-Teachers will demonstrate a greater frequency of individualized task modification in the experimental classes than in the comparison classes.

Hypothesis 2-Teachers will show a higher percentage of aligned task modification for individual students in the experimental classes than in the comparison classes.
Research Question 2

How does a student’s throwing performance differ as a function of the teacher’s pedagogical content knowledge prior to (comparison condition) and following (experimental condition) a teacher professional development workshop?

Research sub-questions

1. Are there any differences in the four body components of throwing (step, trunk, humerus and forearm) between the comparison and experimental classes?

Hypothesis 1-There will be no differences in pretest four body components of throwing (step, trunk, humerus, and forearm) between the comparison and experimental classes.

Hypothesis 2-The experimental classes will have significantly greater pretest to posttest gain scores in four body components of throwing (step, trunk, humerus, and forearm) as compared to the comparison classes.

Hypothesis 3-There will be differences in retention test four body components of throwing (step, trunk, humerus, and forearm) between the comparison and experimental classes.

2. Are there any differences in throwing velocity between the comparison and experimental classes?

Hypothesis 1-There will be no statistically significant differences in the pretest throwing velocity between the comparison and experimental classes.
Hypothesis 2-The experimental classes will have significantly greater the pretest to posttest gain scores in throwing velocity as compared to the comparison classes.

Hypothesis 3-There will be statistically significant differences in the retention test throwing velocity between the comparison and experimental classes.

Limitations

The following are the limitations to this study that may have influenced the findings:

1. Lack of selection of school and teachers - The teachers and the school were purposefully selected for the study.

2. Limited knowledge of student participants’ prior experience and knowledge of throwing - Participants may have experienced the overhand throw outside of the physical education class.

3. The inability to control practice of throwing outside the school setting or within the scheduled school settings.

4. Teachers’ teaching experiences and familiarity with teaching overhand throwing - The teachers who participated in this study had different teaching experiences and they had differing knowledge about teaching overhand throwing prior to the study. One teacher had baseball coaching experience and the other teacher had very little experience with teaching throwing.

5. The facilitator for the professional development workshop - The researcher conducted the professional development workshop, and thus experimenter effects may have occurred.
6. The inability to control testing environment - Factors such as time and place of testing, clothing and shoes the participants wore during the testing varied by school and child.

7. The inability to control participant attendance during data collection - The student attendance for each throwing unit was not controlled.

8. The inability to determine whether the teacher had correctly identified the stage of throwing.

9. The inability to control practice trials for overhand throwing.

10. The inability to control camera reactivity.

**Delimitations**

The participants were first and second grade students in a suburban school district in the Southwestern part of the United States, and the designated task for the study was overhand throwing for force. The unit of instruction was a short, four-day throwing unit commonly seen in elementary physical education. Two elementary physical education teachers with 23 and 5 years of teaching experience took part. Both teachers taught in different elementary schools in the same school district. The professional development workshop was three hours long.
Definition of Terms

In the following section, the terms are designed according to how they are used operationally in this study.

**Common content knowledge:** Knowledge and skills needed to perform an activity (Ball et al., 2009; Ward, 2009a).

**Component approach:** The component approach is a developmental sequence for overhand throwing which describes changes in different body sections. A component is one particular body segment or a joint action of the body (Langendorfer & Roberton, 2002). The component approach in throwing examines five components: step, trunk, backswing, humerus, and forearm.

**Component:** A particular body segment of the throw (Langendorfer & Roberton, 2002).

**Content knowledge:** Knowing both how to perform an activity as well as what activity to teach in physical education (Ward, 2009a).

**Critical element:** The most important aspects of the skill that need to be performed a certain way for the successful performance (Knudson & Morrison, 1996).

**Demonstrations:** The teacher executes desired performance to student(s), and/or visual aids (Rink, 2010).

**Developmentally appropriate feedback:** The feedback the teacher delivers is developmentally appropriate based on student’s skill level.

**Developmentally inappropriate feedback:** The feedback the teacher delivers is developmentally inappropriate based on student’s skill level.
**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).

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

**General feedback:** The feedback the teacher delivers is not skill focused such as “Good job,” or “Nice throw.”

**Intervention:** A procedure, technique, or strategy designed to modify an ongoing process. Intervention refers to 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).

**Knowledge of context:** The teacher’s knowledge of contextual factors that might impact the quality of teaching such as understanding of school culture and expectations, understanding of parents’ expectations for the quality of teaching, and use of educational materials (visual resources, equipment) and facilities effectively.

**Knowledge of instructional strategies:** Knowing how to represent the content in various ways such as descriptions, illustrations, metaphors, examples, and how to instruct the task using various strategies such as demonstrations, feedback, and cues.

**Knowledge of students:** The ability to identify what the students already know about the content, their skills and abilities, and what they still find puzzling about the content (Grossman, 1990).
Pedagogical content knowledge: At the moment the teachers observe a child perform a skill, they draw from their different knowledge bases to inform their instructional decisions (e.g., providing feedback, potentially modifying the task) in order that they align with the child’s developmental level. Thus, PCK is an emergent phenomenon that is context and child specific.

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). It also referred to as 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). It also referred to as outcome measures.

Reliability: The degree to which independent observers agree on what they have observed when using the same definitions and observing the same subjects (Siedentop, Tousegnant, & Parker, 1982).

Specialized content knowledge: Knowledge and skills needed by teachers to teach the content (Ball et al., 2008; Ward, 2009a).

Task: A set of implicit or explicit instructions about what a person is expected to do to successfully cope with a situation (Doyle, 1981).

Task Modification: The task the teacher chooses for the students must be modified based on students’ developmental skill levels.

Task Representation: The simplest way to communicate to the students what they are expected to do and how they are to do it (Rink, 1994).
**Training:** The process of developing interpretations of an observation system which requires learning a common set of concepts, a common symbol language, and a common set of decision conventions (Siedentop et al., 1982). Observers are trained to produce reliable data.
Chapter 2: Review of Literature

This chapter is organized into three sections. First, pedagogical content knowledge (PCK) is reviewed from a historical standpoint, which includes how PCK has been conceptualized in general education and physical education, and which components of PCK have been identified over decades. Furthermore, empirical research focusing on PCK in physical education is reviewed. In the second section, the author proposes a conceptual view of PCK in elementary physical education. This section includes which components affect the teacher’s PCK and how these components are applied to teaching a throwing unit. The final section describes overhand throwing performance including the importance of the overhand throwing skill and the assessment of the skill from the perspective of dynamic system theory and constraints model.

**Conceptualization of PCK**

Pedagogical content knowledge (PCK) is essential for effective teaching because a teacher’s teaching behavior will be determined to a large extent by the depth of their PCK. Several key elements such as content knowledge (CK), general pedagogical knowledge (GPK) and knowledge of student’s affect PCK. The teacher building sufficient PCK can teach students effectively using a variety of approaches ways such as appropriate task representations, task demonstrations, and feedback statements.
Therefore, student learning will increase. The following section describes how PCK has been conceptualized from different perspectives over time.

**Conceptual View of PCK in General Education**

Pedagogical content knowledge (PCK) can be considered part of a knowledge base for teaching. However, the conceptualization of its relationship to that knowledge base has changed over time. The change can be described in terms of three phases.

*Phase 1: PCK as One of Many Knowledge Bases*

In his 1986 seminal article, Shulman placed PCK into one of three categories of knowledge bases that were required for teaching (see Figure 2.1).

![Teacher Knowledge Base](Shulman, 1986)

Subject Matter Knowledge

Pedagogical Content Knowledge (PCK)

Curricular Knowledge

Figure 2.1 Teachers’ knowledge base categories (Shulman, 1986).

Subject matter knowledge is a teacher’s organization and breadth of knowledge about the subject matter. Pedagogical content knowledge has been defined by Shulman as, “the ways of representing and formulating the subject matter that makes it comprehensible to others” (Shulman, 1986, p. 9) in subject areas that teachers teach
regularly and repeatedly. Curricular knowledge is the range of topics planned and sequenced for teaching specific content for the specific group of learners at a given level. For example, the teacher’s awareness of how topics should be arranged not only within the school year but also over long periods of time, or knowledge of how curriculum resources, such as textbooks, can be effectively used to systematize the program of study for students (Hill, Schilling, & Ball, 2004).

A year after emphasizing the importance of content knowledge (CK) in the knowledge bases for teaching, Shulman (1987) added four more categories of knowledge base (general pedagogical knowledge, knowledge of learners, knowledge of context, and knowledge of educational ends) to CK, PCK, and curricular knowledge (see Figure 2.2).

Figure 2.2 Teachers’ knowledge base categories (Shulman, 1987).

*General pedagogical knowledge* included strategies and practices for classroom management and organization. *Knowledge of the learners and their characteristics* is derived from Shulman’s view in 1986 regarding knowledge of students’ conceptions and misconceptions about the subject matter. This category was originally included in the definition of PCK in 1986 but Shulman (1987) classified it as an independent knowledge
base category. *Knowledge of contexts of schooling* meant a range from familiarity with the classroom and districts to practices of the community and cultures. The last category was *knowledge of educational goals* that also included knowledge of philosophical beliefs and values. These four categories were important to teachers to teach. In addition, Shulman’s (1987) categories of knowledge bases have contributed to thinking about which areas influence teacher training and professional development of teacher knowledge.

From a theoretical perspective, proposing seven categories of a knowledge base could have contributed to distinguishing between PCK and other types of knowledge bases; it was a base for developing the concept of PCK. However, in reality, it was not enough to explain what PCK really is. PCK was still recognized as “ways of talking, showing, enacting, or otherwise representing ideas so that the unknowing can come to know, those without understanding can comprehend and discern, and the unskilled become adept” (Shulman, 1987, p. 7).

Therefore, Shulman (1987) defined PCK as the blending of CK and pedagogical knowledge that results in a teacher’s understanding of how the content can be effectively organized, represented, and accommodated for learners having diverse abilities and interests. Shulman (1987) also emphasized teachers’ flexible and multidimensional understanding of their subject matter to provide alternative explanations of the same concepts or principles for learners of different learning stages and interests. As a result, the definition of PCK was refined by Shulman (1987) to include the amalgamation of CK and pedagogy transformed via some selected actions to learners in diverse groups. Yet, the “blending” of content with pedagogy that resulted in PCK was still unclear.

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Phase 2: PCK as Being Influenced By the Knowledge Bases

Teacher knowledge bases were considered as an independent variable while those are interrelated in Phase 1. Therefore, PCK was also deemed one of teacher knowledge bases. However, there was a conceptual shift resulting in other knowledge bases becoming central around PCK over time. Grossman was another researcher who examined how PCK can be conceptualized following the work of Shulman and colleagues (1987).

In 1990, Grossman included PCK as one of four general categories of teachers’ knowledge bases including CK, general pedagogical knowledge, and knowledge of context (see Figure 2.3).

![Figure 2.3 Grossman’s (1990) knowledge bases for teaching.](image)

While Shulman (1987) defined each knowledge base, Grossman (1990) noted that these four categories were interactive rather than isolated. Grossman (1990) included the category, “knowledge of context” which is the teacher’s understanding of the school
setting, the mission of the school, departmental guidelines, expectations, culture, and other contextual factors that might impact the quality of teaching. This category also included knowledge of the students, their strengths and weaknesses, family and background, and community. Grossman’s (1990) contribution was how her delineation of PCK differed compared with the original definition proposed by Shulman. In contrast to Shulman (1987), Grossman (1990) did not consider CK to be a part of the PCK component.

Fifteen years after Grossman’s (1990) postulation of PCK, Grossman et al. (2005) explained that PCK refers to the teacher’s ability to expect students’ understanding or misunderstanding within the subject matter, to respond to learners in diverse settings, and to address their understanding or misunderstanding by providing ample examples and various representations of the content that make the concept being taught more accessible to the students (Grossman et al., 2005). Grossman et al. (2005) attempted to unpack PCK by the using the question “That lie[s] at the heart of PCK—what it means to understand one’s subject matter for the purpose of teaching it to others” (p. 207). This question focuses mostly on PCK, although it also pertains to CK, and is targeted to pre-service teachers in a content specific pedagogy course. For example, some questions address the issue of the subject matter and its importance such as: Which aspects of the subject are most important? How are the curricular materials articulated across grade levels? What are the practices that characterize the teaching of particular content?

Initially, when Shulman (1987) proposed many teacher knowledge bases, these were independent yet related to each other. However, all knowledge bases were operationalized through PCK. Furthermore, Grossman (1990; 2005) argued that teacher
knowledge bases were interactive. This view was different from Shulman’s (1986; 1987) postulation that all teacher knowledge bases were isolated. As a result, the concept of PCK during Phase 2 was more interrelated with other knowledge bases and emphasized than Phase 1.

**Phase 3: PCK as a Sophisticated Concept.**

After an empirical examination of Shulman’s (1986) definition of PCK, Ball et al. (2008) proposed three sub-domains of PCK: a) knowledge of content and students (KCS); b) knowledge of content and teaching (KCT); and c) knowledge of content and curriculum (KCC) in mathematics education (see Figure 2.4).

![Figure 2.4 Domains of mathematic knowledge for teaching (Ball et al., 2008).](image-url)
The first domain, knowledge of content and students (KCS) was defined as the combination of knowledge of students and mathematics. Ball et al. (2008) argued that teachers must be able to anticipate what students are likely to do with tasks and whether they will find tasks easy or hard. Understanding students’ confusion about content and providing appropriate content for learners in diverse groups would be included in the domain of KCS. Ball et al. (2008) distinguished KCS from CCK or SCK, which they had already defined as CK categories.

Knowledge of content and teaching (KCT), which is the combined knowledge of mathematics and pedagogy, was the second sub-domain of PCK. Ball et al. (2008) asserted that teachers having KCT can provide proper task progressions for learners, identify the appropriate means for instructional representation, and make decisions about instructional strategies by considering individual students’ needs. KCT would be teacher knowledge and skills that entail teachers’ different repertories and abilities to represent the content and knowing how to deliver it effectively. Including knowledge of content and curriculum (KCC) into the domain of PCK was done hesitatingly by Ball et al. (2008) due to a lack of empirical foundation. Ball et al. (2008) stated that further empirical evidence is necessary to judge appropriateness for this as one of sub-domains for PCK.

The contribution of Ball et al.’s (2008) work was that they emphasized how strongly CK influences PCK and what types of CK are related to PCK when compared to previous researchers (e.g., Grossman, 1990; 2005, Gudmundsdottir & Shulman, 1987; Marks, 1990; Shulman, 1986) who defined the concept of PCK with empirical testing. In particular, Ball et al. (2008) proposed that certain domains of CK namely: 1) common
content knowledge (CCK); and 2) specialized content knowledge (SCK), drive PCK. These two domains will be described in the section of CK in detail.

In summary, despite some shifts (Ball et al., 2008; Grossman, 1990; Grossman et al., 2005; Gudmundsdottir & Shulman, 1987; Marks, 1990) in the conceptualization of PCK from the original definition (Shulman, 1986), PCK is still considered the amalgam of pedagogical knowledge and the teacher’s approach and delivery of the subject matter (Loughran, Milroy, Berry, Gunstone, & Mulhall, 2001). Even though PCK is frequently cited and referenced (Segall, 2004), until Ball’s work, PCK had not been adequately operationally defined.

**Conceptual View of PCK in Physical Education**

Researchers in physical education have situated the definition of PCK based on the frameworks by Shulman (1986, 1987), Grossman (1990), and Marks (1990). Drawing on the work of Rovegno (1992, 1993) and Ball et al. (2008), scholars have proposed a new conceptualization of PCK in physical education (Ayvazo, 2007; Ward, 2009b).

*Shulman’s view as a framework for PE researchers*

Shulman’s definition of PCK has been adapted as a framework by several researchers in physical education (Chen, 1994; Chen & Ennis, 1995; Doutis, 1997; Kim, 2011; Lee, 2011; Kutame, 2002; Rovegno, 1993; Walkwitz & Lee, 1992). The subject matter in physical education and how a teacher acquired it and used it were central for these studies because of the rationale that the teacher’s understanding of the content influenced their PCK. Pedagogical content knowledge was recognized as a unique
understanding of particular forms of CK that are teachable to others (Graber, 1995). Graham et al. (1993) stated that such understanding is functional referring to descriptive terms, key words, demonstrations and effective classroom settings that make the content enjoyable and helpful to students. However, Rovegno (1994) has argued that Shulman’s definitions (1986, 1987) are insufficient because his definitions were not research-based or consistent, and interacted or overlapped with one another (Rovegno, 1994). Therefore, other researchers (e.g., Chen, 2002; McCaughtry, 2004; Schempp, Manross, Tan, & Fincher, 1998) implemented Grossman’s view of PCK in their studies as a framework.

**Grossman’s view as a framework for PE researchers**

Several studies (Benham, 2002; Chen, 2002; Creasy et al., 2012; McCaughtry, 2001, 2004; Schempp et al., 1998; Schincariol, 2003; Tsangaridou, 2002; Whipple, 2002) have used Grossman’s view of PCK as a main conceptual framework. These studies were conducted based on the notion that knowledge bases are not separate from one another and do not develop without integration. Their research focus was the blending of knowledge of content, students’ cognitions, emotions, and physical abilities, and curricular knowledge to increase student learning. (Benham, 2002; Chen, 2002; Creasy et al., 2012; McCaughtry, 2004; Rovegno, 1994; Schincariol, 2003).

**Mark’s (1990) and Grossman’s (1990) view as a framework for PE researchers**

Several researchers (Marcon, Graca, & Nascimento, 2012; McCaughtry & Rovegno, 2003; Rovegno, 1994; Rovegno, Chen, & Todorovich, 2003) adopted both Marks’s (1990) and Grossman’s (1990) definitions of PCK as a main conceptual
framework for their qualitative research. These studies were conducted based on the notion that teaching cannot be explained by a single knowledge base (McCaughtry & Rovegno, 2003). From their perspective, PCK is the integration of knowledge of content, learners, instructional strategies, curriculum, purposes for teaching, and teacher’s values about the subject matter (Gudmundsdottir, 1990; Marcon et al., 2012; McCaughtry & Rovegno, 2003; Rovegno, 1994; Rovegno et al., 2003). Studies conducted based on Mark’s and Grossman’s view of PCK as a framework were more integrative and interactive in nature (Ayvazo, 2007).

*Ayvazo’s and Ward’s operational definitions of PCK in PE*

Even though many studies delineated the dimensions of PCK, these studies were not strong enough to enable the analysis of how various aspects of PCK get activated, integrated, and transformed in practice due to a lack of the operationalized definitions of PCK. The first person to render a conceptualized functional definition of PCK was Ayvazo (2007).

Ayvazo (2007) defined PCK as “the act of selecting content from one’s knowledge base for the purpose of teaching in a specific context” (p. 77). The act of selection from one’s knowledge base includes several forms: (a) selection of content to be included in the lesson plan; (b) enactment of the content in the act of teaching; and (c) repeated interactions with the same content. The first form, selection of the content to be included in the teacher’s lesson plans, is a part of planning. The choice of skills, strategies, practices, activities, and “the modes of teaching, organizing, managing, and arranging the lesson” (Shulman, 1987, p. 15) refers to selection. A degree of the teacher’s
content knowledge would be judged based on their lesson plans (Ayvazo, 2007). Second, enactment of content in the act of teaching refers to the way one represents the content to the learners. Representation of the content using analogies, questioning, demonstrations, and explanations is included in this form (Ayvazo, 2007). Studies in the physical education literature (e.g., Doutis, 1997; Kim, 2011; Kutame, 2002; Lee, 2011) examined teaching practices such as demonstrations, descriptions, types of tasks provided, and the use of learning cues and feedback. The last form of selection involves practice and refinement of the content in the form of repeated interactions with the same content. This idea was directly derived from Shulman’s (1986) definition. Teaching the same instructional unit repeatedly results in developing PCK specific for that particular unit of instruction (Givens, 1998). For example, if a teacher teaches the same soccer lesson four times a day, it is likely that the last lesson delivered is better than the first one because of a function of repeated teaching of the same content, and increased familiarity of the teacher with the students. However, the teacher must reflect on his or her teaching (Ayvazo, 2007).

A process of adaptation to students’ characteristics (Shulman, 1987) is the first step in selecting what to teach and then teaching it (Ayvazo, 2007). The process includes students’ responses and difficulties, their conceptions and misconceptions, demographic characteristics (e.g., sex, age, and social class), aptitude, interests, and attention. Ayvazo (2007) emphasized that the selection process and adaptation occurred when the teacher selected the content from the teacher’s CK base. Ayvazo’ (2007) s operational definition of PCK promoted our understanding of how to conceptualize and measure PCK using functional analysis.
Recently, Ward (2009b) proposed the concept of PCK. He defined PCK as “a focal point, a locus, or an event in time (and therefore specific contextually) where teachers make decisions in terms of pedagogy and content based on their understandings of a number of knowledge bases (e.g., of understanding students, of curriculum, of context, of content, and of pedagogy)” (see Figure 2.5).

![Diagram of Pedagogical Content Knowledge (Ward, 2009)](image)

Figure 2.5 Ward’s (2009b) view of PCK.

Furthermore, Ward (2009b) conceptualized PCK within two continuums: a) more or less effective and b) more of less mature in teach (see figure 2.6). There are four outcomes in terms of teachers’ PCK in this conceptualization; 1) mature and effective PCK (e.g., providing excellent tasks and representations which are effective for all students); 2) mature and less effective PCK (e.g., providing excellent tasks and representations which are not effective for all students); 3) immature and effective PCK (e.g., providing poor tasks and representations which are effective for all students); and
4) immature and less effective PCK (e.g., providing poor tasks and representations which are not effective for all students).

In summary, the physical education literature on PCK has usually paralleled classroom-based research in terms of its conceptualization and the research methodologies. Especially, Ayvazo (2007) and Ward (2009b) suggested a functional term of PCK in physical education. The next section examines the components of knowledge that influence PCK.

Figure 2.6 Ward’s (2009b) continuums of PCK.
The Components of Pedagogical Content Knowledge

Content Knowledge (CK) is critical and a prerequisite to develop the teacher’s PCK (Chen & Ennis, 1995; Rovegno, 1992). However, many researchers (Shulman, 1986; Gudmundsdottir & Shulman, 1987; Marks, 1990; Grossman, 1990; Grossman et al., 2005) have suggested that PCK is also influenced by different teacher knowledge bases such as knowledge of students or knowledge of the context. This section reviews components of PCK based on different views from researchers.

Components of PCK in General Education

Shulman (1986) emphasized two components of PCK: a) how teachers represent the particular content to learners (e.g., the ways of representation such as useful ideas, analogies, illustrations, examples, and demonstrations); and b) what students know about the content (e.g., their background, their understanding and misunderstanding of some concepts. A year after, Gudmundsdottir and Shulman (1987) suggested dividing PCK into three distinct areas based on the root knowledge that influences them, Marks (1990) also attempted to define PCK in a similar manner.

The first influence on PCK is derived from subject matter knowledge. Knowledge of the main topics and areas of the subject matter (Gudmundsdottir & Shulman, 1987) and the interpretation of those concepts delivering them from CK into PCK (Marks, 1990) were included in this area. The second influence on PCK is derived from general pedagogical knowledge. The use of demonstrations, simulations, and questioning strategies to explain a concept to the learners were referred as a general pedagogical knowledge (Gudmundsdottir & Shulman, 1987; Marks, 1990). This process of using
generic knowledge to create specific PCK in a particular context is entitled “specification” (Marks, 1990). The third influence on PCK is derived from knowledge of learners or previous PCK experiences. Here, Gudmundsdottir and Shulman (1987) and Marks (1990) differed in their views. According to Gudmundsdottir and Shulman (1987), knowledge of the students can have an impact on the third area of PCK. Specifically, they referred to students’ conceptions or misconceptions students bring with them into the learning setting.

On the other hand, Marks (1990) argued that the third type of PCK comes out of previous PCK. Previous use of learning activities, teaching strategies, and awareness of students’ lack of knowledge of the subject matter were included. Marks (1990) suggested that the subject matter and the general pedagogical knowledge were equally situated in PCK.

Furthermore, Marks (1990) proposed that PCK was composed of students’ understanding, subject matter, instructional process, and media for instruction. The latter category was an addition to Shulman’s concepts. In 1990 Grossman proposed that PCK has four central components (see Figure 2.7).
First, PCK includes knowledge and conceptions about the purpose of teaching at different grade levels. For example, if a teacher believes that the purpose of physical education is to increase the students’ physical activity level, more fitness related activities would be included in the curriculum designed by the teacher. In contrast, if a teacher believes that the purpose of PE is to increase students’ social skills, a cooperative learning environment to develop students’ social skills such as cooperation, responsibility, leadership, and trust relationships would be situated in the curriculum. Teachers’ goals for the subject matter influence the structuring of the curriculum, selecting content, as well as, organizing the class activities.

The second component, the knowledge of students’ understanding, is similar to the category knowledge of learners discussed by Shulman (1986), Gudmundsdottir and Shulman (1987), and Marks (1990). This category refers to the teacher’s knowledge of
what the students already know about the subject matter, their skills and ability, and what they still find puzzling about the content (Grossman, 1990).

The third component of PCK is curricular knowledge (Grossman, 1990). Shulman (1986, 1987) argued that curricular knowledge was one of the knowledge based categories required for teaching. However, Shulman (1986, 1987) did not include curricular knowledge as a component of PCK. In contrast, Grossman (1990) postulated that curricular knowledge is one of the four components of PCK. Curricular knowledge refers to knowing about curricular materials that might be used to teach particular content, including vertical and horizontal curricular progressions for a topic. This knowledge may be represented by the teacher’s curriculum plan of teaching for certain content. Grossman (1990) pointed out that the teachers should know what the students already know and what the students need to learn in the future as a part of the curricular knowledge.

The last component of PCK includes teaching strategies and representations in specific topics. It refers to knowing how to deliver content using various representations (e.g., metaphors, examples, and activities) while teaching specific content for the specific learners (Grossman, 1990).

Overall, Grossman (1990) included curricular knowledge and knowledge of the students as components of PCK even though Shulman (1987) indicated those two categories as independent knowledge based categories for teaching. One of the PCK components made by Grossman (1990) was instructional strategies, which resembled the general pedagogical knowledge as discussed by Shulman (1986).
In 2005, Grossman et al. (2005) insisted that PCK is mostly influenced by two components: (a) teachers’ understanding of the subject matter, and (b) teachers’ knowledge of the students and their ability to deal with students misunderstanding (see Figure 2.8). This position of PCK was different from Grossman's initial postulation in 1990. Grossman et al. (2005) did not include emphasis on curricular knowledge or knowledge of instructional strategies as components of PCK from their original conceptualization of PCK.

![Figure 2.8 PCK components (Grossman et al., 2005).](image)

**Components of PCK in Physical Education**

Rovegno (1994) supported the notion that PCK is the integration of several knowledge bases such as knowledge of content, learners, and instructional strategies, and curriculum (Marcon et al., 2012; McCaughtry & Rovegno, 2003; Rovegno, 1994; Rovegno et al., 2003). Rovegno (1994) also expended aspects of PCK including teachers’ understanding of the school’s culture, classroom ecology, discipline, lack of administrative and teachers’ subculture. These aspects of PCK were described through the concept of a “curricular zone of safety” (Rovegno, 1994, p. 272). As preservice teachers in high school began to learn the aspects of PCK they reverted to application
tasks (Rink, 2010) and simply utilized games with the students. Such scenarios indicate a “curricular zone of safety” (Rovegno, 1994, p. 272) and represent how PCK develops in the relationships among the teacher, students, the activity of teaching, and the school culture.

Ayvazo (2007) suggested that PCK is influenced by CK as well as the variables identified by Grossman (1990): (a) conceptions of purposes for teaching, for example, the teacher’s conception may be that students should increase fitness level at the upper grades of elementary school; (b) knowledge of students’ understanding including previous sports experiences, detecting their developmental level, appropriately discriminating their skill level, and providing appropriate learning tasks to them (Chen, 2004; McCaughtry & Rovegno, 2003; Rovegno, 1992; Rovegno, 1995; Sebren, 1995); (c) curricular knowledge, which refers to types of curriculum in physical education; (d) knowledge of instructional strategies such as using the exploration form, direct instruction, or peer tutoring; and finally; and (e) knowledge of the context, for example, the type and amount of equipment, space in the gym, indoor or outdoor instructional unit, weather, sharing space and equipment with other teachers, and number of children in the class. Interestingly, knowledge of the context was not identified as a factor influencing PCK in the general education arena. It may be because of the unique nature of the physical education setting that is not applicable to the general classroom (Ayvazo, 2007).

From Ward’s view (2009b) of PCK, PCK refers to the teachers’ ability to blend the knowledge of content and pedagogy from the four knowledge bases (e.g., context, curriculum, students, and other knowledge bases) and select and transform them to real teaching of a particular content. Specifically, when teachers change the content area, it
influences most of the knowledge bases. Furthermore, the teachers need to use different pedagogical skills for teaching the content when the content is changed. Therefore, CK and pedagogical knowledge should be placed between PCK and knowledge bases to transfer adequate knowledge fitting the content into PCK specific to teachers’ needs. Ward’s view of PCK was derived from the argument that PCK is informed by CK, context, students, pedagogy, and curriculum (Grossman, 1990; Doutis, 1997; Jenkins et al., 2005; Jenkins & Veal, 2002; Kutame, 2002; Rovegno, Chen, & Todorovich, 2003; Sebren, 1995).

Research on PCK in Physical Education

The research on teachers’ PCK in physical education can be organized into three sub-categories; (a) research on preservice teachers’ PCK; (b) research on inservice teachers’ PCK; (c) research on the interactions between PCK and student learning, and; (d) research issues related to PCK in physical education in this section.

Research on preservice teachers’ PCK

Preservice teachers typically acquire PCK from the context of elementary or secondary method classes or during their student teaching period (Ayvazo, 2007). Studies (e.g., Chen, 2004; Jenkins & Veal, 2002; Rovegno, 1992; Sebren, 1995) have examined the effects of the context included in a field-based elementary physical education methods course on preservice teachers’ PCK.

Sebren (1995) found a lack of development of PCK in preservice teachers attending an elementary methods course. Since the preservice teachers had a lack of
PCK, such as how to appropriately respond to students and what to do to assist students to perform (Sebren, 1995), the preservice teachers could not respond pedagogically to their students. Graber (1995) also reported that student teachers had difficulties delivering their PCK and did not receive any specific instructional training related to the CK they were to teach in physical education.

Two studies in physical education found that peer coaching conducted during the methods classes was one of the resources preservice teachers could develop their PCK (Jenkins et al., 2005; Jenkins & Veal, 2002). The results from these studies suggested that observations enhanced the preservice teachers’ PCK due to increased familiarity with the learners (Jenkins et al., 2005; Jenkins, & Veal, 2002). However, these studies did not clarify exactly how the increased familiarity of the students enhanced their PCK (Jenkins et al., 2005; Jenkins, & Veal, 2002). Other studies reported that the development of PCK of preservice teachers occurred during their secondary school internship (Schincariol, 2002), and during student teaching in elementary (Rovegno, 1994, 1995), middle (McCaughrty & Rovegno, 2003), or high schools (Rovegno, 1995).

In conclusion, based on findings from research examining the preservice teachers’ PCK, we can conclude that methods classes and field experiences provide preservice teachers with opportunities to develop some aspects of knowledge on teaching, content, and students. However, preservice teachers experienced difficulties related to delivering CK and realized their lack of ability to appropriately respond to the students’ actions during the lesson. Unfamiliarity with the CK and learners results in inappropriate lesson plans and weak demonstrations of PCK. In other words, when preservice teachers are familiar with CK and the learners they can interact more with students, assign appropriate
tasks, and provide feedback (Chen, 2004; Jenkins et al., 2005; Jenkins & Veal, 2002; McCaughtry & Rovegno, 2003; Rovegno, 1992, 1995; Sebren, 1995; Tsangaridou, 2002; Whipple, 2003) resulting in the development of PCK.

**Research on inservice teachers’ PCK**

Studies conducted with inservice teachers showed differences in PCK between expert and novice teachers, and experienced teachers and inexperienced teachers. A finding from this research was that expert and experienced teachers had detailed CK (Chen & Ennis, 1995; Kutame, 2002; Graham et al., 1993; Schempp et al., 1998). Furthermore, expert and experienced teachers used more accurate and appropriate cues (Graham et al., 1993; Kutame, 2002), understood teachable concepts and skills (Chen & Ennis, 1995), had appropriate presentation skills (Rovegno et al., 2003), and showed a differentiated conceptual structure (Rink, 1994). In contrast, novice teachers mostly used books and classes as resources for planning classes and used less cues than expert teachers (Graham et al., 1993). Novice teachers had written lesson plans but these lesson plans were usually over planned and they usually consulted the lesson plan while teaching. Experienced teachers reported no need for preparation, particularly when teaching their expert areas, a concept called “plan independence” (Graham et al., 1993; Schempp et al., 1998). Experienced teachers constantly modified their instruction with confidence according to student and environmental variations (Graham et al., 1993). If they taught non-expert areas, they searched additional resources such as other colleagues who had already taught the content or were experts in it (Graham et al., 1993).
In summary, the literature indicates that inservice teachers critically consider CK and its teachability to students and make curricular decisions based upon these considerations. Thus, inservice teachers consider both CK and students’ conceptions when selecting content for their curriculum (Chen & Ennis, 1995; Schempp et al., 1998). Experienced teachers were more student-driven while novice teachers were more content-driven (Graham et al., 1993).

**Research on the interconnections between PCK and student learning**

There are few studies which have explored the relationships between PCK and student learning in physical education (Creasy et al., 2012; Kim, 2011; Lee, 2011) based on the assumption that improved teacher PCK can have positive effects on student learning. Lee (2011) examined the effects of implementation of a CK workshop on teachers’ PCK variables and student learning. This study utilizing a soccer unit was conducted under the assumption that improved teachers’ CK would have an influence on teachers’ PCK and consequently student learning. The study found that the CK workshop affected the teachers’ CK and PCK. In addition, the study found that improved teachers’ PCK influenced the improvement of students’ correct performance. This study contributed to finding the effectiveness of a CK workshop and knowledge packet for improving teachers’ CK as well as teachers’ PCK. Furthermore, operational definitions of PCK were observed and measured using several dependent variables.

Following Lee’s (2011) study, Kim (2011) examined the effects of implementation of a CK workshop on teachers’ PCK variables and student learning in a badminton unit. Kim (2011) found that teachers’ PCK improved as a function of CK
which resulted in an increase of students’ correct trials and a decrease of students’ incorrect trials in badminton unit. This study contributed to the methodological practices used to investigate PCK by employing both a behavior analytic approach and experimental approach for designing the research.

Creasy et al. (2012) examined the effects of a community of practice (CoP) on physical educators’ and their students’ health-related fitness CK as well as the physical educators’ health-related fitness PCK construction process. They found that teacher participation in a CoP changed teacher’s teaching practices and teaching culture by focusing on their students’ needs, increasing their engagement in physical education, and also triggered continued learning toward personal professional needs. The study indicated that a CoP based on teachers’ specific needs increased their students’ learning and changed teachers’ teaching culture positively. This study supported the notion that teachers can improve their CK through participating in professional development programs (Ward, 2009a) and also that improved teacher PCK results in increased student learning. However, the limitation of this study was that the results of the students’ knowledge test (written test) were used to measure student learning. That means that this study did not measure students’ real performances of a particular skill.

Research issues related to PCK

There are several concerns regarding the research related to PCK. The first concern is the lack of definition of PCK, which has been emphasized by Marks (1990). Recently, scholars also described the same issue (i.e., poorly defined PCK) in different content areas (Ball et al., 2008; Abell, 2008). Even though the term PCK has been widely
used in the educational literatures since 1986, PCK has not been clearly defined and conceptualized (Ayvazo, 2007). In other words, none of the definitions have been operationally defined. Many studies used different definitions and conceptualizations of PCK in physical education (Ayvazo, 2007) because there is no functional definition of PCK. PCK is the most important form of knowledge (Siedentop, 2002) and how to teach and develop PCK should be identified to help teachers improve their PCK. Without a clear definition, we neither know how to teach and develop PCK nor how to use and discuss it in research and practice (Ayvazo, 2007). To solve this issue, Ayvazo (2007), Ball et al. (2008) and Ward (2009b) suggested conceptualized and operational definitions of PCK in physical education and mathematics education. However, more evidence-based research is necessary to conceptualize their proposed definition of PCK.

The second issue in the PCK literature is the effectiveness of PCK as determined by student performance. PCK can vary based on the teachers’ past teaching experiences, their familiarity of the content, and context. Teachers who have had previous teaching experiences in some content tend to have effective PCK but their PCK is not effective when they teach content they have not taught before. Therefore, the teachers’ PCK can be effective in a particular content, but it may not prove effective in other content. One task can sometimes be effective in one group of students but not others. To clarify this issue a functional definition of PCK is needed. In order to functionally define PCK, PCK variables must also be observed and measured as described in detail below.

Struggle in measuring and observing PCK is the third issue in the PCK literature. It is important to measure and observe PCK; however, because of a lack of definition of PCK, it is not easy to identify how to measure or observe teachers’ PCK. There could be
two ways of measuring and observing PCK. One of these ways is to test teacher’s PCK using written tests (Stuhr et al., 2007). The written test provides a situation or case related to teachers’ misunderstanding and teachers need to answer these questions. The other way to measure teachers’ PCK is to directly measure and observe teachers’ teaching practices (Ayvazo, 2007). If a researcher uses direct observation to measure teachers’ PCK, the researcher needs to functionally define the definition of PCK first and decide which variables can best represent PCK. Recently, Ayvazo (2007), Lee (2011), and Kim (2011) observed and measured PCK directly. These studies contributed to the methodological practices investigating PCK by implementing both a behavior analytical approach and experimental approach. It is a contrast to the research methods prevalent in PCK research in physical education such as descriptive and qualitative approaches to collecting data.

**Conceptual View of PCK in Elementary Physical Education**

Based on different views of PCK from Shulman (1986; 1987), Grossman (1999), Ward (2009b), and Ball et al. (2008), the author proposes the conceptual view of PCK with four central components in elementary physical education (see Figure 2.9). Furthermore, an explanation of how this view is applied to the teacher’s PCK for teaching a throwing unit in lower elementary physical education is discussed.

**Conceptualization of PCK in Elementary Physical Education**

Much of the work on PCK has been conducted at the secondary physical education level. This knowledge base is also relevant to elementary physical education
but unique perspectives apply, especially when dealing with lower elementary physical education. For effective teaching in elementary physical education, the teacher must first detect the students’ present level of skill (knowledge of students). In addition, the teacher needs to have a developmental perspective and meet the emerging developmental needs of young children. After the teacher understands these aspects of development, the teacher can provide tasks, task modifications and task progressions (content knowledge) with appropriate feedback, cues and demonstration through effective representation (pedagogical knowledge). Furthermore, a variety of equipment should be used effectively based on students’ skill level and content (knowledge of context). This series of procedures should be aligned to students’ different skill level or stage of development and influence on the teacher’s PCK. Figure 2.9 shows the conceptual view of PCK in elementary physical education.

Figure 2.9 The conceptual view of PCK in elementary physical education.
Four teacher knowledge bases can impact a teacher’s PCK; (a) content knowledge; (b) knowledge of students; (c) knowledge of instructional strategies; and (d) knowledge of context.

*Content knowledge* refers to teachers’ understanding of content in physical education. Knowing how an activity or skill is performed and which tasks should be taught is significant to improve students’ learning outcomes. *Knowledge of students* refers to the teachers’ knowledge of what the students already know about content in physical education, the students’ developmental level in a skill or the ability to perform sports or activities, and common problems that students face given the content. Furthermore, teachers’ knowledge of students’ previous learning experiences of sports or activities, motivation to learn the content, and potential to be able to execute skills can be included in this category. *Knowledge of instruction strategies* refers to knowing how to represent the content of physical education using various ways such as descriptions, illustrations, metaphors, examples and how to instruct the task using various strategies such as demonstrations, feedback, and cues to student. Knowledge of instructional strategies is also called pedagogical knowledge. Finally, *knowledge of context* refers to the teachers’ knowledge of contextual factors that might impact the quality of teaching such as understanding of school culture and expectations, understanding of parents’ expectations for the quality of physical education, and using educational materials (e.g., visual resources, equipment) and facilities effectively.
Conceptualization of PCK for Teaching a Throwing Unit

Recently, a conceptual view of PCK was identified in previous studies (Kim, 2011; Lee, 2011) that utilized a sport unit (e.g., soccer and badminton). However, this view of PCK has limited application for this study because it involves an overall sport with multiple skills. In lower elementary, the focus of many units of instruction is a single fundamental motor skill. In this study, overhand throwing was the focus of the study. The focus on a single fundamental motor skill is a significant departure from the previous studies (Kim, 2011; Lee, 2011) that investigated teacher PCK for teaching one sport. Therefore, the author needed to conceptualize PCK for teaching a throwing unit differently than the previous studies (Lee, 2011; Kim, 2011). This conceptual view of PCK is more applicable and functional for teaching a throwing unit.

This section describes teachers’ PCK for a throwing unit in lower elementary physical education and which subcomponents are included in each knowledge base (see Figure 2.10). In addition, it discusses the way of training to improve teacher knowledge bases to effectively teach throwing skill.
Figure 2.10 Conceptualization of teacher’s PCK for teaching throwing unit.

The Teacher Knowledge Bases

Content knowledge

In 2009, Ward, drawing on the work of Ball et al. (2008), suggested two forms of subject matter knowledge: (a) knowing how to perform an activity (Common Content Knowledge or “CCK”) such as knowledge of the rules and etiquettes and knowledge of technique and tactics and (b) knowing what to teach as the activity (Specialized Content Knowledge or “SCK”) such as knowledge of student errors, and knowledge of the instructional tasks. To effectively teach throwing, a teacher should know critical elements of a proficient thrower (e.g., taking a long contralateral step, the segmental rotation of the
trunk, the throwing arm follows-through across body) and techniques for throwing first (e.g., stepping on the opposite foot, rotating the hips when the throwing arm moves forward). These two categories are included in CCK. Knowing developmental sequences of throwing (both total body and component approach), selecting appropriate tasks, progressions, and modifications aligned to student’s skill level, and identifying the “next most important thing to focus on instructionally” at different skill levels would be subcategories of SCK for teaching overhand throwing.

Knowledge of students

To effectively teach a throwing unit, a teacher should develop an ability to detect a students’ skill level (stage) in their throwing performance. The teacher needs to be able to know students’ prior learning experiences in sports or activities related to their throwing skill, such as participation in T-ball, baseball, and softball before the beginning of the throwing unit. Furthermore, understanding the students’ level of motivation for learning throwing skills is one of the categories in this domain.

Knowledge of instructional strategies

When a teacher’s representation of a task related to overhand throwing is clear and precise, students may know what they need to do and how to perform the task. Therefore, the teacher should know how tasks are appropriately represented to the whole class or each individual student by using different instructional strategies such as verbal description or examples. Especially, correct task representations are important to students at the elementary level. Furthermore, building knowledge of how individualized
instruction, including appropriate feedback and demonstrations, is aligned to a student’s skill level (stage) of throwing performance is necessary to improve student-learning outcomes.

**Knowledge of context**

The teacher’s knowledge of what kind of equipment or materials is useful to teach throwing and how it is utilized effectively based on a students’ skill level is included in this domain. Furthermore, the teacher should have knowledge of how to utilize the gymnasium spaces to effectively teach throwing.

The next section will introduce a knowledge packet the way to help the teacher improve knowledge bases and PCK for teaching content in physical education.

**Knowledge Packet**

Ayvazo, Ward, and Stuhr (2010) suggested that a knowledge packet (CK packet) should be designed to improve the teacher’s knowledge and PCK in PETE programs. The knowledge packet was defined as a material that is developed over time by continual teaching and modification (Ward, 2009b). The teacher can acquire new ideas and the focus of a particular content in physical education from training with knowledge packets (Lee, 2011). The importance of the knowledge packet has been emphasized by several researchers (Ayvazo et al., 2010; Kim, 2011; Lee, 2011; Ward, 2009b). Especially, Kim (2011) and Lee (2011) developed knowledge packets for teaching badminton (Kim, 2011) and soccer (Lee, 2011) based on the Play Practice model (Launder, 2001) to improve teachers’ PCK. A knowledge packet developed by Kim (2011) and Lee(2011) consisted
of several components: (a) the list of critical elements, (b) the list of common errors, (c) different instructional tasks, (d) organizing arrangements using diagrams, and (d) the set of task progressions based on Ward’s (2009a) four domains of CK in physical education. These knowledge packets (Kim, 2011; Lee, 2011) covered the four domains of CK to improve teacher’s PCK, however, components related to other teacher knowledge bases, such as how to determine a student’s skill level (knowledge of students) were not included in these knowledge packets. The knowledge packet should include not only components related to CK but also components from other knowledge bases such as the ways to discriminate students’ different skill levels, and familiarity with a variety of equipment in order for the teacher to effectively teach overhand throwing. Using a knowledge packet is a useful tool for teachers to develop their knowledge bases for teaching a throwing unit in a short time span.

In summary, this section described the conceptual view of PCK which includes four knowledge bases influencing the development of the teacher’s PCK in elementary physical education as proposed by the author. More specifically, how this view can be applied to the teacher’s PCK for teaching a throwing unit with subcomponents of each teacher knowledge base was discussed. Furthermore, we know that using a knowledge packet will be the best way to improve teacher knowledge bases quickly. The next section will describe how overhand throwing performance was used as a dependent variable in terms of student learning and content the teachers taught in this study.
Overhand Throwing Performance

In this section, the motor development literature is reviewed in order to understand the nature of the overhand throwing skill, how throwing performance is assessed, and what theoretical framework was used for research on overhand throwing.

Fundamental Motor Skills

Throwing is one of the most important fundamental motor skills (FMS). Fundamental motor skills are common movement activities with specific motor patterns (Gabbard, 2012). It is also considered a building block of more advanced and specific movement skills necessary to engage or participate in physical activities, games, and sports later in childhood (Gabbard, 2012; Payne & Isaacs, 2012). Fundamental motor skills consist of two categories: 1) locomotor skills and 2) object control skills. Throwing is an object control skill that focused on the manipulation and projection of objects by the hands (Gabbard, 2012; Payne & Isaacs, 2012; Stodden et al., 2008). Since children do not naturally possess high FMS competency or demonstrate an efficient form of FMS (Goodway & Branta, 2003; Goodway, Crowe & Ward, 2003; Goodway, Robinson & Crowe, 2010; Goodway & Savage, 2001), appropriate practice, encouragement, feedback, and instruction (Clark & Metcalfe, 2001; Gallahue et al., 2012) should be provided.

Importance of Overhand Throwing

Overhand throwing is an intrinsic skill in sports like baseball and softball (Gallahue et al., 2012) and its basic motion is linked with a variety of sport skills such as the tennis serve, the overhead clear in badminton, spiking in volleyball (Butterfield &
Loovis, 1993; East & Hensley, 1985), the javelin throw in track and field, and the netball shoulder pass. In addition, throwing is one of the most complex movement skills (Gabbard, 2012; Payne & Issacs, 2012) because the combination of gross movement components, which include the shoulders and legs, and fine motor components, such as the wrist and fingers, is used to produce the throwing performance. Proficiency in throwing skills is considered to be a prerequisite to succeed and enjoy a variety of activities available in schools and communities because throwing is a critical skill for these sports and games (McKenzie et al., 1998). There are different types of throwing patterns (the underhand throw, two-handed throw and the overhand throw) but the overhand throw is one of the most common patterns which receives more attention and is more researched than any other FMS in the field of motor development (Gallahue et al., 2012).

**Assessment of Throwing**

The changes in throwing performance can be evaluated by using process and product assessments. The following section discusses the assessment of throwing performance. Process measures are concerned with the form or techniques used to throw the ball (Payne & Isaacs, 2012). For example, looking at whether the child stepped with the opposite foot or wound up their arm before the throw is a process measure of throwing. In contrast, product measures assess the outcome of the performance such as the distance thrown, the accuracy of the ball thrown, and the velocity or force of throwing (Gallahue et al., 2012). How many feet the child was able to throw the ball or the velocity
of the throw with no attention to the pattern of movement are examples of the product measure of throwing.

**Process measure**

*Total body developmental sequences of overhand throwing*: The total body movement of all joints and segments related to throwing performance is characterized as one stage based on the total body approach and stage theory (Lorson, 2003).

Monica Wild (1938) set the standards of developmental throwing stages. Wild (1938) analyzed the throwing patterns of 32 boys and girls aged 2 to 12 years and identified four developmental overhand throwing stages (Gallahue et al., 2012; Payne & Isaacs, 2012). Based on findings from Wild (1938), children 2-3 years old showed stage 1 throwing, involving a front facing throw and stationary feet with no trunk action. In contrast, children 6.5 years and older demonstrated more mature patterns of throwing (stage 4) which involves a contralateral step and trunk rotation (Gallahue et al., 2012).

Seefeldt, Reuschlein and Vogel (1972) also proposed a total body developmental sequence for overhand throwing with five stages (Haubenstricker, Branta, & Seefeldt, 1983). The initial stage of throwing (stage 1) is similar to Wild’s (1938) work with the feet stationary, no trunk rotation, and a chopping arm action. Children are stepping and throwing ipsilaterally (same foot and arm) by stage three. By stage 5, the child shows combined characteristics of a proficient thrower such as taking a contralateral step, wind-up the arm, segment trunk rotation, and follow through (Gallahue et al., 2012). A mixed-longitudinal sample of children was used to demonstrate preliminary validation of these five throwing stages (Haubenstricker et al., 1983).
Garcia and Garcia (2002) conducted a two-year longitudinal study with six children aged 2 to 5 years and analyzed 3,469 throws using the five stages of total developmental sequence proposed by Haubenstricker et al (1983). Under the dynamic system approach, the results showed that children moved backward and forward between adjacent and non-adjacent stages across time due to the influence of individual and environmental constraints such as motivation and body awareness. This contrasts with the notion that the developmental sequence of throwing occurs in a linear fashion as a result of maturation (Wild, 1938). Garcia and Garcia (2002) concluded that throwing performance was individual, highly variable, non-linear, and context-sensitive from the dynamic systems perspective (Gallahue et al., 2012).

It is true that the total body approach has contributed to the qualitative analysis of throwing performance. However, this approach is limited in its ability to detect minor changes or changes occurring in particular body components because of the inclusion of all body components into one stage. Therefore, another developmental sequence of overhand throwing was suggested by Roberton (1977).

Component developmental sequences of overhand throwing: Roberton (1977) suggested the component approach to throwing based on the notion that throwing development should be examined at the level of body components rather than the entire body. The component approach names the different levels in each component step or level, which is in contrast to the term “stages” implemented in the total body approach (Langendorfer & Roberton, 2002; Roberton, 1978). Five components of the overhand throw: stepping, trunk motion, backswing, movement of the humerus, and forearm are
considered critical elements for evaluating overhand throwing performance. Roberton’s component developmental sequence verified that development in component parts may occur at different rates and times in the same individual or different individuals and for different components (Gabbard, 2012; Gallahue et al., 2012). The component approach was originally derived from a stage theory perspective. However, dynamic systems theory and the probabilistic view of development are currently used as the theoretical framework to support this approach (Gallahue et al., 2012). Key constraints (individual, task and environmental constraints) in dynamic systems theory are useful to examine the factors influencing the throwing motion, and to describe the wide variety of possible configurations (behavioral attractors) of throwing performance under the component sequences (Gallahue et al., 2012; Hamilton & Tate, 2002).

Product measure

The child’s proficiency level of motor skills can also be captured using product measures. Several variables such as the speed of the ball, distance thrown or accuracy of the ball thrown have been used for product measures of throwing performance (Cohen, 2007; Gallahue et al., 2012; Lorson, 2003). The relationship between product scores and movement patterns are not always linear (Halverson & Roberton, 1979). However, researchers have reported high levels of outcome in product measures have been related to showing more advanced performance (Roberton & Konczak, 2001; Stodden et al., 2006). The assessment tools such as AAHPERD Softball Skill Test (Browning & Shack, 1990) were developed to evaluate the product measures of throwing. A velocimeter and a radar gun have also been used to measure ball velocity (Halverson, Roberton, &
Langendorfer, 1982). Product measures are beneficial for both physical educators and researchers. Physical educators can use product scores to keep children motivated and engaged in activities (Roberton & Konczak, 2001). For researchers, product measures are an easy way to conduct research because these are far less time-consuming, simple in procedures and easier to investigate compared to process measures. Critical factors or constraints can have an effect on positive or negative performance of the throw and can be determined as researchers or teachers keep track of student’s product scores (Roberton & Konczak, 2001).

Theoretical Framework for Research on Overhand Throwing

The Dynamical Systems Theory and the Constraints Model were utilized as the theoretical frameworks for researching overhand throwing. This section describes the concepts of each theoretical framework and how studies related to overhand throwing performance were conducted under this theoretical framework.

Dynamical Systems Theory

Dynamical Systems Theory is a theoretical framework that asserts human movement emerges from the self-organization of multiple interacting subsystems such as genetics, coordination, experience, motivation, and strength (Newell, 1984; 1986; Thelen & Ulrich, 1991). It contrasts with the notion that all movements and behaviors are “hard-wired” and maturationally based (Thelen & Ulrich, 1991) and suggests that coordinated behavior is “softly assembled” (Haywood & Getchell, 2012). That means the acquisition of skill or FMS is a more flexible and interactive process. In Dynamical Systems Theory,
an individual is seen as a motor system consisting of numerous subsystems and these subsystems work dynamically together as a functional unit (Gallahue et al., 2012) which results in the product of human movement. If changes in any one subsystem occur, overall performance may change. Since all individuals are different in terms of their overall development and motor development, their motor skill development is not highly predictable (Clark & Phillips, 1993; Payne & Isaacs, 2012). It is rather that the dynamic changes of patterns or behaviors occurring over time are related to a variety of critical factors internal and external to the person with certain probabilities (Clark & Phillips, 1993; Garcia & Garcia, 2002; Newell, 1984; 1986).

*The Constraints Model*

In 1984, Newell proposed the constraints model to explore how various factors (constraints) influence an individual’s different patterns of movement. Newell (1984; 1986) categorized three constraints; (a) learner; (b) environment; and (c) task constraints. These three types of constraint are discussed in more detail below.

1) *Learner constraints.* Learner constraints, also known as individual or organismic constraints (Newell, 1984; 1986), refer to the learner characteristics such as height, weight, motivation, and attention (Newell, 1984). Learner constraints are also identified as *structural constraints* (Heywood & Getchell, 2012) and functional constraints (Ennis, 1992) such as the individual’s gender, culture, socioeconomic status, and intellectual and physical abilities that influence motor performance. In throwing performance, body segment length, weight of the body, muscular strength, and the
coordination of body segments during the throwing motion would be examples of learner constraints.

2) Environmental constraints. Environmental constraints are external to the learner. Newell (1984; 1986) described environmental constrains as ambient factors for the task. This category may include environmental features relating to the learning environment such as the temperature in the gym, equipment, as well as facilities (Newell, 1984; 1986). Examples of environmental constraints in throwing performance may include the size and weight of the ball and different types of targets as well as differential effects of instruction (Gallahue et al., 2012).

3) Task constraints. Task constraints are strongly related to the goal of the activity (Newell, 1984, 1986). Newell (1986) proposed three categories of task constraints; (a) goal of the task; (b) rules specifying or constraint response dynamics; and (c) implements or machines specifying or constraining response dynamics. In throwing performance, the task of throwing for force (velocity), distance, and accuracy (Hamilton & Tate, 2002; Langendorfer, 1990; Roberton, 1987) would be examples of task constraints.

Research on Overhand Throwing Performance

This section will describe research focusing on the teacher’s role, knowledge, or instructional strategies such as cues and feedback for teaching throwing performance from the perspective of environmental constraints. Teachers should have different types of knowledge such as the specific subject matter knowledge (Stroot, 1990) or knowledge of instructional strategies in order to effectively teach throwing based on students’ different skill levels.
A number of studies have been conducted to the relationship between the role and knowledge of the teacher and students’ performance in throwing. Walkwitz and Lee (1992) conducted a study to explore the influence of content knowledge of throwing on teachers’ ability to observe student performance. Four kindergarten classroom teachers were in the experimental group and attended training regarding the developmental literature related to overhand throwing. The knowledge training session was conducted with a video training packet and provided detailed information about the developmental sequence of mature throwing patterns. The other four teachers were assigned to a comparison group and received no knowledge training related to overhand throwing. Walkwitz and Lee (1992) found that improving teacher content knowledge of throwing through knowledge training improved teacher behaviors, which resulted in improving the ability to identify the components of the throw and assess their student performance during practice. A limitation of this study was the small number of participants.

Oslin, Stroot, and Siedentop (1997) used a specific presentation called “component specific instruction (CSI)” to enhance overhand throwing performance in preschool children. Twenty-two children aged 3-6 years participated in this study. The results of this study showed that CSI increased throwing efficiency, but there was no difference between a force production sequence or forward chaining sequence. Oslin et al. (1997) concluded that effective instruction can promote student learning.

Cohen, et al. (2012) examined the influence of aligned development feedback (ADF) on students’ performance of overhand throwing. Third-grade students (39 girls, 58 boys) participated in this study. Two of the four intact classes were randomly assigned to an ADF group that received feedback based on a student’s developmental level of
throwing performance. The other two intact classes (comparison groups) were given general feedback (GF). A teacher workshop was conducted to help the teacher build knowledge of throwing component sequences, improve the ability to detect student’s different developmental level of throwing, and have knowledge of ADF. Cohen et al. (2012) found that when the teacher delivered aligned development feedback based upon throwing component sequences, throwing body components and ball velocity improved compared to what the teacher did naturally which was more general feedback.

Other studies were conducted to look at the nature of throwing cues and feedback provided within the instructional environment. Stroot and Oslin (1993) examined the ability of the teacher to deliver feedback to improve student overhand throwing performance. The teachers observed students aged 5 to 8 years overhand throwing performance, analyzed the skill performance, and provided instruction and feedback to improve students’ performance. During the study the researchers utilized the process measures of the overhand throwing with five components and the teacher feedback episodes (verbal feedback, verbal corrective feedback, cues, modeling, praise, and manual manipulation). The results of the study showed that students’ throwing performance improved when they received an appropriate feedback congruent with their performance (Stroot & Oslin, 1993). Furthermore, the teachers in the study had knowledge of content for overhand throwing but they did not deliver developmentally appropriate feedback aligned to the student performance. Therefore, the student performance did not improve (Stroot & Oslin, 1993). When the teachers discriminated the critical errors of students’ throwing performance and delivered appropriate feedback, the students improved their throwing patterns. Stroot and Oslin (1993) illustrated the
importance of content knowledge, the ability to detect and analyze the skill, and the
importance of delivering appropriate feedback to enhance student throwing
performances.

Fronske, Blakemore, and Abendroth-Smith (1997) were the first to use critical
cues to help third and fifth-graders with immature throwing patterns improve on throwing
distance as well as the step and backswing components. The throwing instruction with
critical cues such as ‘A big step toward the target with the foot opposite the throwing
arm’ and ‘Take the arm straight down and then stretch it back’ was provided to one
group. The other group received no specific cues or feedback regarding throwing
performance during instruction. The findings showed that the group that received cues
had an improved throwing distance and better step and arm movement than a group that
did not receive specific instruction.

More recently, Stodden & Rudisill (2006) compared a biomechanical-
developmental approach to a traditional approach to teaching throwing with 34
kindergartners. The exploitation of hypothesized control parameters that increase optimal
energy transfer through the kinetic link system was the main concept of the
biomechanical approach (Stodden et al., 2006). Specifically, generating linear and
angular momentum of the trunk and center of mass and optimal preparatory positioning
of the humerus, forearm, and wrist were focused on this instruction to promote energy
transfer during the throwing motion. The results of this study showed that the
instructional strategy utilizing biomechanical concepts was effective in promoting certain
aspects of the throwing performance.
Lorson & Goodway (2007) conducted a study to examine the influence of critical cues and task constraints on body component levels and ball velocity. Eighty-one second and third-grade students participated in this study and they were systematically assigned to one of four strategies; (a) cue (providing five critical cues after each trial); (b) task-feedback (providing prompts to throw the ball "hard and fast" and velocity feedback); (c) task (providing only a prompt to throw the ball "hard"); and (d) comparison (providing the prompt "throw the ball toward the curtain before each throw). Lorson & Goodway (2007) found that there were differences between groups for body component developmental levels and ball velocity. Especially, critical cues were strongly related to improving the step component and the prompts to throw the ball hard and fast influence the ball velocity and body components by developmental levels. Results suggest the use of a motivating forceful throwing task with cues and speed of the throw feedback as an effective and efficient instruction strategy to improve throwing performance (Lorson & Goodway, 2007).

Lorson (Lorson, 2005; Lorson & Goodway, 2008) investigated the influence of three instructional strategies taught by physical education teachers on the throwing performance of 1st and 2nd grade children. The three instructional approaches were: (1) the biomechanical approach developed above by Stodden & Rudisill (2006); (2) a critical cue group emphasizing three critical cues (“laser beams” for sideways orientation, “long step,” and “twist and throw hard”), and; (3) a traditional group using the cues (side to target, arm way back, and throw hard). The results showed that the biomechanical approach was more successful than the other two approaches in promoting change in the humerus and forearm component. There were no differences between the groups for the
step and trunk component, as well as ball velocity. Furthermore, Lorson added the unique aspect of looking at the application of throwing performance to a game situation (Lorson & Goodway, 2008). The results showed that the step, trunk, and forearm components in a throwing game were correlated with body component levels during practice.

In summary, the findings from the literature review indicate that the physical education teachers should carefully monitor and guide students when they teach throwing skills. For effective throwing instruction, it is the teacher’s responsibility to build sufficient knowledge including knowledge of content, students, pedagogy, and context and deliver her/his knowledge to students effectively. In a throwing unit, the teacher should have the ability to identify the developmental levels of the students’ throwing performance (Cohen et al., 2012; Knudson & Morrison, 1996; Walkwitz & Lee, 1992). Knowing the developmental level of the student would be the first step to provide appropriate instructional strategies such as feedback (Cohen et al., 2012; Stroot & Oslin, 1993) and cues (Fronske et al., 1997; Lorson, 2005; Lorson & Goodway, 2007; Lorson & Goodway, 2008; Stodden & Rudisill, 2006).

**Summary**

Based on the literature review, the author found that the teacher’s PCK in elementary physical education has not been well conceptualized and components of PCK that influence the teacher’s PCK were not clearly defined. Furthermore, few studies have examined how the teacher’s PCK has an effect on students’ motor skill development. This study will focus on helping teachers develop four knowledge bases that will positively influence on building PCK; (a) content knowledge; (b) knowledge of students;
(c) knowledge of instructional strategies (pedagogy); and (d) knowledge of context and utilize PCK to improve the students’ throwing performance in a lower elementary physical education setting.
Chapter 3: Method

There are two purposes to this study. The primary focus of this study is to examine the influence of a teacher professional development workshop on a teacher’s PCK in a four-day throwing unit. A secondary focus of this study is to determine the effects of a teacher’s instruction of a four day throwing unit on student throwing performance prior to (comparison condition) and following (experimental condition) the professional development workshop.

Operational Definition of PCK

Teaching is derived from the teacher’s understandings of a number of knowledge bases (e.g., knowledge of students, of context, of content and instructional strategies). Understanding of a student’s demonstrated developmental level of performance is a prerequisite to making appropriate instructional decisions for an individual child. At the moment the teacher observes a child perform a skill, they draw from their different knowledge bases to inform their instructional decisions (providing feedback, potentially modifying the task) in order to align instructional decisions with the child’s developmental level. Thus, the operational definition of pedagogical content knowledge (PCK) in this study is an emergent phenomenon where teachers use different knowledge bases to make pedagogical decisions that are aligned to a child’s developmental level and are context specific.
Conceptual view of PCK for Teaching Throwing

Based on the operational definition of PCK above, a conceptual view of PCK for teaching a throwing unit was proposed (see Figure 3.1). Four central components were identified; (a) teacher’s knowledge of content (content knowledge); (b) knowledge of instructional strategies (pedagogical knowledge); (c) knowledge of students; and (d) knowledge of context in physical education and can play a role in this conceptual view. Sub components under each central component are shown in figure 3.1.

1) Teacher’s knowledge of content (Content Knowledge): The teacher should know how to perform throwing (common content knowledge) such as techniques for throwing and critical elements of a proficient throw. Furthermore, the teacher should know what to teach in throwing (specialized content knowledge). For example, knowledge of task selection, task modifications, and progression aligned to a student’s skill level, common errors at different skill levels, and developmental sequences (both total body and component approach) are important to the teacher.

2) Teacher’s knowledge of instructional strategies (Pedagogical Knowledge): The teacher should have knowledge of how tasks are appropriately represented to the whole class or each individual student. Knowledge of how to manipulate task constraints and individualized instruction aligned to the student’s skill level (stage) is also critical to teach throwing to children. Furthermore, the teacher should utilize appropriate feedback and demonstrations based on the student’s skill level (stage) of throwing performance.

3) Teacher’s knowledge of students: To generate effective teaching, the teacher should also be able to determine the student’s developmental throwing level (stage).
Knowing the student’s prior sport learning experiences related to throwing and the level of motivation for leaning to throw and improve this skill is also important.

4) **Teacher’s knowledge of context:** Choosing the correct type of equipment (materials) and how it is utilized effectively is essential to be able to effectively teach at throwing unit. In addition, understanding how to manipulate environmental constraints and the implications of available gym space to instructional decisions is necessary for the teacher.

*Note= Bold factors considered in study*

Figure 3.1 Teacher’s PCK for teaching a throwing unit.
Application of the Conceptual View of PCK

The logic model in Figure 3.2 briefly describes how the conceptual view of PCK for teaching a throwing unit was applied in this study. Detailed descriptions under each category are described in the next sections.
Figure 3.2 Logical model for development of teacher’s PCK in a lower elementary throwing unit.

**Assumptions:**
1) Teacher’s PCK can be positively influenced by four central components of teacher knowledge bases.
2) Teacher professional development workshop would be the best ways to improve by four central components of teacher knowledge bases.
3) Enacted teachers’ PCK will impact on student learning outcomes.
Research Design

In this study, a randomized control-group pretest-posttest with a retention test design was utilized to examine the change of the teacher’s PCK and students learning in their intact classes prior to and following the professional development workshop. Two elementary physical education teachers were purposively selected for the study. Each teacher had six 1st grade and six 2nd grade classes they taught. The researcher randomly assigned two classes for the comparison condition (one 1st grade and one 2nd grade) and two classes for the experimental condition (one 1st grade and one 2nd grade) from the list of six classes taught by the individual teacher. As classes were intact, the unit of analysis was the class. Since this study was conducted in a naturalistic physical education setting with random assignment of class to condition, the ecological validity is strong (Ary, Jacobs, Sorensen, & Walker, 2013). The researcher randomly selected the comparison or experimental classes and students in both conditions stayed in their intact classes to reduce threats to internal validity (Ary et al., 2013). Furthermore, conducting a pretest helped to determine whether the classes were equivalent to begin with because the students were not randomly assigned to the conditions. Therefore, the pretest provided a way to deal with the threats of internal validity (Ary et al., 2013). An additional advantage of the design for this study was that the intact classes reduced the possibility that the students were aware of the fact that they were in a study because they were not drawn out of their regular classes. Figure 3.3 shows a diagram of research design of an individual teacher for this study.
Figure 3.3 A diagram of research design.

Context of the Study

Setting

The study was conducted in suburban, mid-sized elementary schools in a south western city.

Description of schools

1) Gray Elementary School

The student population at Grey Elementary School is 732 children in grades K-4. There are 359 female students, and 373 male students. The student population is comprised of 636 Caucasian students, 16 African American students, 5 Asian Americans students, 73 Hispanic students, and 2 Multi-Racial students (National Center for
Education Statistics [NCES], 2012). The student to teacher ratio in physical education is 16.5 to 1 (NCES, 2012). Of these students, 271 students (37%) were eligible for discounted/free lunch (NCES, 2012).

2) Scarlet Elementary School

The student population at Scarlet Elementary School is 715 children in grades K-5. There are 336 female students, and 379 male students. The student population is comprised of 515 Caucasian students, 72 African Americans students, 5 Asian American students, 110 Hispanic students, and 13 Multi-Racial students (NCES, 2012). The student to teacher ratio in physical education is 14.7 to 1 (NCES, 2012). Of these students, 308 students (43%) were eligible for discounted/free lunch (NCES, 2012).

Participants

*Physical Education Teachers.* Two physical education teachers were purposively selected as participants for this study according to the following criteria: (1) Teachers who agreed to participate in this study; (2) Teachers who have no experience or participation in professional development for teaching overhand throwing; (3) Teachers who were willing to teach a four-day throwing unit to four classes (two different classes for comparison group and two different classes for experimental group). A description of the teacher demographics can be found in Table 3.1 (all names are pseudonyms).
Table 3.1 Descriptions of the teachers.

<table>
<thead>
<tr>
<th>Characteristic / Teachers</th>
<th>Justin</th>
<th>Izzy</th>
</tr>
</thead>
<tbody>
<tr>
<td>School location</td>
<td>Gray</td>
<td>Scarlet</td>
</tr>
<tr>
<td>Age</td>
<td>45</td>
<td>52</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Race</td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td>Degree</td>
<td>Bachelor</td>
<td>Bachelor</td>
</tr>
<tr>
<td>Number of Years Teaching K-5</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>Number of Years Teaching at the current school</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Grade level</td>
<td>K-4</td>
<td>K-5</td>
</tr>
<tr>
<td>Prior Sports Experiences</td>
<td>Football, Baseball</td>
<td>Track &amp; Field</td>
</tr>
<tr>
<td>Current &amp; Prior Coaching Experiences</td>
<td>Jump Rope, Baseball</td>
<td>Swimming, Basketball</td>
</tr>
</tbody>
</table>

Table 3.1 Descriptions of the teachers.

*Students.* The students from four, first-grade and four, second-grade classes of the teacher participants were selected for this study. Students remained in their intact classes and these classes were randomly assigned to the comparison (n = 2 classes) or experimental (n = 2 classes) classes per each teacher. Table 3.2 displays the number and gender information for each class.
Independent Variable

The independent variable in this study was the professional development workshop which occurred between the teaching of the comparison classes and experimental classes.

Instrumentation

Two categories of dependent variables were investigated during this study (see Figure 3.4) tied to teacher outcomes and student outcomes. The first category was the teacher’s PCK. Based on the conceptual view of PCK (see Figure 3.1), four teacher PCK variables were defined and measured, namely, task representation, task demonstration, feedback statement, and task modification alignment. The second category of dependent variables consisted of two student dependent variables; (a) the developmental level of
throwing body component for step, trunk, humerus and forearm (process measure), and (b) throwing velocity (product measure) during the pretest, posttest, and retention test.

**Measuring Teacher Pedagogical Content Knowledge (PCK)**

To examine the influence of the teacher professional development workshop (independent variable) on the teacher’s instruction (PCK), four variables of PCK were considered as the dependent variables. The teacher’s PCK was examined when the teacher verbally interacted with a group of children (instruction to the whole class) or individual child (instruction to an individual child in class). PCK was only evaluated when teacher-child verbal interactions related to teaching skills or tasks for overhand throwing performance. Other forms of verbal interaction such as class management (e.g. grouping, getting equipment) or behavior management (e.g. managing a child’s behavior) were not coded as part of this study. When the teacher was interacting with a group, the teacher’s task representations and demonstrations were evaluated. When the teacher was interacting with an individual student, the teacher’s feedback and task modification alignment were analyzed.

The variables that were conceptualized to measure the teacher’s PCK were determined from the typical cycle of a throwing lesson. Furthermore, they were considered specific to the elementary motor skill environment. Figure 3.4 briefly portrays the teacher’s PCK variables that were investigated.
The location of camcorders: To collect data on teacher PCK, all throwing lessons for each class were videotaped using two digital camcorders. The camcorders recorded the teachers in a wide-angle view and were set in two corners of the gymnasium during the lesson. The teachers wore a wireless microphone connected to the camcorder. Therefore, observers could clearly hear the teachers’ voice. The videotaping data was used to analyze only the teacher PCK data. Figure 3.5 shows a diagram of the locations of the camcorders.
Group level analysis of Teacher PCK

Two categories of teacher PCK variables were examined: (1) task representations, and (2) task demonstrations by the teacher when the teacher’s verbal interaction occurred to the whole class or group of children.

Task representation

Teacher’s task representation is the simplest way to communicate to the students what they are expected to do and how they are to do it (Rink, 1994). Using correct task representation incorporating the critical elements of the skill is important to teach students in a lower elementary physical education setting. Correct task representation can help students clearly understand what they are supposed to do and on what they need to focus while performing skills. Therefore, the teacher’s task representations including at least one of the critical elements of the throwing skill was defined as a correct task demonstration and measured according to the following criteria:
1) Correct task representation: Teacher’s task representation includes the critical elements of the throwing skill from the list (see Figure 3.6). For example, the teacher mentioned “When you throw the ball, you need to wind-up with your arm, step with the opposite foot, rotate your hips, and follow-through. Let’s start”, or “Let’s throw the ball to different targets 15 feet from the wall. Do not forget standing sideways, step and follow through”. A correct task representation does not require that the teacher mention all critical elements. However, they must identify the critical elements appropriate to the instructional focus.

2) Incorrect task representation: Teacher’s task representations do not include the critical elements of the throwing skill. For example, the teacher mentioned “Let’s practice throwing” or “throw the ball to the target”. This was determined an incorrect task representation.

<table>
<thead>
<tr>
<th>Segments</th>
<th>Critical Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>- Eyes on the target&lt;br&gt;- Sideways orientation</td>
</tr>
<tr>
<td>Step</td>
<td>- Step&lt;br&gt;- Step with opposite foot (contralateral step)&lt;br&gt;- Long step</td>
</tr>
<tr>
<td>Trunk</td>
<td>- Rotate trunk&lt;br&gt;- Belly to the target</td>
</tr>
<tr>
<td>Arm &amp; Shoulder</td>
<td>- Move arm back (Arm windup)&lt;br&gt;- Rotate shoulder</td>
</tr>
<tr>
<td>Release</td>
<td>- Follow through&lt;br&gt;- Hand to hip</td>
</tr>
</tbody>
</table>

Figure 3.6 Critical elements of overhand throwing (Gallahue et al., 2012).

The coder recorded correct or incorrect task representations across each lesson in the coding sheet (see Appendix B) based on criteria through event recording. At the end
of each lesson data were summarized as follows: (a) an average percentage of correct task representations for the comparison and experimental classes from aggregated data by both teachers, and (b) the percentage of correct task representations per lesson (day-by-day) from aggregated data by both teachers for the comparison and experimental classes. Finally, the percentage of correct task representations per lesson by the teacher in comparison and the experimental classes was reported.

**Task demonstration**

Demonstration is an important form of visual communication in physical education. Students usually pay more attention to visual demonstration than verbal representations (Rink, 2010). Correct visual demonstration helps students to clearly see the skill being taught. Also demonstration can be used to highlight a part of the skill and how this part of the skill fits into the overall movement. The teacher should perform a correct demonstration during the lesson at all times. Therefore, the teacher’s task demonstration was one of dependent variables for the teacher and coded according to the following criteria:

1) **Correct demonstration**: The teacher demonstrates skills or tasks correctly based upon the instructional focus. For the demonstration to be correct the teacher must demonstrate the following:

1) Sideways orientation
2) Wind-Up with downward/backward movement of the arm
3) Step with the opposite foot
4) Long step
5) Showing trunk and/or shoulder rotation or shoulder
6) Follow–Through

2) Incorrect demonstration: The teacher demonstrates skills or tasks incorrectly. If the teacher demonstrates any of the following it would be considered an incorrect demonstration:

1) Non-sideways orientation
2) Wind-Up with upward arm.
3) Step with same arm and leg or no step
4) Short step
5) No hips or shoulder rotation
6) No follow through

The coder coded the task demonstration across each lesson using the coding sheet (see Appendix B) through event recording. At the end of each lesson data were summarized as follows: (a) an average percentage of correct task demonstrations for the comparison and experimental classes from aggregated data by both teachers; (b) the percentage of correct task demonstrations per lesson (day-by day) from aggregated data by both teachers for the comparison and experimental classes; and (c) the percentage of correct task representations per lesson by the teacher in the comparison and experimental classes. Furthermore, the following data were also recorded; (a)a total frequency of correct demonstrations by condition from aggregated data by both teachers; (b)the frequency of correct task demonstrations per lesson by condition from aggregated data by
both teachers; and (c) the frequency of correct task demonstrations per lesson by the teacher were reported.

**Individual level analysis of Teacher PCK**

The teachers’ PCK for an individual student was also investigated. The conceptual premise behind the individual level of data is that the teacher is able to correctly identify a student’s developmental stage of throwing and then align the feedback statement to the child’s stage of throwing. Additionally, the teacher can be expected to modify a task that will promote the desired movement outcomes for the student if the task the student is performing does not align to the student’s stage of throwing. It was not anticipated that the teacher would identify the student’s developmental stage of throwing out loud for the researcher to hear. Rather, the researcher would have an indication of whether the teacher had correctly identified the stage of throwing based upon the feedback and the task selected from the teachers to the student.

**Feedback**

Feedback delivered by the teacher helps the students understand their current level of skill performance and improve their movement patterns. More effective teachers provide more feedback than less effective teachers (Oslin et al., 1997). Furthermore, feedback should be aligned to the student’s developmental level (Cohen, 2007). Therefore, the frequency of the teacher’s feedback regardless of the type and two
categories of the teacher’s feedback were examined: (1) skill focused feedback, and (2) general feedback (see Figure 3.7).

Skill focused feedback was divided into two subcategories: 1) Developmentally Appropriate Feedback (DAF) and 2) Developmentally Inappropriate Feedback (DIF) based on the list of appropriate feedback for students in different developmental levels (see Figure 3.8).

<table>
<thead>
<tr>
<th>Developmentally Appropriate Feedback (DAF) for each stage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage 1</strong>: Standing sideways / Stepping with the opposite foot</td>
</tr>
<tr>
<td><strong>Stage 2</strong>: Stepping with your opposite foot / Move arm far back / Wings of an eagle</td>
</tr>
<tr>
<td><strong>Stage 3</strong>: Stepping with your opposite foot / Downward backswing / Elbow back</td>
</tr>
<tr>
<td><strong>Stage 4</strong>: Long step toward target / Downward backswing / Turn your hips/belly button to the target / Follow-through</td>
</tr>
<tr>
<td><strong>Stage 5</strong>: Great long step / Nice wind-up / Good hips</td>
</tr>
</tbody>
</table>

Figure 3.7 Two categories of feedback.

Figure 3.8 A list of DAF for throwing performance in each stage (Cohen et al., 2012; Gallahue et al., 2012).
Feedback statements were measured according to the following criteria.

1) **Developmentally appropriate feedback (DAF):** Feedback the teacher delivers is aligned with student’s skill level. For example, the teacher states “step with the opposite foot” to the student in a stage 1 or “long step with the opposite foot toward the target” to the student in a stage 4.

2) **Developmentally inappropriate feedback (DIF):** Feedback the teacher delivers is not aligned with student’s skill level. For example, the teacher states “move your arm back” to the student in the stage 1.

3) **General feedback:** General feedback refers to feedback statements that are not directly related to overhand throwing performance such as nice job, great work or well done.

The coder coded feedback across each lesson using the coding sheet (see Appendix B) through event recording. At the end of each lesson data were summarized as follows: (a) a total frequency of feedback by condition from aggregated data by both teachers, and (b) the frequency of feedback per lesson (day-by day) by the teacher.

Finally, an average percentage of different types of feedback per by condition and the percentage of different types of feedback per lesson by condition from aggregated data by both teachers were reported.

**Task modification alignment**

The teacher’s ability to determine the appropriate task in helping the students attain learning outcomes is a significant factor for effective teaching. Furthermore, the task selected by the teacher should align to the developmental level of students’ skill
performance. If a teacher observes a student perform a skill, the teacher should examine
the task being performed and make one of three instructional decisions: (a) keep the task
the same as the task aligns with the developmental level; (b) make the task easier; or (c)
make the task harder. These instructional decisions were considered task modification.
The evaluation of task modification alignment is based on whether the task modification
by the teacher is aligned or not aligned with the student’s individual skill level (stage).
Examples of potential tasks relative to each stage can be found in Figure 3.9. The
researcher identified whether the task modification was aligned or not aligned with the
student’s individual stage.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Potential Tasks</th>
</tr>
</thead>
</table>
| 1 & 2 | 1) Have students stand sideways and step on foot print with no ball.  
     | 2) Have students stand sideways, step on foot print with a sticker or scarf on 
     | foot with beanbag, and throw.  
     | 3) Have students stand sideways, step with opposite foot on poly spot with 
     | yarn ball, and throw. |
| 3     | 1) Have students step with opposite foot and throw the form ball from 10 feet 
     | from the wall  
     | - If students are hitting the wall – have them take a few steps further back.  
     | - If student’s ball does not quite get to the wall – have them move a couple of 
     | steps closer.  
     | 2) The teacher stands behind the thrower and holds the throwing object for the 
     | thrower to reach back and to grasp. The student grabs the ball from the 
     | teacher to make a “L” position and throws the ball. *(This task can also be used 
     | for stage 4)* |

Figure 3.9 Examples of potential throwing tasks relative to each stage.
### Figure 3.9 Continued

| 4 | 1) Have students throw a tennis ball about 15 feet from the wall to hit the target with a sticker on the belly button  
   - *The teacher needs to check that the sticker on the belly button turns to the wall.*  
   - *If students are hitting the wall with rotation of the trunk, they can take a few steps further back.*  
   2) Have children throw a tennis ball about 15 feet from the wall to hit the target with the sticker on the opposite hip  
   - *The teacher needs to check that student throws and follows through to the opposite hip.*  
   - *If students are hitting the wall with follow through they can take a few steps further back.* |
| 5 | 1) Make targets (e.g., letters, numbers or animals) and attach to the wall.  
   - *Students throw the ball as hard as they can to hit the target teacher points out (e.g., if teacher says “Feed monkey” students throw the ball to the target of monkey as fast as they can).*  
   - *If students are constantly hitting the each target based on teacher’s direction they can take a few steps further back.*  
   - *This task is for force as well as accuracy.*  
   2) The teacher provides a variety of throwing activities and games  
   3) The teacher provides the activities that are the blend of different fundamental motor skills such as throwing catching, throwing the ball while running to hit the target. |

The coder coded task modification alignment across each lesson using the coding sheet (see Appendix B) through event recording. At the end of each lesson data were summarized as follows: (a) a total frequency of individualized task modifications by condition from aggregated data by both teachers, and (b) the frequency of individualized task modifications per lesson (day-by-day) by the teacher. Finally, an average percentage of aligned task modifications per by condition and the percentage of aligned task modifications per lesson by condition from aggregated data by both teachers were reported.
Type of task modification

During the determination of alignment, the investigator also recorded whether the teacher made the task harder, easier or kept it the same regardless of aligned or not aligned task. Because tasks should be individualized to each child’s developmental level, there were no assumptions about one type of task modification being better than another. However, it was believed valuable to record what kinds of task modifications occurred. The following criteria were used:

1) **Extension task with more difficulty**: The teacher modified the task with a more difficult task compared to the previous task the students performed. For example, the teacher could extend the task by asking the student to take a few steps further back from the target.

2) **Extension task with less difficulty**: The teacher modified the task with a less difficult task compared to the previous task the students performed. For example, the teacher could extend the task by asking the student to move closer toward the target.

3) **Same task (no change)**: the teacher has the student perform the task the same as the previous task the students performed. For example, the teacher could keep the task by restating the task such as “Throw the ball stepping with the opposite foot again”.

The coder coded the type of task modification across each lesson using the coding sheet (see Appendix B) through the event recording. At the end of each lesson the frequency of the type of task modification (difficult, easy or no change) per lesson (day-by-day) was summarized. The data were reported separately for the comparison and experimental classes from the aggregate data by each teacher.
Inter-observer agreement: The IOA for the teacher variables were conducted on 37.5% (6 of 16 lessons per teacher) in the comparison and experimental classes. Table 3.3 summarizes the percentage of the IOA obtained for the two teachers in the comparison and experimental classes.

<table>
<thead>
<tr>
<th></th>
<th>Comparison classes</th>
<th>Experimental Classes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st grade class</td>
<td>2nd grade class</td>
<td>1st grade class</td>
</tr>
<tr>
<td>Justin’s classes</td>
<td>86.8 %</td>
<td>87.5%</td>
<td>89.3%</td>
</tr>
<tr>
<td>Izzy’s classes</td>
<td>86.2 %</td>
<td>88.3%</td>
<td>87.3%</td>
</tr>
</tbody>
</table>

Table 3.3 Inter-observer agreement for the teacher variables.

Measuring Students Throwing Performance

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

The process measure of throwing performance

Component Approach. The Developmental Sequence of Throwing Components (Roberton & Halverson, 1984) was used to analyze the overhand throwing performance during testing sessions. The component developmental sequence for overhand throwing is an assessment tool used to capture qualitative movements of the overhand throw performance. It consists of five body components: step, trunk, backswing, humerus, and
forearm. For the purposes of this study only step, trunk, humerus, and forearm components (see Table 3.4 for a summary of the component approach) were used, as backswing sequence has not been longitudinally validated (Roberton, 1978). Appendix C describes the developmental level for each component in detail. Each component in the sequence is comprised of different levels or steps that represent either an inefficient movement pattern or more advanced movement pattern. The step components consist of four levels. The trunk, humerus, and forearm components each have three levels.

<table>
<thead>
<tr>
<th>Step (Foot) Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1. No step.</td>
</tr>
<tr>
<td>S2. Homolateral step.</td>
</tr>
<tr>
<td>S3. Contralateral, short step.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trunk (Pelvis-Spine) Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1. No trunk rotation.</td>
</tr>
<tr>
<td>T2. Upper trunk rotation or total “block” rotation.</td>
</tr>
<tr>
<td>T3. Differentiated rotation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Humerus (Upper Arm) Action During Forward Swing</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1. Humerus oblique.</td>
</tr>
<tr>
<td>H2. Humerus aligned but independent.</td>
</tr>
<tr>
<td>H3. Humerus lags.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forearm Action Forward Swing</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1. No forearm lag.</td>
</tr>
<tr>
<td>F2. Forearm lag.</td>
</tr>
<tr>
<td>F3. Delayed forearm lag.</td>
</tr>
</tbody>
</table>

Table 3.4 A summary of the component approach.

Component procedures. During each of the testing sessions (the pretest, posttest, and retention test), all participants completed five throwing trials for force. The participants were placed inside of a large box (3ft. by 5 ft.) taped to the floor. The square was 20ft. from the target, which was a 4 by 4ft. square on the wall. The participants were reminded to stand inside the box before they threw at the beginning of each session. The
participants were instructed to throw the tennis ball ‘As hard as and as fast as’ they could toward the target. A prompt for “Hard and Fast” throws was given by the researcher before each throw. Each throw was videotaped and coded to analyze developmental sequences for throwing. Two cameras, a rear view and a side view, were set to capture the throwing trials (Loson, 2003; Roberton & Halverson, 1984; Stodden, 2002). The rear camera was positioned directly behind the participant and the intended line of flight of the ball. The side view camera was set to the student’s dominant throwing arm side. The cameras were focused to capture the participant’s total body movement throughout the throwing trials. Figure 3.10 shows a diagram of the throwing box, square target position, and locations of camcorders and radar gun. Each throw was assessed individually by the researcher, and a level was given for each component for the five throwing trials during video recording analysis. After completing the analysis, the modal level that appeared most often in five throwing trials for each component for each test session was calculated and used in data analysis (e.g. if a child did 4,3,4,3,4 – 4 would be recorded). The reason of using modal level was to control a variability of student’s throwing performance.

Figure 3.10 Diagram of the throwing box, square target position, video camera and radar gun positions.
The product measure of throwing performance

*Throwing velocity*. Measuring product outcomes such as velocity scores can be a very useful way to keep students motivated in the activity, identify student’s progression, and determine student’s learning. A Sports radar gun was used to measure throwing velocity for the five practice trials that occurred to assess body component levels at the pretest, posttest, and retention test. The internal accuracy of the Sports radar is +/- 3% plus 1 MPH or 1 Km/h. The range of velocity is from 10 to 250 miles per hour. The radar gun was set approximately 25 feet directly in front of the participant and the path of the ball (located in line with the flight of the ball) (see Figure 3.10). Immediately after each throwing trial, the velocity of each throw was displayed on the radar gun to be viewed by the recorder. The observer recorded throwing velocity in miles per hour on the data sheet without providing feedback to the participant regarding the speed of the throw. The maximum score of the five throwing velocities for each participant was recorded (during the pretest, posttest, and retention test) and used in the data analysis.

*Inter-observer agreement*. Inter-observer agreement (IOA) was checked periodically throughout the study by the secondary observer (a graduate student), who was trained in the protocol. The two observers watched one-third of the total throwing trials together to determine inter-observer agreement. A reliability coefficient was calculated by dividing the number of agreements by the total number of agreements and disagreements. A level of agreement was achieved between observers on one-third of the throwing trials viewed at the pretest (86%), posttest (87%), and retention test (90%).
**Procedures**

There were four phases to this study (see Figure 3.11). Phase 1 consisted of IRB procedures and development of the teacher training materials for the professional development teacher workshop. The second phase of the study consisted of implementing the comparison condition. In Phase, the professional development workshop was delivered to the teachers. In phase 4, the experimental condition was delivered.

Figure 3.11 Four phases of the procedures.
Phase 1 - Preparation Phase for the Study

Human Consent Procedures

The Institutional Review Board (IRB) at The Ohio State University (IRB #2013B0482) (see Appendix A) approved this study prior to its implementation. IRB approval was secured from the school district and principals, and consent to participate was secured from the physical education teachers. Parental permission to participate was obtained for all children participating in the study and children assented to the study.

Training of Study Coders

Two blinded coders were utilized to evaluate all video measures in the study. These blinded coders received training prior to evaluation of teacher PCK and throwing performance. The primary researcher and coders completed a standardized training protocol before the study to ensure inter-observer agreement for the analysis of throwing trials and teacher behaviors during the sessions. The training procedures for the coders were conducted in three steps.

Step 1. The primary researcher provided the definitions of each dependent variable and explained the definitions of the variables related to both the teacher PCK and components of overhand throwing. In order to check for understanding, the coders completed a written test about the definitions of the teacher and student variables. All coders reached scores in excess of the criterion of 90% or better on that assessment (Coder 1=94%, Coder 2=93%), and thus were able to move to the next step of training.

Step 2. The researcher showed 27 video clips of children throwing to train the coders on the body component levels. Of the 27 video clips, 10 were lower level
performers, 11 were mid-level performers and 6 were advanced performers. The coders
coded a body component level for each of the 3 trials from the video clips and achieved
in excess of the 90% level of agreement (Coder 1=94%, Coder 2=92%), necessary for
completing this step.

**Step 3.** Coders watched a 10-minute video clip of throwing lessons to correctly
identify teacher variables and coded the behaviors using the established rubric. All
attained a criterion of 90% or better on agreement with the coder (Coder 1=93%, Coder
2=91%) and the training was completed.

**Selection of a Four Day Throwing Unit**

Based on the findings from previous studies (Fronske et al., 1997; Lorson, 2007)
and the typical length of an elementary physical education unit, a four day throwing unit
(total of 120 minutes; 30 minutes per the unit) was selected for teaching throwing skill to
students.

**Development of Teacher Training Materials**

*Planning teacher professional development workshop*

The professional development workshop was designed based on the premise that
improving the teacher’ knowledge bases for teaching overhand throwing would result in
better demonstration of the teacher’s PCK and subsequently improve student learning
outcomes in overhand throwing. Figure 3.2 describes the logical assumption of this study
in detail.
The goals of the workshop: The primary goal of the workshop was to enhance four knowledge bases regarding a lower elementary overhand throwing unit that physical education teachers could use in their lesson to represent content to students. The following are seven goals for the workshop:

**Goal 1.** To understand and be able to demonstrate the mechanics of efficient throwing techniques using the following three components; 1) preparatory action, 2) force production, and 3) follow through (Development of content knowledge).

**Goal 2.** To understand, be able to demonstrate, and discriminate the total body and the body components developmental sequences for overhand throwing (Development of content knowledge and knowledge of students).

**Goal 3.** To understand and apply the core principles of overhand throwing tasks (Development of content knowledge).

**Goal 4.** To identify common errors in throwing performance at different skill levels (Development of content knowledge).

**Goal 5.** To be able to correctly identify the most important instructional focus of the overhand throw based upon the child’s development level (Development of content knowledge and knowledge of instructional strategies).

**Goal 6.** To be able to select teaching cues & feedback most appropriately aligned with the child’s stage of throwing development (Development of knowledge of instructional strategies).

**Goal 7.** To have knowledge of, and an ability to perform and modify a wide variety of throwing task progressions in line with a child’s developmental throwing performance (Development of content knowledge, knowledge of context, and knowledge
of instructional strategies). Figure 3.12 shows the goals, process and pedagogy aligned with the goals, rationale why each goal was selected, and assessment for each goal.
<table>
<thead>
<tr>
<th>Goal</th>
<th>Process and Pedagogy</th>
<th>Rationale</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>To understand and be able to demonstrate throwing technique</td>
<td>The researcher introduced techniques for overhand throwing with pictures showing the features of each technique under three areas; 1) preparatory action, 2) force production, and 3) Follow through. The researcher demonstrated all techniques. Then, the teacher was asked to imitate the researcher.</td>
<td>Knowledge of technique to perform activities is necessary for the teacher to teach tasks for their students. In addition, it is hard to plan tasks or progressions for the task if the teacher does not have knowledge of techniques for the task. This goal is included in the category of <strong>content knowledge</strong>.</td>
<td>The teacher was asked to demonstrate throwing techniques under three areas two times. The researcher evaluated whether the teacher showed each technique and coded in the check sheet (see Appendix D). When the teacher reached 90% or better on that assessment they moved to the next training step.</td>
</tr>
<tr>
<td>To understand, be able to demonstrate, and discriminate the total body and the body components developmental sequences for overhand throwing.</td>
<td>The researcher explained both the total body and the body components developmental sequences with descriptions including pictures. In addition, video clips were used to help the teacher understand each stage. The researcher emphasized specific components and critical elements for each stage with demonstrations. Then, the teacher was asked to demonstrate each stage and answer the questions from the researcher (e.g., what are features most students show in stage 1?)</td>
<td>Both the total body and body components development sequences provide knowledge of components and critical elements for different skill levels to discriminate students’ skill level (<strong>Knowledge of students</strong>). Understanding developmental sequences can help teachers identify components related to overhand throwing performance and find common mistakes that can be made by students or sources of errors (<strong>SCK</strong>). In addition, the teacher can have knowledge of techniques (<strong>CCK</strong>) of overhand throwing performance from development sequences.</td>
<td>The teacher was asked to watch 20 video clips showing students in different skill levels two times. The teacher identified which stage the students showed based on both total body and body components developmental sequences in each video clip. The researcher coded on check sheet (see Appendix D). When the teacher reached 90% or better on that assessment they moved on to the next training step.</td>
</tr>
</tbody>
</table>

Figure 3.12 The goals, process and pedagogy, rationale, and assessment for each goal.
To understand and apply the core principles of overhand throwing tasks.

| To understand and apply the core principles of overhand throwing tasks. | The researcher explained core principles of overhand throwing tasks with demonstrations if necessary and the teacher was asked to answer questions regarding core principles of throwing (e.g., when you teach overhand throwing which one is important Fast motion or Slow motion) | When the teacher’s plan organized and appropriate tasks and lessons for teaching overhand throwing, they need to consider core principles of the tasks they want to teach. For example, some principles such as ‘throw overhand for force’, ‘considering developmental sequences of students’, ‘using targets’ or ‘frequent demonstrations’ should be considered when throwing tasks are planned. This goal is in the category of both CCK (techniques) and SCK (the base of instructional representations and tasks) | The teacher was asked to take a T/F test (see Appendix E) to see if the teacher understood the core principles of overhand throwing tasks. When the teacher reached 90% or better on that assessment they moved to the next training step. |
| To identify common errors in performance at different skill levels. | The researcher described common errors in throwing performance based on different students’ skill levels with the knowledge packet. The teacher was asked to answer the questions regarding features of performers in different skill levels (e.g., Would you describe the features of students in stage 2?) | Knowing common errors of throwing performance in different skill levels can help the teacher gain knowledge of techniques (CCK) of the performance for students in different skill levels. This goal is aligned with the category of CCK. | The teacher was asked to take a video test (see Appendix E) to see if the teacher had knowledge of common errors of performers in different skill level. When the teacher reached 90% or better on that assessment the second session of the workshop was completed. |

Continued
To be able to correctly identify the most important instructional focus of the overhand throw based upon the child’s development level.

The researcher explained the focus of instruction based on different students’ skill levels with the knowledge packet. After explanation of contents the researcher asked questions to the teacher (e.g., What is the most important element of instruction you teach students in stage 1?).

For effective teaching the teacher should focus on particular elements based on students’ skill levels when they instruct. For example, the teacher should emphasize ‘Step with the opposite foot’ for students in low skill levels but for students in average skill levels the teacher should focus on ‘Opposite foot with long step’ or ‘throw for force (no accuracy)’ rather than emphasizing stepping. This goal is included in the category of SCK and knowledge of instructional strategies.

The teacher was asked to take a written test (see Appendix E) to see if the teacher understood the focus of instruction for students in different skill levels. When the teacher reached 90% or better on that assessment the second session of the workshop was complete.

To be able to select the teaching cues & feedback most appropriately aligned with the child’s stage of throwing development.

The researcher explained potential teaching cues & feedback statements based on the different skill levels. The teacher was frequently asked to answer questions regarding developmentally appropriate cues and feedback from the researcher (e.g., What kinds of cues or feedback are appropriate when you find that students do not rotate their trunk?)

Developmentally appropriate cues and feedback to improve students’ learning is critical. The teacher should give cues and feedback based on the student’s skill level. If the teacher fail to provide cues or feedback without considering the student’s skill level it would not be helpful for increasing student performance. This goal is associated with the category of knowledge of instructional strategies.

The teacher was asked to take written test (see Appendix E) to see if the teacher understands potential teaching cues & feedback statements for students in different skill levels. When the teacher reached 90% or better on that assessment the second session of the workshop was complete.
To have knowledge of, and ability to perform and modify a wide variety of throwing task progressions in line with a child’s developmental throwing performance. The researcher explained potential tasks, and progressions with diagrams, and factors can be manipulated for each task in different students’ skill levels. The teacher was asked to answer questions regarding tasks and progressions (e.g., If you find student placed in stage 2 what are the next most important developmental tasks and progressions of throwing performance to move to the next stage). In addition, the games considering students’ skill levels were introduced to the teacher with the diagram and specific descriptions.

To select, organize, and deliver developmentally appropriate tasks, the teacher should have knowledge of potential tasks and progressions aligned with different skill levels. For example, the teacher teaches throw with stepping opposite foot (informing task) first and changes task difficulty or complexity such as taking step further back or using a small target (extension task) for students in low skill levels. The tasks and progressions should be differently applied based on different skill levels with appropriate equipment or materials. This goal is aligned with developing SCK, knowledge of context, and knowledge of instructional strategies.

At the end of the second session of the workshop the teacher was asked to take written test (see Appendix E) to see if the teacher understood potential tasks and progressions for students in different skill levels. When the teacher reached 90% or better on that assessment the second session of the workshop was complete.
**Treatment integrity of the professional development workshop**

Treatment integrity ensured that the independent variable (teacher professional development workshop) was correctly implemented to meet the goals and objectives of the professional development workshop. In other words, treatment integrity made sure that the workshop was delivered based on desired specifications. To maximize treatment integrity of the professional development workshop, two strategies were utilized and implemented in the workshop.

**Strategy 1:** The researcher had a rehearsal session of the professional development workshop for teachers with doctoral peers to practice providing correct information to teachers. This session occurred to increase the competence level for the researcher to conduct an effective workshop and to minimize any difficulties or things that should be happening during the actual workshop with two elementary physical education teachers.

**Strategy 2:** The researcher developed checklists (see Appendix F) to ensure that each phase of the professional development workshop was correctly implemented by the researcher. The checklist identified all phases of the workshop and checked whether they were present or absent. For example, if the plan for the workshop was that the teacher was to explain and demonstrate all 5 stages of the total body approach to throwing, the check list would have 10 checkpoints (1 checkpoint for explanation of each of the 5 stages and 1 checkpoint for demonstration of each of the 5 stages). The total number of points for Day 1 was 70 and 110 for Day 2. An independent rater observed the videotape of the workshop and completed the checklists. Workshop fidelity by the researcher was represented as a percentage for each day and the overall workshop.
**Developing the Throwing Content Knowledge Packet**

The professional development workshop included a knowledge packet developed by the researcher. The knowledge packet was sent to four experts in physical education and motor development to ensure the validity of the content in this knowledge packet. They were asked to thoroughly check whether: (a) the sequence of the tasks was appropriate in the knowledge packet, and (b) the content was developmentally appropriate and accurate for throwing activities. To develop the content of the knowledge packet, the book resources of *Children Moving* written by Graham, Holt and Pareker (2012), *Elementary Physical Education* written by Rovegno & Bandhauer (2013), *Dynamic Physical Education for Elementary School Children* written by Pangrazi and Beighle (2012), *Understanding motor development: Infants, children, adolescents, adults* written by Gallahue, Ozman, and Goodway (2012) as well as three doctoral dissertations (Cohen, 2007; Lorson, 2003, Stodden, 2003) were utilized. Appendix G shows the knowledge packet that includes the importance of overhand throwing, the techniques of throwing, features of a proficient thrower, total body and components developmental sequence of overhand throwing with descriptions, teaching overhand throwing for students at different skill levels, and core principles of overhand throwing tasks. In addition, the knowledge packet provided resources of content knowledge for students at different skill levels.
Phase 2 - Comparison Condition

Students

Students in the comparison group (two 1st-grade and two 2nd-grade) were tested on their throwing performance prior to the unit of throwing, after the unit and two weeks after the unit (retention test) on process measures (developmental sequence of throwing components, Roberton & Halverson, 1984) and product measures (throwing velocity) of throwing performance by using a Sports radar gun. The students’ attendance rate in the comparison classes for the four-day unit was an average of 98% for Justin and 97% for Izzy.

Teachers

Two teachers delivered a 4-day overhand throwing unit using his/her own activities and in the manner that he/she typically did. Teachers taught the unit every day. Appendix H shows the block plans of these two throwing units that made up the comparison condition including tasks implemented and equipment. The teacher wore a wireless microphone and all four lessons were videotaped. The teacher’s PCK (as described above) was coded from the videotape for each lesson. The teacher delivered the same throwing unit to both their first and second-grade class. The only adaptation was the use of different balls (e.g. foam balls in 1st grade and tennis balls in 2nd grade) between 1st grade and 2nd grade.

Phase 3 - Professional Development Workshop

Professional development workshop
After the final throwing unit in the comparison condition, a professional development workshop was separately conducted for each teacher for two days. Different types of equipment (yarn balls, rubber balls, tennis balls, scarf, sticker, and poly spots) as well as a knowledge packet developed by the researcher were used in this workshop. Furthermore, the researcher used a variety of video clips and pictures utilizing a tablet in order to help the teachers develop their knowledge bases. The researcher explained the content and demonstrated all tasks while having the teacher go through them and used advanced technology (tablet) to make an educational environment. In addition, the researcher frequently asked questions to check the teacher’s understanding of content implemented in the workshop by using check sheets (see Appendix D) and written tests (see Appendix E). When the teacher demonstrated the competencies associated with that phase of the workshop to teach the content within a specific phase of the training they moved to the next phase. The most important feature of this workshop was that the teacher learned the ways to identify students’ different developmental throwing levels and how to modify instruction to teach these students. The teacher was expected to develop the ability to identify the students’ developmental levels of overhand throwing performance and to deliver appropriate feedback and tasks based on students’ different skill levels through attending the workshop. The workshop occurred two times and the duration of each workshop was one and one-half hours (three hours total per teacher). Each teacher was trained separately.

Sessions of teacher training

The researcher provided two one and a half hour workshop sessions to train the physical education teachers. A variety of pedagogies such as demonstrations, pictures,
video clips and diagrams were used to help the teachers understand the contents of the knowledge packet. The workshops were conducted in the school during two different meetings. Figure 3.13 and 3.14 show the schedule of each session for the workshop. The training sessions for the teachers were as follows:

**Session 1 (One and a half hours).** The researcher briefly explained an overview of the workshop including (a) the purpose of the workshop, (b) the goals of the workshop, and (c) expectations of the researcher. Techniques of the overhand throw: (a) preparatory action; (b) force production; and (c) follow through were described along with demonstrations.

Description of both the total body and body component developmental sequences were provided to teachers with demonstrations as well as pictures from the knowledge packet. The teacher was asked to demonstrate the throwing skill after watching the researcher’s demonstrations regarding components in the developmental throwing sequences. Both throughout and at the end of the session, the teachers were asked to answer a set of questions and a video examination to check their understanding and mastery of content during the workshop using the checklist.
### Session 1 (The first day)

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Content</th>
<th>Type of Pedagogy &amp; Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min</td>
<td><strong>Introduction to the workshop</strong></td>
<td>- Verbal explanations</td>
</tr>
<tr>
<td></td>
<td>- The purpose of the workshop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The goals of the workshop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Expectations of the trainer.</td>
<td></td>
</tr>
<tr>
<td>10 min</td>
<td><strong>Techniques of overhand throwing</strong></td>
<td>- Explanations &amp; Demonstrations</td>
</tr>
<tr>
<td></td>
<td>- Preparatory position</td>
<td>- Pictures</td>
</tr>
<tr>
<td></td>
<td>- Force production</td>
<td>- Practice trials for the teacher</td>
</tr>
<tr>
<td></td>
<td>- Follow Through</td>
<td>- Check sheet (9 items)</td>
</tr>
<tr>
<td>23 min</td>
<td><strong>Total body developmental sequences</strong></td>
<td>- Explanations &amp; Demonstrations</td>
</tr>
<tr>
<td></td>
<td>- Components of each stage</td>
<td>- Descriptions</td>
</tr>
<tr>
<td></td>
<td>- Critical elements</td>
<td>- Pictures and 5 video clips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Practice trials for the teacher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check sheet (video clips) (10 items)</td>
</tr>
<tr>
<td>32 min</td>
<td><strong>Body component developmental sequences</strong></td>
<td>- Explanations &amp; Demonstrations</td>
</tr>
<tr>
<td></td>
<td>- Components of each stage</td>
<td>- Descriptions</td>
</tr>
<tr>
<td></td>
<td>- Critical elements</td>
<td>- Pictures and 5 video clips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Practice trials for the teacher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Check sheet (video clips) (10 items)</td>
</tr>
<tr>
<td>20 min</td>
<td><strong>Evaluation for contents of the first training session</strong></td>
<td>- A short version of written test (20 Qs)</td>
</tr>
<tr>
<td>Total:</td>
<td><em>Three contents were covered</em></td>
<td></td>
</tr>
<tr>
<td>90 min</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Three contents were covered.

Figure 3.13 The schedule of the first session.

**Session 2 (One and a half hours).** The second session was conducted a day after the first session. The researcher briefly went over the content covered during the first session with teachers. First of all, five core teaching principles for teaching units of overhand throwing were described by the researcher. Then, the researcher provided the description of throwing performance at different skill levels including focus of instruction, features of the performer, teaching cues and feedback statements, tasks, and throwing activities for each skill level. Pictures, demonstrations and diagrams were used to explain each component. Throughout the session the researcher frequently asked the teacher questions about the content to ensure his/her understanding of the tasks. In
addition, during the session, the teachers took tests to check their understanding of content they learned during the second session.

<table>
<thead>
<tr>
<th>Content</th>
<th>Type of Pedagogy &amp; Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session 2 (The second day)</strong></td>
<td></td>
</tr>
<tr>
<td>10 min</td>
<td><strong>Going over previous contents</strong></td>
</tr>
<tr>
<td></td>
<td>- Techniques of overhand throwing</td>
</tr>
<tr>
<td></td>
<td>- Total body and component development sequences</td>
</tr>
<tr>
<td></td>
<td>- Conversation</td>
</tr>
<tr>
<td>10 min</td>
<td><strong>Core principles of overhand throwing tasks</strong></td>
</tr>
<tr>
<td></td>
<td>- Explanations</td>
</tr>
<tr>
<td></td>
<td>- T &amp; F test (10 Qs)</td>
</tr>
<tr>
<td>20 min</td>
<td><strong>Teaching students in low skill level</strong></td>
</tr>
<tr>
<td></td>
<td>- Explanations &amp; Demonstrations</td>
</tr>
<tr>
<td></td>
<td>- Practice trials for the teacher</td>
</tr>
<tr>
<td></td>
<td>- Written test (4 Qs)</td>
</tr>
<tr>
<td></td>
<td>- Check sheet (video clips) (5 items)</td>
</tr>
<tr>
<td>20 min</td>
<td><strong>Teaching students in average skill level</strong></td>
</tr>
<tr>
<td></td>
<td>- Explanations &amp; Demonstrations</td>
</tr>
<tr>
<td></td>
<td>- Practice trials for the teacher</td>
</tr>
<tr>
<td></td>
<td>- Written test (4 Qs)</td>
</tr>
<tr>
<td></td>
<td>- Check sheet (video clips) (5 items)</td>
</tr>
<tr>
<td>20 min</td>
<td><strong>Teaching students in high skill level</strong></td>
</tr>
<tr>
<td></td>
<td>- Explanations &amp; Demonstrations</td>
</tr>
<tr>
<td></td>
<td>- Practice trials for the teacher</td>
</tr>
<tr>
<td></td>
<td>- Written test (4 Qs)</td>
</tr>
<tr>
<td></td>
<td>- Check sheet (video clips) (5 items)</td>
</tr>
<tr>
<td>10 min</td>
<td><strong>Wrap up</strong></td>
</tr>
<tr>
<td></td>
<td>- Reflecting on what he/she has learned &amp; what he/she will do differently in teaching overhand throwing</td>
</tr>
<tr>
<td>Total: 90 min</td>
<td>Four contents were covered</td>
</tr>
</tbody>
</table>

Figure 3.14 The schedule of the second session.
**Evaluation of Treatment Integrity of the Workshop**

Treatment integrity was calculated using the checklists identified above for the delivery of each workshop to each teacher. There were a total 70 points available for day 1 of the workshop and 110 points available for day 2. The researcher demonstrated an overall treatment integrity of 92% (Justin=91, Izzy=93%) for day 1 and an overall of 90% (Justin=88%, Izzy=92%) for day 2. The overall treatment integrity for all days and both sessions was 91%. The high percentage of treatment integrity shows that the researcher effectively delivered the professional development workshop as intended for the teachers.

**Retention test for students in the comparison condition**

Two weeks after the unit, students in the comparison classes took a retention test of overhand throwing performance using the procedures outlined above.

**Phase 4 - Experimental Condition**

**Students**

Students in the experimental classes (two 1st-grade and two 2nd-grade) were pretested on their throwing performance prior to the unit of throwing in the same manner as the comparison condition. After the four-day throwing unit, students in the experimental classes were post tested and two weeks later they were retention tested on throwing performance. The students’ attendance rate in the experimental classes for the four-day unit was an average of 97% for Justin and 95% for Izzy.
Teachers

Following the workshop, each teacher taught a four-day unit of throwing instruction to the experimental classes (one 1st grade and one 2nd grade). Prior to the unit each teacher was asked to consider the resources and knowledge from the professional development workshop when they developed and implemented the experimental throwing unit. The teachers were also informed they could teach the throwing unit in any way they wanted to teach. The block plans for each teacher’s experimental throwing unit are provided in Appendix H. The block plan includes the array of throwing tasks selected and equipment used. The teacher’s delivered the same throwing unit to both their first and second-grade class. The only difference between the 1st and 2nd grade was the types of balls (e.g. beanbags in 1st grade and rubber balls in 2nd grade). Teacher’s PCK was observed and videotaped with the experimental classes in the same manner as the comparison condition.

Data Analysis

Several data analysis procedures were utilized. For the analysis of teachers’ PCK variables in terms of task representations, task demonstrations, feedback, and task modification alignment descriptive statistics such as the percentage and frequency were computed for both the comparison and the experimental classes. The data was plotted in bar graphs, or tables to visually display and analyze the data.

A non-parametric test was used to determine differences in developmental levels for each component of over hand throwing. A Mann-Whitney U test was used to determine if there were significant differences for the comparison and experimental
classes for each component. The level of significance was $p = .05$. Furthermore, Independent samples t-test on the highest ball velocity score was used to examine the influence of the teacher’s PCK on student learning of throwing performance (ball velocity). Table 3.5 summarizes the research questions with research sub questions, type of data measured, and method of analysis.

<table>
<thead>
<tr>
<th>Research Question / Sub Research Questions</th>
<th>Types of data measured</th>
<th>How data was collected</th>
<th>Type of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1. How does a teacher’s PCK in teaching a throwing unit differ as a role of their knowledge bases prior to (comparison condition) and following (experimental condition) a teacher professional development workshop?</td>
<td>Correct/Incorrect task representation</td>
<td>Event Recording</td>
<td>Descriptive statistics (percentage measure)</td>
</tr>
<tr>
<td>How does the teachers’ task representation differ between the comparison and experimental classes?</td>
<td>- Correct/Incorrect task representation</td>
<td>Event Recording</td>
<td>Descriptive statistics (Percentage measure)</td>
</tr>
<tr>
<td>How does the teachers’ task demonstration differ between the comparison and experimental classes?</td>
<td>- Correct/Incorrect demonstration</td>
<td>Event Recording</td>
<td>Descriptive statistics (Percentage measure)</td>
</tr>
<tr>
<td>How does the teachers’ feedback differ between the comparison and experimental classes?</td>
<td>Developmentally Appropriate / Inappropriate Feedback - General Feedback</td>
<td>Event Recording</td>
<td>Descriptive statistics (Percentage measure)</td>
</tr>
<tr>
<td>How does the alignment in the teachers’ task modification differ between the comparison and experimental classes?</td>
<td>– Aligned/Not Aligned Task Modification</td>
<td>Event Recording</td>
<td>Descriptive statistics (Percentage measure)</td>
</tr>
</tbody>
</table>

Continued

Table 3.5 A summary the research questions with research sub questions, type of data measured, and method of analysis.
Table 3.5 Continued

<table>
<thead>
<tr>
<th>Research Question / Sub Research Questions</th>
<th>RQ2. How does a student’s throwing performance differ as a function of the teacher’s pedagogical content knowledge prior to (comparison condition) and following (experimental condition) a teacher professional development workshop?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are there any differences in the body components of throwing (step, trunk, humerus and forearm) between the comparison and experimental classes?</td>
<td>The level of step, trunk, humerus, and forearm component in each test</td>
</tr>
<tr>
<td>Are there any differences in throwing velocity between the comparison and experimental classes?</td>
<td>Highest throwing velocity in each test</td>
</tr>
</tbody>
</table>
Chapter 4: Results

This chapter focuses upon the results relative to each research question, corresponding research sub-questions and hypothesis with a summary of results. The first section addresses teachers’ PCK variables according to four research sub-questions with six hypotheses. Furthermore, a summary of results is discussed under each research sub-question. Two elementary physical education teachers’ PCK variables were observed and coded during a four day throwing unit for the comparison classes and another four day unit for the experimental classes. The results of the teacher’s PCK were analyzed by using a descriptive statistical approach such as the percentage and frequency.

The second portion of the chapter presents the research question associated with the influence of teachers’ PCK on the throwing performance and throwing velocity of the comparison and experimental students. Each section examines the influence of teacher’s PCK on the body components and the mean ball velocity before and after the professional development workshop (intervention). Inferential statistics using the Mann -Whitney U test and an Independent Samples t-test was utilized to analyze students’ learning outcomes.
Teacher’s PCK Variables

This portion of the results section will address the research question considering the influence of the professional development workshop on teacher’s PCK. In this study, four PCK variables were measured: (a) task representation; (b) task demonstration; (c) feedback; and (d) task modification alignment prior to and following the professional development workshop.

Research Question 1:

How does a teacher’s PCK in teaching a throwing unit differ as a role of their knowledge bases prior to (comparison condition) and following (experimental condition) a teacher professional development workshop?

Task Representation

Research sub-question

1-1. How does the teachers’ task representation differ between the comparison and experimental classes?

Hypothesis 1-Teachers in the experimental classes will demonstrate a higher percentage of correct task representations than in the comparison classes.

To address Hypothesis 1, the data were collected as a percentage of the teacher’s task representations and reported as an average percentage of correct task representations by condition and the percentage of correct task representations per lesson by condition. Furthermore, data are discussed separately for the comparison and experimental classes by the teacher.
1) An average percentage of correct task representations by condition

Figure 4.1 illustrates the average percentage of correct task representations as a function of the total number of task representations by both teachers. The average percentage of correct task representations greatly increased from 50% in the comparison classes to 100% in the experimental classes.

![Figure 4.1 Average percentage of correct task representations by condition.]

2) The percentage of correct task representations per lesson by condition

Figure 4.2 shows the percentage of correct task representations per lesson in the comparison and experimental classes. The range was from 36% (Day 3) to 62% (Day 1) in the comparison classes. In contrast, all task representations were correct (100%) through all units in the experimental classes for both teachers.
3) The percentage of correct task representations per lesson by the teacher

The percentage of correct task representations per lesson by each teacher for the comparison and experimental classes is shown in figure 4.3 for Justin and figure 4.4 for Izzy.

**The percentage of Justin’s correct task representations**

Figure 4.3 shows the percentage of correct task representations for Justin. Seventy one percent of task presentations were correct and 29% of task was represented incorrectly. The range was from 53% (Day 3) to 86% (Day 1) through units in the comparison classes. In contrast, all task representations were 100% correct in the experimental classes.
The percentage of Izzy’s correct task presentations

Figure 4.4 shows the percentage of correct task presentations for Izzy. The percentage of correct task representations per lesson increased from 0% in the comparison classes to 100% in the experimental classes.
Summary

Across teachers and classes the research sub-question 1-1 was supported. The teachers had a higher percentage of correct task representations following the professional development workshop (100% in the experimental classes) than prior to the workshop (50% in the comparison classes).

Task Demonstration

Research sub-question

1-2. How does the teachers’ task demonstration differ between the comparison and experimental classes?

Hypothesis 1 - Teachers in the experimental classes will show a higher percentage of correct demonstrations than in the comparison classes.

For hypothesis 1, the data were collected as a percentage of the teacher’s demonstrations and reported as an average percentage of correct task demonstrations by condition and the percentage of correct task demonstrations per lesson by condition. Furthermore, data are discussed separately for the comparison and experimental classes by the teacher.

1) An average percentage of correct task demonstrations by condition

Figure 4.5 shows the average percentage of correct task demonstrations as a function of the total number of task demonstration by both teachers. The average percentage of teachers’ correct task demonstrations dramatically increased from 18% in the comparison classes to 95% in the experimental classes.
2) The percentage of correct task demonstrations per lesson by condition

Figure 4.6 shows the percentage of correct task demonstrations per lesson in the comparison and experimental classes. The range was from 4% (Day 1) to 27% (Day 4) in the comparison classes. On the other hand, the overall percentage of correct task demonstrations by lesson in the experimental classes (Range = 91% - 100%) was higher than in the comparison classes (Range = 4% - 27%).
Figure 4.6 Percentage of correct task demonstrations per lesson in the comparison and experimental classes combined for both teachers.

3) The percentage of correct task demonstrations per lesson by the teacher

The percentage of correct task demonstrations per lesson by each teacher for the comparison and experimental classes is shown in figure 4.7 for Justin and figure 4.8 for Izzy.

The percentage of Justin’s correct task demonstrations

Figure 4.7 shows the percentage of correct task demonstrations for Justin. Twenty eight percent of Justin’s task demonstrations were correct in the comparison classes. The range was from 5% (Day 1) to 40% (Day 3) through units. In contrast, all task demonstrations per lesson were coded as correct in the experimental classes.
The percentage of Izzy’s correct task demonstrations

Figure 4.8 shows the percentage of correct task demonstrations for Izzy. The mean percentage of correct task demonstrations was 0 in the comparison classes. This result suggests that all demonstrations were incorrect in the comparison classes. However, the percentage of correct demonstrations per lesson greatly increased in the experimental classes (Range= 73%-100%, Mean= 85%).
Hypothesis 2 - Teachers in the experimental classes will show greater frequency of correct demonstrations than in the comparison classes.

The data were collected as a frequency of the teacher’s demonstrations and reported as a total frequency of correct task demonstrations by condition and the frequency of correct task demonstrations per lesson by condition. Furthermore, data are presented separately for the comparison and experimental classes by the teacher.

1) A total frequency of correct demonstrations by condition

Figure 4.9 shows the total frequency of correct task demonstrations in the comparison classes and experimental classes. Total frequency of correct task demonstrations dramatically increased from 14 in the comparison classes to 121 in the experimental classes.
Figure 4.9 The total frequency of correct task demonstrations by condition.

2) The frequency of correct task demonstrations per lesson by condition

Figure 4.10 shows the frequency of correct demonstrations per lesson in the comparison and experimental classes. The range was from 1 (Day 1) to 5 (Day2) in the comparison classes. On the other hand, the frequency of correct task demonstrations by lesson in the experimental classes (Range = 20-38) is higher than in the comparison classes.

Figure 4.10 The frequency of correct task demonstrations per lesson in the comparison and experimental classes by both teachers.
3) The frequency of correct task demonstrations per lesson by the teacher

The frequency of correct task demonstrations per lesson by each teacher for the comparison and experimental classes is shown in figure 4.11 for Justin and figure 4.12 for Izzy.

**The frequency of Justin’s correct task demonstrations**

The frequency of correct task demonstrations per lesson in Justin’s comparisons and experimental classes is shown in figure 4.11. The range was from 1 (Day 1) to 5 (Day 2) through unit and the mean of frequency was 3.5 in the comparison classes. However, the frequency of correct task demonstrations greatly increased in the experimental classes (Range = 17-29, Mean=23).

![Figure 4.11](image)
The frequency of Izzy’s correct task demonstrations

The frequency of correct task demonstrations per lesson in Izzy’s comparison and experimental classes is shown in figure 4.12. Correct task demonstrations were not observed in the comparison classes. However, the frequency of correct task demonstrations greatly increased in the experimental classes (Range = 4-9, mean=7.5).

Figure 4.12 A frequency of correct task demonstrations per lesson in the experimental and comparison classes for Izzy.

Summary

Across teachers and classes the research sub-question 1-2 was supported. The teachers had a higher percentage of correct task demonstrations following the professional development workshop (94.5% in the experimental classes) than prior to the workshop (17.5% in the comparison classes). Furthermore, the total frequency of correct task demonstrations also increased from 14 in the comparison classes 121 in the experimental class.
**Feedback**

**Research sub-question**

1-3. How does the teachers’ feedback differ between the comparison and experimental classes?

**Hypothesis 1** - Teachers will deliver more feedback to individual students in the experimental classes than in the comparison classes.

The data were collected as a frequency of the feedback from the teachers and reported as a total feedback by condition as well as the frequency of feedback per lesson in the comparison and experimental classes by the teacher.

1) A total frequency of feedback by condition

Figure 4.13 shows the total frequency of feedback in the comparison classes and experimental classes. The total frequency of feedback dramatically increased from 130 in the comparison classes to 236 in the experimental classes.

![Graph showing total feedback by condition](image)

**Figure 4.13** The total frequency of feedback by condition.

125
2) The frequency of feedback per lesson by the teacher

The frequency of feedback per lesson by each teacher for the comparison and experimental classes is shown in figure 4.14. Overall, Justin delivered more feedback in the experimental classes (Range= 12-39, Mean= 26) than in the comparison classes (Range= 8-18, Mean=12). Izzy also delivered more feedback for the experimental classes (Range= 29-40, Mean= 33.5) compared to the comparison classes (Range= 13-26, Mean= 19). Furthermore, figure 4.14 presents that Izzy provided more feedback than Justin in both conditions.

Figure 4.14 The frequency of feedback per lesson in the comparison and experimental classes by the teacher.

Hypothesis 2 - Teachers in the experimental classes will deliver a higher percentage of developmentally appropriate feedback to individual students than in the comparison classes.
The data were collected as a percentage of different types of feedback; (a) developmentally appropriate feedback (DAF); (b) developmentally inappropriate feedback (DIF); and (C) general feedback from the teachers. Data are reported as an average percentage of different types of feedback by condition and per lesson by condition.

1) An average percentage of different types of feedback by condition

Figure 4.15 shows the average percentage of different types of feedback as a function of the total number of feedback statements by both teachers. The average percentage of DAF greatly increased from 12% in the comparison classes to 68% in the experimental classes. On the other hand, the average percentage of DIF and general feedback decreased in the experimental classes compared to the comparison classes.

Figure 4.15 Average percentage of different types of feedback by condition.
2) The percentage of different types of feedback per lesson by condition

Figure 4.16 shows the percentage of different types of feedback per lesson in the comparison and experimental classes. The majority of feedback in the comparison classes was general feedback (Range= 62%-95%, Mean= 77%). In contrast, DAF was frequently delivered in the experimental classes (Range= 57%-76%, Mean= 67%). Especially, the percentage of DIF is low in both the comparison classes (Range= 0% - 24%, Mean= 12%) and experimental classes (Range= 1%-4%, Mean= 2%).

Figure 4.16 The percentage of different types of feedback per lesson in the comparison and experimental classes for both teachers.

Continued
Summary

Across teachers and classes the research sub-question 1-3 was supported. The teachers delivered more feedback following the professional development workshop (236 in the experimental classes) than prior to the workshop (130 in the comparison classes). The percentage of DAF increased from 12% in the comparison classes to 68% in the experimental classes. Furthermore, DAF was usually delivered to individual students in the experimental classes (68%) compared to other two types of feedback (General feedback= 31%, DIF= 2.5%).

Task Modification Alignment

Research sub-question

1-4. How does the alignment in the teachers’ task modification differ between the comparison and experimental classes?
**Hypothesis 1** - Teachers will demonstrate a greater frequency of individualized task modification in the experimental classes than in the comparison classes.

The data were collected as a frequency of individualized task modifications from the teachers and are reported as a total frequency of individualized task modifications by condition as well as the frequency of individualized task modification per lesson in the comparison and experimental classes by the teacher.

1) A total frequency of individualized task modifications by condition

Figure 4.17 shows the total frequency of individualized task modifications in the comparison and experimental classes. The total frequency of individualized task modification dramatically increased from 64 in the comparison classes to 163 in the experimental classes.

Figure 4.17 The total frequency of individualized task modifications by condition.
2) The frequency of individualized task modifications per lesson by the teacher

The frequency of individualized task modifications per lesson by each teacher for the comparison and experimental classes is shown in figure 4.18. Individualized task modification occurred inconsistently through Justin’s and Izzy’s units in both the comparison and experimental classes. Justin provided a total of 22 modified tasks and the mean of modified task per lesson was 15.2 in the comparison classes. Izzy utilized 45 modified tasks for individual students in the comparison classes (Mean=11.2). After the workshop, Justin provided a total of 61 modified tasks to individual students (Mean = 15.2) and Izzy provided 102 modified tasks for individual students (Mean= 25.5) in the experimental classes. Overall, figure 4.14 presents that Izzy applied more individualized task modifications than Justin in both conditions.

Figure 4.18 The frequency of individualized task modifications per lesson in the comparison and experimental classes by the teacher.
Hypothesis 2 - Teachers will show a higher percentage of aligned task modification for individual students in the experimental classes than in the comparison classes.

The data were collected as a percentage of aligned task modifications from the teachers and are reported as an average percentage of aligned task modifications by condition as well as the percentage of aligned task modifications per lesson by condition.

1) An average percentage of aligned task modifications per by condition

Figure 4.19 shows the average percentage of aligned task modifications as a function of the total number of task modifications by both teachers. The average teachers’ aligned task modifications greatly increased from 15% in the comparison classes to 95% in the experimental classes.

![Figure 4.19 Average percentage of aligned task modifications by condition.](chart)

2) The percentage of aligned task modifications per lesson by condition

Figure 4.20 shows the percentage of aligned task modifications per lesson in the comparison and experimental classes. The range was from 0% (Day 1 and Day 4) to 23%
(Day 2) in the comparison classes. On the other hand, the overall percentage of aligned task modifications by lesson in the experimental classes (Range = 89% - 98%) is higher than in the comparison classes (Range = 0% - 23%).

![Figure 4.20](image.png)  
Figure 4.20 The percentage of aligned task modifications per lesson in the comparison and experimental classes by both teachers.

Summary

Across teachers and classes the research sub-question 1-4 was supported. The teachers delivered more individualized task modifications following the professional development workshop (163 in the experimental classes) than prior to the workshop (64 in the comparison classes). The percentage of aligned task modification increased from 16% in the comparison classes to 95% in the experimental classes.

Summary of Teacher’s PCK Results

The figure 4.21 shows the results of four PCK variables; (a) task representations; (b) task demonstrations; (c) feedback; and (d) task modification alignment prior to
(comparison condition) and following (experimental condition) the professional development workshop.

<table>
<thead>
<tr>
<th></th>
<th>Comparison Classes (% or N)</th>
<th>Experimental Classes (% or N)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correct Task Representations</strong></td>
<td>50 %</td>
<td>100 %</td>
</tr>
<tr>
<td><strong>Correct Demonstrations</strong></td>
<td>18%</td>
<td>95 %</td>
</tr>
<tr>
<td><strong>Feedback</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Feedback</td>
<td>N= 130</td>
<td>N= 163</td>
</tr>
<tr>
<td>Developmentally Appropriate Feedback</td>
<td>12 %</td>
<td>68 %</td>
</tr>
<tr>
<td><strong>Task Modification Alignment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual Task Modifications</td>
<td>N= 64</td>
<td>N= 163</td>
</tr>
<tr>
<td>Aligned task Modifications</td>
<td>16 %</td>
<td>95 %</td>
</tr>
</tbody>
</table>

Figure 4.21 The overall results of teacher’s PCK variables.

Both teachers showed more correct task representations in the experimental classes (50%) than in the comparison classes (100%). Justin and Izzy also had more correct throwing demonstrations in the experimental classes (95%) compared to the comparison classes (18%). Feedback was more frequently delivered in the experimental classes (N=163) than the comparison classes (N=130). Especially, the percentage of developmentally appropriate feedback (DAF) increased from 12% in the comparison classes to 68% in the experimental classes. Finally, both teachers focused more on individualized teaching with task modifications in the experimental classes (N=64) than the comparison classes (N=163). Furthermore, the percentage of aligned task
modifications increased following the professional development workshop (95% in the experimental classes) than prior to the workshop (16% in the comparison classes).

Based on the results of teachers’ PCK variables prior to (comparison condition) and following (experimental condition) the professional development workshop, research question 1 with sub-research questions is supported in this study.

**Students’ Throwing Performance**

The second portion of the chapter will present the research question and sub-questions associated with the influence of teacher’s PCK on students’ throwing performance. In this study, four body components of throwing (step, trunk, humerus and forearm) and throwing velocity (mph) were the dependent variables measured prior to and following the professional development workshop.

**Research Question 2**

How does a student’s throwing performance differ as a function of the teacher’s pedagogical content knowledge prior to (comparison condition) and following (experimental condition) a teacher professional development workshop?

**Body Components of Overhand Throwing**

**Research sub-question**

2-1. Are there any differences in the four body components of throwing (step, trunk, humerus and forearm) between the comparison and experimental classes?
Research sub-question 2 determined if class differences existed between the comparison and experimental classes on the four body components of overhand throwing from the pre to post to retention test. Figure 4.22 illustrates the pre, post, and retention test means in the comparison and experimental classes by teacher for four body components (step, trunk, humerus, and forearm).
Figure 4.22 The mean of modal level for each component at the pre, post, and retention test between the comparison and experimental classes by the teacher.
Hypothesis 1—There will be no differences in the pretest for four body components of throwing (step, trunk, humerus, and forearm) between the experimental and comparison classes.

Hypothesis 1 explored whether differences between the comparison and experimental classes existed in body component levels at the pretest. Table 4.1 shows the mean modal level on each body component at the pretest between the comparison and experimental classes by the teacher.

<table>
<thead>
<tr>
<th>Component</th>
<th>Justin’s Classes</th>
<th>Izzy’s Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comparison</td>
<td>Experimental</td>
</tr>
<tr>
<td>Step</td>
<td>2.54</td>
<td>2.09</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.39</td>
<td>1.30</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.33</td>
<td>1.15</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.27</td>
<td>1.09</td>
</tr>
</tbody>
</table>

Table 4.1 The mean of modal level of each body component at the pretest between the comparison and experimental classes by the teacher.

**Justin’s classes**

The Mann-Whitney U test ($p<.05$) revealed that there was no statistically significant differences in the pretest for each component; (a) Step ($U = 411$, $p = .074$); (b) Trunk ($U = 495$, $p = .442$); (c) Humerus ($U = 459$, $p = .134$); and (d) Forearm ($U = 445$, $p = .057$) between the comparison and experimental classes for Justin.

**Izzy’s classes**

The results from Issy’s classes were similar to Justin. There was no statistically significant difference in the pretest for each component; (a) Step ($U = 295$, $p = .090$); (b)
Trunk ($U = 378, p = .784$); (c) Humerus ($U = 350, p = .317$); and (d) Forearm($U = 378, p = .689$) between the comparison and experimental classes for Izzy.

**Hypothesis 2** - The experimental classes will have significantly greater pretest to posttest gain scores in four body components of throwing (step, trunk, humerus, and forearm) as compared to the comparison classes.

Hypothesis 2 examined whether a significantly different gain in the body component levels existed from the pre to posttest in the experimental classes compared to the comparison classes.

**Justin’s classes**

Table 4.2 represents the mean of modal level for each body component at the pretest and posttest, and the gain between two tests for Justin’s classes.

<table>
<thead>
<tr>
<th>Component</th>
<th>Comparison Classes</th>
<th>Experimental Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Step</td>
<td>2.54</td>
<td>3.12</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.39</td>
<td>1.84</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.33</td>
<td>1.63</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.27</td>
<td>1.54</td>
</tr>
</tbody>
</table>

The gain for step in the experimental classes was 1.39 compared to 0.58 in the comparison classes, and that difference was statistically significant ($U = 285, p = .000$). The experimental classes gained 0.85 at trunk component modal level compared to the comparison classes (0.45). This result also shows a statistically significant different gain
between the comparison and experimental classes ($U = 348, p = 003$). Finally, the Mann-Whitney U test revealed that the gain for humerus (0.88 in the experimental classes and 0.30 in the comparison classes) and forearm (0.95 in the experimental and 0.27 in the comparison classes) was also statistically significant difference; Humerus ($U = 231, p = .000$) and Forearm($U = 189, p = .000$). In the comparison classes, the following percent of students had a gain at least one level: (a) Step (45%); (2) Trunk (45%); (c) Humerus (30%); and (d) Forearm (27%). In contrast, students in the experimental classes showed the following percent of gain (at least one level): (a) Step (81%); (2) Trunk (78%); (c) Humerus (87%); and (d) Forearm (90%). Thus it can be see that more students in Justin’s experimental classes had a meaningful gain of at least one stage in contrast to the comparison classes.

**Izzy’s classes**

Table 4.3 represents the mean of modal level for each body component at the pretest and posttest, and the gain between two tests for Izzy’s classes.

<table>
<thead>
<tr>
<th>Component</th>
<th>Comparison Classes</th>
<th>Experimental Classes</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Gain</td>
</tr>
<tr>
<td>Step</td>
<td>1.96</td>
<td>2.75</td>
<td>0.79</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.39</td>
<td>1.85</td>
<td>0.46</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.25</td>
<td>1.46</td>
<td>0.21</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.14</td>
<td>1.46</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Table 4.3 The mean of modal level for each body component at the pre and posttest and the gain between the pre and posttest in Izzy’s classes.

The results from Izzy’s classes were similar to Justin’s classes except for the step component. The gain of step in the experimental classes was 0.97 compared to 0.79 in the comparison classes. The Mann-Whitney U test found that this difference of gain between
two conditions was not statistically significant \((U = 345, p = .419)\). The gain of the trunk component was 0.75 in the experimental classes and 0.46 in the comparison classes. This result shows a statistically significant gain between the comparison and experimental classes \((U = 274, p = .026)\). Finally, the gain for humerus (0.75 in the experimental and 0.21 in the comparison classes) and forearm (0.68 in the experimental and 0.32 in the comparison classes) was also a statistically significant difference; Humerus \((U = 213, p = .001)\) and Forearm \((U = 261, p = .014)\). In the comparison classes, the following percent of students had a gain at least one level: (a) Step (50%); (2); Trunk (43%); (c) Humerus (32%); and (d) Forearm (32%). In contrast, students in the experimental classes showed the following percent of gain (at least one level) : (a) Step (75%); (2); Trunk (71%); (c) Humerus (75%); and (d) Forearm (64%). Thus it can be see that more students in Izzy’s experimental classes had a meaningful gain of at least one stage in contrast to the comparison classes.

**Hypothesis 3** - There will be differences in the retention test four body components of throwing (step, trunk, humerus, and forearm) between the experimental and comparison classes.

Hypothesis 3 explored whether differences between the comparison and experimental classes existed in body component modal levels at the retention test. Table 4.4 shows the mean of modal level for each body component at the retention test between the comparison and experimental classless.
### Component Comparison

<table>
<thead>
<tr>
<th>Component</th>
<th>Justin’s Classes</th>
<th>Izzy’s Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comparison</td>
<td>Experimental</td>
</tr>
<tr>
<td>Step</td>
<td>3.18</td>
<td>3.48</td>
</tr>
<tr>
<td>Trunk</td>
<td>1.96</td>
<td>2.09</td>
</tr>
<tr>
<td>Humerus</td>
<td>1.63</td>
<td>1.90</td>
</tr>
<tr>
<td>Forearm</td>
<td>1.63</td>
<td>1.96</td>
</tr>
</tbody>
</table>

Table 4.4 The mean of modal level for each body component at the retention test between the comparison and experimental classes by the teacher.

**Justin’s classes**

The Mann-Whitney U test \((p < .05)\) revealed that there was statistically significant difference in the retention test for three components; (a) Step \((U = 400, p = .036)\); (b) Humerus \((U = 409, p = .047)\); and (c) Forearm \((U = 384, p = .023)\) between the comparison and experimental classes for Justin. However, the result showed that the component of trunk was not statistically significant difference in the retention test between the comparison and experimental classes \((U = 489, p = .379)\).

**Izzy’s classes**

The results from Issy’s classes were similar to Justin. There was statistically significant difference in the retention test for three components; (a) Step \((U = 258, p = .007)\); (b) Humerus \((U = 249, p = .008)\); and (c) Forearm \((U = 276, p = .032)\) between the comparison and experimental classes for Izzy. Only the component of trunk did not show a statistically significant difference in the retention test between the comparison and experimental classes \((U = 304, p = .091)\).
**Summary**

Overall, the research sub-question 2-1 was supported. The mean of modal level for body components (step, trunk, humerus, and forearm) in the pretest was similar between the comparison and experimental classes for both Justin and Izzy. The gains of four body components (step, trunk, humerus, and forearm) from the pre to posttest in the experimental classes were significantly greater than in the comparison classes for two teachers except for the step for Izzy. Finally, there were statistically significant differences in the retention test for three of the four body components; (a) step; (b) humerus; and (c) forearm between the comparison and experimental classes for Justin and Izzy. However, no significant differences were found for the trunk component in the retention test between two conditions for both teachers.

**Ball Velocity**

**Research sub-question**

2-2. Are there any differences in throwing velocity between the comparison and experimental classes?

Research sub-question 2-2 examined whether group differences existed in mean recorded velocity scores from the pre to the post to the retention test. Table 4.5 reports the mean pretest, posttest, and retention test recorded velocity scores for each class by the teacher.
The mean velocity scores in the comparison and experimental classes for pretest, posttest, and retention test by the teacher is represented in Figure 4.23.
Hypothesis 1 - There will be no statistically significant differences in the pretest throwing velocity between the experimental and comparison classes.

Hypothesis 1 examined whether differences between the comparison and experimental classes existed in mean recorded throwing velocity scores at the pretest. Table 4.6 shows the mean scores of throwing velocity at the pretest in the comparison and experimental classes by the teacher.
<table>
<thead>
<tr>
<th></th>
<th>Justin’s Classes</th>
<th>Izzy’s Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comparison</td>
<td>Experimental</td>
</tr>
<tr>
<td>Mean Velocity Score</td>
<td>22.5 (SD=7.02)</td>
<td>21 (SD=5.76)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20.4 (SD=6.25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20.8 (SD=6.73)</td>
</tr>
</tbody>
</table>

Table 4.6 Mean velocity scores (mph) for each condition at the pretest by the teacher.

Justin’s Classes

Independent samples t-test \((p<.05)\) on the pretest revealed that there was no significant difference in the velocity scores between the comparison (M=22.5, SD=7.02) and experimental (M=21, SD=5.76) classes; \(t(64)=0.95, p = .342\).

Izzy’s Classes

Independent samples t-test \((p<.05)\) on the pretest revealed that there was no significant difference in the velocity scores between the comparison (M=20.4, SD=6.25) and experimental (M=20.8, SD=6.73) classes; \(t(54)=-2.26, p = .822\).

**Hypothesis 2** - The experimental classes will have significantly greater the pretest to posttest gain scores in throwing velocity as compared to the comparison classes.

Hypothesis 2 examined whether a significantly different gain in throwing velocity existed from the pre to posttest in the experimental classes compared to the comparison classes.
Justin’s Classes

Table 4.7 represents the mean scores of ball velocity at the pretest and posttest, and gain scores between two tests from Justin’s classes.

<table>
<thead>
<tr>
<th></th>
<th>Comparison Classes</th>
<th>Experimental Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Mean Velocity Score</td>
<td>22.5</td>
<td>24.9</td>
</tr>
<tr>
<td>(SD=7.02)</td>
<td>(SD=7.44)</td>
<td>(SD=2.63)</td>
</tr>
</tbody>
</table>

Table 4.7 Mean velocity scores (mph) for each condition at the pretest and posttest, and gain scores between pre and posttest for Justin.

The results show that there was an average increase of 4.5 mph from the pre to posttest in the experimental classes and the students in the comparison classes showed an average of 2.4 mph gain from the pre to posttest. Independent samples t-test ($p<0.05$) on the pretest to posttest throwing velocity revealed that the gain score of throwing velocity between the comparison (M=2.4, SD=2.63) and experimental (M=4.5, SD=3.08) classes was statistically significant differences; $t(64)=-2.91, p = .005$. In the comparison classes, 39 percent of students had a gain at least 3mph as opposed to 75 percent of students in the experimental classes who showed an increase in ball velocity of at least 3mph.

Izzy’s Classes

Table 4.8 represents the mean scores of ball velocity at the pretest and posttest, and gain scores between two tests from Izzy’s classes.
Comparison Classes | Experimental Classes
---|---
Pre | Post | Gain | Pre | Post | Gain
Mean Velocity Score | 20.4 | 22.9 | 2.5 | 20.8 | 24.8 | 4.0
(SD=6.25) | (SD=5.82) | (SD=2.41) | (SD=6.73) | (SD=7.84) | (SD=3.14)

Table 4.8 Mean velocity scores (mph) for each condition at the pretest and posttest, and gain scores between pre and posttest for Izzy.

In Izzy’s classes, there was an average increase of 4.0 mph from the pretest to posttest in the experimental classes and an average increase of 2.5 mph gain in the comparison classes. The result from the independent samples t-test ($p<.05$) on the pretest to posttest showed that there was statistically significant gains in throwing velocity between the comparison ($M=2.5$, $SD=2.41$) and experimental ($M=4.0$, $SD=3.14$) classes; $t(54)=-2.05$, $p = .045$. In the comparison classes, 46 percent of students had a gain of at least 3mph as opposed to 68 percent of students in the experimental classes who showed an increase in ball velocity of at least 3mph.

**Hypothesis 3** - There will be statistically significant differences in the retention test throwing velocity between the experimental and comparison classes.

Hypothesis 3 examined whether differences between the comparison and experimental classes existed in mean recorded throwing velocity scores at the retention test. Table 4.9 shows the mean scores of throwing velocity at the retention test between the comparison and experimental classes by the teacher.
<table>
<thead>
<tr>
<th></th>
<th>Justin’s Classes</th>
<th>Izzy’s Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comparison</td>
<td>Experimental</td>
</tr>
<tr>
<td>Mean Velocity Score</td>
<td>22.3 (SD=6.06)</td>
<td>25.4 (SD=6.35)</td>
</tr>
</tbody>
</table>

Table 4.9 Mean velocity scores (mph) for each condition at the retention test by the teacher.

**Justin’s Classes**

Independent samples t-test ($p<.05$) on the retention test revealed that there was a significant difference in throwing velocity between the comparison ($M=22.3$, $SD=6.06$) and experimental ($M=25.4$, $SD=6.35$) classes; $t(64)=-2.02$, $p = .048$.

**Izzy’s Classes**

Independent samples t-test ($p<.05$) on the retention test revealed that there was a significant difference in throwing velocity scores for the comparison ($M=20.5$, $SD=5.79$) and experimental ($M=24.3$, $SD=7.87$) classes; $t(54)=-2.06$, $p = .043$.

**Summary**

Overall, the research sub-question 2-2 was supported. The mean score of ball velocity in the pretest between the comparison and experimental classes by two teachers was not statistically significant difference. The gain of ball velocity score from the pre to posttest in the experimental classes was significantly greater than in the comparison classes for the two teachers. Finally, there were statistically significant differences in the retention test for ball velocity between the comparison and experimental classes for Justin and Izzy.
Summary of Students’ Throwing Performance Results

Overall, the level of body components for throwing performance and the mean score of throwing velocity increased across the teachers and classes in this study. No significant differences in the four body components (step, trunk, humerus, and forearm) and ball velocity were found at the pretest between the comparison and experimental classes for both teachers. In terms of the gain in body component levels and ball velocity from the pre to posttest, students in both conditions showed the improvement of their score across the teachers. Specifically, students in the experimental classes showed more gains for body components and ball velocity from the pre to posttest than in the comparison classes. No statistically significant differences were found for the gain in the step component between the comparison and experimental classes for Izzy. Finally, there were statistically significant differences in three body components: (a) step; (b) humerus; and (c) forearm at the retention test between the comparison and experimental classes for both teachers. However, no significant difference was found for the trunk component at the retention test. Furthermore, there were statistically significant differences of the mean throwing velocity at the retention test between the comparison and experimental classes for both teachers.

Based on the results of students’ performance prior to (comparison) and following (experimental) the professional development workshop, research question 2 with sub-research questions is supported in this study.
Chapter 5: Discussion

The necessity for this study was based on: (a) the need for more data and research on teacher PCK in elementary physical education settings, and; (b) limited research that has focused specifically on the effect of teacher PCK on student learning. Since a number of researchers have suggested that CK is a predominant factor influencing a teacher’s PCK (Capel & Katene, 2000; Shulman, 1986, 1987; Siedentop, 2002; Siedentop & Tannehill, 2000; Ward, 2009a; Ward et al., 2012) the current study sought to enhance a teacher’s CK in overhand throwing through a professional development workshop in order to improve the teacher’s PCK. Furthermore, this study also applied the premise that a teacher’s PCK will be influenced by other knowledge bases (Ball et al., 2008; Grossman, 1990; Grossman et al., 2005) including: (a) knowledge of students; (b) knowledge of instructional strategies (pedagogical knowledge); and (c) knowledge of context. Therefore, four critical components (teacher knowledge bases) with sub categories of PCK were proposed (see Figure 3.1). In addition, PCK variables that were used in previous studies (Ayvazo, 2007; Kim, 2011; Lee, 2011) were modified or defined differently to be suitable for the elementary physical education environment and analyzed in this study. Consequently, the primary focus of this study was to explore how manipulating four critical components of PCK (content knowledge, knowledge of students, knowledge of instructional strategies (pedagogical knowledge), and knowledge
of context) through the professional development workshop would effect changes in the teacher’s PCK in a four-day throwing unit.

A secondary purpose of this study was to determine if enhanced teacher PCK for teaching overhand throwing is demonstrated, would these changes in teaching behaviors result in improved process and product student learning outcomes in overhand throwing? Prior throwing intervention research has suggested that students improved their overhand throwing performance when they received throwing interventions (e.g., SKIP program) or particular instructional strategies (e.g., different cues or feedback) from motor development experts and teachers in physical education (DeRenne, Tracey, & Dunn-Rankin, 1985; Goodway & Branta, 2003; Goodway et al., 2003; Graham et al., 1991; Lorson & Goodway, 2007; Lorson & Goodway, 2008; Stodden et al., 2006). However, a criticism of this literature is the generalizability of this work as most facilitators delivering the interventions were specialists or experienced teachers. As such, they were already highly trained and most likely had a depth of knowledge bases for teaching throwing. We know little about whether: (a) a professional development workshop can enhance physical education teachers’ knowledge bases such as CK and knowledge of students in throwing; (b) enhanced teachers’ knowledge bases will result in changes to PCK when teaching a throwing unit, and; (c) enhanced teachers’ PCK can impact student learning outcomes in throwing. This study assumed that developing stronger knowledge bases in throwing would result in the teacher demonstrating enhanced PCK behaviors when teaching a throwing unit. It also assumed that more effective PCK would result in greater students learning in throwing.
This chapter includes a discussion relating the findings of this study to the empirical and theoretical literature and provides recommendations for future research. Specifically, this chapter is organized into four sections. The first section focuses on the effects of the professional development workshop on a teacher’s PCK. The second section addresses students’ throwing performance (throwing components and ball velocity). The third section discusses the conceptual contribution and strengths and limitations of this study. The implications and future research are in the final section.

**Influence of a Professional Development Workshop on Teacher’s PCK**

*Research sub-question 1-1. How does the teachers’ task representation differ between the comparison and experimental classes?*

**Task Representation**

The purpose of this research question was to examine the difference of the teacher’s task representations in terms of how to represent the task correctly between the comparison and experimental classes. The teacher’s task representation is the simplest way to communicate to the students what they are expected to do and how they are to do it (Rink, 1994). The overall data combined for both Justin and Izzy showed that prior to the professional development workshop only 50% of the tasks teachers presented were correct. However, after the professional development workshop 100% of tasks that the teacher’s presented were correct supporting the hypothesis that there would be more correct task representations following the workshop than prior to the workshop.

The data showed that Justin’s task representations were relatively (Mean=71%, Range 53-86%) correct in the comparison classes. When Justin represented the throwing
tasks, most or parts of the critical elements such as ‘Eyes on the target’, ‘Rotate trunk and shoulder’, ‘Step with the opposite foot’ were mentioned. This finding may be associated with Justin’s sports background and teaching experiences. Justin had played baseball and coached a baseball team. Therefore, the researcher assumed that Justin’s content knowledge of throwing was already well developed in the comparison classes and he had the ability to effectively represent the task including critical elements. These results are supported by Ayvazo (2007), who reported that the teacher’s prior experience in playing sports and teaching content may result in the development of PCK. However, it should be noted that Justin usually missed one of the critical elements, ‘Follow Through’ in the comparison classes. This component is important for the throwing skill because performing the ‘Follow Through’ element can control the accuracy of the ball and increase force. It is also associated with better humeral and forearm arm action (Stodden, 2002)

In terms of Izzy’s task representation, the results showed that all task representations were incorrect in the comparison classes. In the comparison condition Izzy usually focused on explaining the organizational tasks associated with throwing activities or games rather than the technique of how to perform overhand throwing. For example, in the beginning of the class she stated:

“We are going to be practicing overhand throwing today; I need you to get five beanbags. You are going to stand on the line about 10 feet from the wall and throw the beanbag to hit the wall. If you are hitting the wall 10 times take one step further back. Don’t forget to make a big muscle and throw hard. Let’s move.”
This task representation is clear and precise, but this statement does not focus on throwing technique and include critical elements of overhand throwing. It only focuses on the direction of how to do the task. The difference between Justin and Izzy in the comparison classes was that Justin included at least one critical element when he presented the task. For example, he stated that:

“Let’s move to the next station. Get five balls. You are going to stand on the line and throw one ball each time to hit the target. Don’t forget to turn sideways, step, turn your hips and fire.

This statement is simple and easy to understand and includes most critical elements with the direction for the task. Justin usually represented throwing tasks this way. Another potential reason why Izzy’s task representations were incorrect in the comparison classes may be related to her sports background and teaching experience. Izzy’s sport background is track and field, basketball, and swimming, and the one arm overhand throwing motion is not part of these sports. Therefore, the researcher assumed that Izzy’s content knowledge of throwing was not well developed in the comparison classes so that she did not effectively represent the task with the critical elements. In the comparison classes, she was able to organize the students and manage the environment, but significant information to perform throwing was not appropriately delivered to the students.

Following the workshop both teachers delivered all instructional tasks correctly. In the workshop, the researcher emphasized the importance of a correct task representation, went over the critical elements of throwing, and demonstrated how to represent these elements. Furthermore, the researcher provided teachers with enough
practice trials to represent the task correctly in the workshop. The researcher had teachers represent the task and provided feedback or comments if their task representations did not include critical elements of throwing. When Izzy or Justin represented a throwing task incorrectly in the workshop, the researcher would point out the missed component. For example, the researcher would often point out to Justin the need for ‘Follow Through’. Following the workshop Justin’s task representations always included an element of the ‘Follow Though’ in the experimental classes. For Izzy, the researcher reminded Izzy to state the critical elements of throwing while representing the tasks and explained why it was important for teaching students to mention the critical elements. After the workshop, all of Izzy’s task representations were coded as correct representations. Izzy included at least one of the critical elements such as “Look at the target, “Stand side-on to the target” or “Step with the opposite foot” while representing the task. Furthermore, Izzy mentioned the critical elements of throwing while explaining the throwing game or activities. For example,

“Let’s feed fruit to the animals. Pick up the different fruits (ball) and throw it to the animals. Do not forget to stop with the opposite foot and rotate your hip. And keep your eyes on the animal”

In conclusion, there was a substantial difference in task representations between the comparison classes and experimental classes.

Overall, the task representations from Justin and Izzy differed prior to and following the professional developmental workshop. The experimental classes had all correct task representations. The increased percentage of correct task representations may be attributed to the increased knowledge of instructional strategies obtained from the
workshop. These findings are in line with the work of Kim (2011) and Lee (2011) who also found that the teacher’s task representation included more descriptions of the critical elements in the experimental groups. These findings also suggest that teachers’ PCK can be shifted along a continuum from more immature PCK to mature PCK (Ward, 2009b) because of the development of the teacher’s CK. One of the limitations of this study may be the way in which task representation was coded. A teacher only needed to identify one critical element to have a correct task representation. While this might be good in certain circumstances, in other circumstances an expert teacher might have identified 2-3 critical elements. Thus, task representation may be over inflated and account for the 100% task representation for both Justin and Izzy in the experimental classes.

**Research sub-question 1-2. How does the teachers’ task demonstration differ between the comparison and experimental classes?**

**Task demonstration**

The purpose of this research question was to examine the difference of the teachers’ task demonstration between the comparison and experimental classes. It was hypothesized that there would be more correct task demonstrations following the workshop than prior to the workshop. Overall, only 18% of task demonstrations were correct in the comparison classes whereas 95% of task demonstrations were correct in the experimental classrooms following the workshop thus supporting the hypothesis. Furthermore, the overall percentage of correct task demonstrations by lesson in the experimental classes (Range = 91% - 100%) was higher than in the comparison classes (Range = 4% - 27%).
The results revealed that 28% of Justin’s task demonstrations were correct in the comparison classes. The reason why the percentage of correct demonstrations is low in spite of his expertise in throwing is strongly related to the results of task representation. In line with task representations, Justin usually failed to demonstrate the ‘Follow Though’ phase of the overhand throwing motion. The component of the ‘Follow Though’ was missed in 72% of the task demonstrations in the comparison classes. If the teacher’s task demonstration did not show all of the critical elements it was considered as an incorrect task demonstration in this study.

In terms of Izzy’s task demonstration in the comparison classes, she never showed a correct demonstration in any of her demonstrations. Izzy seemed to not have the confidence to demonstrate the throwing skill during the comparison classes. Therefore, only a small number of task demonstrations were observed per day for Izzy (Mean= 6) compared to Justin (Mean=14) regardless of correct or incorrect demonstrations. In addition, a total frequency of task demonstrations across the comparison classes were lower for Izzy (N=23) than Justin (N=57). Izzy’s data may be related to Izzy’s teaching style. Izzy seemed to prefer a verbal representation (e.g., feedback) of the throwing skill rather than a visual representation (e.g., demonstration). This result was also supported by the feedback data which will be explained later. It was not clear from the data collected whether Izzy felt her throwing performance was not good enough for demonstration or she just chose to not demonstrate. Future research should attempt to discern what motivates some of these teaching behaviors by including stimulated recall from videotapes.
In the workshop, both teachers were trained to develop the ability to demonstrate the throwing skill for building knowledge of instructional strategies. During the workshop, the researcher showed correct task demonstrations of throwing with the description of critical elements, and asked the teachers to demonstrate that. If the teachers performed throwing incorrectly, the researcher immediately fixed their incorrect task demonstrations.

Especially, for Izzy, the researcher frequently reminded her that she needs to demonstrate the throwing skill more than before because it is important to teach throwing task for the students. Furthermore, more practice time to help her have the confidence to demonstrate the throwing skill was provided than Justin. Based on the data of task demonstration in the experimental classes, the procedure conducted during the workshop may positively influence the teacher’s task demonstration. However, if the researcher videotapes the task demonstration from the teachers and then discusses about their demonstrations with the video clips for the future research, it would be more reliable and easy to fix teachers’ demonstration if they show correct demonstrations.

Following the workshop, all of Justin’s demonstrations were coded as correct task demonstrations. The total frequency of correct task demonstrations in the experimental classes (N= 91) also increased for Justin compared to in the comparison classes (N= 14).

This result may be influenced by Justin’s teaching background (baseball). That means that Justin was originally comfortable to demonstrate throwing. However, he missed a significant component of throwing skill, ‘Follow Though’ during the comparison classes. In the workshop, Justin realized that he did not typically demonstrate the ‘Follow Though’ component in the comparison classes so he worked on this aspect of
the demonstration during the workshop. Therefore, Justin did not miss the ‘Follow
Though’ component while demonstrating the throwing tasks during the experimental
classes. This fact may effect on the increase of correct task demonstrations in the
experimental classes.

Following the workshop, Izzy’s demonstrations were correct on average 85% of
the time (Range 75-100%). This was a significant change compared to the comparison
classes (0%). In addition, as she progressed across the four days she increased her correct
task demonstrations from 75% to 100% in the experimental classes. In terms of the
frequency of demonstration data, Izzy went from no correct task demonstrations in the
comparison classes to an average of 7.5 correct task demonstrations per lesson observed
in the experimental classes. Also she tried to demonstrate the throwing skill to students
more often even though she showed incorrect demonstrations 15% of the time in the
experimental classes. For example, Izzy missed to demonstrate a part of critical
components such as ‘Wind-Up with downward movement of the arm’ or ‘Follow
Though’. However, Izzy usually demonstrated the throwing skill including ‘Sideways
orientation’, ‘Long step with the opposite foot’, and ‘Rotate trunk and/or shoulder’.

Based on the results from Izzy, this study concluded that Izzy had built more confidence
in demonstrating throwing skills after attending the workshop.

Overall, the results of this study showed that both Justin and Izzy had a higher
percentage and frequency of correct task demonstrations in the experimental classes than
in the comparison classes. That means that the professional developmental workshop
helped the teachers improve the ability to demonstrate a correct throwing task. This result
supports the belief that the teacher’s PCK (i.e., the use of the visual demonstration) is
developed by improving the teacher’s CK (i.e., understanding the critical elements of skill) in the workshop (Ward, 2009b). This result is also in line with Kim (2011) who found that the frequency of teachers’ correct demonstrations increased after increasing their CK. Unlike previous studies (Kim 2011; Lee, 2011) the current study also supports that the teacher’s PCK can be developed by building knowledge of instructional strategies. Both teachers built their ability to use correct throwing demonstrations through the workshop. Practice times, tips or comments to be useful for demonstration, and encouragement by the researcher were utilized to build the teachers’ understanding of instructional strategies related to demonstrations during the workshop. Finally, the increased number of correct demonstrations in the experimental classes is evidence that supports the perspective for PCK that building knowledge of instructional strategies (pedagogical knowledge) can also play a critical role to improve PCK.

Research sub-question 1-3. How does the teachers’ feedback differ between the comparison and experimental classes?

Feedback

The purpose of this research question was to examine the difference of the teachers’ feedback between the comparison and experimental classes. Feedback is considered a significant teaching function in physical education (Lee, Keh, & Magill, 1993; Rink, 2010) and an essential element in learning new skills or performance (Lee et al., 1993; Silverman, 1985; Rink, 2010). Furthermore, feedback is strongly related to the teacher’s knowledge of content (Cohen et al., 2012; Kim, 2011; Lee, 2011) and instructional strategies and delivering appropriate feedback is the sign of an effective
teacher with strong PCK (Kim, 2011; Lee, 2011). There were two parts to the research questions around feedback. The first question looked at the frequency of feedback (regardless of the type of feedback) provided by the teacher and hypothesized that there would be more feedback in the experimental classes than the comparison classes. The second question dealt with the nature of the feedback. In this study, the researcher divided feedback into three categories: (a) developmentally appropriate feedback (DAF); (b) developmentally inappropriate feedback (DIF); and (c) general feedback (GF). Developmentally appropriate feedback (DAF) was defined as feedback the teacher delivered is aligned with student’s different skill level. For example, the teacher states ‘Step with the opposite foot’ to the student who showed ‘No step’ or ‘Long step with the opposite foot’ to the student who showed ‘Shot step with the opposite foot’. In contrast, when feedback given by the teacher is not aligned with student’s skill level (e.g., the feedback statement ‘Move your arm back’ to students who struggled with the step movement), this feedback was defined as developmentally appropriate feedback (DIF). Finally, general feedback was coded when feedback by the teacher was not directly related to the development level of overhand throwing performance such as ‘Nice job’, ‘Great work’, ‘Good throw’, or ‘Well done’. Based on the promise that delivering appropriate feedback by the teacher provides the students with information about their performance and builds a positive learning climate (Magill, 2011; Siedentop & Tannehille, 2000; Tan, 1996), these variables were selected for this study.

The overall findings from examination of feedback revealed that there was a higher frequency of feedback in the experimental classes (236) than the comparison
classes (130). Additionally that following the workshop the teachers provided more DAF, less DIF, and less GF to the experimental classes than the comparison classes.

In the comparison classes, the majority (76%) of feedback given by the teachers was general feedback such as “Well Done”, “Nice Job”, Nice Throw”, or “Good Throw”. The teachers in the comparison classes had 12% of DAF and 12% of DIF. Teacher’s attempts at providing feedback tied to skill development was low and was inconsistent. This result is in line with the literature that suggests teachers frequently deliver positive, simple and general feedback (Stroot, 1990; Rink, 2010). Although there is nothing wrong with general feedback, this type of feedback does not provide specific information to the student about what he/she is doing in terms of technique and is not properly aligned with the student’s different developmental level (Rink, 2010; Stroot, 1990; Tan, 1996).

In terms of each teacher’s data of feedback, Justin delivered total 48 feedback statements across types of feedback in the comparison classes. An average frequency of feedback per lesson was 12. The majority of feedback was GF (N=37, 77%) followed by DAF (N=11, 23%). Similar to Justin, Izzy delivered total 82 feedback statements in the comparison classes. An average frequency of feedback delivered per lesson was 19. General feedback was usually provided (N=62, 76%) followed by DIF (N=15, 18%). Developmentally appropriate feedback (DAF) given by both teachers in the comparison classes was mostly related to preparatory position of students such as ‘Standing sideways’ or step component such as ‘Step with the opposite foot’.

As one looks at the overall findings from the comparison classes it can be determined that this aspect of the teacher’s PCK was low because the teacher did not detect errors of students’ throwing performance and provide DAF for the students. Thus,
these teachers needed to learn how to determining the developmental level of each student’s skill performance through precise observation, and then select an appropriate feedback statement that is aligned to the observed student’s developmental level (Cohen et al., 2012).

Therefore, a variety of strategies were utilized to improve the teacher’s CK and knowledge of students and instructional strategies for delivering effective feedback in the workshop. The teacher professional development workshop sought to identify common errors in throwing performance at different skill levels and to be able to select feedback most appropriately aligned with the student’s stage of throwing development. In order for the teachers to be able to undertake DAF, they first had to understand that children learn how to throw in a progressive manner starting from inefficient patterns of throwing going to more efficient patterns of movement (Gallahue et al., 2012). Thus, in the workshop the teachers were first introduced to the total body (Haubenstricker et al., 1983) and component (Roberton & Halverson, 1984) developmental sequences of overhand throwing which described the different developmental levels of throwing performance. The total body movement of all joints and segments related to throwing performance is characterized as one stage (total 5 stages) in the total body developmental sequences (Lorson, 2003). In contrast, the component developmental sequences names the different levels in each component (total 5 components) (Langendorfer & Roberton, 2002; Roberton, 1978). These qualitative measurement tools were expected to help the teacher improve the ability to determine the level of student’s throwing performance. Furthermore, these developmental sequences would be used as a significant resource for
the teacher to provide developmentally appropriate feedback and throwing tasks to the students.

As the researcher trained each of the teacher’s on the developmental sequences the researcher asked each of them if they had ever heard of this approach. Interestingly, Justin and Izzy never heard about these measurement tools before the workshop. Then the researcher trained both teachers on all components and specific levels of overhand throwing. The researcher checked their understanding using verbal and written tests. After that, the researcher showed video clips that included students demonstrating different skill levels so that the teachers could develop the ability to identify student skill levels. The teachers were given the list of developmentally appropriate feedback (DAF) after completing this procedure. The list of developmentally appropriate feedback was proposed by the researcher and contained potential feedback statements based on different skill levels. While re-watching video clips, the teachers were asked to answer the question what technical errors the student showed and what DAF would be appropriate based on the student’s performance. This procedure helped the teachers develop the ability to determine the students’ skill level (knowledge of students), to detect errors in performance (CK (specialized content knowledge), and to deliver developmentally appropriate feedback (knowledge of instructional strategies).

When one considers the findings from the type of feedback research questions, the workshop was found to be effective. The findings from this study showed that the use of feedback by teachers in the experimental classes (regardless of the type of feedback) increased dramatically after the workshop (236) than prior to the workshop (130). In addition, DAF was delivered 68% of the time in contrast to the comparison classes when
DAF was only provided 12% of the time in the experimental classes. In terms of the data from each teacher, the total frequency of feedback in the experimental classes ($N= 104$) increased for Justin compared to in the comparison classes ($N= 48$). The average of 26 feedback was delivered per unit in the experimental classes. Furthermore, Justin more focused on delivering DAF ($N=72$, 69%) in the experimental classes. For Izzy, the total frequency of feedback also increased from 82 in the comparison classes 134 in the experimental classes. The average of 33.5 feedback was delivered per unit in the experimental classes compared to in the comparison classes (Mean= 19). The percentage of DAF (90%) increased and GF (40%) decreased in the experimental classes compared to in the comparison classes (DAF=6% and GF=76%). The increase of the frequency of feedback and DAF for both teachers may be influenced by the effects of the workshop. Justin and Izzy had in-depth of knowledge of students for the throwing performance by learning of the total body and component developmental sequences and developed the ability to detect errors in performance (CK) by taking video exams in the workshop. Furthermore, both teachers practiced delivering DAF based on the list of DAF through watching video clips. These factors may contribute to changing teacher’s PCK component (feedback). These findings from this study are also supported by previous studies (Cohen et al., 2012; Kim, 2011; Lee, 2011). Cohen et al. (2012) found that the type of feedback significantly changed after a professional development workshop to be more aligned developmental feedback (ADFB) tied to the student’s throwing level. Furthermore, Kim (2011) and Lee (2011) reported that the teachers used more concurrent feedback after the CK workshop. They concluded that the CK workshop helped teachers build knowledge on how and when to deliver feedback (Kim. 2011; Lee, 2011). The
significant difference between the current study and previous studies (Cohen et al., 2012; Kim, 2011; Lee, 2011) was that the workshop conducted in the current study focused on not only increasing CK, but also developing the teacher’s ability to determine the level of student’s skill (knowledge of students). Introducing the assessment tools (total body and components sequences of overhand throwing) to teachers and providing real examples of throwing performances (video clips) in the workshop helped the teachers develop the ability to determine the students’ skill level in a real physical education setting. Furthermore, knowing student’s developmental level (knowledge of students) can be a foundation of delivering DAF.

Overall, the result of this study provided evidence to support the claim that teachers’ PCK variables can be matured by developing their knowledge bases including CK, knowledge of students, and instructional strategies. These PCK variables allowed teachers to understand the student’s skill level of performance, detect students’ errors and provide useful information for correcting student errors.

*Research sub-question 1-4. How does the alignment in the teachers’ task modification differ between the comparison and experimental classes?*

**Task Modification Alignment**

The purpose of this research question was to examine the difference in the teachers’ task modification alignment between the comparison and the experimental classes. The teacher needs to carefully detect the student’s developmental level first before providing the task to individual students. Shulman (1987) defined this ability as knowledge of the learners (students). And then, the teacher should see if the task given to
the student is a developmentally appropriate task. If the task is inappropriate for the student developmentally the teacher should modify the task to be suitable for the student’s skill level (Rink, 2010). The ability to modify the task is derived from the teacher’s CK (e.g., task progressions, task selections, task organization). If the teachers do not have in-depth CK, it is impossible to provide or modify tasks even though the teacher correctly assesses the student’s skill level. Therefore, this study examined whether the teacher can distinguish the student’s skill level precisely, and if the task modified by the teacher is aligned to the developmental level of student’s performance to identify PCK.

There were two parts to the research questions around task modification alignment. The first question looked at the frequency of individualized task modification provided by the teacher and hypothesized that there would be more individualized task modification in the experimental classes than the comparison classes. The second question dealt with aligned task modification for individual students.

The overall findings from examination of individualized task modification revealed that there was a higher frequency of individualized task modification (regardless of aligned or not aligned to a student’s skill level) in the experimental classes \( (N=163) \) than the comparison classes \( (N=64) \). Additionally that following the workshop the teachers provided more aligned task modification (95%) to the experimental classes than the comparison classes (15%).

The results of the study showed that Justin provided 22 modified tasks (5.5 per day) to individual students in the comparison classes. Only 5 tasks were identified as a task aligned to a student’s skill level. That means that Justin did modify the task but he just modified the task without consideration of the students level of throwing
performance. For example, Justin had the student get the bean-bag instead of the tennis ball even though the student showed ‘Chop Throw’ (posterior-anterior in direction, no stepping, and no rotating the trunk). This student should have been given the task to help fix preparatory position or the step component. However, Justin only considered the fact that the student struggled to receive the balls bouncing from the target rather than the student’s skill when modifying the task. Another example was that Justin had the student who showed ‘Humerus oblique’ move three steps back to the target. For this student, the task should be modified to help fix his arm position.

The data for Izzy showed that she modified 45 (11.2 per day) tasks to individual students in the comparison classes. Izzy provided more modified tasks than Justin in the comparison classes. These findings may be related to Izzy’s lesson plans and personal teaching approach. Izzy taught her throwing lessons using stations. A small group of students usually rotated to different station. Izzy went around each station and frequently gave individualized tasks or feedback. These findings can also be connected to the other findings. For example, Izzy chose to provide verbal feedback to individual students and less demonstrations. Despite modifying tasks in the comparison classes Izzy’s tasks were not aligned to the student’s skill level. For example, the modified task for the students who did not step with the opposite foot was moving one step back from the target. This student should have been given the task to help fix the step component such as using a poly spot or wearing a scarf on the opposite foot. Inappropriate task modification is caused by the lack of content knowledge (Ayvazo, 2007) and understating of students in terms of skill. Thus, given these findings it would be deemed that Izzy lacked CK to make the appropriate task modification. This result was supported by Kim (2011) and
Lee (2011) who found that the tasks given to students were developmentally inappropriate for students before the workshop because of the lack of CK in soccer (Lee, 2011) and badminton (Kim, 2011) unit. Kim (2011) suggested that a teachers’ lack of CK limits the teachers’ behaviors (e.g., PCK) in terms of task selections. The researcher also assumed that Izzy’s ability to identify the student’s skill level was not well developed in the comparison classes.

Based on the overall findings from the comparison classes it can be determined that the teacher’s PCK (task modification alignment) was low because the teacher did not develop the ability to detect student’s skill level for throwing performance and provide modified tasks that are aligned to the individual students’ developmental level.

Therefore, several approaches that aimed to develop the teacher’s ability to align tasks to the developmental level of the individual student were utilized in the workshop. Both teachers were given the list of potential tasks based on the student’s different skill levels in the knowledge packet (see Appendix G). The researcher explained why the potential tasks are important for each different skill level (CK). After that, the teacher watched video clips that contained students’ throwing performance at different skill levels. The researcher asked what the student’s level of throwing performance was and why the teacher thinks that to help teachers develop an ability to determine student’s skill level (knowledge of students). This procedure was overlapped with the session for feedback. However, the researcher provided different video clips that were not used in the session for feedback. This repetitive pedagogical strategy helped the teachers build their knowledge bases through the workshop. Finally, the teachers were asked to answer
the questions how the task can be modified to align to the student’s developmental level and what kinds of modified tasks could be provided to improve student learning.

After the workshop, data shows that Justin provided 61 modified tasks (15.25 per lesson as compared to 5.5 per lesson in the comparison classes) to individual students in the experimental classes. This was a substantial increase compared to in the comparison classes. Justin used the first day of the experimental classes to measure student’s initial skill level. In day 2, individual students were assigned to different groups based on the skill level. From day 2 to day 3 Justin set up the different stations with different targets and types of balls. Most tasks modified by Justin were aligned to the student’s skill level. For example, if the students showed stepping with the same foot, a scarf was given to that student to tie to the opposite foot. In terms of the type of modified task, Justin kept the same tasks (no task change) or the tasks with less difficult compared to original task in the experimental classes. The descriptive information of the type of task modification is shown in Appendix I.

Izzy modified 102 tasks (25.5 per lesson) to individual students in the experimental classes in contrast to 45 per lesson in the comparison classes. This was also a substantial increase compared to the comparison classes. Furthermore, most modified tasks were aligned to the students’ skill level. Izzy did not change the format of the throwing lessons for the experimental classes. Izzy still preferred to use stations with a variety of targets in the experimental classes. However, Izzy spent more time initially to determine the student’s skill level and provide modified tasks for students. For example, Izzy observed the throwing performance for each student in a station and then provided a developmentally appropriate task. Izzy did not frequently stay at the station to check on
the student’s skill level in the comparison classes. Izzy just provided general feedback such as ‘Good job’ or ‘Nice throw’ and moved to a different station. The tasks for individual students were also simple and not aligned with the students’ skill level in the comparison classes such as ‘Throw 5 more balls’, ‘Use different balls’, ‘Throw the ball behind the line’. After the workshop, Izzy modified individual tasks to fix incorrect student’s throwing performance and provided potential tasks. For example, a poly spot or scarf was provided for students who struggled with the step component. Physical assist was given to students who did not show correct backswing components. Furthermore, Izzy adjusted distance, multiple difficulty levels of the target, and a variety of equipment to provide developmentally appropriate tasks for individual students. In terms of the type of modified task, Izzy was similar to Justin. Most tasks modified by Izzy were easier tasks or kept the same tasks in the experimental classes (see Appendix I).

The results from this study support the work of Ayvazo (2007) who found that when teachers’ PCK was more mature, a variety of modifications were used. Therefore, this finding can be evidence to support the notion that the teachers’ PCK can be shifted from immature PCK to more mature PCK on a continuum (Ward, 2009b). And also that improved PCK can be influenced by improved CK (Ward, 2009b).

Overall, the teachers’ task modification alignment for throwing performance was different prior to and following the professional developmental workshop. This finding can be interpreted as the change of the approach for teaching. Since individual teaching occurred more in the experimental classes, an increase in individually modified tasks were provided to students. The average teachers’ aligned task modifications also considerably increased from 16 % in the comparison classes to 95 % in the experimental
classes. Thus, the teacher’s ability to identify a student’s skill level was well developed as a result of the workshop. Therefore, most tasks modified by the teachers were aligned to student’s different skill levels. Finally, the results of the current study validate the proposition that the teachers’ selection of appropriate content from their CK base (in the specific learning context) is an indication of their developed PCK (Ayvazo, 2007). In addition, the changes in the teachers’ task modification provides further evidence that PCK exists on a continuum from immature to mature as the result of the transformation of their CK (Ward, 2009b) and knowledge of students.

The findings above support research question 1 revealing that both Izzy and Justin showed substantial changes in their PCK as demonstrated by a greater proportion of correct task representations, correct task demonstrations (frequency and percent), overall feedback, developmentally appropriate feedback, and aligned task modifications following the workshop than prior to the workshop.

The next section of this chapter will discuss a secondary research question: ‘How does a student’s throwing performance differ as a function of the teacher’s pedagogical content knowledge prior to (comparison condition) and following (experimental condition) a teacher professional development workshop?’

Discussion of Student Performance

Research sub-question 2-1. Are there any differences in the four body components of throwing (step, trunk, humerus and forearm) between the experimental and comparison classes?
There were two sub-questions to research question 2. The first sub-question examined the potential difference in the four body components of overhand throwing before and after the professional development workshop.

**Body Components**

*Pretest Body Components*

It was hypothesized that there would be no differences in pretest body components of throwing (step, trunk, humerus, and forearm) between the experimental and comparison classes. The results of the Mann-Whitney U test revealed that there were no significant differences between the comparison and experimental classes for Justin on the four body components (step, trunk, humerus, and forearm) at the pretest. The comparison classes had a mean modal level of 2.54 for the step, 1.39 for the trunk, 1.33 for the humerus, and 1.27 for the forearm at the pretest. Similarly, the experimental classes had a mean pretest component modal level of 2.09 for the step, 1.30 for the trunk, 1.15 for the humerus, and 1.09 for the forearm. In practical terms, students in the comparison and experimental classes showed a homolateral step (S2), no trunk action or forward-backward movements (T1), humerus oblique (H1), and no forearm lag (F1).

The result from Izzy’s classes was the same as Justin. There were no significant differences between two conditions on the four body components at the pretest. Izzy’s comparison classes showed a mean modal level of 1.96 for the step, 1.39 for the trunk, 1.25 for the humerus, and 1.14 for the forearm at the pretest. Similarly, the experimental classes had a mean pretest component modal level of 2.35 for the step, 1.35 for the trunk, 1.14 for the humerus, and 1.10 for the forearm. In practical terms, students in the
comparison classes showed no step (S1) and a homolateral step (S2) was shown in the experimental classes. In addition, no trunk action or forward-backward movements (T1), humerus oblique (H1), and no forearm lag (F1) were commonly found in the comparison and experimental classes. The findings of this study for the humerus, and forearm supports the findings of Langendorfer and Roberton (2002), Lorson (2003), and Cohen (2007) that a common attractor for the humerus, and forearm for children ages 5.7-13 is humerus oblique (level 1) and no forearm lag (level 1). The body component levels for the step component in this study are less advanced than Lorson (2003) and Cohen (2007) who found that students ages 8-11 showed contralateral short step (S3).

Overall, there were no significant differences between the two conditions for the trunk, humerus, and forearm components at the pretest for both teachers. The comparison and experimental classes were statistically similar at the pretest. The reason of the lack of pretest differences may be that the students in this study were similar; they were from the same school and taught by the same physical education teacher. This finding can also contribute to avoiding threats of internal validity because the students who have a similar initial level of throwing performance participated in this study. It would be the strength of the study.

Influence of the Teacher’s PCK on Body Components

Hypothesis 2 suggested that the experimental classes would have significantly greater pretest to posttest gain scores in body components of throwing (step, trunk, humerus, and forearm) as compared to the comparison classes. As would be expected, when Justin and Izzy taught their throwing units, the modal level of all four
body components improved from the pre to posttest in both the comparison and experimental classes. The findings supported similar results from previous studies (Cohen et al., 2012; McKenzie et al., 1998; Lorson & Goodway, 2008; Stodden, 2002) exploring the relationship between different instructional strategies and the improvement of throwing performance. Both the comparison and experimental classes in this study received a four-day unit consisting of 120 minutes of throwing practice and were instructed by the same teacher using the same tasks and lesson plans. In other words, the students in both conditions received the same amount of time to practice throwing skill and a variety of instructions on how to perform the overhand throwing. Therefore, it is not surprising that the modal level of each component increased from the pretest to posttest for students in both conditions over a four-day unit of throwing. This finding is in line with the finding from Lorson (2003) that instruction and practice in overhand throwing consisting of 120 minutes (four sessions with 30 minutes) can improve the throwing performance of first and second grade children.

Furthermore, hypothesis 2 examined whether there were significant differences in body component levels from the pre to posttest between the two conditions as a result of the teacher’s PCK. Therefore, the gain (or change) between the pre to posttest was measured and compared. Performance gains are considered as the immediate gains or positive changes in skill performance due to the result of motor skill instruction (Magill, 2011; Schmidt & Wrisberg, 2007).

The Mann-Whitney U test revealed that there were significant differences in the gain scores between the comparison and experimental classes for the trunk, humerus, and forearm components for Justin at the $p<.05$ level. The gain in the experimental classes
was 1.39 \( (M=0.58 \text{ in the comparison classes}) \) for step, 0.85 for trunk \( (M=0.45 \text{ in the comparison classes}) \), 0.88 for humerus \( (M=0.33 \text{ in the comparison classes}) \), and 0.95 for forearm \( (M=0.27 \text{ in the comparison classes}) \). The results from Izzy’s classes were similar to Justin. There was a significant difference in the gain scores of three components; trunk, humerus and forearm between the experimental and comparison classes at the \( p<.05 \) level. The gain in the experimental classes from Izzy was 0.75 \( (M=0.46 \text{ in the comparison classes}) \) for trunk, 0.75 for humerus \( (M=0.21 \text{ in the comparison classes}) \), and 0.68 for forearm \( (M=0.32 \text{ in the comparison classes}) \). However, the gain for step between the comparison and experimental classes was not statistically significant \( (U = 345, p = 419) \) for Izzy. The gain of step in the experimental classes was 0.97 compared to 0.79 in the comparison classes. Even though there was no difference in the gain for step between the comparison and experimental classes from a statistical stand-point, from the practical stand-point, the step movement improved from homolateral step (S2) at the pretest contralateral short step (S3) at the posttest in Izzy’s experimental classes. The step component in the comparison classes did not change from pre to post test (S2-homolateral step: stepping with same foot).

Overall, this study reported that the gains in throwing body components in the experimental classes were significantly greater than the comparison classes (except for the step component in Izzy’s classes). This result may be influenced by the change of the teacher’s PCK following the workshop.

The workshop intended to model appropriate approaches to teaching throwing to the teachers. The researcher introduced the potential equipment (materials) the teacher could use to teach throwing effectively. A number of strategies were used to prompt the
step and these approaches were taught in the workshop. For example, both teachers were encouraged to use poly spots and a scarf to prompt a contralateral step during the workshop. Justin specifically used these materials more than Izzy in the experimental classes. This may account for the greater gain scores for Justin’s experimental classes and the higher level of significance in the gain scores between the experimental and comparison classes than for Izzy. For example, the mean modal level of step in the experimental classes was 2.09 at the pretest and 3.48 at the posttest and 2.54 at the pretest and 3.12 at the posttest in the comparison classes for Justin. Furthermore, the gain of the step was 1.96 in the experimental classes and 0.58 in the comparison classes. For Izzy, the mean modal level of step in the experimental classes was 2.35 at the pretest and 3.43 at the posttest and 1.96 at the pretest and 2.75 at the posttest in the comparison classes. In addition, the gain of the step was 0.97 in the experimental classes and 0.79 in the comparison classes.

It was much harder to teach the trunk component than the step component but several approaches were taught in the workshop. These were in line with the literature and founded on the notion of teaching a rotating trunk (Langendorfer & Roberton, 2002; Stodden, 2002). In order to get the trunk to rotate teachers were asked to use a sticker on the belly button and to determine whether the trunk rotated or not when the researcher demonstrated throwing with the sticker on the belly button. These instructional activities may have resulted in significant gains for the trunk component for the students in the experimental classes. The results represent that the gain of trunk in the experimental classes was 0.85 (0.45 in the comparison classes) for Justin and 0.75 (0.46 in the comparison classes) for Izzy. In addition, the mean modal level of trunk at the posttest
was 2.15 for Justin and 2.10 for Izzy in the experimental classes. Overall, the trunk component in the experimental classes shifted from no trunk rotation/forward-backward movements (T1) to upper trunk rotation or total “block” rotation (T2). This finding for the trunk is in line with the finding of Loson (2003) that the CUE group improved significantly from the pretest to posttest in trunk component.

As the forearm and the humerus component are more difficult to teach (Lorson, 2003, Oslin et. al., 1997) than other components, several approaches were utilized to help the teachers effectively instruct for the forearm and the humerus component in the workshop. For example, both teachers learned how to use DAF and modify tasks that aligned to the student’s different skill level to fix the incorrect position of the arm. These instructional approaches may have resulted in significant gains for the forearm and the humerus component for the students in the experimental classes. The data revealed that the gain of humerus in the experimental classes (Justin: 0.88 and Izzy: 0.75) was a significantly greater than the comparison classes (Justin: 0.30 and Izzy: 0.21). In addition, the experimental classes improved from the pretest to posttest in humerus ($M=1.15$ in the pretest & $M=2.03$ in the posttest for Justin and $M=1.14$ in the pretest & $M=1.89$ in the posttest for Izzy). Furthermore, the additional effects from changes in humerus may influence the gain of forearm component in the experimental classes. The result showed that the gain of forearm in the experimental classes was 0.95 for Justin (0.27 in the comparison condition) and 0.67 (0.32 in the comparison condition) for Izzy. In addition, the mean modal level of the forearm in the experimental classes increased from 1.09 to 2.06 for Justin and from 1.10 to 1.78 for Izzy.
Especially, Izzy used feedback such as “make a muscle” to fix incorrect humerus and forearm action in the comparison classes. After the workshop, feedback that was related directly to the observed performance and aligned to students’ skill level was delivered. For example, feedback such as “elbow back” or “arm way back” was delivered when students showed humerus oblique or no forearm lag. This feedback can prompt the student to move the humerus to a position behind the shoulder. Therefore, this feedback statement was developmentally appropriate and aligned to the performance of arm actions. The task modifications by the teacher that were aligned to a student’s skill level may also be a contributing factor to the significant gain for the humerus and forearm component in the experimental classes. In the workshop, the teacher was given the potential tasks for students who are struggling with the arm actions. For example, one task required the student to reach back and get the ball from the teacher or peer standing behind the student to help the student pull the humerus backwards rather than in front of the body. Justin and Izzy used this task as a modified task in the experimental classes.

These results from this study have been supported by Stodden (2002) and Cohen (2007) who reported that there were significant changes in both humerus and forearm components from the pretest to posttest when they used the intervention strategies such as the biomechanical cue and developmentally aligned feedback.

Overall, the findings relative to the gain and the mean modal level for body components in the experimental classes clearly demonstrate the importance of the teacher’s PCK in the learning process and how the teacher’s PCK can enhance a student’s performance of overhand throwing. The students in the experimental classes
demonstrated an overall higher level of performance than students in the comparison classes.

Meaningfulness of Changes in Throwing Body Components

At the pretest, the student’s throwing pattern was mechanically inefficient. For example, at the pretest students in Justin’s comparison and experimental classes showed a homolateral step (S2), no trunk action or forward-backward movements (T1), humerus oblique (H1), and no forearm lag (F1). For Izzy, at the pretest students in the comparison and experimental classes showed either no step (S1) or a homolateral step (S2). In addition, no trunk action or forward-backward movements (T1), humerus oblique (H1), and no forearm lag (F1) were commonly found in the comparison and experimental classes at the pretest. However, student’s pattern of throwing performance improved at the posttest, specifically in the experimental classes. For example, students in Justin’s experimental classes ended up performing throwing with a contralateral short step (S3), upper trunk rotation (T2), humerus aligned but independent (H2), and forearm lag (F2) at the posttest. Similar changes were found in Izzy’s experimental classes who ended up performing throwing with a contralateral short step (S3) and upper trunk rotation (T2) at the posttest. The changes in throwing demonstrate meaningful, more biomechanically efficient changes in throwing patterns that enable the children to produce higher velocity. Thus, students’ throwing patterns became more mechanically efficient as a function of increased teacher’s PCK following the professional development workshop.
Retention Test Body Components

It was hypothesized that there would be differences in retention test body components of throwing (step, trunk, humerus, and forearm) between the experimental and comparison classes. The retention test was conducted to assess student learning after the intervention and posttest.

The results of the Mann-Whitney U test revealed that there were significant differences between the comparison and experimental classes for Justin and Izzy on three body components (step, humerus, and forearm) at the retention test at the \( p < .05 \) level. That means that the level of three body components for the students in the experimental classes was still better than students in the comparison classes for both teachers at the retention test. Interestingly, there were no statistically significant differences between the comparison and experimental classes for the trunk component for both teachers \( (U = 489, p = .379 \) for Justin and \( U = 304, p = .091 \) for Izzy at the \( p < .05 \) level). This result may be influenced by the statistics. For example, the mean modal level of the trunk for Justin was 2.09 for comparison classes and 1.96 for experimental classes at the retention test. Since the mean modal level of the trunk component for both conditions was similar, there may be no statistically difference between conditions.

Even though the students participated in physical education lessons and sports for two weeks after the posttest, the differences between the experimental and comparison classes on body components (step, humerus, and forearm) were found at the retention test. Therefore, it is possible to conclude that the effects of the teacher’s PCK did have a lasting impact on the students’ throwing performance. The students in the experimental classes truly “learned” the overhand throwing and maintained it until the retention test. In
addition, these findings show the importance of the teachers’ PCK during the learning process.

**Research sub-question 2-2. Are there any differences in throwing velocity between the experimental and comparison classes?**

The purpose of this research question was to examine the difference in ball velocity before and after the professional development workshop. Ball velocity scores are used as a product measure to assess student towing performance (Cohen, 2007). It is also used by the teacher to identify students’ progression and determine whether learning has occurred. Furthermore, many literatures (Cohen, 2007; Lorson, 2003; Stodden, 2002) included ball velocity as a dependent variable. This study analyzed ball velocity as one of dependent variables for the students to examine the effects of the teacher’s PCK on students throwing performance. Furthermore, it would anticipate that an improvement in process measures (body components) would result in an increase in product measures (ball velocity).

**Ball Velocity**

**Pretest Measures of Ball Velocity**

Hypothesis 1 suggested there would be no statistically significant differences in the pretest throwing velocity between the experimental and comparison classes. An independent samples t-test revealed no significant differences in pretest velocity mean scores between conditions for both teachers. As with the body component data, the comparison and experimental classes were similar prior to the workshop (intervention).
The mean velocity score in the comparison classes was 22.5 mph for Justin and 20.4 mph for Izzy, while the experimental classes’ mean velocity score was 21 mph for Justin and 20.8 mph for Izzy. Lorson (2003) reported similar mean ball velocities for second graders to be 24.34 mph for the CUE group, 23.04 mph for the BP group, and 23.25 mph for TPE group.

Influence of the Teacher’s PCK on Ball Velocity Scores

Hypothesis 2 suggested that the experimental classes would have significantly greater pretest to posttest gain scores in throwing velocity as compared to the comparison classes. As would be expected, both the comparison and experimental classes for Justin and Izzy improved their mean velocity score from pretest to posttest (see Figure 4.23). At the pretest, the students’ throwing performance in both condition seemed to be unstable and variable. For example, students showed no step or homolateral step and no trunk action with humerus oblique and no forearm lag at the pretest. Therefore, students probably did not throw very hard. After the pretest, students in both conditions received a four-day throwing unit with 120 minutes of practice time. It may be one of possible reasons that the ball velocity for both conditions improved from the pre to posttest. Another possible reason is the improvement in the student’s throwing performance across the intervention (improvement in process measures of throwing). Especially, improving trunk and arm actions directly related to the ball velocity (Lorson, 2003).

Even though each condition for Justin and Izzy had increased ball velocity, there were still significant differences in gain scores for ball velocity between the experimental and comparison conditions for both teachers. The gain of the ball velocity in the
experimental classes (Justin: 4.5 mph and Izzy: 4.0 mph) was a significantly greater than the comparison classes (Justin: 2.4 mph and Izzy: 2.5 mph). These findings may be attributed with the change in the teacher’s instruction (PCK) after the workshop and the corresponding changes in the body components (process measures) of throwing. The importance of the forceful part of an overhand throw was consistently emphasized to the teachers during the workshop because if the teacher focused on accuracy rather than the force, a ‘dart (chopping)’ action may be developed. The dart action is one of the characteristics of students in a lower skill level (Haubenstricker et al., 1983; Roberton & Halverson, 1984) who show no step and trunk action, humerus oblique as well as no forearm lag. This action would result in low ball velocity. Therefore, the teachers were told to focus on the throw for force while teaching throwing to young children to improve their overhand throwing skill. During the experimental classes, both teachers frequently instructed students to “throw hard and fast”. This was a change in instructional prompts that could influence the significant gains in ball velocity in the experimental classes.

The development of step action for students in the experimental classes may be one of the reasons that the gain of ball velocity is significantly different compared to the students in the comparison classes. A contralateral (especially contralateral long step) is a critical part of an efficient throw because it helps transfer the body weight over a step to increase ball velocity (Langendorfer, 1990). Both conditions for Justin and Izzy improved the step action from pretest to posttest; however, the students in the experimental classes had a significantly better posttest step (more had a long step) than the comparison classes. Before the workshop, the teachers usually provided generic comments such as “step and throw”. Furthermore, they did not provide tasks that were helpful to fix the step action
with appropriate materials (e.g., the poly spot or scarf) in the comparison classes. After the workshop, both teachers developed the ability to identify a student’s skill level and delivered more skill-focused feedback (DAF) such as “long contralateral step” if they observed the student who showed an incorrect step action. Furthermore, providing modified tasks using materials contributed to increasing step action. The longer step may have accounted for, in part, the better ball velocity scores of the experimental classes over time.

Finally, the development of arm action (humerus and forearm component) as a result of enhanced teacher’s instruction (PCK) may be another reason ball velocity improved. The experimental classes for both teachers had a significantly better humerus and forearm gain scores than the comparison classes. Modified tasks such as pairing up students and developmentally appropriate feedback from the teachers contributed to increasing students’ arm movement in the experimental classes. This resulted in imparting greater velocity to the ball because humeral lag and delayed forearm lag are strongly associated with force production and ball velocity scores (Stodden, 2002; Langendorfer, 1990). Although the experimental classes did not reach humeral lag (H3) and delayed forearm lag (F3), the changes that occurred across the four-day throwing unit may have, in part, accounted for the findings for velocity. Previous studies (Cohen, 2007; Loson, 2003; Roberton & Halverson, 1979) reported similar findings that there was a linear relationship between the process and product measures of the throw.

The results of the current study support the findings from existing studies (Cohen, 2003; Garcia & Garcia, 2002; Lorson, 2003; McKenzie et al., 1998; Stodden, 2002) that sufficient teacher’s instruction results in improvements in ball velocity scores.
Furthermore, this study suggests that the teacher’s PCK in terms of delivering developmentally appropriate feedback and providing modified tasks that are aligned with students’ different skill levels will result in significantly increasing ball velocity scores.

*Meaningfulness of Changes in Throwing Ball Velocity*

The results from this study revealed that 75 percent of students in Justin’s experimental classes and 68 percent of students in Izzy’s experimental classes had a gain of at least 3mph from the pre to posttest. The reason why the ball velocity increased from pre-to posttest may be related to improvement in the students’ throwing patterns. In other words, improvements in process measures of throwing (body components) resulted in improvements in product measures of throwing. For example, more students in the experimental classes demonstrated a contralateral step, trunk rotation, humerus and forearm lag which allows for a greater ability to generate power and increase ball velocity.

*Retention Test Ball Velocity*

Hypothesis 3 suggested there would be statistically significant differences at the retention test for throwing velocity between the experimental and comparison classes. The independent samples *t*-test revealed significant differences in retention test velocity mean scores between the two conditions (experimental and comparison) for both teachers. As with the body component data, the results showed that the velocity scores of students in the experimental classes were still better than the comparison classes at the retention test. Therefore, the findings of this study support that there was a lasting effect of the teacher’s PCK on the student’s ball velocity score in the experimental classes.
other words, students in the experimental classes truly learned the throwing skill as after
time away from throwing they could still produce a good throwing pattern.

Conceptual Contributions

Operational Definition of PCK

The term PCK is widely used in general education as well as physical education, but it has not been clearly defined and conceptualized (Rovegno et al., 2003). The lack of a functional definition for PCK has resulted in the difficulty of observing, measuring, and analyzing PCK in physical education (Ayvazo, 2007). Therefore, Ayvazo (2007) and Ward (2009b) conceptualized an operational definition of PCK and Kim (2011) and Lee (2011) conducted research to identify levels of PCK for secondary physical education that allowed the researchers to observe and measure PCK. Furthermore, Kim (2011) and Lee (2011) investigated changes in levels of PCK after an intervention (CK workshop). However, the functional definition of PCK that Kim (2011) and Lee (2011) used was developed within a secondary physical education framework and thus lacked coherence for the current study in elementary physical education. It was necessary to develop a functional definition of PCK in elementary physical education before being able to determine the critical components of PCK, how they can be measured, and how they influence PCK. Consequently, the following operational definition of PCK was identified in this study:

**Pedagogical content knowledge (PCK) is an emergent phenomenon where teachers use different knowledge bases to make pedagogical decisions that are aligned to a child’s developmental level and are context specific.**
This definition was proposed based on the unique context of an elementary physical education environment, such as a wide range of developmentally different student skill levels, the teacher’s different instructional approaches (i.e., individualized instruction) and the nature of the tasks. In addition, this operational definition was the basis upon which to select variables that played as indicators for determining the existence of PCK in the teacher’s instruction in lower elementary physical education. As a result, this study is unique in that it is the first to define new operational PCK variables and develop corresponding assessments considering the features of lower elementary physical education.

**Components that Influence PCK**

The research has consistently demonstrated that improved teacher CK results in the development of teacher PCK (Creasy et al., 2012; Jenkins et al., 2005; Jenkins & Veal, 2002; Kim, 2011; Kutame, 2002; Lee, 2011; Rovegno et al., 2003; Walkwitz & Lee, 1992). However, the current study was conducted based on the assumption that other knowledge bases may also influence the teacher’s PCK. Many researchers have suggested that CK is critical to develop teacher PCK, but other knowledge bases can also be significant factors that influence teacher PCK (Ball et al., 2008; Grossman, 1990; Grossman, et al., 2005; Gudmundsdottir & Shulman, 1987; Shulman, 1987). Therefore, four teacher knowledge bases were manipulated through the professional development workshop to help the teachers improve their PCK in this study; (a) content knowledge; (b) knowledge of students; (c) knowledge of instructional strategies (pedagogical knowledge); and (d) knowledge of context.
The results of this study supported the assumption that CK is not only the critical factor of a teacher’s PCK but also other knowledge bases can influence teacher PCK. There are various examples from both teachers that demonstrate that improved teacher knowledge bases results in the development of a teacher’s PCK. For instance, Izzy’s task representations included more critical elements of the throwing skill with correct demonstration (knowledge of instruction strategies) and utilized a variety of equipment (knowledge of context) following the workshop compared to prior to the workshop. Furthermore, Justin provided more modified tasks (content knowledge) aligned to the students’ skill level (knowledge of students) after the workshop. Unlike previous studies, the current study is the first attempt to explore how four knowledge bases can influence developing the teacher’s PCK. Especially, the component of ‘Knowledge of Students’ was significant for exploring the teacher PCK in this study. For example, the total body (Haubenstricker et al., 1983) and component (Roberton & Halverson, 1984) developmental sequences of overhand throwing was introduced in the workshop. These qualitative measurement tools describes the different developmental levels of throwing performance and helps the teacher develop the ability to detect the student’s different skill level of throwing performance.

Strengths and Limitations of the Study

Strengths of the Study

Much of the previous research on PCK has used descriptive and qualitative approaches (Benham, 2002; Chen, 2002, 2004; Jenkins & Veal, 2002; Kutame, 2002; McCaughtry, 2001; McCaughtry & Rovegno, 2003; Schincariol, 2002; Whipple, 2002).
Recently, Kim (2011) and Lee (2011) conducted a study using a quantitative approach. Those studies (Kim, 2011; Lee, 2011) contributed to providing observable teacher’s PCK variables and examining the relationship between CK and PCK as well as PCK and student learning. However, operational variables of PCK and the way of measuring the relationship between teachers’ PCK and student learning that were used in previous studies (Kim, 2011; Lee, 2011) were utilized differently in this study.

1) PCK Variables

Three teacher’s PCK variables (i.e., task maturity, task appropriateness and task adaptations) were defined and measured with sub-components in previous studies (Kim, 2011; Lee, 2011). These PCK variables were significant to examine the teacher’s PCK at the secondary physical education level. However, it is difficult to apply these PCK variables to the elementary school level because of the different environment in lower elementary physical education. Therefore, the author modified and proposed four PCK variables suitable for elementary physical education; (a) Task representation; (b) Task demonstration; (C) Frequency and type of feedback; and (d) Task modification alignment.

Correct task representation and demonstration were utilized to identify the teacher’s PCK at the class level. These variables had previously been proposed by Kim (2011) and Lee (2011). However, correct task representation and demonstration were defined differently and measured in this study. According to Kim (2011) and Lee (2011) mature task representations were defined as the teachers’ statement, including verbal and/or visual explanations with a clear task statement of criteria, situation, and behavior
In measuring task demonstration, Lee (2011) only collected the frequency of task demonstrations in his study. Kim (2011) analyzed the correct, incorrect, and partial demonstrations by the teacher, but the specific criteria on which demonstrations were correct or incorrect were not described in her study. Unlike previous studies, this study focused more on the teacher’s statement of critical elements for throwing performance while representing the task as the content being taught by the teacher was focused on one, fundamental motor skill. In order to teach throwing, a teacher needs to know the critical elements of throwing. Furthermore, specific criteria were utilized to determine the correctness of the teachers’ demonstrations for throwing performance in this study.

The teacher’s feedback was also used as one of the variables to measure the teacher’s PCK in previous studies (Kim, 2011; Lee, 2011). Kim (2011) and Lee (2011) analyzed how much the frequency of feedback by teachers increased after the workshop. The current study focused more on both frequency of feedback, and the nature of feedback including DAF, DIF, and general feedback. This study was particularly interested in increasing DAF that was aligned to skill performance and decreasing DIF and GF. According to Cohen et al. (2012), delivering developmentally appropriate feedback resulted from improving the teacher’s CK and PCK. The teacher’s ability to deliver feedback that is individualized and developmentally aligned to a student performance can be a valuable variable that determines whether teachers have strong PCK.

Finally, the teacher’s task modification alignment was included as a new variable in this study. This variable was an important variable in this study as one of the
underlying premises of a teacher with mature PCK was the ability to align tasks to the developmental level of the student thus engaging in individualized and developmentally appropriate instruction. The basic concept of task modification alignment was similar to the task appropriateness (i.e., developmentally appropriate task) and task adaptation (i.e., inter-task or intra-task adaptation). These two variables were considered as an indicator of PCK in previous studies (Ayvazo, 2007; Kim, 2011; Lee, 2011).

In this study, the author simplified these variables as a task modification alignment to examine whether the task modification by the teacher is aligned or not aligned with the student’s individual skill level. The variable of task modification alignment contributed to the examination of the teacher’s ability to select appropriate tasks and modify tasks considering students skill level and was a measure of their PCK maturity.

2) Measuring the Relationship between Teachers’ PCK and Student Learning

In the previous studies, the relationship between the teacher’s PCK and student learning was measured using quantitative approaches such as a momentary-time sampling strategy (Lee, 2011) and non-parametric tests (Kim, 2011). These methodological approaches were an innovative way to explore how the teacher’s PCK influenced student’s achievement. However, there were limitations in both studies (Kim, 2011; Lee, 2011). A major disadvantage of momentary-time sampling is that it can underestimate a student's performance because the student may perform throughout much of an interval, (i.e., 3 minutes in Lee, 2011) but stop right before the end of the interval. In this case, momentary time sampling would not capture the occurrence of student learning.
Furthermore, all students’ learning in the comparison and experimental groups were not measured in Kim’s (2011) study. Therefore, both process (the quality of throwing performance) and product (the outcome of throwing performance) measurements for each student’s performance were analyzed using an experimental approach in this study. The methodological approach in this study contributed to the literature to provide accurate and valuable student data and to support the findings of the teacher data for examining the relationship between the teacher’s PCK and student learning.

**Limitations of the Study**

There were some limitations in this study. First, teachers’ teaching experiences and familiarity with teaching overhand throwing may have affected the results because the researcher purposefully selected the teachers and the school for the study. Both teachers in this study had different teaching experiences and they had differing knowledge about teaching overhand throwing prior to the study. For example, Justin had baseball coaching experience whereas Izzy had very little experience with teaching throwing.

Second, teachers’ teaching styles and preferences may have affected the results of this study. For example, Justin preferred visual representation such as demonstration but Izzy was more likely to use verbal representation such as feedback. In addition, Izzy preferred station based teaching. This may have influenced the results of the data on teaching behaviors and student performance.

Third, the teacher professional development workshop in this study was deemed a ‘Package Intervention’ unlike the workshop (CK workshop) conducted in previous
studies (Kim, 2011; Lee, 2011). In this workshop package, the researcher intervened on changes of the teacher’s CK as well as other knowledge bases (knowledge of students, knowledge of context, and knowledge of instructional strategies). Therefore, it was not possible to determine exactly what part of the teacher’s knowledge base was influenced in the workshop and how this may have influenced the teacher’s PCK. For example, this study found the teacher’s ability to modify the task that aligned to student’s different skill level increased after the workshop. However, it was difficult to decide whether this finding was derived from development of teacher’s CK or increase of teacher’s knowledge of students.

Finally, the presence of the researcher and assistants on site and videotaping each lesson and the three test sessions (pre, post, retention) may have affected the results. The students may have reacted because the researcher videotaped their throwing performance at the three test sections. Furthermore, the teachers’ teaching might have been influenced because the researcher and assistants observed and analyzed their teaching behaviors for all lessons.

**Implications and Future Research**

**Implications**

The following implications represent for P-12 teachers based on findings from the study. This study revealed that teacher knowledge bases (CK, knowledge of students, knowledge of instructional strategies, and knowledge of context) can be developed through the professional development workshop and subsequently developed knowledge bases can impact the teacher’s PCK. Thus:
1. Inservice teachers should continue to engage in their professional development on knowledge bases related to teaching FMS such as throwing.

2. Preservice teachers should be trained on knowledge bases in the workshop to enhance their knowledge bases and PCK.

3. Teachers should have a deep understanding of the content they teach their students, instructional strategies effective to improve student learning, and context such as the use a variety of equipment to motivate students for learning new skills. When this occurs PCK can increase.

4. Instruction and practice in overhand throwing unit consisting of 120 minutes (four, 30 minute sessions) can have positively effects on improving the throwing performance and ball velocity of first and second grade students.

Although there is no direct evidence of these issues, some more detailed implications were abstracted from the workshop delivered to the teachers:

1. Task representation should be simple and easy to understand with one or two critical elements of a movement. Too much information makes the student overwhelmed, especially for students in an elementary school level.

2. Skills or movements should be demonstrated correctly with critical elements of the skill. Incorrect task demonstrations can cause students to follow incorrect skill performance or movement.

3. Feedback statements should be aligned to the student’s skill level. It would be more effective than giving general feedback and will improve student learning.
4. Modified tasks based on student’s skill level would be effective for individual students. One task may be appropriate for a single student, but it may be inappropriate for other students.

5. Teachers should continue to engage in their professional development to extend their knowledge of content and acquire new information related to their teaching.

The following implications represent findings based from this study to the physical education teacher education (PETE) program:

1. Physical education teacher education (PETE) programs need to provide classes and opportunities to help student teachers develop their knowledge bases and PCK.

2. PETE programs should organize content course that allows student teachers to develop their ability to observe, analyze, and differentiate students’ performance.

3. PETE programs should develop teacher knowledge bases with knowledge packets.

4. PETE programs should utilize qualified mentors and supervisors to provide student teachers with specific teaching practices and to create the supportive system, including providing feedback or guidance to student teachers’ PCK.

**Recommendations for Future Research**

This study provides evidence that the teacher professional workshop focusing on developing teacher knowledge bases positively affects the teacher’s PCK and the changes of the teacher’ PCK results in improving students’ throwing performance. The following
recommendations are made in order to obtain a better understanding of the teacher’s PCK relative to the teaching motor skills for children. Future studies should:

1. Investigate the influence of the teacher’s PCK on student learning in different fundamental motor skills (FMS).

2. Explore the difference of teacher’s knowledge bases and PCK between the experienced teachers and novice teachers, and how this different level of expertise can have an effect on learning FMS for students.

3. Investigate the relationship between the teacher’s previous experiences such as sports background and teaching experiences in the content and the teacher’s knowledge bases as well as PCK and how this relationship can influence student leaning of FMS.

4. Investigate the inter-relationship among the teacher’s PCK, practice time, and student learning for FMS.

5. Be conducted in naturalistic settings where the teacher needs to teach FMS to a large group of students (more than 20 students per class).

6. Add or modify variables of PCK based on the purpose of the study.

7. Include more teacher participants for generality.

8. Develop and utilize the knowledge packets that can cover different FMS.

9. Need to utilize more visualized format of knowledge packet rather than a document format.

10. Replicate this study with other grade levels, examining the effect of the teacher’s PCK on the student’s performances in other grades.

11. Consider both quantitative and qualitative perspective of the teacher’s PCK.
12. Use video stimulated recall to get at why teachers make the instructional decisions they do relative to changing or not changing an instructional task.
References


Appendix A: Human Subjects Institutional Review Board Letter
November 22, 2013

Protocol Number: 2013B0-482
Protocol Title: THE EFFECTS OF PROFESSIONAL DEVELOPMENT WORKSHOP ON TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE AND STUDENT LEARNING IN ELEMENTARY SCHOOL PHYSICAL EDUCATION, Jacqueline Goodway, Seung Ho Chang, Human Sciences

Type of Review: Initial Review—Expedited
IRB Staff Contact: Jacob R. Stoddard
Phone: 614-292-0526
Email: stoddard.13@osu.edu

Dear Dr. Goodway,

The Behavioral and Social Sciences IRB APPROVED BY EXPEDITED REVIEW the above referenced research. The Board was able to provide expedited approval under 45 CFR 46.110(b)(1) because the research meets the applicability criteria and one or more categories of research eligible for expedited review, as indicated below:

Date of IRB Approval: November 22, 2013
Date of IRB Approval Expiration: November 22, 2014
Expedited Review Category: 6, 7

In addition, the research was approved for the inclusion of children (permission of one parent sufficient).

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).

This approval is valid for one year from the date of IRB review when approval is granted or modifications are required. The approval will no longer be in effect on the date listed above as the IRB expiration date. A Continuing Review application must be approved within this interval to avoid expiration of IRB approval and cessation of all research activities. A final report must be provided to the IRB and all records relating to the research (including signed consent forms) must be retained and available for audit for at least 3 years after the research has ended.

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

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

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

Michael Edwards, PhD, Chair
Behavioral and Social Sciences Institutional Review Board

hr.017-06 Exp Approval New CR.
Version 01/13/09
Appendix B: Example of Coding Sheet for the Teacher’s PCK
Example of Coding Sheet for PCK

<table>
<thead>
<tr>
<th>Group or Individual</th>
<th>Other Interaction</th>
<th>Task representation</th>
<th>Student’s Stage</th>
<th>Demonstration</th>
<th>Feedback</th>
<th>General Feedback</th>
<th>Task Modification</th>
<th>What task modification was given by teacher?</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>C</td>
<td>N/A</td>
<td>v</td>
<td>A/An</td>
<td>Y/N</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>G</td>
<td>I</td>
<td>N/A</td>
<td>v</td>
<td>Y/NC</td>
<td>Y</td>
<td>EM</td>
<td>Y/NC</td>
<td>Y/NC</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
<td>DAF</td>
<td>v</td>
<td>Y</td>
<td>Y</td>
<td>EM</td>
<td>Y/NC</td>
<td>Y/NC</td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td>1-2-3-4-5-6</td>
<td>Y/NC</td>
<td>Y/NC</td>
<td>Y/NC</td>
<td>EM</td>
<td>Y/NC</td>
<td>Y/NC</td>
</tr>
<tr>
<td>G-Group instruction</td>
<td>Y</td>
<td>Correct</td>
<td>1-2-3-4-5</td>
<td>A-Appropriate</td>
<td>Y</td>
<td>EM</td>
<td>Y/NC</td>
<td>Y/NC</td>
</tr>
<tr>
<td>I-Individual instruction</td>
<td>N-No</td>
<td>Incorrect</td>
<td>1-2-3-4-5</td>
<td>I-Inappropriate</td>
<td>Y</td>
<td>EL</td>
<td>Y/NC</td>
<td>Y/NC</td>
</tr>
</tbody>
</table>

Notes:
- Y/NC - Yes/No change (same task)
- EM - Extension task with more difficult
- EL - Extension task with less difficult
- DAF - Developmentally Appropriate Feedback
- DIF - Developmentally Inappropriate Feedback
- A - Appropriate
- I - Inappropriate
Appendix C: Component Developmental Sequences of Overhand Throwing
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

Trunk-1 (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 intersections 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 D: The Check Sheets for the Teacher’s Understanding of Content in the Workshop
The Check Sheets for the Teacher’s Understanding of Content in the Workshop

1) Understanding techniques for overhand throwing
   - The teacher is asked to demonstrate overhand throwing three times.
   - The researcher observes the teacher’s performance of overhand throwing and codes as a correct or incorrect performance for each technique.

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td>Preparatory position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Feet are slightly wider than shoulder width apart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Stand side-on the target</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Eye focused on the target</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force production</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Stepping with opposite foot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Rotate hip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Weight transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Releasing the ball (hi-five position)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow Through</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Movement after releasing the ball</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- The position of throwing hand (Down and across the opposite hip and knee)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2) Understanding total body developmental sequence of overhand throwing
   - The teacher is asked to watch 10 different video clips showing students in different skill levels two times.
   - The teacher identifies which stage the students showed.

<table>
<thead>
<tr>
<th>No</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Video Clip 1</td>
<td></td>
</tr>
<tr>
<td>Video Clip 2</td>
<td></td>
</tr>
<tr>
<td>Video Clip 3</td>
<td></td>
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<td>Video Clip 4</td>
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<td>Video Clip 5</td>
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<td>Video Clip 6</td>
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<td>Video Clip 7</td>
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<td>Video Clip 8</td>
<td></td>
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<tr>
<td>Video Clip 9</td>
<td></td>
</tr>
<tr>
<td>Video Clip 10</td>
<td></td>
</tr>
</tbody>
</table>
3) Understanding body component developmental sequence of overhand throwing
   - The teacher is asked to watch 10 different video clips showing students in
different skill levels two times.
   - The teacher determines which level the students showed for each segment.

<table>
<thead>
<tr>
<th>No</th>
<th>Segment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foot</td>
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<tr>
<td>Video Clip 1</td>
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<td>Video Clip 2</td>
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<td>Video Clip 3</td>
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<td>Video Clip 4</td>
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<td>Video Clip 5</td>
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<td>Video Clip 6</td>
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<td>Video Clip 7</td>
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<td>Video Clip 8</td>
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<tr>
<td>Video Clip 9</td>
<td></td>
</tr>
<tr>
<td>Video Clip 10</td>
<td></td>
</tr>
</tbody>
</table>

3) Identifying student’s developmental level of overhand throwing
   - The teacher is asked to watch 15 different video clips showing students in three
different skill levels two times.
   - The teacher determines which developmental level the student showed.

<table>
<thead>
<tr>
<th>No</th>
<th>Skill Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Skill (Stage 1 or 2)</td>
</tr>
<tr>
<td>Video Clip 1</td>
<td></td>
</tr>
<tr>
<td>Video Clip 2</td>
<td></td>
</tr>
<tr>
<td>Video Clip 3</td>
<td></td>
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<tr>
<td>Video Clip 4</td>
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<tr>
<td>Video Clip 5</td>
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<td>Video Clip 6</td>
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<td>Video Clip 7</td>
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<td>Video Clip 8</td>
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<tr>
<td>Video Clip 9</td>
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<td>Video Clip 10</td>
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<tr>
<td>Video Clip 11</td>
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<tr>
<td>Video Clip 12</td>
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<tr>
<td>Video Clip 13</td>
<td></td>
</tr>
<tr>
<td>Video Clip 14</td>
<td></td>
</tr>
<tr>
<td>Video Clip 15</td>
<td></td>
</tr>
</tbody>
</table>
Appendix E: The Witten Tests for the Teacher’s Understanding of Overhand Throwing
Content Knowledge and Evaluation Form
The Written Tests for the Teacher’s Understanding of Contents in the Workshop

1) Understanding total body developmental sequence of overhand throwing

- Please fill in the blanks by choosing a word from the square-

<table>
<thead>
<tr>
<th>The features of stage 1:</th>
<th>Throw -</th>
<th>Step -</th>
</tr>
</thead>
<tbody>
<tr>
<td>The features of stage 2:</td>
<td>Throw (Shot) -</td>
<td>Step -</td>
</tr>
<tr>
<td>The features of stage 3:</td>
<td>Step -</td>
<td>Trunk Rotation -</td>
</tr>
<tr>
<td>The features of stage 4:</td>
<td>Step -</td>
<td>Trunk Rotation -</td>
</tr>
<tr>
<td>The features of stage 5:</td>
<td>Step -</td>
<td>Body Rotation -</td>
</tr>
</tbody>
</table>

2) Understanding body component developmental of overhand throwing

- Please describe the feature of each stage for each segment-

**Step**

Stage 1:
Stage 2:
Stage 3:
Stage 4:

**Trunk Action**

Stage 1:
Stage 2:
Stage 3:

**Back Swing**

Stage 1:
Stage 2:
Stage 3:
Stage 4:
3) Understanding core principle of overhand throwing

**True (T) and False (F)**

Q1) Improving the ability to identify student’s developmental skill level is the first step to teach overhand throwing (         ).

Q2) The teacher should focus on throw overhand for accuracy rather than for force (         ).

Q3) Slow motion for throwing should be emphasized by the teacher (         ).

Q4) The teacher should demonstrate as often as possible correctly (         ).

Q5) The teacher provides equipment such as poly spot, scarf, sticker, target regardless of developmental level (         ).

Q6) Environmental constraints/supports will be provided in the early stages and gradually withdrawn as the student moves through the developmental stages (e.g. use footprints to get a step then take them away) (         ).

Q7) The cues or feedback should be provided based on the student’s skill level (         ).

Q8) The task progression (extension) can be designed for all students (         ).

Q9) The activities or games related to overhand throwing should be complex and difficult because the students will be bored if those activities or games are easy to play (         ).

Q10) All students should have to chances to throw the ball as much as they can and then they work together in throwing and other fundamental motor skill such as catching and running (         ).
4) Understanding students in different skill level of overhand throwing

Q1) What are common errors in each skill level?
   Students in low skill:
   Students in average skill:
   Students in high skill:

Q2) What are the most important focuses of instruction of overhand throwing in each skill level?
   Students in low skill:
   Students in average skill:
   Students in high skill:

Q3) What are the most appropriate cues for teaching overhand throwing to students in each skill level?
   Students in low skill:
   Students in average skill:
   Students in high skill:

Q4) What would you like to focus on when you provide the task for overhand throwing to students in different skill levels?
   Students in low skill:
   Students in average skill:
   Students in high skill:
Appendix F: Treatment Integrity Checklists for the Workshop
### TREATEMENT INTEGRITY CHECKLIST FOR THE WORKSHOP

<table>
<thead>
<tr>
<th>Content</th>
<th>Checklists &amp; Checkpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session 1 (The first day)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Introduction to the workshop</strong></td>
<td>- Explanation of the purpose of workshop – 1 point</td>
</tr>
<tr>
<td>- The purpose of the workshop</td>
<td>- Explanation of the goals of the workshop – 1 point</td>
</tr>
<tr>
<td>- The goals of the workshop</td>
<td>- Explanation of expectations of the researcher – 1 point</td>
</tr>
<tr>
<td>- Expectations of the researcher</td>
<td></td>
</tr>
<tr>
<td><strong>Techniques of overhand throwing</strong></td>
<td>- Explanation of preparatory position - 1 point</td>
</tr>
<tr>
<td>1) Preparatory position</td>
<td>- Explanation of force production - 1 point</td>
</tr>
<tr>
<td>2) Force production</td>
<td>- Explanation of follow Through - 1 point</td>
</tr>
<tr>
<td>3) Follow Through</td>
<td>- Demonstrations by the researcher - 2 points</td>
</tr>
<tr>
<td></td>
<td>- Showing pictures – 1 point</td>
</tr>
<tr>
<td></td>
<td>- Practice trials for the teacher - 2 point</td>
</tr>
<tr>
<td></td>
<td>- Conducting teacher assessment – 1 point (TOTAL: 9 points)</td>
</tr>
<tr>
<td><strong>Total body developmental sequences</strong></td>
<td>- Explanations of each stage (1pt/stage) - 5 points</td>
</tr>
<tr>
<td>- Components of each stage</td>
<td>- Demonstrations of each stage (1pt/stage) - 5 points</td>
</tr>
<tr>
<td>- Critical elements</td>
<td>- Showing pictures (1pt/stage) - 5 points</td>
</tr>
<tr>
<td></td>
<td>- Showing 5 video clips (1pt/video) - 5points</td>
</tr>
<tr>
<td></td>
<td>- Practice trials for the teacher - 2 point</td>
</tr>
<tr>
<td></td>
<td>- Conducting teacher assessment - 1point (TOTAL: 23 points)</td>
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<tr>
<td><strong>Body component developmental sequences</strong></td>
<td>- Explanations of each component (1pt/component)- 13 points</td>
</tr>
<tr>
<td>- Components of each stage</td>
<td>- Demonstrations of each component (1pt/component)- 13 points</td>
</tr>
<tr>
<td>- Critical elements</td>
<td>- Showing 5 video clips (1pt/video) - 5points</td>
</tr>
<tr>
<td></td>
<td>- Practice trials for the teacher - 2 point</td>
</tr>
<tr>
<td></td>
<td>- Conducting teacher assessment - 1point (TOTAL: 34 points)</td>
</tr>
<tr>
<td><strong>Evaluation for contents of the first training session</strong></td>
<td>- Conducting a short version of written test – 1point (TOTAL: 1 point)</td>
</tr>
<tr>
<td><strong>Total Points</strong></td>
<td><strong>70 Points</strong> in Day 1</td>
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</tbody>
</table>
## Session 2 (The second day)

### Content

<table>
<thead>
<tr>
<th>Going over previous contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Techniques of overhand throwing</td>
</tr>
<tr>
<td>- Total body and component developmental sequences</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Checklists &amp; Checkpoints</th>
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</thead>
<tbody>
<tr>
<td>- Going over contents in the first day – 2point (TOTAL: 2 points)</td>
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</table>

<table>
<thead>
<tr>
<th>Core principles of overhand throwing tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Explanation of each core principle (1pt/principle)- 5 points</td>
</tr>
<tr>
<td>- Conducting T &amp; F test – 1 point (TOTAL: 5 points)</td>
</tr>
</tbody>
</table>

### Teaching students in low skill level

| - Common errors of performer |
| - Focus of instruction |
| - Potential teaching cues & feedback statements |
| - Potential tasks and progressions and factors can be manipulated |
| - Potential throwing activities |

<table>
<thead>
<tr>
<th>Checklists &amp; Checkpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Explanation of common errors of performer - 4 points</td>
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<tr>
<td>- Explanation of focus of instruction - 5 points</td>
</tr>
<tr>
<td>- Explanation of potential teaching cues- 3 points</td>
</tr>
<tr>
<td>- Explanation of potential feedback statements - 3 point</td>
</tr>
<tr>
<td>- Explanation of potential tasks - 3 point</td>
</tr>
<tr>
<td>- Explanation of potential progressions - 3 point</td>
</tr>
<tr>
<td>- Explanation of potential throwing activities - 2 point</td>
</tr>
<tr>
<td>- Demonstrations of common errors of performer - 4 point</td>
</tr>
<tr>
<td>- Practice trials for the teacher - 2 point</td>
</tr>
<tr>
<td>- Using check sheet – 1 point</td>
</tr>
<tr>
<td>- Conducting written test – 1 point (TOTAL: 31 points)</td>
</tr>
</tbody>
</table>

### Teaching students in average skill level

| - Common errors of performer |
| - Focus of instruction |
| - Potential teaching cues & feedback statements |
| - Potential tasks and progressions and factors can be manipulated |
| - Potential throwing activities |

<table>
<thead>
<tr>
<th>Checklists &amp; Checkpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Explanation of common errors of performer - 4 points</td>
</tr>
<tr>
<td>- Explanation of focus of instruction - 7 points</td>
</tr>
<tr>
<td>- Explanation of potential teaching cues- 5 points</td>
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<tr>
<td>- Explanation of potential feedback statements - 4 point</td>
</tr>
<tr>
<td>- Explanation of potential tasks - 3 point</td>
</tr>
<tr>
<td>- Explanation of potential progressions - 3 point</td>
</tr>
<tr>
<td>- Explanation of potential throwing activities - 2 point</td>
</tr>
<tr>
<td>- Demonstrations of common errors of performer - 4 point</td>
</tr>
<tr>
<td>- Practice trials for the teacher - 2 point</td>
</tr>
<tr>
<td>- Using check sheet – 1 point</td>
</tr>
<tr>
<td>- Conducting written test – 1 point (TOTAL: 36 points)</td>
</tr>
<tr>
<td>Teaching students in high skill level</td>
</tr>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>- Common errors of performer</td>
</tr>
<tr>
<td>- Focus of instruction</td>
</tr>
<tr>
<td>- Potential teaching cues &amp; feedback statements</td>
</tr>
<tr>
<td>- Potential tasks and progressions and factors can be manipulated</td>
</tr>
<tr>
<td>- Potential throwing activities</td>
</tr>
<tr>
<td>- Explanation of common errors of performer - 4 points</td>
</tr>
<tr>
<td>- Explanation of focus of instruction - 6 points</td>
</tr>
<tr>
<td>- Explanation of potential teaching cues - 3 points</td>
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<tr>
<td>- Explanation of potential feedback statements - 3 points</td>
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<tr>
<td>- Explanation of potential tasks - 4 point</td>
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<td>- Explanation of potential progressions - 4 point</td>
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<tr>
<td>- Explanation of potential throwing activities - 2 point</td>
</tr>
<tr>
<td>- Demonstrations of features of performer - 4 point</td>
</tr>
<tr>
<td>- Practice trials for the teacher - 4 point</td>
</tr>
<tr>
<td>- Using check sheet – 1 point</td>
</tr>
<tr>
<td>- Conducting written test – 1 point (TOTAL: 36 points)</td>
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<table>
<thead>
<tr>
<th>Wrap up</th>
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</thead>
<tbody>
<tr>
<td>- Reflecting on what he/she has learned &amp; what he/she will do differently in teaching overhand throwing</td>
<td>-Wrapping up the workshop – 1 point (TOTAL: 1 point)</td>
</tr>
</tbody>
</table>

| Total Points | 110 Points in Day 2 |
Appendix G: The Knowledge Packet for Teaching Overhand Throwing
Teaching
Overhand Throwing
Importance of Overhand Throwing

- Overhand throwing is one of the most functionally useful Fundamental Motor Skill (Gallahue, Ozmun & Goodway, 2012).

- It is an intrinsic skill in sports like baseball and softball and the most critical skill in sports such as basketball, cricket and football.

- The presence of all or part of overhand throwing is the patterns of throwing motion in sports skills such as the tennis serve, the overhead clear in badminton, spiking in volleyball (Butterfield & Loovis, 1993; East & Hensley, 1985), javelin throw in track and field, and netball shoulder pass.

- The proficiency of throwing is important to participate in the activities occurring in schools and communities in North America (McKenzie et al., 1998).

![Relationship between overhand throwing and Specific Sports Skill](image)
Characteristics of a Proficient Thrower

*Proficient throwers demonstrate the following:*
- Long contralateral step
- Segmental rotation of the trunk where the hip rotates first, followed by the spine, shoulder, humerus and forearm.
- Humerus lags behind trunk
- Forearm lags behind humerus
- Throwing arm follows-through across body

(Gallahue, Ozmun & Goodway, 2012)

Equipment for Overhand Throwing

**Ball**

Many different types of balls can be used for overhand throwing performance based on students’ skill level and age, tasks and activities.

1) Yarn ball
2) Form ball
3) Beanbag
4) Rubber ball
5) Tennis ball

**Poly spots**

Poly spots and scarf can be used to fix student’s incorrect stepping performance.

**Scarf**

**Targets** (Stick to a wall at shoulder height or higher on a wall)
Techniques of Overhand Throwing

1. Preparatory Position
   - Feet are slightly wider than shoulder width apart with comfortable position.
   - Stand side-on to the target.
   - Eyes are focused on the target.

2. Force Production
   - Throwing starts with an extended walking step with foot opposite throwing hand.
   - Step should be straight at the target.
   - Rotate hips, body and shoulders to the throwing side.
   - Throwing hand is extended back with the elbow above the shoulder.
   - Weight transfers to the front foot as arm comes forward and over the top.
   - Ball is released at a "high five" position with wrist snap toward the target.

3. Follow Through
   - After release the body continues forward rotation until the throwing shoulder is pointing at the target
   - Throwing hand follows through down and across the opposite hip and knee.
Total Body Developmental Sequence of Overhand Throwing

(Haubenstricker, Branta, & Seefeldt, 1983)

**Stage 1**
- No step
- Throwing motion is posterior-anterior in direction
- Little trunk rotation (no spinal rotation)

**Stage 2**
- Ipsilateral or contralateral step
- Block rotation
- Horizontal wind-up

**Stage 3**
- Ipsilateral step
- Ball is placed into throwing position above the shoulder by a vertical and posterior motion of the arm at the time that the ipsilateral leg is moving forward
- Little rotation of the spine and hips
- Follow-through across body
**Stage 4**

- Contralateral step
- Little or no rotation of the hips and spine during wind-up
- High win-up
- Stride forward with contralateral leg provides a wide base of support and stability
- Follow-through across body

**Stage 5**

- Contralateral step
- Downward arc wind-up
- Segment body rotation
- Mature movement pattern

* Descriptions for each stage come from Gallahue, Ozmun & Goodway (2012).*
Body Component Developmental Sequence of Overhand Throwing  
(Roberton & Halverson, 1984)

*Foot (Step) Action Component*

**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 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.
Preparatory Arm Backswing Component

**B1. No backswing.** The ball in the hand moves directly forward to release from the arm’s original position when the hand first grasped the ball.

**B2. Elbow and humeral flexion.** 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.

**B3. Circular, upward backswing.** 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.

**B4. Circular, downward backswing** 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.

![Step 2](image1)

![Step 4](image2)

Humerus (Upper Arm) Action Component 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.

![Step 2](image3)

![Step 3](image4)
**Forearm Action Component 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.

---

**Core Principles of Overhand Throwing Tasks**

- **Identifying students’ developmental level of throwing performance**
  - The teacher will have knowledge of students’ skill level to effectively teach them.
  - The teacher will recognize the current developmental level of the child and positively reinforce developmental progression through the stages (e.g. if a performer steps ipsilaterally then positively reinforce the step and provide feedback on stepping with opposition next time).

- **Emphasizing the force and stepping**
  - The teacher will focus on throw overhand for force “throw really hard” with contralateral stepping.
  - The teacher will teach fast motion for force. Do not teach slow motion.

- **Task representation & Demonstration**
  - The teacher should represent the task with critical elements of throwing performance (e.g., “Step with opposite foot” or “Rotate your trunk”)
  - The teacher will always demonstrate an efficient throwing pattern regardless of developmental level.
  - The teacher will demonstrate as often as possible correctly.
• Environmental factors
  o The teacher will provide equipment based on students’ skill level
    ▪ Early children will work with low bounce balls, bean bags and fleece balls to maximize learning trials. Later children will throw tennis balls. Hand size to ball size will be considered.
  o The teacher will use the targets to increase speed but not mention or reinforce the accuracy.
  o Environmental constraints/supports will be provided in the early stages and gradually withdrawn as the child moves through the developmental stages (e.g. use foot prints to get a step then take them away).

• Providing appropriate tasks
  o The teacher will push the student to the efficient form but task extensions will manipulate distance, then accuracy, then add partners to extend and simplify the task.
  o Early on throwing drills will be individualized with each child having multiple balls – later children will work together in throwing and catching drills.

Teaching Overhand Throwing

A. Throwers in low skill level
- Throwers in low skill level are usually matched with stage 1 and 2 based on total body developmental sequence (Haubenstricker, Branta, & Seefeldt, 1983).

1) Common errors of performer

<table>
<thead>
<tr>
<th>Component</th>
<th>Features</th>
</tr>
</thead>
</table>
| Step      | - Feet do not move  
- Step same hand same foot (ipsilateral step) or opposite foot (contralateral step but short step) |
| Trunk     | - No trunk rotation  
- Little trunk rotation |
| Backswing | - No backswing |
2) Most important focus of instruction
- Getting the step: step toward the target with opposite foot.
- Sideways orientation: stand with non-throwing side of the facing target.
- Trunk rotation: rotate the hips when the throwing arm moves forward.
- Focusing on throw for force (no accuracy) otherwise a ‘dart’ action may develop.
- Lots of trials.

3) Potential teaching cues & feedback statements

<table>
<thead>
<tr>
<th>Component</th>
<th>Teaching Cues</th>
<th>Feedback Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>- Eyes of target</td>
<td>- Step toward target</td>
</tr>
<tr>
<td></td>
<td>- Straddle the line</td>
<td>- Step with your opposite (sticker) foot</td>
</tr>
<tr>
<td>Step</td>
<td>- Step forward as you throw</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Step with opposite foot</td>
<td></td>
</tr>
<tr>
<td>Trunk</td>
<td>- Point your laser beam</td>
<td>- Turn your hips/belly button to the target</td>
</tr>
<tr>
<td></td>
<td>- Side to target, point to target</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Untwist your hips and point your belly button to the target</td>
<td></td>
</tr>
</tbody>
</table>

4) Potential tasks for children & Factors can be manipulated

<table>
<thead>
<tr>
<th>No</th>
<th>Tasks</th>
<th>Factors</th>
</tr>
</thead>
</table>
| 1  | Have students step on poly spot or foot print with sticker or scarf on foot but no ball.  
   a) After many trials students can get beanbag and throw. | 1. Sticker or scarf  
   2. Poly Spot & Foot print  
   3. Throwing objects |
| 2  | Throw beanbag about 10 feet from the wall to hit the wall with sticker or scarf on foot.  
   a) If students are constantly hitting the wall – have them take a few steps further back.  
   b) If student’s ball does not quiet get to the ball – have them move a couple of steps closer. | 1. Distance from the wall  
   2. Sticker or scarf |
| 3  | Throw yarn ball about 15 feet from the wall to hit the large target with sticker or scarf on foot. | 1. Distance from the wall  
   2. Type of the |
2) Most important focus of instruction
- Getting long contralateral step
- Trunk rotation: rotate the hips when the throwing arm moves forward
- Getting downward backswing
- Arm back
- Focusing on throw for force (no accuracy)
- Weight on back foot
- Lots of trials

B. Throwers in average skill level
- Throwers in average skill level are usually matched with stage 3 or 4 based on total body developmental sequence (Haubenstricker, Branta, & Seefeldt, 1983).

1) Common errors of performer (Body component approach)

<table>
<thead>
<tr>
<th>Component</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step</td>
<td>- Contralateral step, but short step</td>
</tr>
<tr>
<td>Trunk</td>
<td>- Little trunk rotation</td>
</tr>
<tr>
<td>Backswing</td>
<td>- Elbow and upper arm flexion</td>
</tr>
<tr>
<td></td>
<td>- Circular, upward backswing</td>
</tr>
<tr>
<td>Upper arm &amp; Forearm</td>
<td>- Upper arm aligned but independent.</td>
</tr>
<tr>
<td></td>
<td>- Forearm lag</td>
</tr>
</tbody>
</table>

3. Targets

<table>
<thead>
<tr>
<th>Ball</th>
<th>3. Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) If students are constantly hitting the wall – have them take a few steps further back.</td>
<td></td>
</tr>
<tr>
<td>b) If student's ball does not quiet get to the wall – have them move a couple of steps closer.</td>
<td></td>
</tr>
<tr>
<td>c) The teacher can use different sizes or types of target.</td>
<td></td>
</tr>
</tbody>
</table>
3) Potential teaching cues & feedback statements

<table>
<thead>
<tr>
<th>Component</th>
<th>Teaching Cues</th>
<th>Feedback Statements</th>
</tr>
</thead>
</table>
| Step | - Long step with opposite foot  
- Step on line to target  
- Keep your weight moving | - Step toward target  
- Step with your opposite (sticker) foot |
| Trunk | - Point your laser beam  
- Point your belly button to the target  
- Rotate trunk toward the target and shoulders follow | - Turn your hips fast |
| Backswing | - Palm away, thumb down and away | - Downward backswing  
- Arm way back |
| Upper arm & Forearm | - Make an “L” with your arm and reach  
- Make “High five” position  
- Hold tray of food | - Elbow back  
- Elbow past ear |
| Release | - Throw the tray of food  
- Finish long | |

4) Potential tasks for children & Factors can be manipulated

<table>
<thead>
<tr>
<th>No</th>
<th>Tasks</th>
<th>Factors</th>
</tr>
</thead>
</table>
| 1 | Have children throw form or rubber ball about 10 feet from the wall to hit the target (e.g., pictures of letters, animals, diagrams or numbers) with sticker or scarf on foot.  
  a) If students are constantly hitting the wall – have them take a few steps further back.  
  b) If student’s ball does not quite get to the wall – have them move a couple of steps closer. | 1. Different sizes & types of target  
2. Type of the ball  
3. Sticker or scarf  
4. Distance from the wall |
| 2 | Have children throw tennis ball about 15 feet from the wall to hit the target with sticker on belly button.  
  a) Teacher need to check that sticker on bellybutton turns to wall  
  b) If students are constantly hitting the wall with rotation trunk they can take a few steps further back. | 1. Type of the ball  
2. Sticker on belly button  
3. Distance from the wall |
| 3 | Pair up with two students: one would be a teacher. Student throws the ball to hit the target five times.  
  a) Student teacher checks to see if your student shows  
    - Long contralateral step (Big step)  
    - Trunk rotation  
    - Downside backswing | 1. Peer teaching  
2. Different types of ball  
3. Distance from the wall |
C. Throwers in high skill level
- High skill throwers are usually matched with stage 5 based on total body developmental sequence (Haubenstricker, Branta, & Seefeldt, 1983).

1) Features of performer (Body component approach)

<table>
<thead>
<tr>
<th>Component</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step</td>
<td>- Contralateral step, long step</td>
</tr>
<tr>
<td>Trunk</td>
<td>- Differentiated rotation</td>
</tr>
<tr>
<td>Backswing</td>
<td>- Circular, downward backswing</td>
</tr>
<tr>
<td>Upper arm &amp; Forearm</td>
<td>- Upper arm lags</td>
</tr>
<tr>
<td></td>
<td>- Delayed forearm lag</td>
</tr>
</tbody>
</table>

2) Most important focus of instruction
- Focusing on throw for force as well as accuracy
- Providing diverse environments and tasks
- Getting downward backswing constantly
- Weight on back foot and transfer to forward foot
- Wrist snaps downward
- Finish with arm across opposite hip, thumb pointing down and back

3) Potential teaching cues & feedback statements

<table>
<thead>
<tr>
<th>Component</th>
<th>Teaching Cues</th>
<th>Feedback Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backswing</td>
<td>- Big as a bird</td>
<td>- Arm far back</td>
</tr>
<tr>
<td></td>
<td>- Wings of an eagle</td>
<td>- Nice wind-up</td>
</tr>
<tr>
<td>Upper arm &amp; Forearm</td>
<td>- Keep an “L” position</td>
<td>- Elbow back</td>
</tr>
<tr>
<td></td>
<td>- The arm down, back, throw</td>
<td></td>
</tr>
</tbody>
</table>
4) Potential tasks for children in this level

<table>
<thead>
<tr>
<th>No</th>
<th>Tasks</th>
<th>Factors</th>
</tr>
</thead>
</table>
| 1  | **Pair up with two students:** one student stands behind the thrower and holds the throwing object for the thrower to reach back to and grasp. The other student grabs the ball from the partner to make “L” position and throws the ball five times.  
  a) Check arm moves back and make “L” shape with arm  
  b) Use different types of the ball  
  c) Change the role when one student throws 5 times | 1. Cooperative learning  
  2. Type of the ball |
| 2  | Have children throw tennis ball about 15 feet from the wall to hit the target **with sticker on opposite hip.**  
  a) Teacher need to check that student throws and follows through to opposite hip.  
  b) If students are hitting the wall with follow through they can take a few steps further back. | 1. Sticker on opposite hip  
  2. Distance from the wall |
| 3  | Make targets (e.g., letters, numbers or animals) and stick to the wall.  
  a) Students throw the ball as hard as they can to hit the target teacher points out (e.g., if teacher says “Feed monkey” students throw the ball to the target of monkey as fast as they can).  
  b) If students are constantly hitting the each target based on teacher’s direction they can take a few steps further back.  
  b) This task is for force as well as accuracy | 1. Distance from the wall  
  2. Accuracy of throwing  
  3. Different types of target |
| 4  | **Provide a variety of throwing activities and games**  
  - Provide the activities that are the blend of different fundamental motor skills such as throwing catching or throwing the ball while running to hit the target. | 1. Difficulty of tasks |
Throwing Activities

Throwing eggs to the nest
- **Object of game**: to throw the balls into a nest with stepping with opposite foot
- **Description of activity**
  a) One group of 7 students have basket with 35 balls (e.g., form ball or yarn ball)
  b) Place three hula hoops in a line at 20 feet, 30 feet, 40 feet and 50 feet away from the start line. Ploy spots are placed in start line to help students step with opposite foot and throw
  c) Teacher picks one distance that challenges the children throw far and says “Step and throw the egg to the nest (hula hoops)” when everyone is ready. Students throw the ball as far/hard as they can at the same time with stepping on poly spot
  d) After five trials for each student, students run to count how many balls are in the nest and retrieve their balls
  e) Rotate the other group and follow same procedures above.

Knocking out ice cream
- **Object of activity**: To knock the ice cream (big or small beach ball) off the cone (bucket) using correct overhand throwing form
- **Description of activity**
  a) Place big/small beach ball on top of an empty bucket and place it in the middle of big circle
  b) Students are outside the big circle with a ball in their hands facing inside of the circle.
  c) Students throw the ball as fast/many as they can to knock the ice cream from the cone. If the ice cream knocks off teacher puts it on the cone again.
  d) Teacher can use different size of the ice cream and have students step back and forth based on their performance.
Clean out your back yard

- **Object of activity:** To throw as many balls as possible from the throwing team’s side to the opposing team’s side.

- **Description of activity**
  a) Designate two teams:
     1) Offensive team is consisted of one third of the class
     2) Defensive team is consisted of two thirds of the class
  b) Offensive players (OP) throw the balls from hula hoops to opposite area (defensive team’s area and defensive players (DP) try to keep the balls out of there area.
  c) OP can only have one ball in their hand at a time, and must return to the hula hoops to pick up another ball. They can throw the balls only within the throwing zone.
  d) Each participant is throwing in a group during game play for approximately three to five minutes.
  d) Balls are placed in hula hoops having a sufficient amount of yarn balls to be thrown during the game in the baseline area between the wall and the baseline.

Naval Battle

- **Object of activity:** To throw different types of balls using correct overhand technique in a dynamic setting

- **Description of activity**
  a) Place 6 mats equally on each side of the gym with 3 to 4 students per mat (ship).
  b) Set up four bowling pins around each mat as targets and place a scooter (lifeboat) for each team.
  c) Designate someone to ride the lifeboat (scooter) to retrieve balls from the sea (gym floor) and bring them back to their mat (ship).
  d) The students on the mats may catch thrown balls or reach for them on the floor keeping one foot on the mat.
  e) The students on the mat try to knock down the pins at the other mat by throwing balls using correct overhand technique. At least one foot must be on their mat at all times.
Appendix H: The Teachers’ Block Plans for Comparison and Experimental Classes
## Block plans for Justin

### Comparison Classes

<table>
<thead>
<tr>
<th>Task (Min)</th>
<th><strong>Lesson 1</strong></th>
<th><strong>Lesson 2</strong></th>
<th><strong>Lesson 2</strong></th>
<th><strong>Lesson 4</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
</tr>
<tr>
<td></td>
<td>2. Introduction of throwing (5)</td>
<td>2. Going over previous lesson (5)</td>
<td>2. Going over previous lesson (2)</td>
<td>2. Going over throwing performance (2)</td>
</tr>
<tr>
<td></td>
<td>2) How to throw</td>
<td>3. Throwing practice in four different stations (25)</td>
<td>3. Throwing practice in four different stations (20)</td>
<td>3. Throwing activities (25)</td>
</tr>
<tr>
<td></td>
<td>2) Critical elements of throwing</td>
<td>1) Station A: 10 feet from the wall (rubber ball (fleece ball), animal targets)</td>
<td>1) Station A: 10 feet from the wall (rubber balls, animal target)</td>
<td>- Protecting the bowling pins and knowing down</td>
</tr>
<tr>
<td></td>
<td>3. Individual throwing practice (25)</td>
<td>2) Station B: 15 feet from the wall (foam balls, tree targets)</td>
<td>2) Station B: 15 feet from the wall (rubber balls, letter targets)</td>
<td>4. Closure (5)</td>
</tr>
<tr>
<td></td>
<td>1) 10 feet from the wall (rubber balls)</td>
<td>3) Station C: 10 feet from the wall (rubber balls, letter target)</td>
<td>4) Station D: 10 feet from the wall (rubber balls, leaf targets)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) 15 feet from the wall (rubber balls)</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) 20 feet from the wall (rubber balls)</td>
<td>4) Closure (2)</td>
<td>4) Station D: 10 feet from the wall (rubber balls, leaf targets)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Closure (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Equipment

- **Lesson 1**: Rubber balls, Foam balls, Tennis balls.
- **Lesson 2**: Different targets (animal, tree, number, leaf), different ball (rubber ball, fleece ball, foam ball)
- **Lesson 2**: Different targets (letter, animal, number, leaf), different balls (Rubber ball, Fleece ball, Form ball), Small Cones, Bowling Pins
- **Lesson 4**: Rubber ball, Fleece ball, Form ball, Bowling Pins

### Note

- Foam balls for 1st graders
- Rubber balls & Tennis balls for 2nd graders
## Experimental classes

<table>
<thead>
<tr>
<th>Task (Min)</th>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 2</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
</tr>
<tr>
<td>2. Introduction of throwing (5)</td>
<td>2. Going over previous lesson (5)</td>
<td>2. Going over previous lesson (5)</td>
<td>2. Going over throwing performance (3)</td>
<td>2. Going over throwing performance (3)</td>
</tr>
<tr>
<td>1) How to throw</td>
<td></td>
<td>3. Evaluation of individual throwing skill (10)</td>
<td>3. Throwing practice in four different stations (25)</td>
<td>3. Individual practice (5)</td>
</tr>
<tr>
<td>2) Critical elements of throwing</td>
<td>1) Station A: 10 feet from the wall (rubber balls)</td>
<td>1) Station A: 10 feet from the wall (rubber ball, animal targets)</td>
<td>1) Station A: 10 feet from the wall (rubber balls)</td>
<td>4. Throwing activities (22)</td>
</tr>
<tr>
<td>3. Evaluation of individual throwing skill (25)</td>
<td>2) Station B: 15 feet from the wall (tennis balls, tree targets)</td>
<td>2) Station B: 15 feet from the wall (rubber balls, letter target)</td>
<td>2) Station B: 15 feet from the wall (foam balls, tree targets)</td>
<td>1) Clean up your back yard</td>
</tr>
<tr>
<td>1) 10 feet from the wall (rubber balls, beanbags)</td>
<td>3) Station C: 10 feet from the wall (rubber balls, letter target)</td>
<td>3) Station C: 10 feet from the wall (rubber balls, leaf targets)</td>
<td>3) Station C: 10 feet from the wall (rubber balls, leaf targets)</td>
<td>2) Knocking down ice cone</td>
</tr>
<tr>
<td>2) 15 feet from the wall (rubber balls)</td>
<td>4) Station D: 10 feet from the wall (rubber balls, leaf targets)</td>
<td>4) Station D: 10 feet from the wall (rubber balls, leaf targets)</td>
<td>4) Station D: 10 feet from the wall (rubber balls, leaf targets)</td>
<td>5. Closure (2)</td>
</tr>
<tr>
<td>4. Closure (2)</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
</tr>
</tbody>
</table>

### Equipment
- Sticker, Poly spots, Scarf
- Yarn balls, Beach ball, Cones, Poly spots.

### Note
- Beanbags for 1st graders
- Rubber balls for 2nd graders
- Fleece balls for 1st graders
## Block plans for Izzy

### Comparison Classes

<table>
<thead>
<tr>
<th>Task (Min)</th>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 2</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
</tr>
<tr>
<td></td>
<td>2. Introduction of throwing (5)</td>
<td>2. Going over previous lesson (2)</td>
<td>2. Going over previous lesson (2)</td>
<td>2. Going over throwing performance (2)</td>
</tr>
<tr>
<td></td>
<td>1) How to throw</td>
<td>3. Individual throwing practice (10)</td>
<td>3. Throwing practice in four different stations (28)</td>
<td>3. Individual throwing practice (25)</td>
</tr>
<tr>
<td></td>
<td>2) Critical elements of throwing</td>
<td>- 10 feet from the wall (Coated-foam balls)</td>
<td>1) Station A: 10 feet from the wall (bean bags, clown target)</td>
<td>- 15 feet from the wall (Rubber toys, baskets)</td>
</tr>
<tr>
<td></td>
<td>3. Individual throwing practice (25)</td>
<td>4. Throwing practice in two different stations (18)</td>
<td>2) Station B: 10 feet from the wall (tennis balls (rubber balls), dart target)</td>
<td>- 20 feet from the wall (foam balls, baskets)</td>
</tr>
<tr>
<td></td>
<td>1) Practice without the ball</td>
<td>1) Station A: 10 feet from the wall (foam balls, Goals)</td>
<td>3) Station C: 10 feet from the wall (foam balls, number target)</td>
<td>4. Closure (5)</td>
</tr>
<tr>
<td></td>
<td>2) 10 feet from the wall (snow balls)</td>
<td>2) Station B: 15 feet from the wall (Tennis balls, Goals)</td>
<td>4) Station D: 10 feet from the wall (rubber balls, target nets)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) 15 feet from the wall (snow balls)</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
<td>* Students stayed at each station for 5-7 min and rotated.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Closure (2)</td>
<td>5. Closure (2)</td>
<td>4. Closure (2)</td>
<td></td>
</tr>
</tbody>
</table>

### Equipment

<table>
<thead>
<tr>
<th>Task</th>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 2</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Snow balls, Tennis balls.</td>
<td>Different ball (snow ball, foam ball), Target nets, Hula hoops.</td>
<td>Different targets (clown, dart, number, target net), different balls (bean bags, tennis balls, foam balls, rubber balls), rubber rings</td>
<td>Rubber toys, foam balls, cones, baskets.</td>
</tr>
</tbody>
</table>

### Note

<table>
<thead>
<tr>
<th>Task</th>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 2</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Snow balls for 1st graders Tennis balls for 2nd graders</td>
<td>Foam balls for 1st graders Tennis balls for 2nd graders</td>
<td>Snow balls for 1st graders</td>
<td></td>
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</tbody>
</table>
### Experimental classes

#### Task (Min)

<table>
<thead>
<tr>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 2</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
<td>1. Warm up (3)</td>
</tr>
<tr>
<td>2. Introduction of throwing (8) 1) How to throw 2) Critical elements of throwing</td>
<td>2. Going over previous lesson (5) 2. Individual throwing practice (8) 1) 10 feet from the wall with the scarf 2) 10 feet from the wall (rubber toys) 3) 15 feet from the wall (rubber balls)</td>
<td>2. Going over previous lesson (3) 3. Individual throwing practice (5) - 15 feet from the wall (rubber balls)</td>
<td>2. Going over throwing performance (3)</td>
</tr>
<tr>
<td>2. Individual throwing practice (22) 1) 10 feet from the wall without balls 2) 10 feet from the wall (rubber balls) 3) 15 feet from the wall (tennis balls)</td>
<td>3. Throwing practice in two different stations (17) 1) Station A: 10 feet from the wall (foam balls, number targets) 2) Station B: 15 feet from the wall (Tennis balls (rubber balls), Animal targets)</td>
<td>4. Throwing practice in three different stations (22) 1) Station A: 10 feet from the wall (beanbags (foam balls, clown target) 2) Station B: 15 feet from the wall (rubber balls (rubber balls), dart target) 3) Station C: 20 feet from the wall (tennis balls, number target)</td>
<td>4. Throwing activities (22) - Knocking down ice cone</td>
</tr>
<tr>
<td>3. Closure (2)</td>
<td>4. Closure (2)</td>
<td>5. Closure (2)</td>
<td>5. Closure (2)</td>
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#### Equipment

<table>
<thead>
<tr>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 2</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber balls, Tennis balls</td>
<td>Scarf, Rubber toys, Tennis balls, Different targets (animal, number), Poly spots</td>
<td>Scarf, Different targets (clown, dart, number), Different balls (beanbags, tennis balls, foam balls, rubber balls),</td>
<td>Plastic balls, Beach ball, Cones, Poly spots. Rubber balls, Baskets, Scarf,</td>
</tr>
</tbody>
</table>

#### Note

<table>
<thead>
<tr>
<th>Lesson 1</th>
<th>Lesson 2</th>
<th>Lesson 2</th>
<th>Lesson 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber balls for 1st graders</td>
<td>Rubber balls for 1st graders Tennis balls for 2nd graders</td>
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<td></td>
</tr>
</tbody>
</table>
Appendix I: The Type of Task Modification for the Teachers
### Justin

<table>
<thead>
<tr>
<th></th>
<th>Comparison Classes</th>
<th>Experimental Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Task Modification</td>
<td>22</td>
<td>61</td>
</tr>
<tr>
<td><strong>Type of Task</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Difficult</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>No change</td>
<td>16</td>
<td>45</td>
</tr>
</tbody>
</table>

### Izzy

<table>
<thead>
<tr>
<th></th>
<th>Comparison Classes</th>
<th>Experimental Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Task Modification</td>
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<td>92</td>
</tr>
<tr>
<td><strong>Type of Task</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Easy</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Difficult</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>No change</td>
<td>37</td>
<td>76</td>
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</table>

254