The Effects of a Badminton Content Knowledge Workshop on Middle School Physical Education Teachers' Pedagogical Content Knowledge and Student Learning

Dissertation

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ABSTRACT

A majority of studies have argued that content knowledge (CK) is related to the development of pedagogical content knowledge (PCK). Yet few studies have examined this relationship directly. Moreover, many of the studies have not functionally identified what PCK is, and under what conditions PCK develops. In the absence of a functional definition of PCK, there has been a significant problem in discussing and using PCK in research and in practice (Amade-Escot, 2000). Ward’s (2010) definition of PCK has allowed researchers to observe and measure PCK; however, several questions remain unanswered relative to PCK. The most important are: “Is there a causal relationship (a) between CK and PCK; and (b) between PCK and student achievement?” These questions can be answered using experimental analysis only by manipulating the level of teachers’ CK to determine if there are changes in teachers’ PCK and subsequent changes in student learning. Therefore, the purpose of the study was to investigate the effects of a CK workshop on teachers’ PCK and student achievement in a badminton unit. A quasi-experimental design with two middle school PE teachers as a block was used to examine the change of teachers’ teaching behaviors and student learning behaviors in their intact classes before and after a badminton CK workshop in a natural PE setting. The subsequent teachers’ PCK variables were measured by a video analysis method: the
maturity of task representation, the appropriateness of task selection, and the adaptations of tasks between and within the tasks. For the students’ performance data, students’ correct and incorrect trials on skills and tactics and other trials (i.e., unfair opportunity, missed opportunity, and non-target performance) were measured using a live coding method during practice and game play. For the analysis of teachers’ dependent variables, descriptive statistics (i.e., means and ranges) were used for both the comparison and the experimental classes. For the analysis of students’ dependent variables, descriptive statistics (i.e., means and ranges) and inferential statistics (i.e., non-parametric tests) were used for both the comparison and the experimental classes. The results of the descriptive and inferential statistics on student data showed that the improved teachers’ PCK as a function of CK influence the increase of student’s correct trials and the decrease of students’ incorrect trials in badminton. The results of the descriptive analysis of teachers’ data showed that teachers’ PCK variables including task maturity, task appropriateness and task adaptations can be changed from immature to mature as a function of teachers’ CK. The findings of the study suggest that the teacher education programs for preservice and inservice teachers should improve teacher’s CK with specific practices and relevant and specific feedback on teaching that influences teachers’ PCK and student learning.
Dedicated to my beloved husband and daughter:

Seunghoon Lee and Jiyoo Lee
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힘든 박사과정 속에서 처음으로 만난 아버님은 내게 너무나도 관대하고, 따뜻하고, 완벽한 분이셨습니다. 박사학위를 내주신 아버님께 감사 드립니다.
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Pedagogical content knowledge (PCK) was originally conceptualized by Shulman as “the ways of representing and formulating the subject matter that makes it comprehensible to others” (1986, p. 9). Shulman argued that teachers who have PCK use the most powerful forms of representations (i.e., analogies, illustrations, examples, explanations, and demonstrations) to provide learners with the subject matter most effective for learning (Shulman, 1986). In 1987, Shulman refined PCK as the blending of content and pedagogy, and situated PCK within a number of knowledge bases that serve as the foundation for teaching (i.e., CK, curricular knowledge, general pedagogical knowledge, knowledge of learners, knowledge of context, and knowledge of educational ends).

In 1990, Grossman expanded Shulman’s conceptualization by arguing that five knowledge bases inform PCK: (a) Conceptions of purposes for teaching subject matter (e.g., knowledge and conceptions about the purpose of teaching at different grade levels), (b) knowledge of curricular materials (e.g., knowledge about curricular materials to teach particular content, and vertical and horizontal curricula progressions for a particular
(c) knowledge of students (e.g., knowledge of what the students already know about the subject matter, their skills and ability, and what content they are still struggling with), (d) knowledge of pedagogy (e.g., teachers’ repertoire of metaphors, examples, and activities that are effective for teaching a particular topic), and (e) knowledge of context (e.g., the teachers’ understanding of the context to adapt their knowledge to the setting and the individuals).

While Shulman (1987) viewed CK, curricular knowledge, knowledge of pedagogy, and knowledge of students as independent knowledge bases for teaching, Grossman (1990) viewed those knowledge bases as components of PCK. This shift in conceptualization moved PCK from merely a combination of pedagogy and content to a more sophisticated interdependent conceptualization. In 2005, after more than a decade and a half of research, Grossman et al. (2005) concluded that PCK is mostly influenced by teachers’ understanding of the subject matter (i.e., CK) and by teachers’ knowledge of the students. In her conclusion, Grossman reduced the emphasis she had originally placed on curricular knowledge and knowledge of instructional strategies.

Most definitions of PCK in the literature have borrowed heavily from the work of Shulman (1986; 1987) and Grossman (1990). Most recently, Ball, Thames, and Phelps (2008) proposed two sub-domains of PCK: (a) knowledge of content and students (e.g., the amalgam of knowledge of students and content including the anticipation of what students are likely to do with the task and understanding of what tasks are easy or hard for the students), and (b) knowledge of content and teaching (e.g., the amalgam of knowledge of content and pedagogy including the identification of the appropriate
instructional representations by evaluating the instruction and individual student’s performances). Ball et al. proposed a relationship between knowledge of content and other knowledge domains, arguing that each PCK domain included knowledge of content. In 2010, most researchers viewed PCK as a cognitive construct that involves the blending of several domains of knowledge into a new general knowledge domain or as the blending of pedagogy and content used in particular learning contexts and learners (Loughran, Milroy, Berry, Gunston, & Mulhall, 2001).

In physical education (PE), research on PCK has paralleled classroom-based research in terms of its conceptualization and the research methodologies used to investigate PCK (Amade-Escot, 2000; Jenkins and Veal, 2002; Tsangaridou, N. 2002; Roveno, 1992, 1995, 2005). One of the first researchers to investigate PCK in PE was Rovegno (1992), who argued that PCK was not a static representation, but both experiential and developmental in nature. That is, PCK develops with experience in school settings and over time. Rovegno (1995) was the first to discuss that PCK varied on a continuum of more or less quality. The notion of PCK occurring on a continuum has been reported by other authors. These authors have used adjectives such as strong, weak, immature, and content rich to describe the extent to which a teacher demonstrates PCK (Chen, 2004; McCaughtry & Rovegno, 2003; Rovegno, 1992; Tsangaridou, 2002).

Though there have been several studies in PE investigating PCK (Doolittle, Schowager, & Mitchell, 1996; Graber, 1995; Romar, 1995), the conclusions of this research have best been summarized by Amade-Escot’s (2000) review of PCK. Amade-Escot (2000) concluded that PCK (a) is embedded in the practice of teaching, (b) is
composed of intimately linked and integrated knowledge, beliefs, and experiences, (c) has undergone long-term evolution in relation to professional competence, and (d) is dependent on contextual factors. According to Amade-Escot, “PCK has gradually become a generic term to signify teachers’ professional knowledge” (2000, p. 86). In short, many criteria are attributed to PCK that may or may not be PCK.

PCK has been described differently in many studies (Loughran, Berry, & Mulhall, 2006). The use of different conceptualizations of PCK has led to what Mark’s (1990) called the “fuzziness” of the construct. This ambiguity is reflected in problems of definition that in turn result in a literature which, as Amade and Escot (2000) noted, is not always talking about the same concept. A part of the issue of clarity stems from Shulman’s conceptualization of PCK. One problem is that a teacher’s PCK might work well for some learners, but not for other learners. For example, a teacher may use a progression for teaching the overhead pass in volleyball that is understood by some class members, but not by others. This problem raises a second problem as to whether a given example of PCK is to be defined in terms of its effectiveness. It is implicit in Shulman’s (1986, 1987) definitions that PCK leads to learning (i.e., it is effective). But this issue does not explain how PCK might be effective for some students and not for others. This in turn raises a third question. In the volleyball example, if the progression that was effective for some students was called an example of PCK, then what is the progression (i.e., the same progression) to be called when it is ineffective with other students?

To address these questions, researchers at The Ohio State University have begun to look at PCK from a behavior analytic perspective (Ward, 2005). Ward (2009) proposed
a new definition of PCK as “a focal point, a locus, as such 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 pedagogy, of content, of curriculum).” In this definition, Ward emphasizes that PCK is not defined as what teachers know in a passive sense for teaching, but what teachers do when they apply what they know in the acts of teaching and planning.

Drawing upon the earlier work of researchers who had reported that PCK varied along a continuum (Rovegno, 1992; Tsangaridou, 2002), Ward (2010) conceptualized PCK as occurring on two continuums: (a) ranging from less to more mature, and (b) ranging from less to more effective. In the continuum of maturity, there are two components that distinguish the more or less mature PCK: (a) task representations which include the most useful forms of visual and verbal representation ways, and (b) appropriate task selections which include developmentally and principally appropriate tasks. In the continuum of the effectiveness, students’ correct performances or learning outcomes are considered as the variable defining effectiveness. In combining the two continuums, four potential outcomes of a teachers’ PCK can be evaluated. They emerge in events where the PCK is: (a) mature and effective, (b) mature and ineffective, (c) immature and effective, and (d) immature and ineffective (Ward, 2010). In these interactions, a teacher’s PCK can be situated from immature/ineffective to mature/effective forms of PCK, regardless of the teacher’s years of teaching (Ward, 2010). The goal of professional development at the pre-service and in-service contexts is to move teachers toward the mature and effective PCK in which teachers provide excellent
tasks and representations and lead to students’ successful learning.

**Statement of the Problem**

To date, researchers in PE pedagogy have used descriptive/qualitative studies of PCK relying on high inference data. Most studies in PE have drawn upon Shulman’s 1986 and 1987 papers as well as Grossman’s (1990) knowledge bases in their discussion of PCK in PE. A majority of studies have argued that CK is related to the development of PCK. Yet few studies have examined this relationship directly. Moreover, many of the studies have not functionally identified PCK, and under what conditions PCK develops. There is a critical need for clarity in the definition of PCK.

Because of the absence of a functional definition of PCK, there has been a significant problem in discussing and using PCK in research and in practice (Amade-Escot, 2000). Ward’s (2010) definition of PCK has allowed researchers to observe and measure PCK, however, several questions remain unanswered relative to PCK, the most important of which are: “Is there a relationship (a) between CK and PCK?” and (b)” Is there a relationship between PCK and student achievement?” These questions can be answered only using experimental analysis by manipulating the level of teachers’ CK to determine if there are changes in teachers PCK and subsequent changes in student learning. Therefore, this study investigates the effects of a CK workshop on teachers’ PCK and student achievement in a badminton unit.
Research Questions

The main research questions of this study were: (a) How does student achievement differ as a function of PCK? and (b) How does teachers’ PCK differ in teaching as a function of CK? The answers to these questions were pursued via examination of the following research sub-questions:

1. How many total, correct, incorrect, and other trials are made by the students in the comparison and the experimental classes?
2. What percentage of correct, incorrect, and other trials are made by the students in the comparison and the experimental classes?
3. Is there a statistical difference in the mean percentage of correct, incorrect, and other trials between the comparison and the experimental classes?
4. How does the teachers’ maturity of tasks differ in the comparison and the experimental classes?
5. How does the teachers’ use of verbal representations differ in the comparison and the experimental classes?
6. How does the teachers’ use of visual representations differ in the comparison and the experimental classes?
7. What level of the teachers’ developmental and principle appropriate tasks occur in the comparison and the experimental classes?
8. What level of the teachers’ maturity and developmental/principle appropriate tasks occur in the comparison and the experimental classes?
9. How do the teachers’ inter-task adaptations differ between the comparison and
the experimental classes?

10. How do the teachers’ intra-task adaptations differ between the comparison and the experimental classes?

**Anthropological Assumptions**

According to Siedentop (1983), research should include a brief statement about the view of humanity from which the study’s methodologies come.

*Such a section would not only alert the reader to the basic point of view of the researcher but, more importantly would require the researcher to consider seriously the implications of the questions asked and the assumptions underlying the implications of the questions asked and the methodologies used to answer those questions* (p. 11).

This study was conducted under the behavior analytic theoretical framework. The behaviors of the teachers and the students were the dependent variables of the study and they were explained in terms of the effects of independent variable (i.e., the CK workshop and daily feedback) on their teaching behaviors.

This study holds several important anthropological assumptions.

1. The evidence of knowledge is shown while a person demonstrates it. For example, if a student knows what to perform and how to perform a specific skill, he/she can demonstrate it with a correct performance and success.

2. Information on the occurrence of the behavior is achieved by conducting the descriptive studies. For example, the descriptive study shows how many times
a teacher provided mature and appropriate tasks for learners during the lesson.

3. Students’ existing behaviors can be changed as well as new student behaviors can be developed by teachers’ teaching behaviors. For example, when a teacher provides a mature form of task representations using diverse verbal and visual representations, the rate of students’ correct performances can be increased.

4. Student behavior changes can be the evident data for determining teachers’ teaching effectiveness. For example, the improvement of students’ correct performances shows that a teacher taught the students effectively.

5. PCK is represented by teachers’ behaviors during the lesson. PCK variables were identified and measurable in this study. For example, PCK is the selections of appropriate tasks, the representations of tasks using diverse representations and the adaptations of tasks within the tasks or between tasks for learners at the teaching moment in a particular context.

Significance of the study

This study extends the literature in at least three ways. First, it is part of a systematic line of inquiry beginning with Ayvazo, 2007 and more recently Lee (2010) that uses a behavior analytic framework to examine environmental–behavior relationships. The proposed operational definition of PCK enables the inclusion or exclusion of behaviors under the umbrella of PCK variables. Observed and measured PCK can be utilized to evaluate teaching practices and can offer valuable information to
systematically develop inservice and preservice teachers’ PCK.

Second, this study used a functional definition of PCK that identified elements of PCK. The components of PCK were thus able to be defined, observed, and measured. Quantifying PCK is a significant advance in this literature because it allows levels PCK to be identified along continuums and intervened upon to improve student learning.

Third, this study contributes to the methodological practices that can be used to investigate PCK by employing both a behavior analytic approach and experimental approach for designing research, and collecting and analyzing data in contrast to the predominantly descriptive and qualitative approach that has been utilized to date. Under the natural science of behavior, teachers and students produce their continuous behaviors at the individual level as a temporal locus where the past and present ontogenic history of the individuals interact with the environment. The behavior analytic approach enables the researcher to observe, measure, and analyze the individual teachers and students’ behaviors continuously in diverse contexts as well as explain the variability of contextual variables in their behaviors in terms of their functional relations. An experimental approach allows the demonstration of a relationship between teachers’ PCK and student achievement by manipulating teachers’ CK levels.

**Limitations**

This study is limited:

1. The teachers and the school were purposefully selected for the study.

Therefore, the teachers or the school’s characteristics may have affected the
results.

2. The data which were collected on site as well as videotaped may be sensitive.

3. The degree of the investigator’s expertise on the subject matter for implementing a CK workshop for the teachers may not comparable to that of other investigators.

4. The absence of the effects of teacher’s repeated teaching experiences may not be verified.

**Delimitations**

This study is delimited to:

1. Two physical education teachers who are not expert in the content area and teach 7-8 grade students in the same public middle school.

2. A large Midwestern city within the United States.

3. A specific subject matter (e.g., badminton) taught by the teachers to middle school students.

4. The specific observation methods and variables as introduced.

5. The request of support of several experts on the content area.

6. The implementation of the short of unit (Six days of teaching unit).

**Definition of Terms**

*Adaptation:* Change of task or instruction to an individual student or a small group of students while considering the student’s “conception, preconceptions,
misconceptions, and difficulties, language, culture, and motivations, social class, gender, age, ability, aptitude, interests, self concepts, and attention” (Shulman, 1987, p. 15).

**Analogies:** Teachers’ use of similar or different examples to explain the skills.

**Applying task:** A task that centers on assessment of form or on how to use the movement, rather than just how to do the movement (Rink, 2006).

**Appropriateness:** The task that teacher provided was developmentally appropriate, content specific, and context specific.

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

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

**Correct trials:** Students met the criteria (i.e., critical elements) that teachers provided for them. If the students met all criteria, it would be coded as a correct trial.

**Cues:** Cues are not full sentences (i.e., clause) but shorten words (i.e., phrase) that related to the information about the performance of the movement provided by the teacher (Rink & Werner, 1989; Rink, 2006). Cues can be technical, visual, or metaphoric (Kutame, 1997).

**Demonstrations:** “Modeling desired performance executed by teacher, student(s), and/or visual aids” (Rink, 2006, p. 372).

**Descriptions:** Teacher’s verbal explanation or illustration on what a particular skill (activity) is like.
Extending task: A task that increases the level of difficulty of a previous task (Rink, 2006).

Refining task: A task that expresses additional focus on the quality of performance (Rink, 2006).

Gestures: Positive nonverbal behaviors for students’ effort or success. It includes “a body contact, hand gesture, or facial expression” (Quarterman, 1989, p. 330).

Immaturity: The task was presented in an unsophisticated manner with simplistic or poor descriptions or illustrations.

Inappropriateness: The task that the teacher provided was NOT developmentally appropriate, and/or content specific, and/or context specific.

Incorrect trials: Students did NOT meet the criteria that teachers provided for them. If the students did not meet all criteria, it would be coded as an incorrect trial.

Informing task: “The initial task in the progression of a skill” (Rink, 2006, p.115).

Instructions: Teacher’s verbal description or prompt to the students about how to perform a skill (Hawkins & Wiegand, 1989).

Inter task development: The task development between tasks for entire class.

Intra task development: The task development within tasks for small groups or individuals.

Maturity: The degree to which a task is well represented to the students using cues, descriptions, analogies, metaphors, or demonstrations. Students clearly understand what to do. What distinguishes task representations is the quality and sophistication of the representation to the students.

Metaphors: Teachers’ imaginative ways of describing something using different names
with the same characteristics.

*Pedagogical content knowledge:* 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, 2009).

*Physical assistance:* “Physically moving the player’s (student’s) body to the proper position or through the correct range of motion of a skill” (Lacy & Darst, 1989, p. 371).

*Principle task:* The principles that underpin Play Practice, which is teaching sport through the game and, in the game, using the pragmatic and goal-directed methods, should be understood and used by teachers or coaches to help players to become more effective (Launder, 2001). Play practice in action is based on three fundamental processes, which are a) shaping play by manipulating specific variables (ex., rules, size, and shape of the playing area, the nature of the goal, the number of player, and differential scoring), (b) focusing play by teaching in the game to develop or refine sophisticated techniques and tactics, and c) enhancing play by making improved performance appear to be important and meaningful (ex., presenting challenges, using time constraints or action fantasy games and handicapping individuals and teams) (Launder, 2001).

*Specialized content knowledge:* Knowledge and skills needed by teachers to teach the content (Ball et al., 2008).
Specific congruent feedback: Feedback that related to the focus of the activity that stated by the teacher (Graham, 2001; Rink & Werner, 1989).

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 cards, pictures, video clips or diagrams: Examples of visual equipments to help student understand what to perform and how to perform.

Verbal representation: Teachers’ use of words to explain the tasks.

Visual representation: Teachers’ use of visual aids to help students understand the tasks.
CHAPTER 2

REVIEW OF LITERATURE

This chapter is organized into five sections. First, the conceptualization of content knowledge (CK) is reviewed in the general education. The second section reviews the conceptualization of CK in physical education (PE). The third section describes the conceptualization of pedagogical content knowledge (PCK) in the general education. In the fourth section, a conceptual and methodological standpoint of PCK in PE is reviewed. The fifth section reviews inquires in the relationship between CK and PCK.

Content Knowledge in the General Education

In this section, Shulman’s (1986, 1987) initial definition and conceptualization of CK, Grossman’s (1990, 2005) view of CK and Ball’s (2005, 2008) new notion of CK will be reviewed because their work was so influential by widely implementing their conceptual frameworks in conducting the studies on CK in the education fields.

Shulman’s View of CK

Shulman (1986) defined CK as “the amount and organization of knowledge per se in the mind of the teacher” (p.9). Shulman (1986) proposed three forms of CK: (a)
subject matter content knowledge (i.e., teachers' organization and breadth of knowledge about the subject matter, (b) PCK (i.e., the ways of representing and formulating content that makes it easy to understand for learners), and (c) curricular knowledge (i.e., a range of topics planned and sequenced for teaching specific content at a given level of learners) (see Figure 2.1).

**Figure 2.1 Shulman’s (1986) Three Forms of CK**

<table>
<thead>
<tr>
<th>Teacher Content Knowledge</th>
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</thead>
<tbody>
<tr>
<td>Subject Matter Knowledge</td>
</tr>
<tr>
<td>Pedagogical Content Knowledge</td>
</tr>
<tr>
<td>Curricular Knowledge</td>
</tr>
</tbody>
</table>

In the Shulman’s (1986) initial conceptualization of CK, CK refers to total knowledge that is necessary for teaching which encompasses three knowledge bases for teaching. In the paper, subject matter knowledge was used interchangeably with CK as well as it was distinguished from other kinds of CK. In his view, subject matter knowledge was required to know more than the facts and concepts presented in a field and organize them with the set of the representation ways. In other words, a teacher who has CK must be able to not only understand that something is so, but also further understand why it is so under a certain learning circumstance (Shulman, 1986).

Shulman (1987) extended his theoretical framework of teacher knowledge base to seven categories: (a) content knowledge. (b) General pedagogical knowledge, (c) curriculum knowledge, (d) PCK, (e) knowledge of learners, (f) knowledge of contexts, and (g) knowledge of educational ends (see Figure 2.2). In the Shulman’s (1987) paper,
CK was situated as one of the seven components of teacher knowledge base that was required for teaching.

**Figure 2.2 Shulman’s (1987) Teacher Knowledge Base**

<table>
<thead>
<tr>
<th>Content Knowledge</th>
<th>Pedagogical Content Knowledge</th>
<th>Curricular Knowledge</th>
<th>General Pedagogical Knowledge</th>
<th>Knowledge of Learners</th>
<th>Knowledge of Context</th>
<th>Knowledge of Educational Ends</th>
</tr>
</thead>
</table>

According to Shulman (1987), CK which is the understanding of content was recognized as one of distinct body of PCK which is the amalgam of content and pedagogy. His argument was that CK is basic knowledge that is to be learned by students including their knowledge, understanding, skill and disposition. That is, CK should be the knowledge and skills that are to be taught in schools (Shulman, 1987). He also mentioned two foundations of CK: the accumulated literature and studies in the content area, and the historical and philosophical orientation on the nature of knowledge.

The work of Shulman and his colleagues has contributed to not only directly paying attention to the role of content in teaching by distinguishing from other types of knowledge but also understanding the content as a key knowledge to the profession of teaching (Ball, Thames, & Phelps, 2008). However, it has been less useful in further explaining what CK really is due to the problems of definition, empirical evidence, and practical utility (Ball et al., 2008). In term of the definition of CK, across and within the subject areas, there have been significant differences in the breadth of what is included
and how the term is used to relate CK to the practice of teaching (Ball et al. 2008). In addition, few empirical studies have been conducted to examine whether there are distinct domains of CK that matter for teaching with the developed measurement tool to test the definitions and the effects of CK (Ball et al., 2008). Without this empirical evidence on CK, there are huge limitations to facilitate teachers’ CK by reforming teacher education curriculum and professional development program, developing polices about teacher certification, and extending our interests in the relationship among teachers’ CK, PCK and student learning (Ball et al., 2008). Moreover, practical information is needed for teachers in order to develop the quality of teaching in terms of what types of CK they need to know as well as the role, the nature and the importance of different types of knowledge for teaching (Ball et al., 2008).

**Grossman’s View of CK**

Grossman (1990) defined CK as “knowledge of content and knowledge of substantive and syntactic structures in subject area” (p.25). It was one of four teacher professional knowledge bases: (a)subject matter knowledge, (b) general pedagogical knowledge, (c) PCK, and (d) knowledge of context (see Figure 2.3).

**Figure 2.3 Grossman’s (1990) Teacher Professional Knowledge**

<table>
<thead>
<tr>
<th>Teacher Professional Knowledge</th>
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<tbody>
<tr>
<td>Subject Matter Knowledge</td>
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<tr>
<td>General Pedagogical Knowledge</td>
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<tr>
<td>Pedagogical Content Knowledge</td>
</tr>
<tr>
<td>Knowledge of Context</td>
</tr>
</tbody>
</table>
Likewise with Shulman’s initial view of CK, Grossman (1990) emphasized teachers’ mastery of the content including knowing how to solve the problems teachers pose to students, and knowing that there are a variety of ways to solving the problems.

In 2005, Grossman, Schoenfeld, and Lee argued that the subject matter competence is not sufficient to teach successfully for students who have different kinds of errors or mistakes. Grossman et al. (2005) argued that a teacher must be able to not only know identify such mistakes when they occur but also address the sources of the students’ errors to fix their errors. Grossman et al. (2005) stated that effective teachers must know more than their subjects in order to link to PCK which includes knowing how students tend to understand or misunderstand; how to anticipate and diagnose such misunderstandings; and how to deal with them when they occur. They also believed learning through the coursework is not sufficient to develop a profound understanding of content providing a possible example that an expert elementary mathematics teacher has a deeper, richer organization of subject matter knowledge than do mathematics professional (Ma, 1999). However, they also argued that prospective teachers need a solid foundation in the subject matters and the requisite disciplinary tools by taking the content coursework in order to continue learning within the subject matter throughout their careers.

In addition, Grossman et al. (2005) reported inconclusive findings of several studies that examined the relationship between CK preparation and student achievement. For example, Goldhaber and Brewer (2000) found teachers’ major in the subject was a significant predictor of student achievement in mathematics but not in science. Monk
(1994) found the general positive relationship between the number of undergraduate content courses and student achievement in mathematics. Because these studies has not well defined CK as well as indirectly measured CK using proxy measures of CK (e.g., teachers’ coursework or major), it is difficult to make a strong argument about the relationship between teachers’ CK and student achievement.

Ball’s View of CK

In mathematics education, Ball and her colleagues elaborated Shulman’s initial definition of CK and PCK by conducting two lines of study. With the most importance question of What do teachers need to know and be able to do to carry out the work of teaching effectively?, Ball et al. (2005) examined what teachers do in teaching and qualitatively analyzed the demands of teaching in practice. Ball et al. (2005) indicated that it is largely unknown that the extent of teachers’ CK that has been influenced on increased student learning was their simple knowledge for teaching or complex and sophisticated CK. Based on their analysis of the mathematical demands of teaching, Ball et al. (2005) recognized two distinct mathematical CK categories for teaching including common content knowledge (CCK) and specialized content knowledge (SCK) (see Figure 2.4). Ball et al. (2005) found that teachers need to possess SCK which is in-depth and detail knowledge beyond merely carrying out the mathematical procedure without mistakes (i.e., CCK).

In the later work, Ball and her colleagues designed a measurement instrument for the mathematics knowledge for teaching. Ball et al. (2008) measured CK for teaching in
mathematics. From the empirical work, Ball et al. (2008) found that the mathematical knowledge teaching is multi-dimensional. That is, knowledge and skills entailed in teaching is not fully produced from general mathematical ability (Hill, Ball, & Schilling, 2004). In addition, the authors found two empirically discernable sub-domains that they already defined in the previous work.

Figure 2.4 Ball at al.’s (2005, 2008) CCK and SCK

According to Ball et al. (2008), CCK refers to the mathematical knowledge and skills necessary for correctly solving the mathematics problems. For instance, in 30 X 45, CCK is to know how to perform the steps for the procedure, or algorithm having the correct answer. The second domain, SCK refers to the mathematical knowledge and skill that is unique knowledge for teachers to teach including how to represent the mathematical reasoning and error analysis (Ball et al. 2008). For instance, in 30 X 45, beside of knowing how to correctly answer the mathematical problems, teachers should know more sophisticated knowledge (e.g., analyzing the source of the error, explaining
the basic algorithm, and using different way to represent multiplication) while teachers have students who have wrong answers.

Ball et al.’s (2008) view of CK is that teachers’ CCK is obviously essential for teaching but it is not sufficient for helping students who are struggling with the tasks. They argued that SCK is vital and core knowledge for teaching. Thus they suggested that teachers’ SCK should be examined by identifying teachers’ specific tasks in which teachers engage in any other subject areas. Ball et al. (2008) also suggested that teachers learn this specialized form of knowledge in focused ways in professional education.

**Content Knowledge in Physical Education**

**Siedentop’s View of CK**

Siedentop (2002) described his strong view of CK using Shulman’s (1986) umbrella term of “subject matter content knowledge” in PE. Siedentop (2002) argued that the core subject matter of PE is sport and physical activities that teachers will teach for their students in school. In his paper, Siedentop (2002) described what teachers or coaches should know to teach the sport activities. In his broad view of CK components, a wide range of knowledge, skills and dispositions within psychomotor, cognitive and social dimensions that teachers or coaches should know in an educational or sport context were encompassed (Siedentop, 2002).

“They should know the technical aspects of the skills involved, the strengths and weakness of various strategic approaches to the sport, the training implications for improved performance in the sport, the developmental considerations, the
norms, values, and traditions of the sport, the role it does, and the developing technologies within the sport, the psychosocial considerations associated with individual and group dynamics of players, and the ethnical/moral dilemmas posed by competition” (p.374).

In addition, Siedentop (2002) pointed out that the task of defining the CK is straightforward in math, English, art, or music because preservice teachers learn math, English, music and art that children learn in schools. However, physical educators have disavowed focusing on and valuing the physical activity and sport due to the general belief that sport and physical activity is worthy to establish a academic status which is advocated by some (Siedentop, 2002). For this reason, many physical education teacher education (PETE) programs have emphasized the discipline of PE (i.e., exercise physiology, sport philosophy, kinesiology, and biomechanics) as the core of CK base for PE and our attention was directed away from the crux of the matter (i.e., physical activity or sport) (Siedentop, 2002). Siedentop (2002) also argued that prospective teachers might not be able to develop CK foundations because they learn CK (e.g., sport philosophy, biomechanics, or kinesiology) differently with children learn in schools (e.g., physical activity or sport).

In terms of how to develop CK, Siedentop (1989) found that elementary teachers who were competent in many curriculum areas, often displayed expertise in areas where they were the subject matter specialist. Siedentop (2002) emphasized the participation in sport performance providing an example of the Ohio State University’s dance education program which devoted to many credits to performing dance. Siedentop (2002) has
argued that full engagement in the sport by doing it is the best way to allow prospective teachers to deeply understand the nature of the content and develop their CK for teaching.

**Ward’s View of CK**

Ward (2009) raised an important question “What is the subject matter knowledge one needs to teach a subject?” and suggested two forms of subject matter knowledge: (a) knowing how to perform an activity (i.e., CCK) and (b) knowing what to teach as the activity (i.e., SCK). Ward (2009) challenged the prevalent assumption that teachers must be able to perform the activity to teach the activity. Ward (2009) argued that learning through performing is only part of the knowledge that is needed for someone to teach the activity.

Ward’s (2009) concept of CK was analogous with Ball et al.’s (2008) conceptualization on CCK and SCK in mathematics. In other words, CCK is the knowledge that one must possess to simply perform an activity or play a sport including basic rules, technique and tactics, whereas SCK is the knowledge that is necessary for someone to teach the activity, including error analysis and proper selection of tasks. In his view, it is no doubt that in playing volleyball a player must know basic rules, etiquette, techniques and tactics. However, in teaching volleyball, a teacher must know how to play volleyball knowing the rules, etiquette, techniques and tactics as well as the teacher must know more explicit knowledge such as recognizing students’ working performances, analyzing the source of the errors, correcting students’ performances using correct feedback and cues, and providing appropriate tasks. Ward (2009) argued that PE teachers
should possess more sophisticated knowledge for teaching beyond merely knowing the rules, techniques, and tactics for performing the activities.

In terms of how to develop CK, Ward (2009a) argued that the activity classes merely focusing on prospective teachers’ performance ability that many PETE programs offer cannot significantly impact to their knowledge development of how to teach the activity. Ward (2009a) argued that knowing how to perform and knowing what is to be taught are acquired with the differential forms. Ward (2009a) suggested that PETE programs should emphasize on both prospective teachers’ CCK and SCK considering that both knowledge might exist independently. To verify his conceptual view of CK and to strengthen the claim that effective teaching entails teachers’ SCK beyond their common content knowledge, continuous efforts for conducting the studies regarding CK are needed in our field.

**Four Domains of CK**

Ward (2009a) proposed four domains of CK in PE: (a) knowledge of the rules and, etiquettes, (b) knowledge of technique and tactics, (c) knowledge of the student errors, and (d) knowledge of the instructional tasks.

**Knowledge of the rules and etiquettes.** This domain includes knowledge of rules such as when a player loses the point in tennis or when and where a corner kick occurs in soccer. Moreover, this domain includes knowledge of the essential concepts of the activity. For example, a teacher should know which rules are the primary rules that define the fundamental rule of the game that is not able to be changed (e.g., advance the ball
forward by throwing it or running with it in football) or secondary rules that can be
changed to make the game more developmentally appropriate (e.g., the offense team has
4 tries (downs) to advance at least 10 yards). Besides the rules of sports, it includes
knowledge about some important unwritten etiquette in sports such knowing that only the
playing captain can speak to the referees in volleyball. It also includes knowledge relating
to issues of safety and knowing how to set up equipment.

Knowledge of the technique and tactics. This domain includes knowledge of
technique of the skills required to perform an activity such as knowing that the ball
should be contacted just above and in front of the head when setting the volleyball. It also
contains knowledge of basic tactics such as placing attackers in the middle of the court or
along the borders to reach the ball quickly and hit it across the court in volleyball.

Knowledge of the student errors. This domain requires knowledge of the correct
performance in order to discriminate students’ errors of technical and tactical
performances. For example, it includes some examples of knowledge or errors such as
when a teacher recognizes that the player’s arms were not fully extended at the contact to
the ball in golf, or in badminton when the teacher recognizes that the player did not return
to the center after every shot in a badminton single play, or in dance when the teacher
recognizes that the steps of a German Folk dance are in the correct sequence with the
music, or in volleyball when the teacher recognizes that the student did not fully stretch
the arm when spiking the ball.

Knowledge of the instructional tasks. This domain requires knowledge of the
tasks containing progressions or experiences that are used to teach the activity (Griffey &
Housner, 2007). For example, in tennis it would be having the player place his striking against the wall and hitting the ball over the net. In gymnastics, it would include using an inclined mat to help a student place their hands closer to their feet to facilitate the forward roll before using a flat mat. In dance it includes asking students to clap their hands to identify if they can hear the rhythm of the music. In golf it would include constraining shift of students’ weight backwards to avoid hitting the ball with the toe of the club.

The Continuum of CK

Ward (2009a) conceptualized the four domains of CK under the Ball et al.’s (2008) CCK and SCK in the continuum (see Figure 2.5).

In this continuum, the breadth of CCK and SCK arrows shows the degrees that encompass each category. The continuum shows that CCK includes a large part of knowledge of the rules, etiquette, safety, techniques and tactics because the majority of this knowledge is needed for someone to perform an activity. In addition CCK includes a small part of knowledge of errors and tasks to facilitate players’ skill performances to detect their own mistakes during game or practice within an appropriate practice setting. On the other hand, SCK includes a large part of knowledge of student errors, the instructional tasks, and the representation of tasks because the majority of this knowledge is uniquely needed for someone to teach the activity. In the continuum, SCK also include a small part of knowledge of understanding of the rules, etiquettes, safety, techniques, and tactics which could be grounded knowledge for SCK.
In this view, both knowing how to perform and knowing what to teach should be learned independently since knowing how to perform is only part of knowledge necessary for someone to teach an activity (Ward, 2009b). Ward’s new notion of CK is fundamentally remarkable because it inform the reform of PETE curriculum to produce specific outcomes for pre-service teachers as well as professional development programs for inservice teachers to identify the strengths and weakness of teachers’ CK.

Siedentop and Ward’s Views of CK

Although Siedentop and Ward have a slightly different view of CK, both Siedentop (2002) and Ward (2009a) emphasized the need of well defined CK in PE since a lack of clarity of CK has significantly influenced our confusion of what to teach and how to teach content in initial and continuing PETE context. They agreed that the subject matter of PE has been ill-defined. Both had a consensus about the important omission of teachers’ understanding of their subject matter mentioning about “PE missing paradigm”
as Shulman (1986) described. Siedentop (2002) stated that teacher educators are emphasizing pedagogy without a corresponding emphasis on content knowledge. Ward (2009a) agreed with Siedentop’s observation in that many prospective teachers are prepared by developing their pedagogical skills, but they exit their program with insufficient CK. Both addressed the important concern about insufficient CK of preservice teachers necessary for their teaching profession.

Siedentop (2007) and Ward (2009a) also were concerned about our future PE teachers’ CK deficiency. They pointed out that our future PE teachers enter the program with various backgrounds in the subject matter. Siedentop (2007) reported the majority of the PETE students’ negative school PE experiences having the short unit with little instruction and organized activity that was dominated by skilled students and inappropriate activities in their school PE. He argued that PETE students enter the PETE program with fairly narrow backgrounds in physical activity. Ward (2009a) noted that these backgrounds that PETE students had negative experiences in their school PE with developmentally inappropriate activities. Ward (2009a) concluded that “We ought not to expect students who were participated in such as a system to enter PETE programs with adequate subject matter knowledge to draw upon in their teaching” (p.344).

For the future PE teachers who have little CK background, both scholars raised the same voice that PETE programs should provide them with more learning opportunities to develop their CK during their programs. Both were concerned about the current PETE programs which have seriously underestimated CK courses as their program requirement. While Siedentop (2007) argued for an increase of credit hours of
sport performance courses providing an example of music education which have 53 credit hours in music performance content courses, Ward (2009a) argued that preservice teachers need to study more in-depth subject matter focusing on developing their knowledge for teaching going beyond the ability to perform the activities in PETE.

Both scholars disavowed the multi-activity curriculum offered in schools and argued that to a larger degree the multi-activity curriculum exists because teachers lack CK. Siedentop (2002) argues that PE teachers offer a “short unit” of activity curriculum because they do not have sufficient CK for teaching an extended unit. Likewise, Ward (2009a) argued that

“This lack of subject matter knowledge is a strong explanatory variable as to why the multi-activity curriculum is prevalent in physical education in the United States; and why students leave school not well skilled and with limited understanding and appreciation of the physical education activities in which they have participated” (p.346).

Research on CK

Even though the research on CK is still young field in PE, several qualitative and descriptive studies that examined CK were reviewed in order to find some different perspectives on CK, methodology standpoints as well as the influences on the design of this study. In addition, several research problems and concerns related to CK were discussed in this section.
Rovegno (1993) conducted a study that examine how PETE majors acquired CK of a nontraditional approach to PE, called a movement approach which emphasize creativity and movement response rather than teaching set exercises and skills within three forms of movement: games, dance, and gymnastics during their PETE program. The field and course observation, document analysis and in-depth interviews with 12 PETE major students were utilized for the study. The study described three aspects of learning about the movement approach: (a) critiquing K-12 experiences and coming to a deeper and different understanding of PE content and teaching, (b) understanding the movement approach as a program that they could be proud of, and (c) learning through practical experiences. Rovegno (1993) argued that prospective teachers come to recognize taken-for granted conceptions associated with the cultural institution of sport and to overcome these cultural templates by becoming committed to the movement approach. The author also valued the prospective teachers’ ethical concerns about the equal opportunity of children further suggested that the values of embedded in the theories underlying a curricular approach are important to facilitate prospective teachers’ learning to teach.

Rovego and Gregg (2007) examined the meanings the children (i.e., 17 eight-year olds) made in response to the folk dance curriculum integrated within an interdisciplinary unit called ‘People and the Land: Native Americans and their Environments’ at a predominantly African-American elementary school within the ecological perspective. By undergirding the instruction (i.e., dance and geography), the investigators were desired to honor the children’s culture, Native American culture, and the children’s
developmental levels. Standard qualitative research methods were used to collect evidence from multiple sources (e.g., videotape of the lessons, field notes, lesson plan, daily writing assignment for children, and reflection paper), induced coding categories, identified themes, and critical incidents. The findings indicated that the children learned the CK taught. Yet, the authors came to recognize the ways in which their own cultural and subject matter ignorance or weakness can limit the effectiveness of their teaching and even their ability to reflect on the quality of their unit. The authors also pointed out that the sensitive problem of the theory of CK that the teacher delivers when designing and teaching a unit. The study showed that teachers’ sensitive knowledge of culture and subject matter influence their teaching effectiveness as well as their ability to reflect their teaching for the quality of PE.

Wallhead and O’Sullivan (2007) examined the development of CK and performance of a team of six students (i.e., 27 eighth grade students) during the peer teaching tasks of a Sport Education (SE) season of tag rugby within the didactic perspective. To collect student data regarding student intentions, actions, and interpretations of content, class observation and pre and post lesson interviews were conducted. The findings indicated that students demonstrated a high level of participation and compliance with the intended content of the peer teaching tasks. The study showed the effects of the instructional approach of peer teaching in developing students’ CK in the lower complexity learning tasks. The use of pre-lesson coaching task cards and teacher intervention within tasks were effective to meet the learning goals. Despite these positive findings, students failed to reach higher order content goals during peer teaching.
because of deficiencies in the student coach’s ability to elaborate content using appropriate demonstration, error detection and task modification. The authors suggested that it is important for teachers to adequately prepare for the student coaches including relevant CK and effective pedagogical principles for elaborating the intended content to peers to successfully utilize the SE curriculum model in PE. One of the implication of this study was that teacher’ in-depth CK and PCK including error diagnosis and task adaptation is needed for teaching complex tasks because they should fix the students’ errors by analyzing their sources of errors and providing appropriate tasks.

In summary, the naturalistic inquires of CK indicated several findings: (a) learning through practical experience in PETE allows preservice teachers to change their perspective on CK, b) preservice teachers’ own cultural and subject matter ignorance or weakness influence on the quality of teaching and the ability to reflect the teaching, and (c) teachers need to have in-depth understanding of content and through preparation in teaching particular high level of learning tasks.

**Descriptive Research on CK**

Capel and Katene (2000) conducted a study that examines secondary 27 college students’ perceptions of amount of subject matter knowledge in the six areas of activity in the National Curriculum in Physical Education (NCPE) and in specific games taught in many schools in England. The questionnaire about knowledge in the six areas of activity was used to collect pre and post data. Results indicated that the highest percentage of students perceived good subject knowledge in traditional team games, whereas the
highest percentage of students perceived little CK in outdoor and adventure activities and dance. The results was explained by the dominance of games identified in students’ prior experiences, qualifications and knowledge of activities on entry to the PETE program and limited introduction to dance or outdoor activities at school (Capel & Katene, 2000). In addition, college students’ perception of CK significantly increased in some activities (e.g., dance, gymnastics, outdoor and adventure activities, and volleyball) from the course, whereas they did not perceive their CK to have increased in football for male students and netball for female students in the result of spending less time and effort in these activities, relying on what they already know in activities. This study showed the influence of prior qualification and knowledge of the activity on students’ confidence on the subject matter as well as the identification of strong and weak units for teaching. However, further studies are needed to examine what students should know and what they do not know for teaching in each activity in order to structure the content courses in PETE.

Castelli and Williams (2007) examined 73 middle school PE teachers’ health-related fitness CK and self-efficacy using a cognitive health-related fitness test and a self-efficacy questionnaire. Results indicated that PE teachers possessed high self-confidence in teaching health-related fitness content but their test scores did not meet the goal. The authors suggested a continuous effort for developing teachers’ CK through professional development programs.

To test the rationale that students’ prior playing experience influence on their subject matter knowledge, Stuhr, et al. (2009) conducted a pilot study to examine the
relationship between prior experience of 96 undergraduate students at Ohio State and their subject matter knowledge in basketball and soccer. In this study, some students were PE majors, whereas others were enrolled in elective basic instruction classes. The participants were distributed into groups who had at least one season sport experience and those who had not. They were asked to answer 30 multiple-choice questions about 15 questions devoted to rules/etiquette, and technique/tactics for measuring their common content knowledge (CCK), and 15 questions devoted to error analysis and task selection for measuring their specialized content knowledge (SCK). The results showed that students’ soccer scores were much lower than students’ basketball scores regardless of their CCK and SCK areas as well as their prior playing experience. It could be explained that most of people knows something about basketball even non-players because basketball is the most popular sport in the United States. However, while CCK scores in each sport are higher for players, students’ SCK scores remain low for both players and non-players in both sports. It indicated our contention that merely performing the activity is not sufficient to develop in-depth understanding of content for teaching.

Recently, Kim, Ward, Li, Stuhr and Lorson (2010) further examined the relationship between prior teaching or coaching experience of undergraduates and their subject matter knowledge in basketball. 64 college students enrolled in three different courses (i.e., PETE basketball content course, basketball activity course, and general education course (e.g., first aid class)) were involved. Under Ward’s (2009a) four domains of CK, open ended questions on basketball were developed, including questions related to rules and etiquette, and technique and tactics for CCK and skill discrimination
and instructional tasks for SCK. The results showed that playing experience with the sport positively influence on improvement CK pre and post test scores in basketball. However, students’ previous playing experiences in the activity were not sufficient to achieve high CK test scores and in particular SCK. The results also confirmed the previous results. In addition, participants’ CK in PETE basketball content course improved significantly than those in general basketball activity course and general education course from pre to post. The results of this study support Ward’s (2009a) argument that teacher education programs should provide a focused environment to facilitate candidates’ CCK and SCK. However, further research is needed to strengthen the claim that effective teaching entails teachers’ specialized knowledge above and beyond their common knowledge.

Under the belief that PETE CK course work should be focused on CCK or SCK from Ball et al.’s (2008) and Ward (2009a) conceptualization of CK, Ward, Kim, Lee, and Li (2011, in review) examined the difference of the focus of content courses between Ohio and Korean PETE program. The syllabus from 28 PETE programs in Korea and Ohio was analyzed in terms of the focus of content courses. Results showed that all of the Korean PETE programs and the majority of the Ohio PETE programs primarily focused on CCK in the content classes. On the other hand, from the closer examination of the syllabus, the findings indicated that Korean programs clearly focused on CCK, whereas approximately 40% of the programs in Ohio have some SCK embedded in their content course work and two institutions in Ohio had considerable SCK included in their coursework. The authors argued that both Korea and Ohio PETE programs need to be
restructured to increase the amount of SCK under the strong assumption that increasing SCK will impact teachers’ PCK. Ward et al. (2011) suggested the class activities for improving SCK including (a) the use video clips of basic movements, (b) repeated episodes of repeated peer teaching of content, (c) scenario driven instructional problems, (d) freeze replay of teaching episodes, and (e) assessment of SCK knowledge in the form of online quizzes.

In summary, the descriptive studies indicated several findings: (a) the variations of teachers’ CK in each activity, (b) the influences of prior learning or teaching experiences on CK, (c) the lack of teachers’ CK in particular SCK, (d) the existence of CCK and SCK focused courses in PETE and (d) the focus of preservice teachers’ sport performance in the content courses in PETE.

**Research Problems Related to CK**

There are several concerns on the research related to CK. First, the term of CK or subject matter knowledge has been widely used in our field, but it is still unclear about what CK is really is. Ward (2009a) stated that “a lack of conceptual clarity relative to what is the subject matter knowledge that best serves a teacher” (p. 346). The lack of CK definition has limited to answer to the important questions regarding CK such as How can we facilitate teachers’ CK?; What should we emphasize to improve teachers’ CK?; and What should we measure to identify teachers’ CK?

Second, little empirical research on CK has been conducted in PE so that the discourse on CK has not been made with empirical evidence (Ward, 2009a). Although
many researchers have argued that CK is key knowledge for PCK and there is a relationship between CK and PCK (Ayvazo, 2007; Ayvazo et al., 2009; Rovegno, Chen & Todorovich, 2003; Siedentop, 2002; Ward, 2009b), only few studies (Ayvazo, 2007 and Lee, 2010) have descriptively showed a direct relationship between CK and PCK in PE. We need more empirical research in order to discuss CK with data based evidence.

Third, most of the studies on CK that have been conducted in PE have used a qualitative method (i.e., field observation and interview) or descriptive method (i.e., field observation and self-reported survey). To generalize the findings, experimental studies on CK with a large sample of teachers should be conducted.

Fourth, research on CK have focused on the investigation of preservice teachers’ CK or the content of PETE programs, whereas little research has been conducted to examine inservice teachers’ CK or the content of professional programs. In order to design an effective professional program for improving inservice teachers’ CK, we need more information about what inservice teachers know and do not know in each content area. Thus, further studies with inservice teachers are needed to find more valuable information about the CK of inservice teachers.

**Pedagogical Content Knowledge in the General Education**

In this section, Shulman’s (1986, 1987) initial definition and conceptualization of PCK, Grossman’s (2005) view of PCK and Ball’s (2008) view of PCK will be reviewed because their works have been so influential in the education field by widely implementing their conceptual frameworks in conducting the studies on PCK. In addition,
their works have informed me to establish a conceptual and methodological standpoint for this dissertation work.

**Shulman’s PCK**

In 1986, Shulman originally introduced the notion of PCK which was one of the components of CK and distinguished other two forms of CK including subject matter knowledge (i.e., teachers’ organization and breadth of knowledge about the subject matter) and curricular knowledge (i.e., a range of topics planned and sequenced for teaching specific content for the specific group of learners) (see Figure 2.6).

![Figure 2.6 Shulman’s (1986) Three Forms of CK](image)

<table>
<thead>
<tr>
<th>Teacher Content Knowledge</th>
<th>Subject Matter Knowledge</th>
<th>Pedagogical Content Knowledge</th>
<th>Curricular Knowledge</th>
</tr>
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</table>

Shulman (1986) defined PCK as “the ways of representing and formulating the subject that it comprehensible to others” (p. 9). He argued that teachers who have PCK should possess “the most useful forms of representations (i.e., analogies, illustrations, examples, explanations) to provide learners with the explicit subject matter” (p. 9). In his definition of PCK, the special nature of subject matter knowledge in which includes two components: a) knowing how teachers represent the particular content to learners, and b) what students know or unknown about the content were emphasized.

In 1987, Shulman extended the categories of knowledge base required for
teaching including more knowledge bases to three forms of knowledge that were already postulated in 1986 (see Figure 2.7).

### Figure 2.7 Shulman’s (1987) Teacher Knowledge Base

<table>
<thead>
<tr>
<th>Teacher Knowledge Base</th>
<th>Pedagogical Knowledge</th>
<th>Content Knowledge</th>
<th>General Pedagogical Knowledge</th>
<th>Knowledge of Learners</th>
<th>Knowledge of Context</th>
<th>Knowledge of Educational Ends</th>
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<tr>
<td><strong>Curricular Knowledge</strong></td>
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<td><strong>General Pedagogical Knowledge</strong></td>
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<td><strong>Knowledge of Learners</strong></td>
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<td><strong>Knowledge of Context</strong></td>
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<td><strong>Knowledge of Educational Ends</strong></td>
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</table>

PCK was situated as one of the components of teacher knowledge base and distinguished from other teacher knowledge bases. Shulman also included four more knowledge bases into the three initial postulation of teacher knowledge. First, teachers’ general pedagogical knowledge (i.e., knowing how to manage and structure classroom) was included as one of teacher knowledge base for teaching. Second, knowledge of learners (i.e., knowing students’ characteristics and whether they understand content or not) was included. The third included category was knowledge of context (i.e., understanding of classroom ecology and school and community culture). The fourth category that was added was knowledge of educational ends (i.e., teachers’ educational goals, and philosophical beliefs and values on education).

Shulman (1987) refined a PCK definition as follows: “The blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction” (p. 8). In this definition, PCK represents the blending of CK and pedagogical knowledge derived from other knowledge bases (i.e., a teacher’s
understanding of how the content should be organized, represented, and adapted to learners who have different interests and needs). He also emphasized teachers’ flexible and multidimensional understanding of subject matter necessary for providing alternative explanations of the same concepts or principles for learners who have different learning stages and interests.

Moreover, Shulman’s initial conceptualization of PCK has widely postulated and refined by many researchers. Cochran et al. (1993) proposed the slightly different term “pedagogical content knowing”, which is defined as “a teacher’s integrated understanding of four components of pedagogy, subject matter content, student characteristics, and the environmental context of teaching” (p. 266). Marks (1990) defined PCK as the integration of what to teach, how to teach, and how students learn in particular content. de Berg & Greive (1999) used the term “transforming” defining PCK as “the product of transforming subject matter into from that all facilitate student learning” (p. 20). Loughran et al. (2001) defined PCK as “the amalgam of content knowledge and teaching knowledge that makes that content better able to be understood through the particular approach adopted” (p. 289). Lowery (2002) described that PCK is “the domain of teachers’ knowledge that combines subject matter knowledge and knowledge of pedagogy” (p. 69). Niess (2005) proposed PCK as “the intersection of knowledge of the subject with knowledge of teaching and learning” (p. 510).

PCK has been described differently in many studies using slightly different terms to describe PCK such as “integration, transformation, combination, or
amalgam.” It indicates that PCK is not sole knowledge that can be investigated in isolation (Grossman, 1990). In addition, the researchers have used different PCK domains (i.e., knowledge of content, pedagogy, learners, educational context, and curriculum) emphasizing one or two components of PCK depending on their view of PCK.

It is obvious that Shulman’s conceptualization of PCK could have contributed to further distinction between PCK and other types of knowledge bases theoretically and it has been used by many researchers for conducting research related to PCK as a conceptual framework in reality. However, the use of different conceptualizations of PCK has led to the ambiguity of the construct. That is, the researchers have different perspective on PCK and they are not always talking about the same concept (Amade Escot, 2000).

**Grossman’s View of PCK**

Grossman (1990) postulated PCK as one of four knowledge bases including CK, general pedagogical knowledge and knowledge of context (see Figure 2.8).

**Figure 2.8 Grossman’s (1990) Knowledge Bases for Teaching**

<table>
<thead>
<tr>
<th>Knowledge Bases</th>
<th>Content Knowledge</th>
<th>Pedagogical Content Knowledge</th>
<th>General Pedagogical Knowledge</th>
<th>Knowledge of Context</th>
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<tr>
<td>Content Knowledge</td>
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<td>Pedagogical Content</td>
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<td>Knowledge</td>
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<td>General Pedagogical</td>
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<td>Knowledge of Context</td>
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43
While Shulman distinctively defined each knowledge base, Grossman (1990) pointed out the interrelations among the four categories. In this construct, Grossman (1990) also included the category, knowledge of context which is the teacher’s understanding of the school setting, the mission of the school, culture, and other contextual factors that might impact on the quality of teaching. In contrast to Shulman, Grossman (1990) did not include CK as a part of the PCK components. Yet, she introduced several components of PCK (see Figure 2.9).

**Figure 2.9 Grossman’s (1990) PCK Components**

<table>
<thead>
<tr>
<th>Pedagogical Content Knowledge</th>
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<tr>
<td><strong>Conceptions of Purposes of</strong></td>
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<tr>
<td><strong>Teaching Subject Matter</strong></td>
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<tr>
<td>Knowledge of Students’ Understanding</td>
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</tbody>
</table>

The first component of PCK includes knowledge of conceptions about the purpose of teaching subject matter. For example, if a teacher believes that the purpose of PE is to increase students’ physical activity levels, the teacher’s curriculum would be designed accordingly by including more fitness activities. If a teacher believes that the purpose of PE is to increase students’ social skills, his or her curriculum would be designed within a cooperative learning environment to develop students’ social skills such as cooperation, responsibility, leadership and trust relationship. From the view of Grossman (1990), the teacher’s conception of purpose of the subject matter influence on the teachers’ decision on structuring of the curriculum, selecting content that they cover.
in each lesson, as well as organizing the class activities to meet the goal.

The second component of PCK, the knowledge of students’ understanding refers to the teachers’ knowledge about the students’ levels of understanding of the subject matter and their potential abilities and skills. This category is similar to the category, knowledge of learners early discussed by Shulman (1986).

The third component 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 example, in teaching badminton, teachers must know how to design the lessons considering developmentally and sequentially appropriate activities for diverse learners (i.e., 2 versus 2 passing game, followed by 2 versus 1 passing with a warm defense for fourth graders, and 3 versus 3 passing game, followed by 3 versus 1 with a hot defense for six graders). Grossman (1990) pointed out that the teachers should know what the students already know and what they need to learn in the future as a part of the curricular knowledge. While curricular knowledge was defined as one of the PCK components by Grossman (1990), it was defined as one of the knowledge bases for teaching by Shulman (1986, 1987). There has been a disagreement about the view of PCK among scholars by postulating it with different components of knowledge.

The last component of PCK, knowledge of instructional strategies refers to know how to represent content using various representations (e.g., metaphors, examples, and activities) while teaching specific content for the specific learners. For example, in teaching log roll in gymnastics, teachers might say “Make a straight body like a log” to
make children easily understand what their correct form looks like. This knowledge would be the similar concept of pedagogical knowledge described by Shulman (1987).

In 2005, Grossman, Schoenfeld, and Lee refined PCK as the heart of knowledge “what it means to understand one’s subject matter for the purpose of teaching it to others” (p. 207). They addressed the set of questions that underlie courses in CK and PCK (e.g., What aspects of the subject are most important?; How are the curriculum materials articulated across grade levels?; or What are the practices that characterize the teaching of particular content?). They also generated responses to these questions with two illustrative domains (arts and language) because PCK is inherently content specific.

Grossman et al. (2005) suggested that teacher education help students to develop their PCK in subject matter methods classes by asking them to investigate the PCK concepts (i.e., how different purpose of teaching a subject to different groups of students can reinforce exiting inequities and affect access to higher education, how students understand within the subject matter with their own learning strategies and cultural backgrounds related to student achievement, how students understand from teachers’ multiple perspectives and representations, how teachers use student information to inform instruction). In addition, the authors emphasized teachers’ pedagogical repertoire for the particular content they teach as well as the understanding of the issues of the most effective practices for different group of students. Finally the authors suggested continuously fostering the appropriately structured teacher preparation programs and professional development programs for preservice and inservice teachers’ PCK.
Ball’s View of PCK

Ball et al. (2008) empirically examined Shulman’s definition of PCK and 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) (see Figure 2.10)

<table>
<thead>
<tr>
<th>Pedagogical Content Knowledge</th>
<th>Knowledge of Content and Students (KCS)</th>
<th>Knowledge of Content and Teaching (KCS)</th>
<th>Knowledge of Content and Curriculum (KCC)</th>
</tr>
</thead>
</table>

The first domain, knowledge of content and students (KCS) was defined as the amalgam of knowledge of students and mathematics. Ball et al. argued that teachers must be able to anticipate what students are likely to do with the task and whether they will find the task easy or hard. Ball et al. (2008) distinguished KCS from CCK or SCK that they already defined as CK categories providing the following example to clarify the distinct knowledge domains.

“For instance, in the subtraction example, knowing that students often “subtract up” when confronted with a problem such as 307-168 means that a teacher, who has seen this happen and knows that it is common student response, is able to recognize it without extensive mathematical analysis or probing. In other words, recognizing a wrong answer is common content knowledge (CCK), while sizing up the nature of the error may be either
specialized content knowledge (SCK) or knowledge of content and students (KCS) depending on whether a teacher draws predominantly from her knowledge of mathematics and her ability to carry out a kind of mathematical analysis or instead draws from familiarity with common student errors” (p. 38).

In PE, KCS would be knowledge and skills needed to understand students’ confusion about the content as well as provide appropriate content for different groups of learners. For example, in teaching a “give and go” tactic in basketball, teachers need to recognize why students are struggling with the task and what makes them be easy or challenging for them based on the familiarity with students’ common errors and their specific knowledge of basketball content. PE Teachers’ KCS would be largely drawn from engaging in understanding of students who are learning in the specific content within the actual learning context.

The second sub-domain of PCK was knowledge of content and teaching (KCT) which is the combined knowledge of mathematics and pedagogy. Ball et al. asserted that teachers who have KCT can provide proper task progressions for learners, identify the appropriate instructional representation ways by evaluating their instruction, and make sound decisions about instructional strategies by considering individual student’s needs. According to the authors, “one example of KCT would be knowing different possible models for place value, what each can be used to make visible about the subtraction algorithm, as well as how to deploy them effectively (p.40).”
In PE, KCT would be teacher knowledge and skills that entail teachers’ different repertories to represent the content and knowing how to deliver it effectively. For example, if a teacher teaches a diamond formation in a hockey game, teachers need to be able to clearly explain why students move with this formation and how to move, and what each attacker’s and defender’s roles are. In addition, teacher should decide effective ways to represent the task and deliver it using the selected useful representations (i.e., diagram, demonstration, verbal explanation, analogies and examples) based on their knowledge of pedagogy and specific knowledge of content.

Although Ball et al. included knowledge of content and curriculum (KCC) in the third domain of PCK, they frankly reported that they were not yet sure whether this may be a part of PCK because of a lack of empirical foundation. Thus, further empirical evidence is needed to elaborate this domain of knowledge.

**Pedagogical Content Knowledge in Physical Education**

In this section, Inez Rovegno’s view of PCK, Shiri Ayvazo’s view of PCK and Phillip Ward’ view of PCK will be reviewed because their works have been so influential to me in conceptualizing my view of PCK and establishing my methodological standpoint for designing the study on PCK.

**Rovegno’s View of PCK**

Rovegno (1992) adopted Shulman’s initial definition of PCK as a framework for
the qualitative research and emphasized teachers’ reflection about teaching to improve teachers’ PCK. Rovegno noted the heuristic continuum of PCK development using the words “immature” and “mature”. Other investigators also used words such as "strong," "weak" and "immature" PCK in PE (Chen, 2004; McCaughtry & Rovegno, 2003; Tsangaridou, 2002). This early notion of conceptualizing PCK with mature/immature forms influenced the researchers to conceptualize teachers’ PCK on the continuums. Yet little formation about what mature/immature or strong/weak forms of PCK look like in teaching has not been provided.

Rovegno (1992, 1993) found that student teachers spend time planning to teach, teaching, and then reflecting on what happened and planning for the next lesson as a main structure and content during the method courses. Rovegno argued that field experiences may have a positive or negative impact on student teachers’ PCK development mentioning that the choice of schools for application and of mentors is particularly important for a positive experience.

In 1994, Rovegno argued that Shulman’s definitions of PCK were not empirically based and not consistent under the belief that the domains of PCK are interacted or overlapped with one another. Rovegno (1994) further expanded aspects of PCK including teachers’ understanding of the school’s culture, classroom ecology, discipline, and lack of administrative. These aspects of PCK shows a “curricular zone of safety” (Rovegno, 1994, p. 272) and represents how PCK develops in the relationships among the teacher, students, the activity of teaching, and the school culture. Rovegno (1994) emphasized the teachers’ recognition of culture that influence on PCK.
Rovegno (2003) proposed more integrative and interactive view of PCK in nature by integrating the broader components of knowledge and skills (e.g., curricular knowledge, CK, knowledge of the learners, of instructional strategies, and of purpose and values of teaching). Rovegno (2003) argued that improved PCK was linked to more acute observations of children’s movement, and enhanced capacity to match tasks with students’ abilities. In addition, Rovegno pointed out the influence of teachers’ value and perspective on teaching and learning as well as the needs of guided and systematic observation of teaching practices and the learners as a way to evaluate teaching effectiveness.

Early in 1992, Rovegno recommended studying PCK experimentally but most of the studies on PCK have been conducted since then with a qualitative method in nature. In order to conduct the experimental research on PCK, we need a functional definition of PCK in order to measure PCK as a variable.

Ayvazo’s View of PCK

Along with the need of functional definition of PCK, Ayvazo (2007) proposed PCK definition in a way to measure and observe it as it is “the act of selecting content from one’s knowledge base for the purpose of teaching in a specific context” (p. 77). In her definition, the act of selection from one’s knowledge include several forms: (a) selection of content to be included in the lesson plan, (b) enactment of the content in the actual act of teaching, and (c) repeated interactions with the same content. Ayvazo (2007) emphasized the selection process and adaptation which occurred when a teacher selected
Ayvazo (2007) argued that teachers have a different degree of PCK based on their developmental status, content specificity, and context specificity. First, Ayvazo argued that teachers might have developmentally different levels of PCK depending on what unit they are teaching. For example, a teacher might be very strong knowledge in teaching badminton but might not be strong in teaching soccer. Second, Ayvazo argued that PCK is content specific with the agreement of Grossman et al. (2005)’s early argument. For example, a teacher might have mature PCK in teaching softball to seventh grade students which might be explained by the teacher’s prior teaching experiences with seventh grade students in a softball unit. However, the teacher might not be have mature PCK in teaching swimming to the same grade students because of the lack of content familiarity of the teacher with this group of students. Third, Ayvazo argued that PCK is context specific. For example, a teacher might have mature PCK in teaching dance to advanced performers, but the teacher might be struggling with teaching dance to beginners because of the lack of teaching experience with beginners.

**Ward’ View of PCK**

Recently, Ward (2009b) 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 2.11).
In this model, PCK can be mostly formed through a transformation of knowledge of content and pedagogy based on the four knowledge bases (e.g., context, curriculum, students, and other knowledge bases). When teachers change the content area from one content area to another content area, most of the knowledge bases are influenced by the change of the content. In addition, when the content is changed, teachers might use different pedagogical skills for teaching the content. Thus, PCK should be placed in the top and CK should be placed in the middle between PCK and the knowledge bases in that PCK is influenced by the knowledge bases which are filtered through content and pedagogy. It allows teachers to transform content into PCK specific to teachers’ needs.

Ward (2009b) argued the problem of a lack of PCK clarity stems from Shulman’s conceptualization of PCK. First, under the Shulman’s definition of PCK, we cannot solve the problem that a teachers’ PCK might teach successful for some learners, but not for other learners. For example, a teacher may use a task progression for teaching the volley
skill in tennis that is understandable for some students, but not by others. Ward (2009b) raised a second problem that we can determine the teacher’s teaching effectiveness from a given example of PCK. It is implicit in Shulman’s (1986, 1987) definitions that PCK leads to student learning (i.e., it is effective). But this does not explain how PCK might be effective for some students and not for others. This problem in turn raises a third concern. In the tennis example if the progression that was effective for some students was called an example of PCK, then what is the progression (i.e., the same progression) to be called when it is ineffective with other students? To answer these questions further examination of PCK in teaching with the functional definition of PCK was needed (Ward, 2009b).

**Ward’s Continuums of PCK**

Ward (2009b) conceptualized PCK within the two continuums: a) less and more effective and b) less and more mature in teaching (see Figure 2.12). There are four cases in terms of teachers’ PCK in this model. The first case would be the top right corner where most teachers should be by having mature and effective PCK. The second case would be the top left corner where teachers provide excellent tasks and representations but they are not effective for all students. The third case would be the bottom right corner where teachers sometimes have immature PCK but they are effective for all students. The fourth case would be the bottom left corner where most teachers often stay with immature PCK and less effectiveness in teaching.

Ward (2009b) referred to PCK as a class of behaviors that develop on a continuum, from immature to mature forms of PCK. Based on the proposed definition of
PCK, all teachers, in the act of teaching, are necessarily selecting content to teach, and make choices as to how to teach. Thus, the PCK for every teacher can be situated on the continuum from immature to mature, regardless of the teachers’ years of teaching or level of expertise (Ayvazo, 2007; Ward, 2010).

**Figure 2.12 Ward’ Continuums of PCK**

**Relationship between CK and PCK**

Hastie and Vlaisavljevic (1999) examined the relationship between a teachers’ self-reported content expertise and the conduct of a teachers’ instructional system with nine high school PE teachers. To determine teachers’ subject matter expertise (SME) (i.e., highest or lowest level), the structured questions were used. The teachers were asked to report their final level of SME that they taught. Finally each teacher had eight highest
determined and lowest determined SME lessons. The researchers observed both highest and lowest determined SME lessons to examine teachers’ presentation of instructional tasks. The findings indicated that teachers who have strong CK in certain area provided more tasks and practically more extending tasks as well as considered on the quality of the performance than a level of participation or effort in terms of a student accountability focus. In addition, the study found that there were significant differences in class ecologies of teachers who have differential amounts of SME. Even though the study has determined that teachers’ degrees of CK in a variety of subject areas are related to the academic work of PE classes, the interpretation of the results would be limited because the extents of teachers’ CK in each area vary. Hastie and Vlaisavljevic (1999) suggested a further study that examines a series of experts and novices teaching within the same content area as well as examines the role of teachers’ CK when providing instruction in specific curriculum model (e.g., game for understanding).

Under the belief that teachers might have a different level of maturity of PCK within their strong or weak content areas, Ayvazo (2007) examined the differences of the content development (i.e., informing, extending, refining, and applying tasks) as well as of task adaptations (i.e., modifying difficulty of task, breaking down the skill, different task, restating, and changing the competition condition) for learners of two effective elementary teachers within their strong and weak units. The results showed that teachers have different levels of teaching quality within their strong and weak units. For example, while a teacher used all types of content tasks (i.e., informing, extension, refinement, and application) in the strong unit, teachers used dominantly informing tasks (86%) were
used in conjunction with some extension tasks (14%) in the weak unit. The results also showed that both teachers used mostly verbal instructions and a few demonstrations and metaphors in both strong and weak units. Ayvazo (2007) argued that the teachers’ mature form of PCK could be explained by teachers’ diverse representation ways using both verbal and visual representations. This result verified that PCK exists on a continuum regardless of the teachers’ years of teaching or expert level (Ayvazo, 2007). Ayvazo also found that there were the difference of the teachers’ ability to modify the selected tasks based on the teachers’ recognition of students’ understandings and misunderstandings, and the context CK. With regard to the adaptation, the result of the study showed that both teachers responded primarily to students’ incorrect performance and modified tasks for individual students. It indicated that both teachers have richer knowledge of skill. She argued that teachers’ adaptations could be one of the dependent variables to measure teachers’ PCK.

As a follow up study of Ayvazo (2007), Lee (2011) examined the effects of implementation of a CK workshop on teachers’ PCK variables and student learning in a soccer unit under the assumption that improved teachers’ CK would influence on teachers’ PCK and student learning. In this study, two middle school teachers who did not have a strong CK in teaching soccer were involved. To improve teachers’ CK, Lee (2011) provided a content knowledge workshop using a knowledge packet. For collecting teacher data, teachers’ soccer lessons were videotaped, whereas a live coding method was used for collecting student data. The study descriptively analyzed teachers’ knowledge of teaching and effectiveness of teaching in terms of the maturity of task representations, the
appropriateness of the tasks, and student correct performance to create the profiles of each teacher. The study found that the CK workshop affected the teachers’ CK and PCK. That is, the improved teachers’ CK lead to the improved PCK of teachers in terms of their task representations and task selections. In addition, the study found that the improved teachers’ PCK influence the improvement of students’ correct performance. The results showed that teachers’ PCK can move from immature to mature as a function of their CK within a continuum in terms of task maturity and appropriateness. The study validated that the effectiveness of a CK workshop and knowledge packet for improving teachers’ CK as well as teachers’ PCK were able to be observed and measured using several dependent variables. Lee (2011) suggested further experimental research which examines statistically significant differences of teachers’ CK and PCK as well as student performance before and after the CK workshop in a different content area to verify the current results.
CHAPTER 3

METHOD

This study is designed to answer the two primary research questions: (a) How do pedagogical content knowledge (PCK) variables differ before and after a content knowledge (CK) workshop? and (b) How does student achievement differ between the comparison and experimental group? Figure 3.1 shows the three phases of the study.

Figure 3.1 Three Phases of the Study

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Collect comparison group data from intact PE classes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 2</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Provide teachers with the CK workshop using badminton knowledge packet and daily teaching feedback</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase 3</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Collect experimental group data from intact PE classes</td>
</tr>
</tbody>
</table>
The basic strategy was to collect data as teachers taught their typical badminton unit of instruction. The teachers were then asked to attend a CK workshop where the purpose was to increase their badminton CK. The teachers were then observed in terms of their teaching behaviors to determine if their teaching had changed after the CK workshop as well as if they had followed lessons on a daily basis feedback provided by the researcher. Measures of teacher behaviors and student performance in each condition were also recorded.

**Research Design**

A quasi-experimental design with two teachers as a block was used to examine the change of teachers’ teaching behaviors and student learning behaviors in their intact classes before and after a badminton content knowledge (CK) workshop in a natural PE setting. The purpose of the design was to test the hypotheses that there are relationships between teachers’ pedagogical content knowledge (PCK) and student achievement by manipulating the level of teachers’ CK. In this study, the independent variable was a badminton CK workshop which includes three hours of training of teachers’ specialized content knowledge (SCK) for successfully teaching badminton in physical education (PE) classes and daily teaching feedback. The dependent variables were teachers’ teaching practices that indicate their PCK and student achievement in PE lessons. Figure 3.2 shows a diagram of research design of individual teacher and three phases of the study.
The researcher selected two classes for the comparison group and two classes for the experimental group from the list of six classes taught by the individual teacher for this study. A stratified sampling was used, and in each class, six students were randomly selected based on students’ gender and skill level to be representative of the class.

The study was organized in three phases. In the first phase, the investigators observed student performances and videotaped the six-day badminton unit with two comparison classes per teacher without any assistance or interruptions. In the second phase, the researcher implemented a badminton CK workshop in the school site with a badminton knowledge packet after completing six-day lessons with two comparison classes. In the third phase, the investigators observed and videotaped another six-day
badminton unit with two experimental classes per teacher to examine whether any
differences in students’ performances and teacher behaviors occurred before and after the
CK workshop.

Selection of Participants

Two physical education (PE) teachers were purposely selected as participants for
this study according to the following criteria: (a) teachers who agreed to participate in
this study; (b) teachers who did not consider badminton as an area of their expertise; and
(c) teachers who were able to teach a six-day badminton 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 |
|---------------------------------------|---|---|
|                                       | Ray | Tyler |
| Age                                   | 47  | 34   |
| Gender                                | Male | Male |
| Ethnicity                             | White | White |
| Grade level                           | 6-8 | 6-8 |
| Number of years teaching K-12         | 6   | 2    |
| Number of years teaching at the current school | 4   | 1    |
| Number of years playing badminton     | 6   | 5    |
| Number of years teaching badminton    | 6   | 4    |
Students in the teachers’ intact classes were selected as participants for the study. Students who were frequently absent, misbehaved, or had a significant disability were not included in the selection of participants in order to ensure that data collection would not be interrupted.

Each teacher created a list of students in their classes based on the students’ skill levels (i.e., high, average, and low). Participants were stratified based on teacher’s rating of skill levels and gender. Then, the investigator randomly selected two high skilled students (one boy and one girl), two average skilled students (one boy and one girl) and two lower skilled students (one boy and one girl). The characteristics of the students in the classes are presented in Table 3.2. Individual student characteristics were described in Appendix G).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Ray</th>
<th>Tyler</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Grade</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>% of</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>white</td>
<td>white</td>
</tr>
<tr>
<td>% of</td>
<td>65%</td>
<td>55%</td>
</tr>
<tr>
<td>Gender</td>
<td>boys</td>
<td>boys</td>
</tr>
</tbody>
</table>

(Note: C – Comparison group, E- Experimental group)
School Settings

One public suburban middle school in a Midwestern city was selected for this study. Ray and Tyler taught health and PE classes as a PE teacher in Euphoria middle school (pseudonym). The school has an enrollment of 631 students (Public School Review, 2010). In terms of students’ ethnicity data, the majority of students were white (N=587), the remainder were African-American (N=3), Hispanic (N=7), and Asian (N=25) (Public School Review, 2010). No student received reduced or free lunch in this school. The average PE class size was 18-23. Students received PE classes in 43-minute lessons with an every-other day schedule for a six weeks block. The characteristics of the school setting are shown in Table 3.3.

<table>
<thead>
<tr>
<th>Location</th>
<th>Student Race</th>
<th>No. of Students</th>
<th>No. of PE students</th>
<th>Reduced/Free Lunch</th>
<th>PE Class per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban</td>
<td>White: 587</td>
<td>631</td>
<td>18-23</td>
<td>0%</td>
<td>2 or 3 days</td>
</tr>
<tr>
<td></td>
<td>African-Am.: 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hispanic: 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Asian: 25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>American Indian: 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gaining Access

Permission to conduct this research was obtained from the Institutional Review Board (IRB) at The Ohio State University (IRB # 2010B0424) (see Appendix A). The investigator obtained permissions from the districts, the principals, and the teachers. A letter of the study participation was sent to the teacher as an informal inquiry prior to the
formal request (see Appendix B) and then the teacher signed the teacher consent form (see Appendix C). The teacher then explained the research to the students, and asked for their assent to participate in the study (see Appendix D and E). In addition, the investigator obtained consent forms from the parents (see Appendix F). All of the participants in the study (i.e., teachers and students) were assured that the data would be kept confidential and accessible only to the primary investigator and her assistants.

**Independent Variables**

The independent variable consisted of two components: (a) The CK workshop which occurred between the teaching of the comparison group classes and the experimental group classes, and (b) Teaching feedback provided to teachers following lessons on a daily basis.

**Badminton Content Knowledge Workshop**

To increase the teachers’ CK of badminton, the investigator conducted a CK workshop using appropriate equipment (e.g., rackets, shuttles, badminton court, cones, and poly spots) as well as a knowledge packet developed by the researcher. The duration of workshop was a total three and a half hours with individual teachers for two days. The workshop was structured with three components: (a) introduction to the workshop, (b) modeling the knowledge packet, and (c) evaluation which occurred both throughout and at the end of the workshop.
Introduction to the Workshop

The researcher provided an overview of the workshop including (a) the purpose of the workshop, (b) expectations of the trainer, and (c) basic principles of Play Practice (Launder, 2001) (see Appendix I). Table 3.4 describes six objectives of the CK workshop, process and criteria during the workshop.

Modeling the Knowledge Packet

The researcher and her assistants modeled each task in the knowledge packet during the workshop. In this modeling, the following were presented (a) the objective of each task, (b) examples of developmentally and principally appropriate tasks, (c) examples of verbal and visual representations of the tasks, (d) critical elements of each skill and tactic, (e) the organization of the tasks, and (f) task adaptations for students who have different ages and skill levels, and (g) task progressions for teaching a badminton unit.

Evaluation

After watching a particular demonstration of each task performed by the researcher or students, the teachers were asked to answer a set of questions that the researcher developed in terms of skill discrimination, error detection and corrections, task presentation, task progressions and task adaptations for student learning. Evaluation occurred both throughout and at the end of the workshop. When the teachers met the criteria for the each goal (see Table 3.4), the workshop was completed.
Table 3.4 Objectives, Process and Criteria of the CK Workshop

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Process</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Teachers will discriminate between correct and incorrect performances.</strong></td>
<td>During the workshop whenever a new skill or progression was introduced the teachers were asked to discriminate between correct performances (e.g., drop racket down and swing it quickly up to contact shuttle for executing an underhand clear) and incorrect performances (e.g., a lack of full arm extension at contact) by students.</td>
<td>For each skill presented, each teacher was asked to meet the criteria (e.g., 3 out of 3 trials) to identify correct and incorrect performances by students. The assessment occurred throughout the workshop, typically following the presentation of the skill.</td>
</tr>
<tr>
<td><strong>2. Teachers will identify common mistakes that can be made by students and sources of errors.</strong></td>
<td>During the workshop the teachers were asked to identify common mistakes in performances by students (e.g., having an incorrect grip, and inconsistent contact point) and different sources of errors (e.g., late backswing, low speed of racket swing, and a lack of deception).</td>
<td>For each skill presented, each teacher was asked to meet the criteria (e.g., 3 out of 3 trials) for detecting students’ common errors and (3 out of 3 trials) for detecting different sources of errors. The assessment occurred throughout the workshop, typically following the presentation of the skill.</td>
</tr>
<tr>
<td><strong>3. Teachers will recommend appropriate solutions to the common mistakes made by students.</strong></td>
<td>During the workshop the teachers were asked to remediate common errors made by students by providing appropriate feedback, cues and tasks (e.g., in response to the common error ‘a lack of arm extension when performing an overhead stork made by a student a teacher might provide appropriate feedback like “throw the racket upward as if attempting to scrape the ceiling).</td>
<td>For each skill presented, each teacher was asked to meet the criteria (e.g., 3 out of 3 trials) to correct students’ common errors. The assessment occurred throughout the workshop, typically following the presentation of the skill and in conjunction with the first two objectives.</td>
</tr>
</tbody>
</table>

Continued
4. Teachers will represent tasks using a variety of visual and verbal representations. During the workshop, the investigator modeled a task (e.g., target game ‘four squared’ to teach the overhead clear) using clear instructions and descriptions. In addition, the investigator used analogies (e.g., big rainbow trajectory), cues (e.g., shuttle up high in a rally), and specific congruent feedback (e.g., I like the way that you contacted the shuttle at the highest point). The investigator also modeled gestures (e.g., thumbs up when students perform correctly) and physical assistant (e.g., physically correcting students’ wrong backswing position by touching them). The teachers were asked to model task representations and visual represents on 50% of the tasks presented. The assessment occurred throughout the workshop.

5. Teachers will select and organize developmentally appropriate tasks considering students’ age and skill level. The teachers were asked to answer to the questions regarding the developmentally appropriate tasks that the researcher already presented. (e.g., challenge service game using different targets) The teachers were asked to meet the criteria (4 out of 5 questions) for selecting and organizing developmentally appropriate tasks. The assessment occurred at the end of the workshop.

6. Teachers will select and organize principally appropriate tasks by understanding of three fundamental principles of the Play Practice. The teachers were asked to answer to the questions regarding the principally appropriate tasks that the researcher already presented. (e.g., self testing target and challenge games, floor zone game, and target games for specific techniques). The teachers were asked to meet the criteria (4 out of 5 questions) for selecting and organizing developmentally appropriate tasks. The assessment occurred at the end of the workshop.
If the teacher did not meet the criteria, further training occurred and another set of questions were provided until the teacher met the criteria. Appendix H shows the set of questions for each goal and evaluation forms.

The Badminton Knowledge Packet

The knowledge packet was developed by the researcher. To ensure the validity of the content in this knowledge packet, two badminton experts who have been long-term teachers and players of badminton were asked to thoroughly check whether: (a) the sequence of the tasks was appropriate (i.e., sequential content development in a manner that has the potential to facilitate learning); (b) the content was developmentally appropriate (i.e., practices and content that are suitable for students’ age and individual capabilities); and (c) the content was principally appropriate (i.e., consistent with play practice assumptions including shaping, focusing, and enhancing the play).

To develop the content of knowledge packet, the book resources of ‘Play Practice’ written by Alan Launder (2001), ‘Badminton Steps to Success’ written by Tony Grice (1996) as well as the workshop materials under the Play Practice principles by Wendy Piltz (2010) were utilized. Table 3.5 indicates the descriptions of three basic principles of the Play Practice that were employed as a conceptual framework for developing the knowledge packet. The knowledge packet was used as one of the components for the badminton CK workshop. Prior to the start of the workshop, the knowledge packet was provided to the teachers. The investigator asked teachers to review the knowledge packet independently before starting the workshop.
Table 3.5 Three Principles of Play Practice = Principle Appropriate

| Shaping Play | The process of shaping play is to manipulate specific variables (e.g., game rules, size and shape of the playing area, the nature of the goal, the number of player and different scoring) that can readily be applied to most sports. The notion of shaping play is to develop far more extreme learning situation using progression in order to layer and scaffolding learning building confidence and competence. Through this process, it is possible to create environment that will more easily improve specific elements of effective performance. |
| Focusing Play | Using targets and minimized/simplified key cues, most important points, and simple concepts are presented to the learner. The focusing process is vital because it determines both the quality and the direction of the practice and helps ensure positive transfer from the practice to real game. Moreover, instructors can use this focusing process to point out the similarities and differences between a specific play practice and the real game. |
| Enhancing Play | It is to enhance learning by making improved performance appear to be important and meaningful. It is to enhance player commitment and performance by presenting challenges, using time constraints or action fantasy games, handicapping individuals or teams and the freeze replay. Instructor can also change the aspects of the learning environment (e.g., racket, partner, task, court and game) is to maintain students’ interests and engagement. |

In the knowledge packet, six primary activities: (a) serves, (b) overhead strokes, (c) underhand strokes, (d) smash shots, (e) drop shots and (d) doubles were included to facilitate teachers’ badminton CK (see Table 3.6). The developed activities were principle appropriate (e.g., designing target games with specific conditions or scoring only if the shuttle lands in the zones indicated), and developmental appropriate (e.g., using a wide range of target area for beginners). Appendix I shows the knowledge packet that includes the objective of the workshop, the expectations of the workshop, introduction to Play...
Practice, the set of task progressions for teaching badminton, the list of critical elements of each skill and tactic, the list of common errors and error corrections, and the set of tasks for a six-day badminton unit.

<table>
<thead>
<tr>
<th>Activity 1</th>
<th>Forehand and Backhand Long and Short Serves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 2</td>
<td>Forehand and Backhand Overhead Strokes</td>
</tr>
<tr>
<td>Activity 3</td>
<td>Forehand and Backhand Underhand Strokes</td>
</tr>
<tr>
<td>Activity 4</td>
<td>Forehand and Backhand Smash Shots</td>
</tr>
<tr>
<td>Activity 5</td>
<td>Forehand and Backhand Drop Shots</td>
</tr>
<tr>
<td>Activity 6</td>
<td>Doubles’ Strategies</td>
</tr>
</tbody>
</table>

**Teaching Feedback**

After each lesson with the experimental group, the investigator met with the teachers and provided them with specific feedback about their teaching. Using the treatment checklist for teachers (see Appendix O), the investigator identified whether the teachers implemented the tasks that they learned from the workshop and then provided specific feedback in terms of their selection, representation, and adaptation of the tasks during the lessons.
Dependent Variables

Two general categories of dependent variables were used in this study: measures of student performance and measures of two teacher behaviors that represent PCK (see Figure 3.3).

Figure 3.3 Dependent Variables

Student Variable
- Student Performance

Teacher Variables
- Task Maturity
- Task Appropriateness
- Task Adaptation

To verify the teachers’ teaching effectiveness, student performances in terms of the total, correct, incorrect and other trials were defined and measured. In addition, three teachers’ PCK variables were defined and measured in terms of the maturity of task representations, appropriateness of task selections and task adaptations. Using Ward’s (2010) model of PCK and Shulman’s (1986) definition of PCK, the teachers’ maturity of task representations and appropriateness of task selections were defined and used for measuring teachers’ PCK. Further, the teachers’ ability to adapt the tasks using different repertories of representations and task progressions was used to measure the teachers’ PCK.
Student Variables

Student Performance

To measure each teacher’s teaching effectiveness, student performance was collected according to three sub-categories: (a) correct trial, (b) incorrect trial, and (c) other trial (see Figure 3.4).

Figure 3.4 Sub-Categories of Student Performance

Student performance was measured using the criteria (e.g., the critical elements of the skills or tactics) that teachers stated. In addition, the investigator developed the list of the five critical elements of the skills based on the six primary skills that the teachers normally teach during six-day badminton lessons (see Figure 3.5). The book source of ‘Badminton Step to Success’ (Grice, 1996) was used to create the list of the critical elements of the skills. Two badminton experts were asked to thoroughly check whether the selection of the critical elements of the skills as well as the criteria of the correct trial were appropriate.
### Figure 3.5 List of Critical Elements of Skills and Tactics in Badminton

<table>
<thead>
<tr>
<th>Skills or Tactics</th>
<th>Critical Elements</th>
</tr>
</thead>
</table>
| Serve             | - Up and back stance  
|                   | - Racket arm in backswing  
|                   | - **Push or guide shuttle** (Short)  
|                   | - Low, close to net (Short)  
|                   | - Use wrist action (Long)  
|                   | - **High and deep** (Long)  
|                   | - Cross racket over in front of opposite shoulder  |
| Overhead strokes  | - Sideways hitting stance  
|                   | - Both arms up  
|                   | - **Rotate upper body**  
|                   | - **Reach high to hit**  
|                   | - Cross racket to opposite side of the body (forehand)  
|                   | - Racket follow-through contact area downward in line with the return (backhand)  |
| Underhand stroke  | - Reach with dominant hand and foot  
|                   | - Racket arm up with palm pointed upward (forehand) and downward (backhand)  
|                   | - **Pivot and reach for the oncoming shuttle**  
|                   | - **Drop racket down and swing it up**  
|                   | - **Continue swing up with shuttle’s flight**  |
| Drop Shot         | - Racket arm up  
|                   | - Pivot and turn to oncoming shuttle  
|                   | - **Contact shuttle at high as possible**  
|                   | - **Shuttle is blocked not hit**  
|                   | - **Continue swing up with shuttle’s flight**  |
| Smash             | - Hold racket arm up  
|                   | - Forward swing up to contact high as possible  
|                   | - **Throw racket out and upward with racket face down**  
|                   | - Turn shoulders with feet up and back (forehand)  
|                   | - Turn shoulders with back toward the net. (backhand)  
|                   | - Swing down and across body (forehand)  
|                   | - Swing in the line with flight of shuttle (backhand)  |
| Returning to Center court | - As soon as you make your return, recover to your center court (Singles)  |
| Aiming for the backcourt for a defense shot | - Anticipate where the shuttle is going and get into position quickly  
|                   | - Making high serve, clear or lifts (Singles)  |
| Changing the place | - Anticipate where the shuttle is going and get into position quickly  
|                   | - Making alternatively slow and quick shots or long and short shots(Singles)  |
| Playing downward shots wherever possible | - Adopting the attacking position  
|                   | - Attack straight down or flat the court or into open spaces (Doubles)  |
| Aiming low and short serve over the net to the center | - Starting close to service line  
|                   | - Low and short serve over the net to the center (Doubles)  |

(Note: Normal font –Preparation, Bolded font – Execution, Italic font – Follow Through)
The teachers were asked to teach badminton in each lesson with three sections: (a) warm up (i.e., any kind of activities for warming up), (b) practice (i.e., the activities for developing specific skills and tactics either in the practice or game situation), and (c) game play (i.e., the activities for applying the learned skills or tactics into a modified or real game).

For both comparison and experimental classes, the teachers were asked to organize the lessons with a seven to eight minute warm up activity, a 15-20 minute practice, and a 10-15 minute game play. During the warm up, the observers did not measure student performance regardless of the activities the teachers provided. The observers measured student performances separately during practice and game plays. During the practice section, either badminton skills or tactics were taught by the teachers, and student performances on the skills and tactics were measured using the partial critical elements that the teachers stated or the full critical elements that the researcher developed. During the game plays, student performances on the skills over the tactics were measured unless the teachers asked to play a game with only specific skills and tactics.

The procedure for the data coding for student performance was followed by three stages: (a) determining what skill or tactic should be observed based on a teacher’s statements, (b) judging whether the observers use the full list of the critical elements of the skill when a teacher did not mention about the critical elements of the skill, or use the partial critical elements that the teacher mentioned, and (c) watching every trial of the individual selected students and coding their performances in terms of their correct trial, incorrect trial, and other trials including unfair opportunity, missed opportunity, and non-
Figure 3.6 Example of Student Data Coding Sheet

| Observer: Insook | IOA: Jim | Date: 01/14/2010 | Session #: 3 out of 6 | Class: 2 |
| Teacher: Ray | Student A: | Student B: |

### Task #2: Forehand Stroke (Partial)

| A | V | V | / | V | / | V | V | O | V | O | V | V | V | V |
| B | / | / | / | V | V | V | / | / | O | / | / | / | | |

### Task #3: Backhand Stroke (Full)

| A | / | / | O | O | / | / | / | / | O | O | O | / | / | / |
| B | / | V | V | V | V | V | V | V | O | O | O | / | / | / |

### Task #4: Long serve and Overhead return (Full)

| A | / | V | V | / | / | O | O | O | V | / | / | / | / | |
| B | / | V | V | V | V | V | V | O | / | V | / | V | V | V | O | / | / |

### Task #5: Game Play (Doubles)

| A | V | V | O | V | V | / | / | O |
| B | V | V | O | / | V | V | - | V | V | / | V | V | - |

(Note: V – Correct trial, / – Incorrect trial, O – Other trial)
Correct or Incorrect Trials on the Skills

When a student’s trial met the partial critical element outcomes that a teacher stated or the object criteria using full critical element outcomes that the researcher developed (i.e., correct demonstration of critical elements of the skills within two or three phases), it was coded as a correct trial. For example, when the teacher correctly stated one or two critical elements of the skill (e.g., reach high to hit and rotate upper body for the forehand overhead stroke), the observers coded student performance as a correct trial when students demonstrated these critical elements that the teacher mentioned during practice.

If the teacher did not mention critical elements of the skill or the teacher’s presentation of the critical elements of the skill was not appropriate, the observers used the list of the object critical elements of the skills that measured the students’ correct or incorrect performances. For example, the teachers asked students to practice a forehand overhead stroke with a partner without mentioning the critical elements of the forehand overhead stroke. The observers coded their performance as a correct trial when they correctly demonstrated the critical elements of the forehand overhead stroke in two or three phases. If the student demonstrated the critical elements of the skill within no or one phase, it was coded as an incorrect trial.

When a student’s trial did not meet the partial critical element outcomes that the teacher described or the object criteria of full critical elements of the skills (i.e., correct demonstration of critical elements of the skills within no or one phase), it was coded as an incorrect trial. For example, a teacher asked students to perform a short serve with two
critical elements (e.g., racket arm in backswing and push or guide shuttle). If the student performed the short serve without demonstrating these critical elements that the teacher stated, it was coded as an incorrect trial. When the teacher asked students to practice a backhand overhead stroke with a partner without mentioning any critical elements of the backhand overhead stroke, the observers coded student performance as an incorrect trial using the object criteria. For example, if the student demonstrated the critical elements of the backhand overhead stroke within no or one phase, an incorrect trial resulted in the coding.

During the practice section, students’ correct trial, incorrect trial, and other trial (i.e., unfair opportunity, missed opportunity, and non-target performance) on skills were observed and measured. During the game plays, students’ correct trial, incorrect trial, and other trial (i.e., missed opportunity) were measured. The observers depended on the teachers’ task statements for the practice section using either partial critical elements that the teacher described or full critical elements that the researcher developed. But the observers instantly determined the skills that the students were performing and coded their performances only using the checklist of critical elements of the skills during the game play section.

**Correct or Incorrect Trials on the Tactics**

When a student’s trial met either the partial critical elements that the teacher stated or the object criteria (i.e., all the critical elements of the tactic) from the list of critical elements of the tactic that the researcher developed, it was coded as a correct trial.
For example, when the teacher correctly stated one or two critical elements of the tactic (e.g., return to the center court after returning the shuttle in singles), and when the student demonstrated the tactic that the teacher stated, the observers coded student performance as a correct trial.

When a student’s trial did not meet either the partial critical element outcomes that the teacher described or the full object criteria (i.e., no critical element or one out of two critical element outcomes of the tactic) that the researcher developed, it was coded as an incorrect trial. For example, the teacher asked students to play double games with two critical elements (e.g., adopting the attacking position and make downward shots). If the student did not demonstrate two critical elements of the tactic, it was coded as an incorrect trial.

If the teacher did not mention the critical elements of the tactic, the observers did not measure the students’ tactical movements during the practice. Only students’ skill performances were observed and coded. However, if the teacher’s presentations of the critical elements of the tactic were not appropriate, the observers used the checklist of the object critical elements of the tactics to measure the students’ correct or incorrect tactical performances. For example, if the teacher had a wrong statement about one of the tactic in doubles (e.g., aiming long and deep serve), the observers coded student performance using the checklist of the object critical element of the tactic (e.g., starting close to service line and making low and short serve over the net to the center). When student performance was demonstrated in all the critical elements of the tactic, it was coded as a correct trial. During only practice section, students’ correct or incorrect trials of the
tactical movements were observed and measured.

During the practice section, the students’ tactical movements were measured based on the teachers’ statements about the critical elements of the tactics, whereas the observers did not observe or measure the students’ tactical performances during the game plays.

**Other Performances**

Other performances were defined with the three categories: missed opportunity, unfair opportunity and non-target performance.

**Missed opportunity.** When a student missed hitting the shuttle due to the mistakes made by the student, the observers coded it as a missed opportunity. For example, if the student failed to hit the shuttle which was appropriately coming to the student because of his or her own mistake, the observer coded the student’s trial as other trials. During the practice and game play sections, students’ missed opportunities were observed and coded.

**Unfair opportunity.** When a student missed hitting the shuttle due to an unhittable shuttle made by the partner (e.g., the shuttle on the net, the shuttle landing on the outside boundary, or a too short or too long shuttle), the observers coded it as other trials. For example, if a student was supposed to return a serve using forehand overhead stroke but he or she could not hit the shuttle because the partner did not make the serve over the net or the shuttle was too short or long to make the target performance, the observer coded his or her trials as other trials. During the practice and game play sections, students’ unfair opportunities were observed and coded.
Non-target performance. When a student made the skill or tactical movement that the teacher did not ask during the practice sections, the observers coded it as a non-target performance. For instance, such a case would be when the student was asked to practice only forehand strokes toward the target by the teacher. When the student performed a different skill (e.g., backhand stroke or drop shot) on the task, the observers coded the trial as other trials. Students’ non-target performances were observed and measured only during the practice section.

The individual student data were reported by the frequency of correct, incorrect, and other trials per lesson and the mean of the percentages of each category were reported to compare the differences between the comparison and the experimental classes.

Teacher Variables

Maturity of Task Representation

The first level for measuring teachers’ PCK was the maturity of task representations. Tasks were coded as mature and immature according to the following criteria:

Maturity referred to the degree to which a task is represented in ways that provide clarity and show refinement beyond a simplistic description. A mature task includes the elements such as cues, descriptions, analogies, metaphors, or demonstrations that make it comprehensible to learners. What distinguishes maturity in task representations is the quality and sophistication of the representation to the students (Lee, 2011). The mature form of task representations also should include verbal and/or visual explanation of the
critical elements of the skill and a clear task statement with criteria, situation, and behavior. For example, the following task statement provided by the teacher is clear and concise.

“What we are going to do is to practice a long serve; Watch my demonstration of the long serve (without saying). First, start with the handshake grip and stand close to the centerline and behind the short service line on your court staggering your feet up and back. You can adjust a starting position according to your serves but attempt to serve from as close to the center court. Second, serve a shuttle in the court diagonally opposite your end of service court (put the cones for the target areas) rolling your hips and shoulders into the long serve. I want to see your long, high and deep serves. Your good long serves should be shaped like a huge rainbow. Let’s start to practice 20 forehand long serves to the targets from right and left sides in your court. Ready Go!”

In this presentation, students can understand exactly what they are supposed to do. This statement shows the teacher’s in-depth knowledge about the content.

*Immaturity* referred to the degree to which a task was represented in ways that lacked detail and refinement, causing overly simplistic and/or incomplete representations of content. Immature tasks often lack visual and/or verbal explanation of critical elements of the skill and unclear task statement without mentioning criterion, situation, and behavior.

For example, when the following task statement shows a lack of direction and clarity: “What we are going to do is to practice a serve; I want to see your long and high
serves. Let’s start to practice long serves in your court. Ready Go!” With such simple and unsophisticated instruction, students might not understand the focus of the practice or how to execute correct serves because the task poorly has been represented. This statement shows that the teacher did not have in-depth understanding of the content.

The observers reported each task’s maturity or immaturity in the coding sheet and the means of mature and immature tasks per lesson and per unit before and after a workshop were compared.

**Task Representations**

To measure the teachers’ maturity of task representations, the teachers’ task representations including verbal and visual representation categories which were observed and coded independently. Shulman (1986) defined PCK as having several characteristics such as “analogies, illustrations, examples, explanations, and demonstrations” (p. 8). These characteristics can be categorized into verbal and visual categories. Figure 3.7 shows that both verbal and visual representations encompass diverse types of representations under the maturity of task representation. Moreover, each category can include additional pedagogical strategies for delivering the content within two teaching conditions (i.e., during task representation and during practice).

**Verbal representations.** The five sub categories of the verbal representations included: (a) instructions, (b) descriptions, (c) analogies and metaphors, (d) cues, and (e) specific congruent feedback within two teaching conditions (i.e., during task
representation and practice). Three sub-categories including instructions, descriptions, and analogies/metaphors were observed when the teachers represented the tasks, whereas teachers’ cues and specific congruent feedback were observed during the practice. While watching the video clip of the lessons, the investigator coded each task during the task representation and practice in terms of verbal representations.

**Figure 3.7 Sub-Categories of Maturity of Task Representation**

Each sub category was defined as follows:

- **Instructions**: “Teacher is verbally describing to the students how to do a skill, or using a verbal prompt to direct students in attempting a skill or activity” (Hawkins & Wiegand, 1989, p. 279). For example, the teacher states “we are going to do a
‘return forehand clear drill’ with a partner having 30 high, deep, clear forehand returns over your partner’s head” in a badminton unit.

- **Descriptions**: Descriptions are the teacher’s verbal explanation or illustration about what a particular skill (activity) looks like (Lee, 2011). For example, the teacher describes “The critical elements of execution of backhand clear shot are to pivot and turn with back to net, wrist in cocked position, racket head trails hand up to contact, and contact as high as possible” in a badminton unit.

- **Analogies and metaphors**: While analogies are used by teachers to explain the skills using similar or different examples, metaphors are used by teachers to describe the content in imaginative ways using different names with the same characteristics (Lee, 2011). For example, the teacher states, “When you make a high clear shot, make sure your shuttle shapes a big rainbow and it lands in the opponent’s backcourt.” Here, the teacher explains the important technique in badminton using a metaphor.

- **Cues**: Cues are shortened technical, visual, or metaphoric words that relate to the information about the performance of the movement provided by teachers (Kutame, 1997; Rink & Werner, 1989; Rink, 2006). For example, during the practice, the teacher provides skill-related cues using technical words such as “hit a high and deep shot” in badminton to fix students’ performance or enhance their performance. Another example is a metaphoric cue such as “Scratch your back” for backswing in badminton during the practice.
Specific congruent feedback: Specific congruent feedback is “the degree to which teacher feedback during activity is congruent with (matched to) the focus of the task” (Rink, 2006, p. 372). For example, the teacher explains and emphasizes the follow through in the forehand clear shot in badminton. The teacher looks around the class and provides specific congruent skill-related feedback such as “Continue swing up with shuttles’ flight” when recognizing some students’ wrong performance.

Data were reported as a frequency measure using event recording and tallied as to how many each category occurred per lesson. Then these data were analyzed to compare the mean of each category of verbal representations per lesson between the comparison and experimental groups. Figure 3.8 shows the teachers’ verbal representation coding sheet.

**Visual representation.** The three sub-categories of the visual representations were included: (a) demonstrations, (b) task cards, pictures, diagrams, and video clips, and (c) physical assistance within two teaching conditions (i.e., during task presentation and practice). The investigator coded each category of visual representations while watching video clips.
<table>
<thead>
<tr>
<th>Task</th>
<th>Instructions</th>
<th>Descriptions</th>
<th>Analogies &amp; Metaphors</th>
<th>Cues</th>
<th>Specific Congruent Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>3</td>
<td>/</td>
<td>/</td>
<td>/</td>
<td>///</td>
<td>/</td>
</tr>
<tr>
<td>4</td>
<td>/</td>
<td>/</td>
<td>//</td>
<td>///</td>
<td>///</td>
</tr>
</tbody>
</table>

- Tally (/) if it occurs
Each sub category of visual representation was defined as follows:

- **Demonstrations**: Demonstrations are “modeling desired performance executed by teacher, student(s), and/or visual aids” (Rink, 2006, p. 372). For example, the teacher showed the correct or incorrect performances of the forehand short serve, or asked students to show it to the class in badminton.

- **Task cards/pictures/diagrams/video**: To help students’ visual understanding about what to perform and how to perform, teacher might use task cards, pictures, video clips, or diagrams. For example, when teacher explains “the high serve and overhand return drill” with five players in badminton, the teacher could prepare for a big diagram of this drill in order to help students to understand how to perform it correctly. Also, the teacher could provide students with task cards that included the critical elements of overhead stroke and high deep serve in badminton.

- **Physical assistance**: Physical assistance is “physically moving the player’s body to the proper position or through the correct range of motion of a skill” (Lacy & Darst, 1989, p. 371). For example, the teacher corrects students’ backswing position in badminton through physical prompts while they are practicing.

Data were reported as a frequency measure using event recording and then these data were analyzed to compare the mean of each category of visual representations per lesson between the comparison and experimental groups. Figure 3.9 shows the teachers’ visual representation coding sheet.
### Figure 3.9 Example of Visual Representation Coding Sheet

<table>
<thead>
<tr>
<th>Task</th>
<th>Demonstrations</th>
<th>Task Cards/ Pictures/Diagrams/Video Clips</th>
<th>Physical Assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Correct</td>
<td>Partial Correct</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>5</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>6</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>/</td>
<td>/</td>
<td></td>
</tr>
</tbody>
</table>

- Tally (/) if it occurs
Task Appropriateness

The second level for measuring teachers’ PCK was appropriateness of task selections. Appropriateness of task selections consisted of two sub components: developmental appropriate and principle appropriate (see Figure 3.10).

Figure 3.10 Sub-Categories of Task Appropriateness

*Developmental appropriate* activities refer to the practices and contents that are suitable for students' age and individual capabilities. When considering that students’ skill development is sequential, age related as well as the rate of their skill development varies, teachers must make decisions to provide the best tasks for learners who have different backgrounds (Thomas & Thomas, 2008).

*Principle appropriate* activities refer to the tasks that teacher provided are principle appropriate activities that underpin the Play Practice (Launder, 2001) which
teaches sport through the game and in the game using three fundamental processes: (a) shaping play (i.e., manipulating specific variables to layer and scaffolding learning for success); (b) focusing play (i.e., using target or challenges to focus on specific techniques and tactics); and (c) enhancing play (i.e., making improved performance using the freeze replay and changing aspects of the learning environment).

Using the combined categories of development and principal appropriateness of task selection, four combinations of developmental and principal appropriate tasks were used. Each subcategory was defined as follows:

- **Developmental appropriate & Principle appropriate:** The task that the teacher provided was suitable for students' age and individual capabilities and but it did not underpin fundamental principles of the Play Practice. For example, the teacher taught a long serve drill to sixth graders (developmental appropriate) focusing on only correct services and returns in this game situation (principle appropriate) in badminton. The task is developmental appropriate because it was an appropriate task for upper graders as well as principle appropriate because it focused on the serve drill in the game situation.

- **Developmental appropriate & Principle inappropriate:** The task that the teacher provided was suitable for students’ age and individual capabilities but it did not underpin fundamental principles of Play Practice. For example, the teacher taught a long serve drill to eighth graders (developmental appropriate) asking students to perform 10 serves in the service area (principle inappropriate). The task is developmental appropriate because it was the appropriate task for upper graders
but it is not principle appropriate because it was taught without shaping or focusing the play through the game or in the game.

- **Developmental inappropriate & Principle appropriate:** The task that the teacher provided was not suitable for students’ age and skill level but it was used with the fundamental principles of Play Practice. For example, the teacher taught a long serve drill to first graders (developmental inappropriate) using only correct services and returns in a game situation (principle appropriate) in badminton. The task is developmental inappropriate because a long serve drill is too difficult for first graders who do not have sufficient muscle strength and eye coordination. However, the task is principle appropriate because it was focused on the serve drill in the game situation.

- **Developmental inappropriate & Principle inappropriate:** the task that teachers provided was not suitable for student’s age and individual capabilities nor did it use the fundamental principles of the Play Practice. For example, the teacher provided a long serve drill to first graders without any modification of rules, size, and shape of the playing area. This task is developmental inappropriate because a long serve drill is difficult for first graders who do not have sufficient muscle strength and eye coordination (developmental inappropriate). In addition, the teacher taught a long serve drill to first graders without having any target areas or challenges, without changing the equipment and settings (e.g., using lighter shuttles and rackets and using a low net and small court), and without using freeze-replay strategy to enhance student’s plays (principle inappropriate).
Using an event recording system, the investigators coded each task’s developmental and principle appropriateness or inappropriateness separately and then reported the category number of each task with four scales. The frequency of each category numbers per lesson was recorded in the coding sheet. The average percent of each category per unit was calculated to compare the differences between the comparison classes and experimental classes. The coding sheet was shown in Figure 3.11

**Task Maturity & Appropriateness**

Using the model of PCK which combines the categories of maturity of task representations and appropriateness of task selections by Ward (2010), full and partial combinations of maturity and appropriateness of tasks were utilized. Eight scales of combined coding categories were developed.

Each sub-category was defined as follows:

- **Mature task representation & Developmental/Principle appropriate**: The tasks were represented with diverse uses of verbal and visual representations as well as the selected tasks that were suitable for students’ age and skill level using Play Practice assumptions.

- **Mature task representation & Developmental/Principle inappropriate**: The tasks were represented with diverse uses of verbal and visual representations but the selected tasks were not suitable for students’ age and skill level without using Play Practice assumptions.
### Figure 3.11 Example of Maturity, Appropriateness and Maturity & Appropriateness of Task Coding Sheet

<table>
<thead>
<tr>
<th>Task</th>
<th>What teacher mentioned about the task (verbatim)</th>
<th>Maturity</th>
<th>Developmental Appropriateness</th>
<th>Principle Appropriateness</th>
<th>Maturity &amp; Appropriateness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>O</td>
<td>X</td>
<td>O</td>
<td>3-P</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>X</td>
<td>O</td>
<td>X</td>
<td>2-D</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>O</td>
<td>O</td>
<td>X</td>
<td>3-D</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>X</td>
<td>X</td>
<td>O</td>
<td>2-P</td>
</tr>
</tbody>
</table>

**Maturity and Appropriateness**

- Mature or Appropriate – O,
- Immature or Inappropriate – X,

- M & DA & PA - #4
- M & DI & PI - #3
- M & DA & PI - #3-D
- M & DI & PA - #3-P
- IM & DA & PA - #2
- IM & DA & PI - #2-D
- IM & DI & PA - #2-P
- IM & DI & PI - #1
• **Mature task representation & Developmental appropriate & Principle inappropriate**: The tasks were represented with diverse uses of verbal and visual representations but the selected tasks were suitable for students’ age without using Play Practice assumptions.

• **Mature task representation & Developmental inappropriate & Principle appropriate**: The tasks were represented with diverse uses of verbal and visual representations but the selected tasks used Play Practice assumptions without considering students’ age and skill level.

• **Immature task representation & Developmental/Principle appropriate**: The teacher represented the content with simple or poor uses of cues, descriptions, analogies, metaphors, or demonstrations but the selected tasks were developmentally and principally appropriate.

• **Immature task representation & Developmental appropriate & Principle inappropriate**: The tasks were represented with simple or poor uses of verbal and visual representations but the selected tasks were suitable for students’ age and skill level using Play Practice assumptions.

• **Immature task representation & Developmental inappropriate & Principle appropriate**: The tasks were represented with simple or poor uses of verbal and visual representations but the selected tasks were suitable for students’ age and skill level without using Play Practice assumptions.

• **Immature task representation & Developmental/Principle inappropriate**: The tasks were represented with simple or poor uses of verbal and visual
representations, and the selected tasks were not suitable for students’ age and skill level without using Play Practice assumptions.

Using an event recording system, the investigators coded each task representation’s maturity and each task selection’s developmental/principle appropriateness separately and then reported the category number of each task from the above combined categories with eight scales while watching videotapes. The average percentages of each category per unit were calculated to compare the differences between the comparison classes and the experimental classes. Figure 3.11 shows an example of coding sheet for task representation maturity, task appropriateness, and the combined maturity and appropriateness of tasks.

Task Adaptations

According to Rink (2006), adaptations allow the tasks to be more appropriate to the learners. Task adaptations were recorded with two levels: (a) inter-task adaptation (i.e., task development between tasks for the entire class), and (b) intra-task adaptation (i.e., task development within tasks for small groups or individuals) (see Figure 3.12).

Inter-Task Adaptations

A teacher’s inter-task adaptations toward the whole class were measured according to the following four categories: (a) informing task, (b) extending task, (c) refining task, and (d) applying task determined by Rink (2010) and Siedentop and Tannehill (2000).
Each sub-category was defined as follows:

- **Informing Task**: This category refers to the initial task in the progression of a skill. For example, the teacher could start to teach the forehand overhead stroke by having students toss the shuttle upward, placing the shuttle overhead for a forehand overhead stroke.

- **Extending Task**: This refers to the task that changes the complexity or difficulty of student performance. For example, the teacher could have students hit the shuttle using the forehand overhead stroke coming from the opponent after the self-practice.

- **Refining Task**: This category refers to a task that focuses the quality of student performance. For example, the teacher could emphasize students’ correct execution saying, “Rotate your upper body and reach high to hit” as they practice toward the whole class.

- **Applying Task**: This category refers to the task that changes the focus of learning from how to do the skill to how to use the skill in a game situation. For example,
the teacher could divide the whole class into several groups and have five students play a serve and overhead return game by rotating positions after three attempts.

**Intra-Task Adaptations**

A teacher’s intra-task adaptations within tasks toward small groups of students or individuals were recorded according to the following six categories: (a) modifying task complexity, (b) refining or breaking task, (c) restating task, (d) extending task, (e) changing competition conditions and (f) different tasks. These categories were specifically determined by Avyazo (2007) in a dissertation that examined the effective teachers’ PCK based on the review of the books authored by Rink (2006) and Siedentop and Tannehill (2000).

Each sub-category was defined as follows.

- **Modifying Task Complexity:** This category refers to modifications made by the teachers under the following conditions (Avyazo, 2007): (a) space (e.g., changing the dimensions of the playing area changes the complexity of games); (b) equipment (e.g., using a lighter shuttle in badminton decreases the difficulty of the task); (c) number of participant (e.g., increasing the number of participants results in the increase of complexity); and (d) rules (e.g., using a single court for playing doubles in badminton reduces the difficulty of the game).

- **Refining or Breaking Task:** The teacher simplifies the task by asking the student to perform only one or two elements of it for the quality of performance without changing the task (Rink, 2006). For example, when teaching the ‘wall rally drill’
for badminton overhead stroke, the teacher could emphasize a high, deep return to have enough time to prepare before each shot.

- **Restating Task:** The teacher repeats the entire task in forms other than the ones used when the task is delivered to the entire class. For example, the teacher restated, “Make a serve long and deep into the diagonal court corner”, rather than saying “Serve toward the opponent receiver’s deep court.”

- **Extending Task:** The teacher expands the task’s complexity by adding more elements to the skill that is being practiced. For example, the teacher could extend the task by asking the students to hit unexpected shuttles while the entire class practices expected shuttles from the feeder.

- **Different task:** The teacher assigns a different task to small group of students or individuals, than the one that is performed by the entire class, for example, changing a long serve task practiced by the entire class to a short serve task performed by a single student.

- **Competition Condition:** The teacher moves the students from noncompetitive to competitive situations and vice versa (Rink, 2006), such as practicing long serves to the target area, and then practicing long serves it under timed conditions.

An event recording system was used to collect data and IOA on task adaptations (see Figure 3.13). The data were reported by a frequency measure of response, the number of each type of adaptation that was made per lesson, and per unit within two levels.
**Figure 3.13 Example of Coding Sheet for Task Adaptations**

<table>
<thead>
<tr>
<th>Task</th>
<th>Description of Adaptation</th>
<th>Type of Adaptation</th>
<th>Congruence/Appropriateness of Adaptation</th>
<th>Recipients</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Serve the shuttle from the right five times and switch the side, make sure you need to serve to the target area.</td>
<td>I</td>
<td>O</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>Remember to serve the bird from high to low.</td>
<td>RB</td>
<td>X</td>
<td>I</td>
</tr>
</tbody>
</table>

**IOA**

- **Type of Adaptations:**
  - Inter Task Adaptation:
    - I: Informing task
    - E: Extending task
    - R: Refining task
    - A: Applying task
  - Intra Task Adaptation:
    - MC – Modifying complexity of task
    - DT - Assigning a different task
    - RT - Restating the task
    - R/B – Refining/breaking skill down
    - EX - Extending the task
    - CC – Changing competition conditions

- **Congruence/Appropriateness of adaptation:**
  - O – Congruent/Appropriate
  - X – Incongruent/Inappropriate

- **Recipients:**
  - C - Class
  - S – Small groups
  - I - Individuals

- **IOA:**
  - 100%
  - 90%
  - 100%
Observation Procedure for Teacher Behaviors

All badminton lessons for each class were videotaped using two digital camcorders to create a permanent product. The camcorders recorded the teachers in a wide range of views, and were positioned in two corners of the gymnasium during the lesson. One is for the main camcorder and the other one is for the back-up. These camcorders videotaped the entire gym so that the teacher could be captured in one range of view.

Videotaping started when the teacher began a lesson and finished when all students were out of the gymnasium. At the beginning of the lesson, the teachers were asked to wear wireless microphones, which were connected to the camcorder so observers could listen to the teachers’ voice. The videotaping data were used to analyze only teacher data (i.e., teacher’s maturity of task representation, appropriateness of task selections, and task adaptations). Figure 3.14 shows a diagram of location of camcorders.

Figure 3.14 Diagram of Location of Camcorders

: Video camera
For collecting student data, three primary observers were involved in the study and they were present in the school to observe the six selected students’ performances in each class. For the IOA procedure, one additional observer was involved in the study. Each observer was in charge of coding two students in each class. Figure 3.15 shows a diagram of the students’ and observers’ location in the gym.

**Figure 3.15 Diagram of Students and Observers’ Location in the Gym**

![Diagram of Students and Observers’ Location in the Gym]

(Note: X1~X3- Main observers, X4-IOA observer, A~F- Students)

**Observation Procedure for Student Behaviors**

During the observation, six participants were divided into two or three courts by the teachers. For example, four students (i.e., A, B, C, and D) played badminton in court 1, whereas two other students (i.e., E and F) played badminton in court 2, regardless of the number of courts that the teachers used in the school site. The observers were placed in the designated courts where the selected students would play. Each observer measured two individual students’ performances when they are performing a task, facing each other in a court. Ray and Tyler used six badminton courts for the lesson. While observer 1
observed students A and B and observer 2 observed students C and D in one court, observe 3 observed students E and F in the other court, positing them in the middle of the court to better view the students’ plays from each side. The observers watched each student’s trial and instantly they recoded student performance in the coding sheet based on the partial critical elements that the teachers described or the full critical elements that the researcher developed.

**Participant Reactivity**

Participant reactivity refers to “the person being observed is aware of the observer’s presence and purpose” (Cooper et al., 2007, p. 55). The result of some extraneous variable such as the presence of observers, video cameras, or written assignments (Kazdin, 1982) might have affected the changes observed in the teachers and students’ behaviors.

In order to reduce participants’ reactivity, the following strategies were implemented in this study.

- The observers were introduced to the classes by the teacher and the purpose of the presence of observers was explained before the unit started.
- The observers did not communicate with any students or the teacher during the lesson.
Description and Training of Observers

In this study, both live coding and video coding methods were used but the training procedures for observers were the same. Four primary and Inter Observer Agreement (IOA) observers -- a primary investigator, visiting scholar, and external key personnel -- were involved in the study to conduct data coding.

The training procedure for the observers was conducted with three phases.

- **Phase 1**: The primary investigator provided the definitions of each dependent variable and explained the definitions of the variables related to both teacher behavior and student performance (see Appendix J and K). In order to check for their understanding, the observers were asked to take the written test about the definitions of the teacher and student variables (see Appendix L and M). When observers correctly answer 23 out of 26 questions relevant to the teacher variables and 9 out of 10 questions relevant to the student variables, they were able to move to the next training phase.

- **Phase 2**: The investigator trained the observers how to code student variables and asked to code students’ performance variables when they were watching a 15-minute badminton lesson offered in the Sport Fitness and Health Program at the Ohio State University. IOAs between the observers and the investigator were conducted. The training did not move forward to Phase 3 unless the IOAs for each observer met the 85 % criteria.

- **Phase 3**: The investigator trained the observers how to code teacher variables and asked the observer to code teachers’ variables when they were watching a 15-minute video clip of badminton lessons. Finally, IOA between the observer and
the investigator was conducted. When IOA reached the 85% criteria, the training was completed.

**Inter-Observer Agreement**

Inter observer agreement (IOA) refers to “the degree to which two or more independent observers report the same observed values after measuring the same events” (Cooper et al., 2007, p. 113). With the purpose of reducing observer drift and subjectivity as well as increasing observers’ confidence about the definition of target behavior, IOA is conducted (Cooper et al., 2007). The unit of analysis of the research was the tasks provided to the students. Therefore IOA was obtained on the occurrences of the teacher and the students’ behaviors during the distinct tasks, and was organized and reported according to two categories.

The first category was IOA data IOA for student achievement represented in research sub-question 1-3. Second category was IOA for teacher PCK components represented in research sub-questions 4-10. The IOA was performed on a third of all observation of the students (i.e., 24 out of 72 observations per teacher) and third of all observations of each teacher (i.e., 8 out of 24 lessons per teacher) for teacher variables between the observer and the IOA observer, respectively. The acceptable criterion for IOA was set to 85%. The percentage of agreement was calculated using the following formula: Agreement divided by total trials (i.e., agreement plus disagreement) and then multiplied by 100 in order to compute the percentage of agreement (Cooper et al., 2007).
Treatment Integrity

Treatment integrity, also called treatment fidelity, refers to “the extent to which the independent variable is implemented and carried out as planned” (Cooper et al., 2007, p. 235). To maximize treatment integrity, several strategies were used.

- Prior to implementation of the CK workshop, the researcher had a rehearsal session with peers to correctly provide information to teachers. The goal of this rehearsal session was to increase the investigator’s competence level for conducting the workshop and to find difficulties that might occur during the actual workshop with three teachers.

- The researcher used the checklist (see Appendix N) to ensure that the treatment was correctly implemented in each phase during the workshop periods.

- The researcher developed an intervention lesson plan (see Appendix I) which specifies the intervention procedure including a time limit and organization of the tasks.

- The researcher used the checklist (see Appendix O) to ensure that the teachers implemented the tasks that were presented in the workshop as they teach their classes.

Data Analysis

Data analysis methods were used to answer the research questions. Directly measured teacher and student dependent variables were analyzed separately using the Statistical Package for the Social Sciences (SPSS) v17.
**Student Variables**

**Descriptive Statistics**

For the analysis of students’ dependent variables in terms of correct trials, incorrect trials, and other trials, descriptive statistics (i.e., means, ranges, and percentages) were used for both the comparison and the experimental groups. The data were plotted in line graphs, bar graphs, or tables to visually inspect and analyze the data.

**Inferential Statistics**

A non-parametric test was used to analyze the student performance data because of a violation of normality. The distribution of the percentages of correct, incorrect, and other trials were compared between the comparison and the experimental classes. Independent variables were teachers as a block and treatments (i.e., no CK workshop versus CK workshop and daily teaching feedback). The homogenous variance was examined by using the “Levene’s Test for Equality of Variances” and “Spearman rho” was conducted to examine the relationships among three dependent variables.

**Teacher Variables**

**Descriptive Statistics**

For the analysis of teachers’ dependent variables in terms of maturity, appropriateness, and adaptation of tasks, descriptive statistics (i.e., means and ranges) were computed for both the comparison and the experimental groups. The data were plotted in line graphs, bar graphs, or tables to visually display and analyze the data.

Table 3.7 summarizes all variables that were measured in phase 1 and 3 of this
study. It also summarizes how the data were collected and how they were reported. The results are presented in chapter four.
### Table 3.7 Summary of All Research Sub-questions, Types of Variables, Data Collection Method and Analysis

<table>
<thead>
<tr>
<th>Research sub-questions</th>
<th>Types of variables measured</th>
<th>How data were collected</th>
<th>How data were reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How many times does students’ performance occur in the comparison and the experimental groups?</td>
<td>Total trial</td>
<td>Event Recording</td>
<td>Frequency measure, average per unit. (e.g. 67 trials were correct, 22 trials were incorrect and 10 trials were other performance in the comparison group) Graphic presentation</td>
</tr>
<tr>
<td></td>
<td>Correct trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incorrect trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. What percentage of students’ performance occurs in the comparison and experimental groups?</td>
<td>Correct trial</td>
<td>Event Recording</td>
<td>Percentage measure, average per unit. (e.g. 77% of the trials was correct and 23% of trials was incorrect in the experimental group but 36% of trials was correct, 48% of trials was incorrect and 8% was other performance in the comparison group) Graphic presentation</td>
</tr>
<tr>
<td></td>
<td>Incorrect trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Is there a statistical difference of the percentage of student performance between the comparison and experimental groups?</td>
<td>Correct trial</td>
<td>Event Recording</td>
<td>Non-parametric test value, p value, and effect size Statistics tables</td>
</tr>
<tr>
<td></td>
<td>Incorrect trial</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Trial</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. How does the teachers’ maturity of task differ between the comparison and the experimental group lessons?</strong></td>
<td>Mature</td>
<td>Event Recording</td>
<td>Frequency measure and percentage measure per unit. (e.g. 30% of task representations was the mature forms) Graphic presentation</td>
</tr>
<tr>
<td></td>
<td>Immature</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5. How does the teachers’ use of visual representation differ between the comparison and the experimental group lesson?</strong></td>
<td>Demonstrations (full, partial, incorrect) Task cards, pictures, diagrams, videos Physical Assistance</td>
<td>Event Recording</td>
<td>Frequency measure per lesson and unit. (e.g. teacher used 8 demonstrations and 15 gestures) Table presentation</td>
</tr>
<tr>
<td><strong>6. How does the teachers’ use of verbal representation differ between the comparison and the experimental group lesson?</strong></td>
<td>Instructions Descriptions Analogies and Metaphors Cues Specific congruent feedback</td>
<td>Event Recording</td>
<td>Frequency measure per lesson and unit. (e.g. teacher stated 5 metaphors and 40 cues) Table presentation</td>
</tr>
<tr>
<td><strong>7. What level of the teachers’ developmental and principle appropriateness of tasks occur in the comparison and the experimental group lessons?</strong></td>
<td><strong>Level 1:</strong> Both developmentally and principally appropriate <strong>Level 2:</strong> Only developmentally appropriate <strong>Level 3:</strong> Only principally appropriate <strong>Level 4:</strong> Both developmentally and principally inappropriate</td>
<td>Event recording</td>
<td>Frequency measure per unit. (e.g. nine tasks was both developmentally and principally appropriate) Graphic presentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued
8. What level of the teachers’ maturity and developmental/principle appropriateness of tasks occur in the comparison and the experimental group lessons?

| Level 4: Mature & Developmental/Principle Appropriate |
| Level 3: Mature & Developmental/Principle Inappropriate |
| Level 3-D: Mature & Developmental Appropriate & Principle Inappropriate |
| Level 3-P: Mature & Developmental Inappropriate & Principle Appropriate |
| Level 2: Immature & Developmental/Principle Appropriate |
| Level 2-D: Immature & Developmental Appropriate & Principle Inappropriate |
| Level 2-P: Immature & Developmental Inappropriate & Principle Appropriate |
| Level 1: Immature & Developmental/Principle Inappropriate |

Event Recording

Frequency measure per unit. (e.g. 10 tasks were mature and developmental appropriate but 4 tasks were principle inappropriate)

Graphic presentation

Continued
<table>
<thead>
<tr>
<th>Question</th>
<th>Tasks</th>
<th>Event Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. How does the teachers’ inter task adaptation of tasks differ between the comparison and the experimental group lessons?</td>
<td>Informing Task, Extending Task, Refining Task, Applying Task</td>
<td>Frequency measure per unit. (e.g. teacher stated 5 appropriate for the whole group refining tasks and 2 inappropriate extending tasks in the comparison group) Graphic presentation</td>
</tr>
<tr>
<td>10. How does the teachers’ intra adaptation of tasks differ between the comparison and the experimental group lessons?</td>
<td>Modifying task complexity, Refining/breaking task, Extending task, Different task, Competition condition</td>
<td>Frequency measure per unit. (e.g. teacher stated 5 appropriate for the whole group refining tasks and 2 inappropriate extending tasks for the small groups in the comparison group) Graphic presentation</td>
</tr>
</tbody>
</table>
CHAPTER 4

RESULTS

The results of the study were reported in the following manner. First, the results of the treatment integrity and Inter-Observer Agreement (IOA) for the student variables were reported followed by a report on the results for the student variables according to three research questions. Next, the IOA for the teacher variables were reported followed by the results for the teacher variables according to seven research questions. Under each question, Ray’s results were presented first and then Tyler’s results were presented.

Treatment Integrity

The treatment integrity was checked using a checklist in both teachers’ experimental classes (see Appendix P). The data for the treatment integrity were recorded as one of four:

Level 1—As taught
Level 2—Partially correct
Level 3—Different task but consistent with workshop
Level 4—Different task and not consistent with workshop
Table 4.1 shows the treatment integrity data for both teachers. The data were calculated using the following formula: a number of tasks in each level divided by the total amount of tasks and then multiplied by 100 in order to compute the percentage of treatment integrity data. Overall, both teachers’ treatment integrity met above 80% criterion for the study. Ray used 83.3% correct tasks and 16.7% partially correct tasks which he learned from the content knowledge (CK) workshop. Similarly, Tyler used over 88% correct tasks for both classes using Play Practice approach and 11.8% tasks for class 1 and 13.5% tasks for class 2 were partially correct. Both teachers did not use any different tasks then those from the CK workshop. Overall, the data showed that both teachers effectively implemented the tasks that they learned from the CK workshop in their teaching for the experimental classes.

<table>
<thead>
<tr>
<th>Level</th>
<th>Teacher</th>
<th>Class 1</th>
<th>Class 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1: As taught</td>
<td>Ray</td>
<td>83.3%</td>
<td>87.5%</td>
</tr>
<tr>
<td></td>
<td>Tyler</td>
<td>88.2%</td>
<td>89.5%</td>
</tr>
<tr>
<td>Level 2: Partially correct</td>
<td>Ray</td>
<td>16.7%</td>
<td>12.5%</td>
</tr>
<tr>
<td></td>
<td>Tyler</td>
<td>11.8%</td>
<td>13.5%</td>
</tr>
<tr>
<td>Level 3: Different task but</td>
<td>Ray</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>consistent with workshop</td>
<td>Tyler</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Level 4: Different task and</td>
<td>Ray</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>not consistent with workshop</td>
<td>Tyler</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Inter-Observer Agreement for the Student Variables

The Inter-Observer Agreements (IOAs) for the student variables were conducted on a third of all student observations (i.e., 24 of 72 observations per teacher) in the comparison and the experimental classes. Table 4.2 summarizes the mean and range of the IOAs obtained for the six target students in each class per teacher in the comparison and the experimental classes. Overall, the mean of the IOAs obtained for six students exceeded 88% (range=85.3~99.3%) in Ray and Tyler’s comparison and experimental classes, and all IOAs of the students met the acceptable criterion of 85% for IOA.

Table 4.2 Inter-Observer Agreement for the Student Variables

<table>
<thead>
<tr>
<th></th>
<th>Comparison</th>
<th>Experimental</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class 1</td>
<td>Class 2</td>
<td>Class 1</td>
</tr>
<tr>
<td>Mean and Range of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ray’s Classes</td>
<td>93.5%</td>
<td>87.2%</td>
<td>92%</td>
</tr>
<tr>
<td></td>
<td>(92~95%)</td>
<td>(85.3~89%)</td>
<td>(87.1~97%)</td>
</tr>
<tr>
<td>Mean and Range of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tyler’s Classes</td>
<td>88%</td>
<td>87.4%</td>
<td>89.5%</td>
</tr>
<tr>
<td></td>
<td>(86.1~90%)</td>
<td>(86.8~88%)</td>
<td>(88.7~90.2%)</td>
</tr>
</tbody>
</table>

Research Sub-Question 1: How many total, correct, incorrect, and other trials were made by the students in the comparison and experimental classes?

The data were collected as a frequency of student response and are reported as the mean of student performance per lesson as well as the mean percentage of student performance per lesson. The data were reported separately for the comparison and the experimental classes by teacher and then the aggregate data were reported comparing for
the comparison and the experimental classes by teacher.

**Frequency of Student Performance**

*Ray’s Lesson-by-Lesson Data in the Comparison Classes*

**Comparison class 1.** Figure 4.1 represents the mean of students’ total, correct, incorrect, and other trials per lesson in the comparison class 1. The mean of students’ total trials per lesson was 70.8 (range=52.2 -94.2). The mean of students’ correct trials per lesson was only 6.7 (range=0.3-20.7). The mean of incorrect trials per lesson was 48.8 (range=39.7–71.2). The mean of students’ incorrect trials was more than seven times larger than that the mean of correct trials in class 1. The mean of other trials per lesson was 15.8 (range= 8–23.3). Students’ other trials were more frequently coded than the students’ correct trials, but less frequently than incorrect trials. The data showed that most students performed the skills incorrectly in this class.

**Figure 4.1 Student Performance in Ray’s Comparison Class 1**

![Figure 4.1 Student Performance in Ray’s Comparison Class 1](image)
Comparison class 2. Figure 4.2 represents the mean of students’ total, correct, incorrect, and other trials per lesson in the comparison class 2. The mean of total trials per lesson was 114.3 (range=60-190.8). The mean of students’ correct trials per lesson was 12.4 (range=8–23.3). The mean of incorrect trials per lesson was 83 (range=40.2-146.3). The data showed that most students performed the skills incorrectly in this class. The mean of students’ other trials per lesson was 18.9 (range= 9.8-28.5).

Figure 4.2 Student Performance in Ray’s Comparison Class 2

Ray’s Lesson-by-Lesson Data in the Experimental Classes

Experimental class 1. Figure 4.3 shows the mean of students’ total, correct, incorrect, and other trials per lesson. The mean of total trials per lesson were 91.4 (range=55.1-139.7). The mean of correct trials per lesson was 51.4 (range=31.3–84.2). The mean of incorrect trials per lesson was 22.9 (range=14.8–29.3). The mean of other trials per lesson was 17.2 (range= 6.2–26.2).
Experimental class 2. Figure 4.4 shows the mean of students’ total, correct, incorrect, and other trials per lesson. The means of total trials and correct trials per lesson were 91.8 (range= 51.8-139) and 56.7 (range= 31.8-86.2), respectively. The means of students’ incorrect trials and other trials per lesson were 17.8 (range= 8.5-26) and 17.3 (range, 1.3-26.8), respectively.
Ray’s Aggregate Data in the Comparison and Experimental Classes

**Total trials.** Figure 4.5 represents the mean of total trials per lesson in Ray’s comparison and experimental classes. The mean of total trials in the comparison was 92.3 (range= 58.8-139.4), and in the experimental class 91.2 (range= 58.2-118.9). Overall, the mean of total trials in both groups across the six-day unit was similar. However, there were variations on lesson one and lesson five.

**Correct trials.** The means of correct trials per lesson in the comparison and the experimental classes are shown in Figure 4.6. The mean of correct trials per lesson in the comparison classes was 9.7 (range= 4.5-15.6), but the mean of correct trials in the experimental classes was 54.7 (range = 32.3-74.7).

Figure 4.5 Total Trials in Ray’s Comparison and Experimental Classes
**Incorrect trials.** Figure 4.7 shows the mean of incorrect trials per lesson in each comparison and experimental class. Students tended to perform the skills incorrectly in the comparison classes ($M=65.6$, range=$41.9-98.6$) than those in the experimental classes ($M=20.4$, range=$11.7-27.3$).
**Other trials.** The means of other trials per lesson in the comparison and the experimental classes were 17.3 (range=11.5-25.9) and 17.4 (range=3.8-22.6), respectively (see Figure 4.8). The data showed that the means of other trials in both comparison and experimental classes were similar.

![Figure 4.8 Other Trials in Ray’s Comparison and Experimental Classes](chart)

**Tyler’s Lesson-by-Lesson Data in the Comparison Classes**

**Comparison class 1.** Figure 4.9 shows the means of total, correct, incorrect, and other trials per lesson in the experimental class 1. The mean of total trials per lesson was 80.2 (range= 59.5-93.2). The mean of correct trials per lesson was 13.5 (range= 8.3-20). In terms of incorrect trials, the mean of incorrect trials was 54.6 (range= 43.7–65.5). The mean of other trials was 14.4 (range= 12.8–20.3).

**Comparison class 2.** Figure 4.10 represents the means of students’ total, correct, incorrect, and other trials per lesson in the experimental class 2. The mean of total trials per lesson was 59.5 (range= 30.2-86.8). The mean of correct trials per lesson was 6.7
(range, 1.5–11.2). The mean of incorrect trials per lesson was 42.9 (range= 24-58.3). The mean of other trials was 9.9 (range= 4-17.3).

**Figure 4.9 Student Performance in Tyler’s Comparison Class 1**

![Bar graph showing student performance in Class 1.]

**Figure 4.10 Student Performance in Tyler’s Comparison Class 2**

![Bar graph showing student performance in Class 2.]

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Tyler’s Lesson-by-Lesson Data in the Experimental Classes

Experimental class 1. The means of students’ total, correct, incorrect, and other trials per lesson are shown in Figure 4.11. The mean of total trials per lesson was 81.6 (range= 29.3-110). The mean of correct trials per lesson was 37.4 (range= 9.7-52). The data showed that the means of correct trials gradually increased throughout the unit. The mean of incorrect trials per lesson was 29.7 (range= 16.8-40). The data showed that the students performed more correct trials than incorrect trials except on the first day. The mean of other trials per lesson was 15.5 (range= 2.7–18.5).

![Figure 4.11 Student Performance in Tyler’s Experimental Class 1](image)

Experimental class 2. The means of students’ total, correct, incorrect, and other trials per lesson are shown in Figure 4.12. The mean of total trials per lesson was 97 (range= 60-116.2). Overall, the total trial data formed an upward variable trend for the first three lessons and a stable trend for the two later lessons in the unit. The mean of
correct trials per lesson was 42.1 (range= 21.3-53.3). The means of incorrect trials and other trials per lesson were 39.0 (range= 33-45.7) and 15.8 (range= 2.7-20), respectively.

**Figure 4.12 Student Performance in Tyler’s Experimental Class 2**

![Histogram showing student performance in Tyler’s Experimental Class 2]

**Tyler’s Aggregate Data in the Comparison and Experimental Classes**

While Tyler’s data were collected over six lessons for the comparison classes, the student data for Tyler’s experimental classes only comprise five days because he could not teach the sixth lesson due to an illness. Thus, the aggregate data for five lessons in the comparison and experimental classes were compared in this section.

**Total trials.** Figure 4.13 represents the means of students’ total trials per lesson in each comparison and experimental class. The means of total trials in the comparison and experimental classes were respectively 66.1 (range= 44.8-85.1) and 89.3 (range= 44.7-111.9). The data showed that students’ total trials gradually increased for the first four lessons in both classes.

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Correct trials. The mean of students’ correct trials per lesson is represented in Figure 4.14. The mean for the comparison group was 9.6 (range=4.9-11.8), and the mean for the experimental group was 39.8 (range= 15.5-52.7).
**Incorrect trials.** Figure 4.15 shows the means of students’ incorrect trials per lesson in the comparison and experimental classes. The participants in the comparison classes had more incorrect trials (M=46.1, range=33.8-58.3) than those in the experimental classes (M= 38.9, range=26.4-39.3).

![Incorrect Trials in Tyler’s Comparison and Experimental Classes](image)

**Figure 4.15 Incorrect Trials in Tyler’s Comparison and Experimental Classes**

**Other trials.** Figure 4.16 shows the mean of students’ other trials per lesson. The means of other trials in the comparison and the experimental classes were respectively 11.8 (range= 8.5-15.1) and 15.7 (range= 2.7-22.4). The data showed that the mean of other trials in the experimental group was greater than in the comparison group over five lessons.
Figure 4.16 Other Trials in Tyler’s Comparison and Experimental Classes

**Research Sub-Question 2: What percentage of correct, incorrect and other trials were made by the students in the comparison and the experimental classes?**

For this research question, data were collected as a percentage of students’ correct, incorrect, and other trials and are reported by the mean percentage of occurrences of students’ correct, incorrect, and other performances per lesson. In addition, the student data were reported separately for the comparison and experimental classes by teacher as well as the aggregate data were reported comparably for the comparison and the experimental classes by teacher.

**Percentage of Student Performance**

**Ray’s Lesson-by-Lesson Data in the Comparison Classes**

**Comparison class 1.** Figure 4.17 represents the percentages of student correct, incorrect, and other trials per lesson. While less than 10% of students’ trials per lesson was correct (M= 8.3 %, range=0.6 -25.8%), over 70% of trials was incorrect (M=70.5%,
range=54.8-82.5%). The mean percentage of other trials was 21.9% (range = 15.2-26.5%). Overall, the data showed that more than 90% of the students’ trials were either incorrect or labeled as ‘other’ in the comparison class 1.

Figure 4.17 Student Performance in Ray’s Comparison Class 1

Comparison class 2. The percentages of correct, incorrect, and other trials per lesson are shown in Figure 4.18. The mean percentage of correct trials was only 11.6% (range= 6.6-19.4%). More than 70% of total trials was incorrect (M=71.6%, range =64.8-76.7%). The mean percentage of other trials per lesson was 16.7% (range= 15.7-18.6%). Similar to comparison class 1, the data indicated that more than 90% of the students’ trials were in the category of either incorrect or ‘other’ trials.
Ray’s Lesson-by-Lesson Data in the Experimental Classes

Experimental class 1. The percentages of student correct, incorrect, and other trials per lesson are shown in Figure 4.19. The mean percentage of correct trials was 55.9% (range= 47.3- 68.5%). The mean percentage of incorrect trials was 27% (range= 21.8-35.7%). The mean of the percentage of other trials was 19.3% (range= 9.6-25.4%).

Experimental class 2. Figure 4.20 shows the percentages of students’ correct, incorrect, and other trials per lesson. The mean percentage of correct trials was 61.5% (range=59.5- 65.1%). The mean percentage of incorrect trials per lesson was 20.2% (range=13.3-36.1%). The mean percentage of other trials was 18 % other (range= 2.5-27%). The data showed that the mean percentage of correct trials was highly larger than the mean of the percentages of incorrect and ‘other’ trials for the entire unit in the experimental class 2.
Figure 4.19 Student Performance in Ray’s Experimental Class 1

Class 1

![Bar chart showing student performance in Class 1 with categories: Correct, Incorrect, Other.]

Figure 4.20 Student Performances in Ray’s Experimental Class 2

Class 2

![Bar chart showing student performance in Class 2 with categories: Correct, Incorrect, Other.]

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Ray’s Aggregate Data in the Comparison and Experimental Classes

Correct trials. The percentages of student’s correct trials per lesson in the comparison and experimental classes are presented in Figure 4.21. The mean percentage of correct trials per lesson in the comparison classes was 10.1 % (range=5.4-15.5%), but the mean percentage of correct trials was 59.1 % (range=54.3-64.5%) in the experimental classes.

Figure 4.21 Correct Trials in Rays’ Comparison and Experimental Classes

Incorrect trials. The percentages of students’ incorrect trials per lesson in the comparison and experimental classes are presented in Figure 4.22. The mean percentage of incorrect trials in the comparison classes was 71.3 % (range=66.4-77%), but the mean percentage of incorrect trials in the experimental classes was 23.2 % (range=19.2-35.7%).
Other trials. Figure 4.23 shows the percentages of student’s other trials per lesson in the comparison and experimental classes. The mean percentage of other trials in the comparison classes was 18.9 % (range= 17.7-20%) and the mean for the experimental classes was 18.8 % (range= 6.5-26.2%). The data showed that the mean percentages of other trials in both groups were similar.
**Tyler’s Lesson-by-Lesson Data in the Comparison Classes**

*Comparison class 1.* Figure 4.24 represents the percentages of student correct, incorrect, and other trials per lesson. The mean percentage of correct trials was 16.7% (range= 13.9- 24.8%), and the mean percentage of incorrect trials was 68.2% (range= 59.4-73.4%). The mean percentage of other trials was 18.7% (range= 14.7-34.1%).

![Figure 4.24 Student Performance in Tyler’s Comparison Class 1](image)

*Comparison class 2.* The percentages of student correct, incorrect, and other trials per lesson are shown in Figure 4.25. The means percentage of correct, and incorrect trials per lesson were 10.8 % (range= 5.0- 18.7 %) and 78.2% (range= 67.2-79.5%), respectively. The mean percentage of other trials was 16.0% (range= 9.0-19.9%).

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Figure 4.25 Student Performances in Tyler’s Comparison 2

Tyler’s Lesson-by-Lesson Data in the Experimental Classes

Experimental class 1. The means percentage of students’ correct, incorrect, and other trials per lesson are shown in Figure 4.26. The mean percentage of correct trials was 43.6% (range= 33.1-51.1%). The mean percentage of incorrect trials per lesson was 38.6% (range= 28.6-57.3%). Overall, the data showed that the students reported more incorrect trials for the first two lessons, and the students’ correct trials were larger than their incorrect trials for the later three lessons. The mean percentage of other trials was 17.8% (range= 9.2- 23.3%).

Experimental class 2. The percentages of student correct, incorrect, and other trials per lesson are shown in Figure 4.27. The mean percentage of correct trials was 42.4 % (range= 35.5- 48.2%). The mean percentage of incorrect trials was 42.0% (range= 35-60%). The mean percentage of other trials was 15.5% (range= 4.5-22.7%). The data showed the mean percentages of correct trials and incorrect trials were similar.
Tyler’s Aggregate Data in the Comparison and Experimental Classes

Correct trials. The percentages of student’s correct trials per lesson in the comparison and the experimental classes are presented in Figure 4.28. The mean percentage of correct trials in the comparison classes was 14.3 % (range= 10.9-16.9%), but 43.1 % (range= 34.7-49%) in the experimental classes.
Figure 4.28 Correct Trials in Tyler’ Comparison and Experimental Classes

Incorrect trials. Figure 4.29 represents the percentages of student’s incorrect trials per lesson in each comparison and experimental class. The mean percentage of incorrect trials in the comparison class was 70.2 % (range= 65.8-75.4%). The mean percentage of incorrect trials in the experimental class was 40.5% (range= 33.1-59%). The data showed that students in the experimental classes performed 30% fewer incorrect trials than those in the comparison classes.

Other trials. Figure 4.30 shows the percentages of students’ other trials per lesson in the comparison and the experimental classes. The mean percentages of other trials in the comparison and the experimental classes were respectively 18.4 (range= 13.8-28%), and 16.5 (range= 6-20%). The mean percentage of other trials in the comparison classes was larger than that in the comparison classes.
Research Sub-Question 3: Is there a statistical difference of the mean percentage of correct, incorrect, and other trials between the comparison and experimental classes?

In this research question, the data were collected as a frequency of student performances and analyzed by the mean percentage of student performances between two
groups. For the data analysis, the statistical assumptions were checked first. Spearman’s rho was conducted to examine the relationships among the three dependent variables: correct trials, incorrect trials, and other trials. Non-parametric tests were conducted to examine the differences of the distribution of the percentage of student performances between the comparison and the experimental classes. Independent variables were teachers as a block and treatments (i.e., no CK workshop versus CK workshop and daily teaching feedback). Students were used as a unit analysis rather than classes.

**Inferential Statics for Student Performance**

**Statistical Assumptions**

The tests on homogeneous variances of all variables by teachers did not show any violations of the assumption of homogeneity (see Table 4.3). In order to check any severe outliers, visual inspection of the matrix scatter plots was conducted but significant outliers were not detected (see Figure 4.31).

<table>
<thead>
<tr>
<th></th>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (%)</td>
<td>1.335</td>
<td>7</td>
<td>40</td>
<td>.260</td>
</tr>
<tr>
<td>Incorrect (%)</td>
<td>1.068</td>
<td>7</td>
<td>40</td>
<td>.402</td>
</tr>
<tr>
<td>Other (%)</td>
<td>1.239</td>
<td>7</td>
<td>40</td>
<td>.305</td>
</tr>
</tbody>
</table>
Correlational Analysis of Dependent Variables

In order to examine the relationships among three dependent variables, a Spearman’s Rank Order Correlation ($r_s$) was conducted. The results indicated there was a strong, negative correlation between correct trials and the incorrect trials, $r_s(48) = -.940$, $p = .000$. There was negative rank correlation between correct trials and other trials, $r_s(48) = -.370$, $p = .010$. However, there was a non-significant relationship between incorrect trials and other trials, $r_s(48) = -.135$, $p = .360$. The results of correlational analysis are presented in Table 4.4.
Table 4.4 Correlational Analysis of Three Dependent Variables

<table>
<thead>
<tr>
<th></th>
<th>Spearman rho</th>
<th>Correct (%)</th>
<th>Incorrect (%)</th>
<th>Other (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (%)</td>
<td></td>
<td>1.000</td>
<td>-.940**</td>
<td>-.370**</td>
</tr>
<tr>
<td>Sig. (2 tailed)</td>
<td></td>
<td>.</td>
<td>.000</td>
<td>.010</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Incorrect (%)</td>
<td></td>
<td>-.940**</td>
<td>1.000</td>
<td>.135</td>
</tr>
<tr>
<td>Sig. (2 tailed)</td>
<td></td>
<td>.000</td>
<td>.</td>
<td>.360</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Other (%)</td>
<td></td>
<td>-.370**</td>
<td>.135</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (2 tailed)</td>
<td></td>
<td>.010</td>
<td>.360</td>
<td>.</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
</tbody>
</table>

**p < .01    *p < .05

Non-Parametric Test

A Mann-Whitney (2 independent samples) test was conducted to examine statistically significant differences between the underlying distribution of the percentage of student performances in the comparison classes, and the percentage of student performances in the experimental classes. Table 4.5 shows the medians and ranges of the percentage of students’ correct, incorrect, and other trials in each group. In terms of the percentage of correct trials, the median of experimental classes, Mdn=2.9% (range= 0-56.4%) was 20 times larger than the median of comparison classes, Mdn=58.1% (range= 9.0-84.5%). The median percentage of incorrect trials in the comparison class was 76.0% (range= 32.5-88.6%), and the experimental class was 253% (range=5.2-61.7%). The median percentage of other trials for the comparison class was 18.3% (range= 8.5-32.4%), and the experimental class as 16.8% (range= 8.7-32.2%). The analyzed Alpha level of 0.017 was used.
Table 4.5 Median and Range of Percentage of Correct, Incorrect and Other Trials

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison</td>
<td>2.9</td>
<td>0-56.5</td>
</tr>
<tr>
<td>Experimental</td>
<td>58.1</td>
<td>9.0-84.5</td>
</tr>
<tr>
<td>Incorrect (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison</td>
<td>76.0</td>
<td>32.5-88.6</td>
</tr>
<tr>
<td>Experimental</td>
<td>25.3</td>
<td>5.2-61.7</td>
</tr>
<tr>
<td>Other (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison</td>
<td>18.3</td>
<td>8.5-32.4</td>
</tr>
<tr>
<td>Experimental</td>
<td>16.8</td>
<td>8.7-32.2</td>
</tr>
</tbody>
</table>

Table 4.6 shows the results of the Mann-Whitney test for the percentages of correct, incorrect, and other trials. The effect size (r) which is calculated by dividing Z by the square root of N (Field & Hole, 2003) was also reported. The results indicated the percentage of correct trials for the experimental groups was greater than for the comparison groups, $U = 33.0, p = .000, r = -.76$. The results of the Mann-Whitney test with the percentage of incorrect trials indicated that there was a significant difference of the distribution of the mean percentage of incorrect trials between the comparison and experimental classes, $U = 18.0, p = .000, r = -.80$. The results also showed that there was no significant difference of the distribution of the percentage of students’ other trials between two groups, $U = 275, p = .789, r = -.04$. 

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### Table 4.6 Results of Non-parametric Test for the Student Performances

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>U</th>
<th>Z</th>
<th>r</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct (%)</td>
<td>48</td>
<td>33.0</td>
<td>-5.26</td>
<td>-.76</td>
<td>.000</td>
</tr>
<tr>
<td>Incorrect (%)</td>
<td>48</td>
<td>18.0</td>
<td>-5.57</td>
<td>-.80</td>
<td>.000</td>
</tr>
<tr>
<td>Other (%)</td>
<td>48</td>
<td>275</td>
<td>-.27</td>
<td>-.04</td>
<td>.789</td>
</tr>
</tbody>
</table>

### Inter-Observer Agreement for the Teacher Variables

The IOAs for the teacher variables were conducted on a third of all lessons (i.e., 8 of 24 lessons per teacher) in the comparison and the experimental classes. Table 4.7 summarizes the mean and range of the IOAs obtained for the two teachers in the comparison and the experimental classes. Overall, the mean IOAs obtained for the two teachers exceeded 85% (range=78.9-92.3%) in Ray and Tyler’s comparison and experimental classes, and total IOAs of the teachers met the acceptable criterion of 85% for IOA.

### Table 4.7 Inter-Observer Agreement for the Teacher Variables

<table>
<thead>
<tr>
<th></th>
<th>Comparison</th>
<th>Experimental</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class 1</td>
<td>Class 2</td>
<td>Class 1</td>
</tr>
<tr>
<td>Mean and range of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ray’s classes</td>
<td>87.9% (87.5-88.2)</td>
<td>87.0% (84.2-92.3)</td>
<td>88.3% (85.0-88.9)</td>
</tr>
<tr>
<td>Mean and range of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tyler’s classes</td>
<td>80.9% (80.5-87.5)</td>
<td>83.6% (78.9-88.2)</td>
<td>89.3% (86.7-92.3)</td>
</tr>
</tbody>
</table>
Research Sub-Question 4: How does the teachers’ maturity of tasks differ between the comparison and the experimental classes?

In this question, data were collected as a frequency of the teachers’ maturity of task representations. The teacher data were reported separately for the comparison and the experimental classes per lesson and then the aggregate data on the percentage of teachers’ task maturity were reported comparably for the comparison and the experimental classes per unit by teacher.

Frequency of Teachers’ Task Maturity

Ray’s Lesson-by-Lesson Data in the Comparison Classes

Figure 4.32 represents the number of mature tasks per lesson in the comparison classes. No mature tasks were coded during the unit and the mean of immature tasks per lesson in both classes was 2.7 (range= 2-3). The teacher provided all immature tasks during the instructional unit.

Ray’s Lesson-by-Lesson Data in the Experimental Classes

Figure 4.33 shows the number of mature tasks per lesson in both experimental classes. The mean of mature tasks was 3 (range= 2-4) and the mean of immature tasks per lesson was one (range= 0-2) in class 1. The mean of immature tasks per lesson was 0.7 (range= 0-1) in the class1 and the mean of mature tasks was 2.9 (range= 2-4) in class 2. In both classes, the teacher provided fewer immature tasks, and most tasks that the teacher provided were coded as mature tasks rather than immature tasks in the comparison classes.
Rays Aggregate Data in the Comparison and Experimental Classes

Figure 4.34 shows the means of mature and immature tasks per unit in the comparison and the experimental classes. All the tasks that the teacher provided were immature in the comparison classes, and the teacher provided seven immature tasks per unit in the experimental classes. On average, 26.5 tasks that teacher stated over the lessons were coded as mature tasks in the experimental classes, and the teacher did not present any mature tasks in the comparison classes.
Figure 4.33 Task Maturity in Ray’s Experimental Class 1 and 2

![Bar chart showing task maturity in Ray’s Experimental Class 1 and 2.]

Figure 4.34 Task Maturity in Ray’s Comparison and Experimental Classes

![Bar chart showing task maturity in Ray’s Comparison and Experimental Classes.]

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**Tyler’s Lesson-by-Lesson Data in the Comparison Classes**

Figure 4.35 represents the number of mature or immature tasks per lesson in the comparison classes. Tyler provided only one mature task throughout the unit, namely in lesson 4. The mean of immature tasks per lesson in class 1 were four and 2.8 (range= 1-4) in class 2.

**Figure 4.35 Task Maturity in Tyler’s Comparison Class 1 and 2**
**Tyler’s Lesson-by-Lesson Data in the Experimental Classes**

The number of mature and immature tasks per lesson in the experimental classes is shown in Figure 4.36. Most tasks that the teacher provided in each lesson were mature (M= 3.2, range= 1-5), and the mean of immature tasks was only 0.4 (range= 0-1) in class 1. Similar to class 1, the mean of mature tasks was 3.5 (range= 1-4), and the mean of immature tasks was 0.4 (range= 0-1) per lesson in class 2.

![Figure 4.36 Task Maturity in Tyler’s Experimental Class 1 and 2](image)
Tyler’s Aggregate Data in the Comparison and Experimental Classes

The mean of mature and immature tasks per unit in the comparison and the experimental classes is shown in Figure 4.37. On average, 25.5 tasks were coded as immature tasks in the comparison classes, and only three immature tasks per unit were coded in the experimental classes. 24.5 tasks were coded as mature tasks in the experimental classes, but less than one task per unit was coded as a mature task in the comparison classes.

Figure 4.37 Task Maturity in Tyler’s Comparison and Experimental Classes

Ray’s Aggregate Data in the Comparison and Experimental Classes

Figure 4.38 shows the means of the percentage of task maturity per unit in the comparison and the experimental classes. On average, 81.4 % of tasks were mature in the experimental classes. However, no mature tasks were coded in the comparison classes.

Percentage of Teachers’ Task Maturity

Ray’s Aggregate Data in the Comparison and Experimental Classes

Figure 4.38 shows the means of the percentage of task maturity per unit in the comparison and the experimental classes. On average, 81.4 % of tasks were mature in the experimental classes. However, no mature tasks were coded in the comparison classes.
Figure 4.38 Task Maturity in Ray’s Comparison and Experimental Classes

![Figure 4.38 Task Maturity in Ray’s Comparison and Experimental Classes]

Tyler’s Aggregate Data in the Comparison and Experimental Classes

The percentage of task maturity per unit in the comparison and the experimental classes is shown in Figure 4.39. Overall, Tyler provided 89.1% of mature tasks per unit in the experimental classes, but he did not provide any mature tasks in the comparison classes.

Figure 4.39 Task Maturity in Tyler’s Comparison and Experimental Classes

![Figure 4.39 Task Maturity in Tyler’s Comparison and Experimental Classes]
Research Sub-Question 5: How does the teacher’s use of verbal representations differ between the comparison and the experimental classes?

In this research question, the data were collected as a frequency of the teachers’ uses of instructions, descriptions, analogies/metaphors, verbal cues, and specific congruent feedback per lesson in the comparison and the experimental classes. The teacher data were reported separately for the comparison and the experimental classes per lesson by teacher. The aggregate teacher data were also reported comparably for the comparison and the experimental classes per unit by teacher.

Frequency of Teachers’ Verbal Representations

Ray’s Lesson-by-Lesson Data in the Comparison Classes

Figure 4.40 shows the use of verbal representations per lesson in the comparison classes. The means of instructions in the comparison class 1 and 2 were 5.7 (range= 4-8) and 5.2 (range= 4-7), respectively. The means of descriptions in class 1 and 2 were 1.8 (range= 1-3), and 0.8 (range= 0-1), respectively. In terms of the use of analogies or metaphors, the mean of 0.3 (range= 0-1) analogies or metaphors was coded in class 1, and the teacher did not use any analogies or metaphors over six-day lessons in class 2. On average, Ray used one cue (range= 0-3) per lesson in class 1, and 1.2 cues (range= 0-4) in class 2. The teacher provided students with the mean of 2.5 (range= 1-4) specific congruent feedback statements per lesson in class 1, and the mean of one specific congruent feedback (range= 0-3) per lesson was used in class 2.
Ray’s Lesson-by-Lesson Data in the Experimental Classes

Figure 4.41 shows the use of verbal representations per lesson in the experimental classes. The mean of instructions per lesson in class 1 was 10.3 (range= 6-20), and 13.3 (range= 6-22) in class 2. The mean of descriptions in class 1 was 5.7 (range= 4-8), and 6.5 (range= 6-9) in class 2. The teacher used the mean of 3.8 analogies or metaphors (range= 1-8) per lesson for class 1, and three analogies or metaphors (range= 2-6) for the class 2. In terms of the use of cues, the teacher used the mean of 6.7 cues (range= 3-11) per lesson for class 1, and the mean of 9.5 cues (range= 6-15) for class 2. The mean of
specific congruent feedback in class 1 was 13.8 (range= 9-24), and 17.8 (range= 15-24) in class 2.

**Figure 4.41 Ray’ Verbal Representations in the Experimental Class 1 and 2**

![Bar chart showing verbal representations per unit in Class 1 and Class 2 over 6 lessons.](image)

**Ray’s Aggregate Data in the Comparison and Experimental Class**

Figure 4.42 provides the mean of verbal representations per unit in the comparison and the experimental classes. The means of verbal instructions, descriptions, and analogies/metaphors that the teacher used over the unit were 32.5, 8, and 1.0,
respectively in the comparisons classes. The means of cues and specific congruent feedback were 6.5 and 10.5 in the comparison classes.

The means of verbal representations per unit that the teacher used in the experimental classes were much greater than those in the comparison classes. The teacher used the means of 61 instructions, 36.5 descriptions, and 22 analogies/metaphores per unit in the experimental classes. The means of 48.5 cues, and 95 specific congruent feedback were provided to enhance student performances in the experimental classes.

Figure 4.42 Ray’s Verbal Representations in the Comparison and Experimental Classes

Tyler’s Lesson-by-Lesson Data in the Comparison Classes

Figure 4.43 shows the number of verbal representations per lesson in Tyler’s comparison class 1 and 2. The means of verbal instructions, descriptions, and analogies/metaphors were 5.5 (range= 2-10), 2.0 (range= 1-4), and 0.3 (range= 0-2), respectively in class 1. During practice, the teacher provided the mean of 2.8 cues
(range= 1-5) and 4.3 specific congruent feedback (range= 1-7) in class 1. The means of verbal instructions, descriptions, and analogies/metaphors in class 2 were 3.8 (range= 2-7), 1.8 (range= 1-5), and 0.7 (range= 0-1), respectively. During practice, the teacher used the mean of 3.7 cues (range= 3-5) and 3.8 specific congruent feedback (range= 1-9) in class 2.

**Figure 4.43 Tyler’s Verbal Representations in the Comparison Class 1 and 2**

**Tyler’s Lesson-by-Lesson Data in the Experimental Classes**

The number of verbal representations per lesson in the experimental classes is represented in Figure 4.44. In class 1, the means of verbal instructions, descriptions, and analogies/metaphors per lesson were 10.2 (range= 6-19), 6.0 (range= 4-9), and 4.2
(range= 2-8), respectively. During practice, the teacher provided the mean of 10.8 cues (range= 6-19) and 16.4 specific congruent feedback (range= 12-22) in class 1. The means of verbal instructions, descriptions, and analogies/metaphors were 8.6 (range= 6-12), 6.2 (range= 4-8), and 3.4 (range= 2-6), respectively in class 2. The teacher used the mean 8.2 cues (range= 3-16) and 11.0 specific congruent feedback (range= 6-15) in class 2.

Figure 4.44 Tyler’s Verbal Representations in the Experimental Classe 1 and 2

![Bar chart showing verbal representations in Class 1 and Class 2. The x-axis represents lessons 1 to 5 and the mean, while the y-axis represents the number of instructions, descriptions, analogies/metaphors, cues, and feedback. The charts show the comparison between Class 1 and Class 2, highlighting the differences in the number of verbal representations provided by the teacher.]
Tyler’s Aggregate Data in the Comparison and Experimental Class

Figure 4.45 shows the number of verbal representations per unit in the comparison and experimental classes. On average, the teacher used 28.0 instructions, 11.5 descriptions, and three analogies/metaphors per unit in the comparison classes. The teacher used the mean of 47 instructions, 30.5 descriptions, and 19 analogies/metaphors per unit in the experimental classes. The means of cues and feedback were 19.5 and 24.5 per unit for the comparison classes, and the means of experimental classes were 47.5 cues and 68.5 specific congruent feedback.

Research Sub-Question 6: How does the teachers’ use of visual representations differ between the comparison and the experimental classes?

For this research question, the data were collected as a frequency of the teachers’ uses of fully correct, partially correct, and incorrect demonstrations as well as the use of
task cards/pictures/diagrams/videos, and appropriate physical assistance in the comparison and experimental classes. The data were reported as the number of teachers’ visual representations per lesson. The teacher data were also reported separately for the comparison and the experimental classes per lesson by teacher and then the aggregate data were reported comparably for the comparison and the experimental classes per unit by teacher.

**Frequency of Teachers’ Visual Representations**

*Ray’s Lesson-by-Lesson Data in the Comparison Classes*

Figure 4.46 shows the number of visual representations per lesson in the comparison classes. Ray did not provide any fully correct demonstrations over six days for both classes. The teacher provided less than one partially correct demonstration and incorrect demonstration per lesson in the comparison classes. The teacher did not use any visual aids including task cards/pictures/diagrams/videos and physical assistance in both classes.

*Ray’s Lesson-by-Lesson Data in the Experimental Classes*

Figure 4.47 shows the number of visual representations per lesson in the experimental classes. The mean of fully correct demonstrations in class 1 was 7.8 (range=3-14), and 9.8 (range=5-13) in class 2. The teacher provided the mean of 4.3 partially correct demonstrations (range=0-10) in class 1, and 5.7 (range=3-11) in class 2. In both classes, less than one incorrect demonstration was coded in each lesson. The teacher used task cards/pictures/diagrams/videos at least twice per lesson in both classes. In terms of
the use of physical assistance, the means of 0.7 (range= 0-4) in class 1, and 1.2 (range= 0-2) in class 2 were reported.

**Figure 4.46 Ray’s Visual Representations in the Comparison Class 1 and 2**

![Graph showing visual representations in Class 1 and Class 2](image)
Ray’s Visual Representations in the Experimental Class 1 and 2

The number of visual representations per unit in the comparison and experimental classes is shown in Figure 4.48. While no fully correct demonstration was observed in the comparison classes, the teacher provided the mean of 76.5 fully correct demonstrations in the experimental classes for the unit. In the comparison classes, only one partially correct demonstration was coded over the unit, but 43 partially correct demonstrations were coded in the experimental classes. Four demonstrations in the comparison classes and six
demonstrations in the experimental classes were coded as incorrect trials. On average, the teacher had a mean of 1.5 for task cards/pictures/diagrams/videos use per unit in the comparison classes. The mean 6.5 tasks in the experimental classes were represented by one of the task cards/pictures/diagrams/videos across the unit. The teacher provided only once physical assistance in the comparison classes, but the mean of 8.5 physical assistance was used by the teacher in the experimental classes throughout the unit.

**Figure 4.48 Ray’s Visual Representations in the Comparison and Experimental Classes**

![Bar chart showing visual representations](image)

**Tyler’s Lesson-by-Lesson Data in the Comparison Classes**

Figure 4.49 shows the number of visual representations per lesson in the comparison classes. The teacher did not provide any fully correct demonstration over six lessons in both classes. The mean of partially correct demonstrations was 2.2 (range= 0-4) in class 1, and 2.0 (range= 0-5) in class 2. On average, the teacher provided 2.7 (range= 0-5) incorrect demonstrations in class 1, and 1.5 (range= 0-3) incorrect demonstrations in
class 2. Tyler did not use any task cards/pictures/diagrams/videos in both comparisons classes. He used less than once physical assistance for both classes.

Figure 4.49 Tyler’s Visual Representations in the Comparison Class 1 and 2

![Graphs showing Tyler's visual representations for Class 1 and Class 2](image)

Tyler’s Lesson-by-Lesson Data in the Experimental Classes

Figure 4.50 shows the number of visual representations per lesson in the experimental classes. The mean of fully correct demonstrations was 11.6 (range= 1-20) in class 1, and nine (range= 6-11) in class 2. The mean of partially correct demonstrations
was 5.4 (range= 2-10) in class 1, and 2.6 (range= 0-11) in class 2. Tyler had the mean 1.2 (range= 0-4) incorrect demonstrations in class 1, and no incorrect demonstration was coded in class 2. The teacher did not use any visual aids in both experimental classes and less than one physical assistance was used in both experimental classes.

**Figure 4.50 Tyler’s Visual Representations in the Experimental Class 1 and 2**

![Bar charts showing visual representations](image)

**Tyler’s Aggregate Data in the Comparison and Experimental Classes**

The number of visual representations per unit in the comparison and the experimental classes is shown in Figure 4.51. A fully correct demonstration in the
comparison classes was not coded. The mean of fully correct demonstrations in the experimental classes was 80.5. On average, the teacher used 19 partially correct demonstrations in the comparison classes, and 33.5 demonstrations in the experimental classes were coded as partially correct demonstrations. In the comparison classes, the teacher used 20.5 incorrect demonstrations, but only six incorrect demonstrations were coded in the experimental classes over six lessons. Tyler did not use any visual aids including task cards/pictures/diagrams/videos for both groups. Yet the teacher used the mean of nine physical assistance in both comparison and experimental classes throughout the unit.

**Figure 4.51 Tyler’s Visual Representations in the Comparison and Experimental Classes**

![Visual Representations Chart]

- **Comparison**
- **Experimental**
Research Sub-Question 7: What level of the teachers’ developmental and principle appropriate tasks occur in the comparison and the experimental classes?

In this research question, the data were collected as a frequency of teachers’ developmental and principle appropriate tasks per lesson in the comparison and experimental classes. The data for the task appropriateness were recorded on a level of one to four:

Level 1 — Both developmental and principle inappropriate
Level 2 — Only principle appropriate
Level 3 — Only developmental appropriate
Level 4 — Both developmental and principle appropriate

The data were reported separately for the comparison and the experimental classes per unit by teacher and then the aggregate data were reported comparably for the comparison and the experimental classes per unit by teacher.

Frequency of Teachers’ Task Appropriateness

Ray’s Separate Data in the Comparison Classes

The levels of developmental appropriate and principle appropriate tasks in the comparison classes are shown in Figure 4.52. The means of tasks that the teacher used per lesson were 2.7 (range= 2-3) in class 1, and 3.2 (range= 3-4) in class 2. 12 out of 16 tasks in class 1, and 15 out of 19 tasks in class 2 were developmental appropriate but principle inappropriate (level 3). In both classes, three tasks were coded as developmental and principle inappropriate tasks (level 1). One task was coded as a developmental and principle appropriate task (level 4). Only principle appropriate tasks (level 2) were not
coded in both classes.

**Figure 4.52 Developmental and Principle Appropriate Tasks in Ray’s Comparison Class 1 and 2**

**Ray’s Separate Data in the Experimental Classes**

Figure 4.53 represents the levels of developmental and principle appropriate tasks in the experimental classes. The number of tasks that the teacher provided per unit was 22 in class 1, and 18 in class 2. The means of the tasks per lesson were 3.7 (range= 3-5) in class 1, and 3.0 (range= 2-4) in class 2. In both classes, all the tasks were coded as
developmental and principle appropriate (level 4) for the unit.

**Figure 4.53 Developmental and Principle Appropriate Tasks in Ray’s Experimental Class 1 and 2**

![Graph showing developmental and principle appropriate tasks in Class 1 and 2.](image)

**Ray’s Aggregate Data in the Comparison and Experimental Classes**

Figure 4.54 shows the numbers of developmental and principle appropriate tasks per unit in the comparison and the experimental classes. Most tasks in the comparison classes were developmental appropriate but principle inappropriate (level 3). All the tasks were developmental and principle appropriate (level 4) in the experimental classes. On average, three tasks per unit in the comparison classes were developmental and principle inappropriate (level 1).
Figure 4.54 Developmental and Principle Appropriate Tasks in Ray’s Comparison and Experimental Classes

Task Appropriateness

<table>
<thead>
<tr>
<th>Levels</th>
<th>Comparison</th>
<th>Experimental</th>
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<tbody>
<tr>
<td>Level 1</td>
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<tr>
<td>Level 2</td>
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<tr>
<td>Level 3</td>
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<td>0</td>
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<tr>
<td>Level 4</td>
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</table>

Tyler’s Separate Data in the Comparison Classes

Figure 4.55 shows the levels of developmental and principle appropriate tasks per unit in the comparison classes. The mean of the tasks that the teacher used per lesson was 2.7 (range= 2-4) in both classes. Six out of 16 tasks in class 1, and 11 out of 16 tasks in class 2 were developmental appropriate but principle inappropriate tasks (level 3). Six tasks in class 1, and three tasks in class 2 were coded as both developmental and principle appropriateness (level 4). Two or three tasks were coded as both developmental and principle inappropriate tasks (level 1) over the unit. Only principle appropriate tasks (level 2) were not coded in both classes.
Figure 4.55 Levels of Developmental and Principle Appropriate Tasks in Tyler’s Comparison Class 1 and 2

Figure 4.56 shows the levels of developmental and principle appropriate tasks in the experimental classes. The mean of the tasks that the teacher used per lesson was three (range= 2-4) in both classes. 17 out of 18 tasks in the class 1, and all 19 tasks in the class 2 were developmental and principle appropriate tasks (level 4). On the first day of the experimental class 1, one task was coded as a developmental inappropriate but principle appropriate task (level 2). Both developmental and principle inappropriate tasks (level 1) or only developmental appropriate tasks (level 3) were not coded in both classes.
Tyler’s Aggregate Data in the Comparison and Experimental Classes

Figure 4.57 shows the numbers of developmental and principle appropriate task levels per unit in the comparison and the experimental classes. Only 4.5 tasks per unit were developmental and principle appropriate (level 4) in the comparison classes. 17.5 developmental and principle appropriate tasks (level 4) were used by the teacher in the experimental classes. In the comparison classes, most tasks the teacher used were developmental appropriate but principle inappropriate (level 3). 2.5 tasks were developmental and principle inappropriate (level 1). In both comparison and
experimental classes, only principle appropriate tasks (level 2) were not coded throughout the unit.

**Figure 4.57 Developmental and Principle Appropriate Tasks in Tyler’s Comparison and Experimental Classes**

![Bar Chart](image)

**Research Sub-Question 8: What level of the teachers’ maturity and developmental/principle appropriate tasks occur in the comparison and the experimental classes?**

In this research question, the data were collected as a frequency of the combined teachers’ task maturity, and developmental/principle appropriate tasks in the comparison and the experimental classes. The data for the task maturity and appropriateness were recorded as one of eight:

- Level 1 — Immature & both developmental and principle inappropriate
- Level 2 — Immature & only principle appropriate
- Level 3 — Immature & only developmental appropriate
- Level 4 — Both appropriate
Level 4 — Immature & both developmental and principle appropriate
Level 5 — Mature & both developmental and principle inappropriate
Level 6 — Mature & only principle appropriate
Level 7 — Mature & only developmental appropriate
Level 8 — Mature & both developmental and principle appropriate

The data were reported as the number of teachers’ task maturity and developmental or/and principle appropriate task levels. The teacher data were reported separately for the comparison and the experimental classes per lesson by teacher and then the aggregate data were reported comparably for the comparison and the experimental classes per unit by teacher.

Frequency of Teachers’ Maturity and Developmental/Principle Appropriate Tasks

Ray’s Separate Data in the Comparison Classes

Figure 4.58 shows the level of task maturity and developmental/principle appropriate tasks in the comparison classes. 12 out of 16 tasks in class 1, and 13 out of 17 tasks in class 2 were immature and developmental appropriate but principle inappropriate (level 3). In both classes, three tasks were coded as immature and developmental/principle inappropriate (level 1). In each class, one task was coded as immature but developmental/principle appropriate (level 4). Both mature and developmental/principle appropriate tasks (level 8) were not coded in both comparison classes.
Ray’s Separate Data in the Experimental Classes

The levels of task maturity and developmental/principle appropriate tasks in the experimental classes are shown in Figure 4.59. 18 out of 24 tasks in class 1, and 17 out of 19 tasks in class 2 were coded as mature and developmental/principle appropriate tasks (level 8). Six tasks in class 1, and two tasks in class 2 were immature but developmental/principle appropriate (level 3). No tasks were coded as immature and developmental/principle inappropriate tasks (level 1) in both experimental classes throughout the unit.
Figure 4.59 Task Maturity and Appropriateness in Ray’s Experimental Class 1 and 2

Ray’s Aggregate Data in the Comparison and Experimental Classes

Figure 4.60 shows the means of task maturity and developmental/principle appropriate tasks in the comparison and the experimental classes. The data showed that Ray presented mostly immature and only developmental appropriate tasks (level 3) in the comparison classes. However, most tasks were mature and developmental/principle appropriate (level 8) in the experimental classes. On average, three level 1 tasks (i.e., immature and developmental/principle inappropraite task) were coded in the comparison classes. In both comparison and experimental classes, the level 7, 6 and 5 and 2 tasks
were not coded throughout the unit.

Figure 4.60 Task Maturity and Appropriateness in Ray’s Comparison and Experimental Classes

Figure 4.61 shows the levels of task maturity and developmental/principle appropriate tasks in the comparison classes. Seven of 17 tasks in class 1, and three of 17 tasks in class 2 were immature but developmental/principle appropriate (level 4). Seven tasks in class 1, and 12 tasks in class 2 were coded as immature and developmental appropriate but principle inappropriate (level 3). Three tasks in class 1, and one task in class 2 were immature and developmental/principle inappropriate (level 1). In class 2, one level 7 task (i.e., mature and developmental appropriate but principle inappropriate) was coded. In both classes, the level 8 task was not coded (i.e., mature and developmental/principle appropriate tasks).
Figure 4.61 Task Maturity and Appropriateness in Tyler’s Comparison Class 1 and 2

**Tyler’s Separate Data in the Experimental Classes**

The levels of task maturity and developmental/principle appropriate tasks in the experimental classes are shown in Figure 4.62. 14 of 17 tasks in class 1, and 15 of 17 tasks in class 2 were coded as mature and both developmental/principle appropriate tasks (level 8). One task in class 1 was coded as mature and developmental appropriate but principle inappropriate (level 7). In each class, the teacher used one level 4 task (i.e., immature but both developmental/principle appropriate) and one level 3 task (i.e., immature and developmetal appropriate but principle inappropriate) throughout the unit. There was no task coded as immature and developmental/principle inappropriate (level 1).
in both classes.

Figure 4.62 Task Maturity and Appropriateness in Tyler’s Experimental Class 1 and 2

Tyler’s Aggregate Data in the Comparison and Experimental Classes

Figure 4.63 shows the means of task maturity and developmental/principle appropriate tasks in the comparison and experimental classes. The data showed most tasks in the comparison classes were coded as either immature and developmental/principle appropriate (level 4) or immature and only developmental appropriate (level 3). The mean of 15.5 tasks was mature and developmental/principle
appropriate in the experimental classes. The level 8 tasks were not coded in the comparison classes.

**Figure 4.63 Task Maturity and Appropriateness in Tyler’s Comparison and Experimental Classes**

<table>
<thead>
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<th>Level</th>
<th>Description</th>
<th>Comparison</th>
<th>Experimental</th>
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</thead>
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<td>2</td>
<td>Extending task</td>
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</tr>
<tr>
<td>4</td>
<td>Applying task</td>
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</tr>
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</table>

**Research Sub-Question 9: How does the teachers’ inter-task adaptation of tasks differ between the comparison and experimental classes?**

In this research question, the data were collected as a frequency of teachers’ inter-task adaptations in the comparison and experimental classes. The data for the inter task adaptations were recorded as one of four:

- Level 1 — Informing task
- Level 2 — Extending task
- Level 3 — Refining task
- Level 4 — Applying task
The data were reported as the number of teacher’s inter-task adaptation levels. The teacher data were also reported separately for the comparison and the experimental classes per unit by teacher and then the aggregate data were reported comparably for the comparison and the experimental classes per unit by teacher.

**Frequency of Teacher’s Inter-Task Adaptations**

**Ray’s Separate Data in the Comparison Classes**

Figure 4.64 shows the number of inter-task adaptions in the comparison classes. The data showed that the teacher presented five of 14 tasks in class 1, and six of 15 in class 2 were coded as informing tasks (level 1). Three extending tasks (level 2), one refining task (level 3), and five applying tasks (level 4) were coded in both classes.

**Ray’s Separate Data in the Experimental Classes**

Figure 4.65 shows the number of inter-task adaptations in the experimental classes. The data showed the teacher presented 10 informing tasks (level 1) out of 28 total tasks in class 1, and nine informing tasks out of 26 total tasks in class 2. Eight extending tasks (level 2), five refining tasks (level 3), and five applying tasks (level 4) were coded in class 1. In class 2, five extending tasks (level 2), seven refining tasks (level 3), and four applying tasks (level 4) were used by the teacher throughout the unit.
Ray’s Aggregate Data in the Comparison and Experimental Classes

The mean of inter-task adaptations per unit in the comparison and experimental classes is represented in Figure 4.66. On average, the teacher stated six informing tasks (level 1) in the comparison classes, and 9.5 informing tasks were stated by the teacher in the experimental classes. The means of extending tasks (level 2) per unit were three in the comparison classes, and 5.5 in the experimental classes. The teacher used only 0.5 refining task (level 3) per unit in the comparison classes. However, the mean of 6.5 refining tasks was coded in the experimental classes. In terms of the use of applying tasks
(level 4), the mean per unit in the comparison classes was 5.5 and 4.5 in the experimental classes.

**Figure 4.65 Inter-Task Adaptations in Ray’s Experimental Class 1 and 2**

*Class 1*

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Level 1 — Informing</th>
<th>Level 2 — Extending</th>
<th>Level 3 — Refining</th>
<th>Level 4 — Applying</th>
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*Class 2*

<table>
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<th>Level 3 — Refining</th>
<th>Level 4 — Applying</th>
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</tbody>
</table>

Tasks

Levels

180
Figure 4.66 Inter-Task Adaptations in Ray’s Comparison and Experimental Classes

Tyler’s Separate Data in the Comparison Classes

Figure 4.67 shows the number of inter-task adaptations in each level in the comparison classes. The data showed that six of 19 tasks in class 1, and six out of 20 tasks in class 2 were coded as informing tasks (level 1). Five or six extending tasks (level 2), two or four refining tasks (level 3), and five applying tasks (level 4) were coded in each class.

Tyler’s Separate Data in the Experimental Classes

Figure 4.68 shows the numbers of inter-task adaptations over six lessons in the experimental classes. 7 of 31 tasks in class 1, and 8 of 30 tasks in class 2 were coded as informing tasks (level 1). The number of refining tasks (level 3) in class 1 was 13, and 10 in class 2. In both classes, the teacher used six extending tasks (level 2) and five applying tasks (level 4).
Figure 4.67 Inter-Task Adaptations in Tyler’s Comparison Class 1 and 2

Tyler’s Aggregate Data in the Comparison Classes and Experimental Classes

Figure 4.69 represents the means of inter-task adaptations per unit in the comparison and the experimental classes. On average, the teacher stated six informing tasks (level 1) in the comparison classes, and 7.5 informing tasks were stated by the teacher in the experimental classes. The means of extending tasks (level 2) were 5.5 in the comparison classes, and 6.5 in the experimental classes. The teacher stated only three refining tasks (level 3) per unit in the comparison classes. The mean of 11 refining tasks were stated by the teacher in the experimental classes. The teacher provided the mean of five applying tasks (level 4) for both comparison and experimental classes.
Figure 4.68 Inter-Task Adaptations in Tyler’s Experimental Class 1 and 2

Class 1

- Level 1 — Informing
- Level 2 — Extending
- Level 3 — Refining
- Level 4 — Applying

Figure 4.69 Inter-Task Adaptations in Tyler’s Comparison and Experimental Classes

Inter-Task Adaptations

Comparison
Experimental

Number

Informing  Extending  Refining  Applying

0  5  10  15  20

183
Research Sub-Question 10: How does the teachers’ intra-task adaptation of tasks differ between the comparison and experimental classes?

In this research question, data were collected as a frequency of teachers’ intra-task adaptations for small groups or individuals in the comparison and the experimental classes.

The data for the intra-task adaptation were recorded as one of six:

Level 1 — Modifying task complexity
Level 2 — Different task
Level 3 — Restating task
Level 4 — Refining/breaking task
Level 5 — Extending task
Level 6 — Competition condition

The data were reported as the number of teacher’s intra-task adaptation levels. The teacher data were also reported separately for the comparison and the experimental classes per unit by teacher and then the aggregate data were reported comparably for the comparison and the experimental classes per unit by teacher.

Frequency of Teacher’s Intra-Task Adaptations

Ray’s Separate Data in the Comparison Classes

Figure 4.70 shows the number of intra-task adaptations for small groups or individuals within the tasks in the comparison classes. The numbers of lessons and inter-tasks as well as the types of inter-task adaptations occurred intra-task adaptations are presented in Table 4.8. Three different task adaptations (level 2) followed by informing
tasks and four restating task adaptations (level 3) followed by the teacher’s informing, extending, or applying tasks were provided in class 1. Three restating task adaptations (level 3) and one refining task adaptation (level 4) followed by either informing or applying tasks in class 2 were coded over six lessons. Total intra-task adaptations in both classes were less than eight.

Figure 4.70 Intra-Task Adaptaions in Ray’s Comparison Class 1 and 2

Class 1

Class 2

- Level 1 — Modifying task complexity
- Level 2 — Different task
- Level 3 — Restating task
- Level 4 — Refining or breaking task
- Level 5 — Extending task
- Level 6 — Competition condition
Table 4.8 Lessons and Inter-Tasks for the Intra-Task Adaptions

<table>
<thead>
<tr>
<th>Intra-Task #</th>
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<th>Class 2</th>
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</thead>
<tbody>
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<td>Lesson #</td>
<td>Inter-Task #</td>
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Ray’s Separate Data in the Experimental Classes

The number of intra-task adaptations for small groups or individuals within the tasks per unit in the experimental classes is shown in Figure 4.71. The numbers of lessons and inter-tasks as well as the types of inter-task adaptions occurred intra-task adaptions are presented in Table 4.9. The teacher modified the complexity of the tasks (level 1) and provided different tasks (level 2) once or twice in both class 1 and 2. 12 of 21 tasks in class 1, and 11 of 23 tasks in class 2 were coded as restating tasks (level 3). One refining/breaking tasks (level 4) was coded in class 1 and four in class 2. Six extending tasks (level 5) were coded in class 1 and four in class 2. The level 6 task adaptation (i.e., changing competition conditions) was not coded in both classes.

Ray’s Aggregate Data in the Comparison and Experimental Classes

The number of intra-task adaptations for small groups or individuals within the tasks in the comparison and experimental classes is shown in Figure 4.72. The majority of the intra-task adaptions for both comparison and experimental classes were restating tasks (level 3). The mean of restating tasks per unit was 12.0 in the experimental classes,
but the mean of 3.5 restating tasks were coded in the comparison classes. In the experimental classes, the teacher adapted the tasks for small groups or individuals with five different levels of intra-task adaptations except the level 6 adaptation per unit. However, three different levels of intra-task adaptations (i.e., level 2, 3, or 4) were utilized in the comparison classes.

![Figure 4.71 Intra-Task Adaptations in Ray’s Experimental Class 1 and 2](image)

- Level 1 — Modifying task complexity
- Level 2 — Different task
- Level 3 — Restating task
- Level 4 — Refining or breaking task
- Level 5 — Extending task
- Level 6 — Competition condition

Class 1

Class 2
Table 4.9 Lessons and Inter-Tasks for the Intra-Task Adaptations

<table>
<thead>
<tr>
<th>Intra-Task #</th>
<th>Class 1</th>
<th>Class 2</th>
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</thead>
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</table>

Figure 4.72 Intra-Task Adaptations in Ray’s Comparison and Experimental Classes
**Tyler’s Separate Data in the Comparison Classes**

Figure 4.73 shows the number of intra-task adaptations for small groups or individuals in the comparison classes. The numbers of lessons and inter-tasks as well as the type of intertasks occurred intra-task adaptations are presented in Table 4.10. Three restating tasks (level 3) and one refining/breaking task (level 4) followed by extending or applying tasks were provided in class 1. In class 2, two restating tasks followed by the extending or applying tasks on lesson 2 or 4, two refining/breaking tasks followed by the extending tasks on lesson 2, and one different task (level 2) followed by the third refining tasks on lesson 4 were recorded. The number of intra-task adaptations for the unit were not over five in both classes.
Table 4.10 Lessons and Inter-Tasks for the Intra-Task Adaptations

<table>
<thead>
<tr>
<th>Intra-Task #</th>
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<th></th>
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</tr>
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<tbody>
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<td>Lesson #</td>
<td>Inter-Task #</td>
<td>Inter-Task</td>
<td>Lesson #</td>
</tr>
<tr>
<td>1</td>
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<td>Extending</td>
<td>2</td>
</tr>
<tr>
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<td>Applying</td>
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</table>

Tyler’s Separate Data in th Experimental Classes

The number of intra-task adaptations for small groups or individuals in the experimental classes is shown in Figure 4.74. The numbers of lessons and inter-tasks as well as the type of inter-tasks occurred intra-task adaptations are presented in Table 4.11. 10 of 21 intra-task adaptations in class 1, and 7 of 14 intra-task adaptations in class 2 were coded as a restating task (level 3). The numbers of refining/breaking tasks (level 4) followed by the teacher’s refining or applying tasks were eight in class 1, and seven in class 2. Tyler used only two different levels of intra-task adaptations (i.e., level 2 and 3) in class 2, but five different levels of task adaptations except the level 6 were used in class 1. The number of intra-task adaptations per unit was 21 in class 1, and 14 in class 2.

Tyler’s Aggregate Data in the Comparison and Experimental Classes

The means of intra-task adaptations for small groups or individuals within the tasks in the comparison and the experimental classes are shown in Figure 4.75. Most of the intra-task adaptations for both comparison and experimental classes were restating tasks (level 3) or refining/breaking tasks (level 4). On average, 17 of 18 task adaptations
per unit in the experimental classes, and 4 of 4.5 task adaptations in the comparison classes were coded as either level 3 or level 4. In both comparison and experimental classes, level 1, 2, 5 and 6 task adaptations were not frequently used by the teacher.

**Figure 4.74 Intra-Task Adaptations in Tyler’s Experimental Class 1 and 2**
Table 4.11 Lessons and Inter-Tasks for the Intra-Task Adaptations

<table>
<thead>
<tr>
<th>Intra-Task #</th>
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Figure 4.75 Intra-Task Adaptations in Tyler’s Comparison and Experimental Classes

![Intra-Task Adaptations Chart](chart.png)
Summary of Aggregate Data

In order to provide the teaching profiles of the teachers, the mean data of both classes for Ray’s comparison and experimental groups per unit are presented in Figure 4.76. The mean data of both classes for Tyler’s comparison and experimental classes per lessons are presented in Figure 4.77.
Figure 4.76 Ray’s Summary Data

**Task Maturity**

- Comparison
- Experimental

**Verbal Representations**

- Comparison
- Experimental

**Visual Representations**

- Comparison
- Experimental

**Task Appropriateness**

- Comparison
- Experimental
Figure 4.77 Tyler’s Summary Data

**Task Maturity**

- Comparison
- Experimental

**Verbal Representations**

- Instruction Descriptions
- Analytical/Strategic
- Cues
- Feedback

**Visual Representations**

- Full Demo
- Partial Demo
- Incorrect Demo
- Task Cards
- Physical Assistance

**Task Appropriateness**

- Both Inappropriate
- Only Appropriate in Principle
- Only Developmentally Appropriate
- Both Appropriate
CHAPTER 5

DISCUSSION

This chapter is organized into five sections. Section one presents the effectiveness of the intervention for the study and the conclusions made for each of the research questions. Section two discusses the conceptual contributions and section three discusses methodological contributions. Section four discusses the limitations to the study. Finally, section five suggests implications for preservice and inservice teacher education programs.

The Effectiveness of the Intervention

In order to determine whether the teachers successfully implemented what they were taught in the CK workshop, the effectiveness of the interventions (i.e., the badminton CK workshop with the knowledge packet and daily feedback) was examined using a treatment integrity checklist. Treatment integrity for Ray was 85.4% and for Tyler 88.9%. The high percentage of treatment integrity showed that both teachers effectively implemented the tasks that they learned from the CK workshop and the investigator’s daily feedback. During the CK workshop, the investigator introduced the fundamental
principles (i.e., shaping play, focusing play, and enhancing play) of Play Practice (Lander, 2001) and modeled the six primary activities in the knowledge packet (i.e., serves, overhead strokes, underhand strokes, smash shots, drop shots, and doubles’ game play). The teachers were asked to answer a set of questions about skill discrimination, error detection and corrections, task presentation, task progressions, and task adaptations for student learning. Both teachers met all the criteria for each skill presented in the CK workshop.

In addition to the CK workshop, the investigator provided the teachers with specific feedback about their teaching in terms of how to set up the tasks, how to represent the tasks, and how to fix students’ common mistakes for the experimental groups. Because the teachers had a tight teaching schedule, the investigator was able to provide short and quick daily feedback spending two or three minutes between the classes or after the class. For example, the investigator gave verbal feedback and correct demonstrations to fix Tyler’s partially correct demonstration of the drop shot (e.g., stopping at the execution phase) without mentioning the critical element of the skill for the first lesson on lesson 5. Providing the teachers with immediate feedback about their teaching was useful because the teachers immediately fixed their incorrect information about the performance and delivered the tasks using correct verbal and visual representations in the next lesson.
Conclusions of the Research Questions on the Student Performances

Research Sub-Question 1: How many total, correct, incorrect, and other trials were made by the students in the comparison and experimental classes?

In this question, learning trials were used as a dependent variable to examine differences between the comparison and the experimental classes. Trials have been the standard used by pedagogy researchers to assess student learning, particularly when validated skills tests are not available (Siedentop, et al. 1992; Silverman, 1985). As Alexander (1983) notes “discrete trials procedures are capable of measuring behavior change directly while ALT-PE can only predict such changes (p 45),” the investigator considered the number, type, and quality of practice trials as a meaningful measure of engagement with the skill than simple time on task. Studies (Ashy, Lee, & Landin, 1988; Dugas, 1983; Silverman, 1985) have shown a positive relationship between correct practice trials and student achievement using closed skills (i.e., archery, bowling, gymnastics, and golf) and open-skilled skills such as volleyball (Buck, Harrison, Bryce, & Yong 1990). In this study, total trials, correct trials, incorrect trials, and other forms of trials were examined.

Number of Total Trials

The number of total trials was measured in the comparison and the experimental classes with the rationale that students who receive ample learning opportunities to respond (OTR) have more opportunities to be successful in skill acquisition (Alexander, 1983; Silverman, 1985). The mean of total trials in Ray’s comparison classes was 92.3
(range= 58.2~118.9), and 66.1 (range= 44.8~85.1) in Tyler’s comparison classes. The mean of total trials in Ray’s experimental classes was 91.2 (range= 58.5~139.4) and 89.3 (range= 44.7~111.9) in Tyler’s experimental classes. The results showed that the mean of total trials in Ray’s experimental classes was similar to that in Ray’s comparison classes. The mean of total trials in Tyler’s experimental classes was larger than that in Tyler’s comparison classes. Those variations in total trials across unit as well as by teacher were consistent with the literature. For example, Buck et al. (1990) reported a large variance in lesson to lesson trials in her study of volleyball. Variations in lessons to lessons can occur because of the difficulty of tasks (e.g., serve versus drop shot) on one day versus another day, and the structure of the learning environment (e.g., skill practice versus game play).

**Number of Correct Trials**

The results showed that the students in the experimental classes had more correct trials than those in the comparison classes. The mean for Ray’s comparison classes per lesson was 9.7 and 9.6 for Tyler. The mean for Ray’s experimental classes per lesson was 54.7 and 39.8 for Tyler. The data showed that there was a significant difference in the number of correct performances between the comparison and the experimental classes. This represents a desirable outcome, because correct trials are positively and strongly correlated to student learning (Silverman, 1985).

**Number of Incorrect Trials**

The results showed that the mean of incorrect trials per lesson in the experimental
classes was lower than the mean in the comparison classes. In the comparison classes, the means of incorrect trials were 65.5 for Ray and 46.1 for Tyler. In the experimental classes, the means for incorrect trials were 20.4 for Ray and 38.9 for Tyler. Reducing incorrect trials is an important outcome in teaching effectiveness research; for instance, Silverman (1990) found that incorrect practice trials are negatively related to student achievement.

**Number of Other Trials**

The results showed that the mean of other trials per lesson in both Ray’s comparison (M=17.3) and experimental classes (M=17.4) was similar. The mean of other trials in Tyler’s comparison classes (M=11.8) was lower than that in Tyler’s experimental classes (M=15.7). In both comparison and experimental classes, the similar numbers of students’ missed shots were a result of either their own mistakes or the opponent player’s mistakes. It is true that students commonly make a lot of mistakes and thus miss the shots when they learn the new skills in racket sports, but it is also true that the teachers need to reduce students’ consecutive failures by refining or breaking down the skills, adapting the tasks for the individual needs and providing specific congruent feedback and cues.

**Research Sub-Question 2: What percentage of correct, incorrect, and other trials were made by the students in the comparison and the experimental classes?**

The purpose of the research question was to examine the difference of the percentage of students’ correct, incorrect, and other trials between the comparison and the experimental classes. Percentage is an important dependent measure because there are
variations in lesson length, practice opportunity, teachers’ class management, and transition. Even though students may have more correct trials in each lesson (e.g., 30 of 40 versus 50 of 100), the students’ correct trial ratio to total trials would have an opposite result (e.g., 75% versus 50%) due to the difference in total practice trials. In this example, it is difficult to determine whether students who have more correct trials are successful in the classes. Thus, the percentage of correct, incorrect, and other trials were measured in this study.

**Percentage of Correct Trials**

The percentage data on student performance for both teachers showed that the mean percentage of correct trials in the comparison classes was 10.1% for Ray and 14.3% for Tyler. The mean percentage of correct trials in the experimental classes was 59.1% for Ray and 43.1% for Tyler. The data showed that the students were more successful in the experimental classes than in the comparison classes. There are no scientific guidelines as to what the percentage of correct trials should be in PE. Brophy (1980) recommended an 80% success rate when students are working on new skills and 95% when reviewing the skills in reading. Brophy (1980) argued that teachers should allow students to continue with practice and review until smooth, rapid, and correct performance is achieved. Regardless of the significant increase of the percentage of correct trials in the experimental classes, the students’ percentage of correct trials was not high enough to meet above 80% criterion suggested by Brophy (1980) in this study. One possible explanation of this result would be that the students in the experimental classes might not
be able to reach to the 80% success rate during practice and game within five or six day instructional unit that encompasses new and challenging activities in each lesson. In order to increase the success rate, teachers should consider designing a longer instructional unit that allows teachers to provide students with more guided and individual practices, and reviews.

In PE, Lee (2011) compared the differences of student performance before and after CK acquisition in a soccer unit. The results showed that the percentage of student correct performance in the experimental classes was similar to those in the comparison classes, reporting approximately 40%. In his study, student correct performance was measured by the critical elements of the skills that the teachers stated as their criteria without determining whether the teachers’ statements were correct. In his study, Lee (2011) used a momentary-time sampling strategy that recorded student performance for the last three minutes of each task, a process which might cause unreliable results in terms of the percentage of student correct performance.

**Percentage of Incorrect Trials**

The results showed that the mean of the percentage of incorrect trials in both teacher’ experimental classes was less than that in both teachers’ comparison classes. The means of the percentage of incorrect trials in the comparison classes were 71.3% for Ray and 70.2% for Tyler. The means of the percentage of incorrect trials in the experimental classes were 23.2% for Ray and 40.5% for Tyler. Comparison class lessons with 70% of trials being performed incorrectly by students suggests that much of the work is
negatively correlated to student learning (Silverman, 1985; 1990). In short, students spend the majority of their practice trials being unsuccessful and practicing incorrect techniques. In the experimental classes, students’ incorrect trials decreased dramatically. However, in Tyler’s experimental classes, approximately 40% of students’ incorrect trials were still remained. Anderson, Evertson, and Brophy (1982) suggested a 20-30% error rate when students are working on new skills arguing that error rate is one of considerations for programming for continuous progress. Rosenshine and Stevens (1986) emphasized teaching new skills in small steps and practicing until over learning occurs to reduce the student error rate. In this study, one possible explanation of the high percentage of incorrect trials for Tyler’s experimental classes would be that Tyler involved in teaching as a player. It may prevent him from providing students with more skill-related congruent feedback and cues to fix students’ incorrect performances in the lessons. Teachers’ consistent active teaching behaviors throughout the lesson and unit are important to decrease the student error rate. In addition, Ray used a five-day instructional unit instead of six days because of his illness for the experimental classes. . The use of a short instructional unit with the new skill practices and challenging activities may have prevented him to review the previous skills and provide more repeated practices of the skills to students in order to decrease their error rate.

**Percentage of Other Trials**

The data showed the mean percentage of other trials in the comparison classes was 18.9% for Ray and 18.4% for Tyler. The mean for the experimental classes was 18.8%
for Ray and 16.5% for Tyler. The results showed that students in both comparison and experimental classes performed over 16% percentage of missed, unfair, or non-target performances.

In the comparison classes, the low skilled students had consecutive missed opportunities without any assistance and the students negotiated the teachers’ intended tasks so that many non-target performances were observed in the comparison classes. On the other hand, due to the challenging tasks, the students had missed or unfair opportunities to hit the shuttle in the experimental classes. Because of both teachers’ lack of pedagogical skills such as scanning with back to wall and timing for moving to the next task, some students performed non-target performances (e.g., making a rally back and forth instead of practicing a serve to the target area) in both comparison and experimental classes.

*Research Sub-Question 3: Is there a statistical difference in the mean percentage of correct, incorrect, and other trials between the comparison and experimental classes?*

The purpose of the research question was to examine the statistical difference of the mean percentage of student correct, incorrect, and other trials between the comparison and experimental classes.

The investigator used a non-parametric test (Mann-Whitney test), and found that the percentage of correct trials for the students in experimental classes was greater than those in the comparison classes ($U=33.0$, $p=.000$, $r=-.76$). There was a significant difference in the mean percentage of incorrect trials between the comparison and
experimental classes \((U=18.0, p=.000, r=-.80)\). However, there was no significant difference in the mean percentage of other trials between the comparison and experimental classes for both teachers \((U=275, p=.789, r=-.04)\).

The significant differences in the percentage of correct trials and incorrect trials can be attributed to the improved teachers’ PCK as a result of the CK workshop. In the CK workshop, the teachers developed their knowledge for teaching going beyond the ability to perform the activities, including analyzing the source of the errors and selecting the instructional tasks and appropriate progressions (Ward, 2009b). Their knowledge influenced the change of teaching behaviors (e.g., mature PCK) and finally the teachers’ mature PCK influenced the increase of students’ correct trials and the decrease of student’s incorrect trials in student learning. The results suggest that the developed teachers’ specialized content knowledge (SCK) which is vital and core knowledge for teaching can bridge knowledge connecting between CK and PCK (Ball et al. 2008). The results related to teachers’ PCK variables were presented in the research sub-questions 4-10.

**Research Sub-Question 4: How does the teachers’ maturity of tasks differ between the comparison and the experimental classes?**

The purpose of this research question was to examine the difference of the teacher’s task maturity in terms of how to represent the task between the comparison and the experimental classes. Shulman (1986) initially defined PCK as “the ways of representing and formulating the subject that it comprehensible to others” (p. 9). He argued that teachers who have PCK should represent the tasks using analogies,
illustrations, examples, and explanations in order to provide learners with the explicit content.

The data showed that both teachers did not use any mature forms of task representations in their comparison classes; however, for both teachers, over 80% of tasks in their experimental classes were coded as mature. The investigator hypothesized that teachers did not demonstrate an in-depth understanding of the content before the workshop, whereas the teachers’ CK which was developed in the workshop contributed to their more mature forms of task representations. The findings are similar to those of Lee (2011), who found that teachers used more immature tasks before his soccer CK workshop and more mature tasks following the CK workshop.

In the comparison classes, the teachers often represented the tasks simplistically (e.g., limited use of verbal or visual representations) and incompletely when they taught in the comparison classes. For example, when teaching drop and drive shots, Ray stated “Let’s make a rally with a partner. During the play, try to use drop shots or drive shots making your opponent player move. Let’s go.” This representation can be viewed as simplistic and incomplete because it does not include a description of the critical elements of the drop shots and drive shots, instruction about how to make the opponent player move in a play, or as visual demonstration of correct performance.

The teachers depended on the use of verbal instructions to explain the tasks and frequently provided students with incorrect descriptions or analogies for the skills (e.g., “a badminton serve looks like an underhand volleyball serve” and “step forward when you are serving,” when teaching a serve). For the comparison classes, both teachers
focused only on teaching a serve without distinguishing the differences between the long and short serves. Both teachers emphasized the rules of the game (e.g., scoring or correct serve order) instead of asking students to perform the skills correctly or describing the critical elements of the serve during game and practice. Hastie and Viasavljevic (1999) observed that teachers who have strong CK focused on developing the quality of student performance instead of focusing on a level of participation or effort. Ayvazo (2007) also reported that teachers held students accountable for knowing the rules of the game, but typically did not hold them accountable for correctly performing the technique or tactic. Tousignant and Siedentop (1983) and Jones (1992) have shown that PE teachers seldom hold students accountable for skill acquisition. In this study, since the teachers did not have strong CK before the workshop, they mostly used incorrect or incomplete representations of content so that the students did not understand what they were supposed to do. The results can be seen in the student data, where students had less correct trials and more incorrect trials in the comparison classes than in the experimental classes.

Following the workshop, the teachers provided the mature tasks that included more detailed information about how to execute the skills using richer verbal and visual representations. For example, when Tyler taught the long serve on lesson one, he stated:

“Watch my demonstration at first for a forehand long serve. The critical elements of the long serve are an up and back stance with racket arm in backswing position in the preparation phase. Hit the shuttle at the knee level using wrist action in the execution phase and continue to follow through to the opposite side of your
shoulder. The target area would be a deep and corner in the diagonally opponent service box. See the poly spots. The good long serve would make a big rainbow shape. Stand closely from the service line and practice the long serve to the target areas five times each.”

This statement is an example of rich and sophisticated task representation, because it includes the fully correct demonstration, the description of the critical elements of the skill, the use of metaphor, and the clear task statement with behavior, situation, and criterion for the task. When they taught the experimental classes, the teachers also reviewed the previous skills at the beginning of the lessons by asking students to demonstrate the correct performances and answer the critical elements of the skills for the experimental classes. The increased use of more mature tasks using diverse visual and verbal representations can be attributed to an increase in teachers’ CK, obtained from the workshop. The investigator’s use of rich and sophisticated task representations when modeling the tasks during the workshop resulted in the increased use of mature task representations by the teachers. The results support Ayvazo (2007), who found that when the teachers’ PCK was more mature, a variety of tasks, cues, and modifications were used. Thus, the results provided evidence to support the proposition that the teachers’ PCK can be located on a continuum from immature to mature PCK and that improved PCK can be influenced by CK (Ward, 2009b).
Research Sub-Question 5: How does the teacher’s use of verbal representations differ between the comparison and the experimental classes?

The purpose of the research question was to examine the difference of the teachers’ verbal representations between the comparison and the experimental classes. Based on Shulman’s (1986) initial definition of PCK, the teachers’ use of illustrations, analogies, examples, metaphors, and demonstrations is considered as an indicator of more developed PCK. In this study, five verbal representations (i.e., instructions, descriptions, analogies/metaphors, cues, and specific congruent feedback) were used as a determinant of the task maturity within two teaching conditions (i.e., during task representation and during practice).

Instructions, Descriptions and Analogies/Metaphors

The data showed that the teachers used more verbal instructions, descriptions, and analogies/metaphors per unit in the experimental classes than in the comparison classes. The means of instructions, descriptions, and analogies/metaphors per unit were 49.5, 13.5 and 1.0 for Ray and 48.5, 17.5, and 4.0 for Tyler in the comparison classes. The means of instructions, descriptions and analogies/metaphors were 102.0, 53.5 and 33.5 for Ray and 72.5, 45.4 and 29.5 for Tyler in the experimental classes.

These data show that both teachers relied on verbal instructions for conveying the content with the infrequent use of other forms of representation before the CK workshop. The teachers did not teach the fundamental skills except the serve during the unit so that descriptions and analogies/metaphors were seldom used by the teachers. However, their
descriptions and analogies/metaphors were sometimes inappropriate (e.g., “hold the shuttle behind the racket for the serve,” “do the long serve like a volleyball underhand serve”).

After the workshop, the teachers used more diverse verbal representations for delivering the content over the unit based on their understanding of the critical elements of the skills. Lee (2011) reported a similar finding following his soccer workshop. In each lesson, the teachers taught a new technique or tactic with a set of tasks. To represent the tasks, more than 72 instructions, 45 descriptions, and 29 analogies/metaphors per unit were used for both teachers in the experimental classes compared with fewer than 50 instructions, 18 descriptions, and four analogies/metaphors per unit in the comparison classes. Teachers often used useful analogies and metaphors (e.g., “back scratch position,” “scrape the ceiling,” “big rainbow shape”) that they learned through the workshop as well as developed their own analogies and metaphors (e.g., “guide or block it,” “like a volleyball spike”) to help students to understand correct performance. The increased use of analogies and metaphors can be attributed to the increase in teachers’ CK obtained from the workshop including the critical elements of the techniques and tactics, game rules and etiquettes, possible common errors and error corrections, and instructional tasks (Ward, 2009b). In addition, the investigator’s use of analogies and metaphors when modeling the tasks during the workshop resulted in the teacher’s frequent use of analogies or metaphors in their teaching.
Appropriate Cues and Specific Congruent Feedback

The use of appropriate cues and specific congruent feedback by teachers during practice significantly increased after the CK workshop. In the comparison classes, the means of appropriate cues and specific congruent feedback per unit were 9.5 and 18.5 for Ray and 28.0 and 37.5 for Tyler. After the workshop, the means of appropriate cues and specific congruent feedback per unit were 68.5 and 136.5 for Ray and 74.5 and 109.5 for Tyler. For example, the teachers provided information about the performance using shortened words such as “Turn your body,” “Hit it at the top,” “High and deep,” “Guide it,” “Block it,” “Wrist action,” “Reach high,” “Follow through,” “Both arms up,” “Move your feet,” “Push it,” “Shift your weight,” “Continue your swing,” “Ready position,” “Back scratch position,” “Rainbow shape.” Additionally, the teacher used specific congruent feedback such as “Drop the shuttle first between your feet and you should hit the shuttle at the knee level” when teaching the serve. The increased use of appropriate cues and specific congruent feedback can be attributed to the increase of teachers’ CK in badminton obtained in the CK workshop. Moreover, the investigator instructed teachers to use cues and provide specific congruent feedback by detecting students’ errors to facilitate student learning during the workshop.

This represents a measurable increase in appropriate cues and specific congruent feedback from gaining CK. Chen and Ennis (1995) reported similar findings that content rich teachers used a total of 121 cues in volleyball; Kutame (2002) also reported that teachers who have strong CK provided more appropriate and accurate cues. Ayvazo (2007) likewise supported the current findings, reporting that teachers used more
technical and visual cues in discriminating correct and incorrect performance in the instructional units where they had more knowledge. When teachers detect students’ common mistakes, they should act on them. If teachers do not provide instruction remediation for students’ incorrect performances, it is an indication that they may have a limited ability to detect errors (i.e., weak CK) and limited selection of content to overcome the learning difficulty (i.e., immature PCK) (Ayvazo, 2007). Lee (2011) also found that the teachers who developed their CK in the workshop used more appropriate cues in their lessons. He also argued that the number of cues that teachers used is an indicator of PCK, but that the quality of cues should also be considered. Based on clear understanding of the critical elements of the techniques and tactics (i.e., strong CK), teachers could use short technical, visual or metaphoric words that enhance student performance (i.e., mature PCK). The results of this study provided evidence to support the claim that teachers’ PCK variables can move from immature (i.e., the fewer appropriate cues and specific congruent feedback) to mature (i.e., the numerous appropriate cues and specific congruent feedback) on a continuum by developing their CK, which allows them to detect students’ errors and provide useful information for correcting student errors. Moreover, teacher education programs should provide teachers with a leaning opportunity to develop their CK with the list of appropriate cues and specific congruent feedback in a specific content that teachers can use in their future classes.
**Research Sub-Question 6: How does the teachers’ use of visual representations differ between the comparison and the experimental classes?**

The purpose of the research question was to examine the difference in the teachers’ visual representations between the comparison and experimental classes. Shulman (1986) defined PCK as having several characteristics such as “analogies, illustrations, examples, explanations and demonstrations” (p.8). In this study, these characteristics were categorized into verbal and visual representations. The verbal categories were already discussed in research question five, and three sub-categories of visual representations (i.e., demonstrations, task cards/pictures/diagrams/ videos, and physical assistance) were used within two teaching conditions (i.e., during task representation and practice). The teachers’ demonstrations in this study were coded with three sub-categories: (a) fully correct demonstrations, (b) partially correct demonstrations, and (c) incorrect demonstrations.

Four findings were drawn from the data of the teachers’ visual representations. The teachers: (a) used few visual representations in the comparison classes and more fully and partially correct demonstrations in the experimental classes, (b) they provided more incorrect demonstrations for the comparison classes, (c) they did not use many visual aids in either comparison or experimental classes, and (d) they used more physical assistance in the experimental classes.
Demonstrations

In terms of fully or partially correct demonstrations, there were large differences between the comparison and the experimental classes. In the comparison classes, neither teacher provided complete and correct demonstration during the six lessons. In the comparison classes, Ray provided one partially correct demonstration and Tyler used 19 partially correct demonstrations per unit. After the workshop, the teachers used many demonstrations. Ray used the mean of 76.5 fully correct demonstrations and Tyler 80.5. The mean of partially correct demonstrations was 43 for Ray and 33.5 for Tyler in the experimental classes.

Before the workshop, the teachers did not use many correct demonstrations. The investigator hypothesizes that this was because of their lack of CK. Tyler used more demonstrations than Ray because of his proficiency of the activity, but all of his demonstrations were only partially correct. After the workshop, both teachers started to use many fully correct demonstrations describing the critical elements of the skills in each phase (e.g., preparation, execution and follow-throw). In the workshop, the investigator showed fully correct demonstrations of each skill, and asked the teachers to demonstrate the skills. If they did not perform the skills correctly, the investigator immediately fixed their incorrect demonstrations. This experience gave the teachers the confidence to demonstrate the skills and increase the use of demonstrations in the experimental classes. This result of the study is supported by Lee (2011), who found that the teachers used more demonstrations after achieving their CK. He argued that more than one demonstration of a task is necessary for student success, depending on the
difficulty of the tasks. Rink (2010) also noted that accurate demonstration can enhance the clarity of the task when teachers introduce a new task. Through demonstration, students will know what they are supposed to do and what a successful task will achieve (Siedentop & Tannehill, 2000). When the teachers in the experimental classes introduced a new skill in each lesson, they provided fully correct demonstrations multiple times by breaking down the skills in each phase. During practice the teachers also showed self-correct demonstrations several times for individuals or small groups in the experimental classes. Teachers should provide fully correct demonstrations multiple times in different angles, since students cannot know what they need to do and what a successful task looks like by watching only one or two demonstrations. The teachers in the experimental classes also used the students as demonstrators to review the previous skills or model the tasks (e.g., combinations shots with a partner). The results supported the contention that the teachers’ PCK (i.e., the use of visual demonstrations) is developed by the improved CK (i.e., the critical elements of the skills) in the workshop (Ward, 2009b).

In terms of incorrect demonstrations, the means of incorrect demonstrations in the comparison classes per unit were 4.0 for Ray and 20.5 for Tyler. In the experimental classes, both teachers performed the mean of 6.0 incorrect demonstrations per unit. Tyler performed approximately three incorrect demonstrations per lesson in the comparison classes describing incorrect critical elements of the skills. However, after the workshop, the reason that both teachers used six demonstrations in the unit was to distinguish between correct and incorrect performances. Both teachers also intentionally used some incorrect examples to check for student understanding about the critical elements of the
skills in the experimental classes. The use of incorrect demonstrations can be attributed to the teachers’ CK obtained from the CK workshop. In the workshop, the investigator intended to provide incorrect demonstrations to help the teachers to discriminate between correct and incorrect performances.

Task Cards/Pictures/Diagrams/Videos

Shulman (1986) emphasized that teachers’ multidimensional understanding of the subject matter is necessary for providing alternative explanations of the same concepts or principles for effectively representing content to learners. Ball et al., (2008) also described knowledge of content and teaching that entails teachers’ different repertoires for representing content and how to deliver it as one of the sub-domains of PCK. Moreover, in the PE setting, movement components could not be successfully represented without visualizations. Based on these conceptualizations of PCK, teachers’ ability to use diverse representations, including visual tools and verbal representations, can be a good indicator for measuring teachers’ PCK.

The results showed that the mean of 1.5 visual aids per unit in the comparison classes and the mean of 6.5 visual aids per unit in the experimental classes were used by Ray to help students’ understanding about skills and tactics. But Tyler did not use any visual aids in either comparison or experimental classes.

Before the workshop, Ray used the video clip for introducing the tactical movements in doubles on lesson five. However, his explanation about the positions of doubles (e.g., side and side position and back and up position) was unclear while
watching the clip. During the workshop, the investigator used the task cards and diagrams to represent the tasks and encouraged the teachers to use task cards or diagrams for their teaching. After the workshop, Ray used the diagrams and pictures while teaching a new skill or reviewing the previous skills. The results are supported by Lee (2011), who found that the teachers used visual tools after obtaining deeper CK and PCK through the workshop. The teachers’ use of these visual tools shows their ability to deliver the content to students in different ways when teaching specific content to learners (Grossman, 1990). However, Tyler did not utilize any visual tools for his students even though these were accessible to him. One possible reason for that might be his personal dislike for using visual aids that might entail more work for him.

**Physical Assistance**

One important visual representation observed in this study was the teachers’ physical assistance. Teachers’ ability to physically move the learner’s body to the proper position or through the correct range of motion of a skill (Lacy & Darst, 1989) provides an indication that teachers possess mature CK/PCK. Clearly, teachers cannot provide accurate physical assistances to learners without having mature CK and PCK.

The data showed that the means of physical assistance in the experimental classes were greater than those in the comparison classes. The means of physical assistance per unit in the comparison classes were 0.5 for Ray and 1.0 for Tyler. But the means of physical assistances per unit were 8.5 for Ray and 9.0 for Tyler in the experimental classes. Before the workshop, the teachers did not use physical assistance. After the
workshop the teachers physically touched their student’s bodies to correct their incorrect movements based on their knowledge about the error source and how to correct it. Teachers’ increased CK from the CK workshop resulted in the use of physical assistance in teaching. During the workshop, the investigator also used some physical assistance when fixing the performer’s incorrect performances. The increased use of physical assistance teaching indicated that their PCK (i.e., different ways to deliver the content) changed from immature to mature through the CK (i.e., critical elements of the skills, error detection and tasks) (Ward, 2009b).

**Research Sub-Question 7: What level of the teachers’ developmental and principle appropriate tasks occur in the comparison and experimental classes?**

The purpose of the research question was to examine the difference of teachers’ developmental and principle appropriate tasks before and after the CK workshop. Appropriateness of task selections as a measure of teachers’ PCK consisted of two sub-components: developmental appropriate and principle appropriate.

Teachers should select developmental appropriate activities that are suitable for students’ age and skill levels (Thomas & Thomas, 2008). For example, a teacher’s decision about appropriate tasks for learners who have different backgrounds (e.g., a fourth grade badminton lesson versus an eighth grade badminton lesson, or highly skilled seventh versus low skilled seventh graders) should be different because the students have different skill levels. In addition, teachers should provide student with instructional practices to develop both learners’ technical and tactical abilities within both realistic and
enjoyable learning conditions. In this study, Play Practice (Launder, 2001) was used as representative of current best practices to teach both techniques and tactics through the game and in the game and it was also used as a criterion for determining the teachers’ principle appropriate tasks. Through the workshop, the teachers had an opportunity to understand theory and practice of Play Practice. The teachers were expected to use the principle appropriate tasks that were developed by the investigator using the principles of Play Practice (i.e., shaping, focusing, and enhancing play) for the experimental classes.

The results of the study showed that most tasks used by both teachers in the comparison classes were coded as either developmental appropriate but principle inappropriate (level 3) or both developmental and principle inappropriate (level 1). The mean of 13 out of 17 tasks for Ray and 9 out of 16 tasks for Tyler were coded as developmental appropriate but principle inappropriate in the comparison classes. For example, the teachers provided the tasks such as “Serve to the opponent court” or “Make a rally with a partner.” When considering students’ age and skill development, the tasks were coded as developmental appropriate in that the serve drill and rally play were suitable for seventh or eighth graders who have some previous learning experiences in playing badminton. However, the tasks were not coded as appropriate according to the principles of Play Practice in that these tasks did not use any of the principles of Play Practice such as manipulating secondary rules, scaffolding learning for success, and using target and freeze replay to enhance student learning (Launder, 2001).

Using a traditional teaching method, the teachers in the comparison classes focused entirely on the development of the serve skill and the understanding of the
scoring system for doubles during the unit. After practicing the serve and some rally plays for a couple of days, the teachers let students play doubles without any specific purpose. This traditional teaching approach failed not only to teach the critical aspects of effective play but also deprived learners from plenty of perfect practice under realistic and enjoyable learning conditions (Launher, 2001). Before the workshop, the teachers were able to consider students’ age and skill development when selecting the content, but they could not provide efficient learning conditions to enhance student learning with their lack of CK in the activity. Within both developmental and principle inappropriate tasks or only developmental appropriate tasks (i.e., immature PCK), students had more incorrect trials and fewer correct trials. The results of the study provide a validation for the contention that teachers’ immature PCK negatively influences student learning.

After the workshop, both teachers used more developmental and principle appropriate tasks (level 4). On average, all 21 tasks for Ray and 17.5 out of 18.5 tasks for Tyler were coded as developmental and principle appropriate. The teachers developed CK in terms of task progressions, critical elements of the techniques and tactics, and task organization using the principles of Play Practice through the workshop, which helped teachers to use more appropriate tasks. For example, in teaching a forehand overhead stroke, the teachers provided students with more learning opportunities by using a target zone (i.e., down in line back corner or cross line back corner), a point system (i.e., only earning a point when they successfully make the forehand overhead stroke to the target area) and a limited play area (i.e., right side of court). In such learning conditions, students had more opportunities to correctly perform a forehand overhead stroke rather
than allowing students to make a rally back and forth without any specific focus of teaching in the comparison classes. The results can be seen in the student data, in which students had more correct trials and fewer incorrect trials in the experimental classes than in the comparison classes.

The results of the study validated the proposition that teachers’ act of selecting appropriate content from their CK base for the purpose of teaching in a specific learning context in the experimental classes is an indication of their more developed PCK (Ayvazo, 2007). In addition, the changes in teachers’ content selection provide further evidence that PCK exists on a continuum from immature to mature (Ward, 2009b).

**Research Sub-Question 8: What level of the teachers’ maturity and developmental/principle appropriate tasks occur in the comparison and the experimental classes?**

The purpose of the research question was to examine the differences of the teachers’ maturity of tasks and developmental/principle appropriate tasks between the comparison and the experimental classes. In the research question four and seven, teachers’ ability -- which is to select the developmental and principle appropriate tasks as well as to present the content using various representations to learners -- was separately examined as good indicators of teachers’ PCK. In this research question, based on the rationale that teachers’ acts of selecting the content and representing it stem from their CK, the combinations of task maturity and task appropriateness were examined together.

The data of the teachers’ task maturity and developmental and principle
appropriate tasks showed the following results. First, the teachers presented mostly immature and only developmental appropriate tasks before the CK workshop. Several immature and both developmental/principle inappropriate tasks were observed in the comparison classes. On average, Ray stated 12.5 immature and only developmental appropriate tasks out of 16.5 tasks, and Tyler stated 15.5 immature and only developmental appropriate tasks out of 17.5 per unit. The teachers did not state any mature tasks or any developmental/principle appropriate tasks in the comparison classes. For example, Tyler selected the task “a rally play for teaching a smash shot.” His task statement was “With a partner, hit the shuttle back and forth in your court. I encourage you to use smash shots, as many as you can during the rally. Let’s play.” This task was represented with simple or poor uses of verbal representations lacking rich descriptions of the critical elements of the skill, clear instructions about how to make the shot in a play, and visual demonstration about what the stroke should look like. The selected task was determined as a task suitable for seventh or eighth graders who have sufficient muscle strength and eye coordination to hit the shuttle coming from the opponent court. But it was coded as a principle inappropriate task because the teachers did not use any Play Practice assumptions (i.e., not taking into account the importance of shaping play - changing of the game rules, size and shape of the court, the nature of the goal, the number of players and different scoring, focusing play - using targets and minimized key cues for providing simple concepts of the play to the learner, and enhancing play - using time constraints and freeze replay). The result supports the notion that teachers’ lack of CK limits teachers’ behaviors in terms of task selections and representations (i.e., PCK).
Second, following the workshop, both teachers presented most tasks that were mature and developmental and principle appropriate for the experimental classes. On average, 17.5 of 21.5 tasks for Ray and 15.5 of 17.5 tasks for Tyler were coded as mature and developmental/principle appropriate for the experimental classes. No tasks were coded as immature, and no tasks were both developmental/principle inappropriate in the experimental classes. For example, Tyler selected the task “High serve and smash return to the down in line” for teaching a smash shot on the lesson four. He stated that

“Watch my demonstration first. To perform the forehand smash, turn shoulders facing to the net, and the racket should be in the back scratch position, like that; this is the preparation phase. Then contact the shuttle at your highest point, like scraping the ceiling. Make sure that you use wrist action to improve the power of your swing in the execution phase. Move forward the swing and continue to swing across your body. To practice this shot, two players will work together. Player A should set up the other by hitting a high serve to the partners’ forehand side diagonally close to the net. Player B returns each serve with a forehand smash to the target area. See the poly spot in the down line. You can earn one point when you make a correct smash shot and you can also get an extra point when your shuttle lands on the poly spot. Each of you should rotate your job after 10 trials. Let’s start the game.”

This task was represented as a mature form of representations because of rich descriptions of the critical elements of the skill in each phase, clear instructions about how to play the skill, and the use of metaphors (i.e., back scratch position and scraping
the ceiling) and visual demonstration to clarify what the correct performance should look like. In addition, the task was determined as a developmental appropriate task because the student was given some practice time to hit the shuttle coming from the opponent court as well as to increase the speed of their swing using his or her wrist actions in the previous lessons. It was coded as a principle appropriate task because the task used Play Practice assumptions (i.e., shaping play – different scoring, focusing play - using targets for down line shot). In the experimental classes, teachers’ selection of both developmental and principle appropriate tasks represents the finding that the mature tasks can be attributed to the increase of teachers’ CK obtained from the workshop that provided information about the critical elements of the skills, possible common errors, instructional tasks, and diverse verbal and visual representations. The findings confirmed that the teachers’ PCK variables in terms of task selections and representations changed from immature to mature on the continuum as the result of the transformation of their CK (Ward, 2009b).

Third, these results showed that the tasks which were coded as immature but developmental and principle appropriate were observed for both teachers in the comparison and experimental classes. The means of immature but developmental and principle appropriate tasks were one of 16.5 tasks for Ray and five of 17 tasks for Tyler in the comparison classes. In the comparison classes, the teachers selected the appropriate tasks for learners but sometimes their task representations were not mature because of their lack of CK.

For example, both teachers selected a task, “serve to the target area,” in teaching a serve. Using hula hoops, the teachers asked students to practice the serve into the target
area (i.e., focusing play) stating that “Practice a serve to the target area using an underhand serve. Switch the side after five trials. Let’s do it.” This task was coded as developmental and principle appropriate. However, the teacher’s representation was poor and simple because it included neither the descriptions of the critical elements of the serve or the correct demonstrations. This result supports the notion that teachers might be able to select the appropriate tasks for learners by understanding students and context, but they might not be able to represent the tasks using various forms of representations with their lack of CK. In addition, the tasks which were coded mature but developmental and principle inappropriate were not observed for both teachers in the comparison and experimental classes. This result showed that teachers’ task representations with a mature form guided their selections of the appropriate tasks. It also showed that task maturity could be a primary indicator in determining teachers’ CK and PCK.

**Research Sub-Question 9: How do the teachers’ inter-task adaptations differ between the comparison and experimental classes?**

The purpose of the research question was to examine the differences of the teacher’s inter-task adaptations between the comparison and the experimental classes. Rink (2006) classified tasks into four categories: informing, extending, refining, and applying tasks to distinguish teachers’ development of content in an actual lesson. Using these four categories, teachers’ content development was analyzed in both comparison and experimental classes. In Shulman’s (1987) initial definition of PCK, PCK represents the amalgam of CK and pedagogical knowledge derived from teachers’ understanding of
how the content should be adapted to learners who have different interests and needs. Grossman (1990) pointed out that the teachers should know what the students already know and what they need to learn in the future as a part of PCK. Recently, Ball et al. (2008) argued that teachers must be able to anticipate what students are likely to do with the task and whether they will find the task easy or hard. Ball et al. (2008) also emphasized the teachers’ knowledge of content and teaching as one of the PCK sub-domains which allow teachers to provide proper task progressions for learners and make sound decisions about instructional strategies by considering individual’s needs. Under these definitions and arguments on PCK, the teachers’ ability to adapt the tasks using four types of tasks presented based on their understanding of the content and students was examined to identify their PCK.

The results showed that the teachers in the experimental classes used more diversified informing, extending, and refining tasks than they did in the comparison classes. In the comparison classes, the means of informing, extending, refining, and applying tasks per unit were respectively 6.0, 3.0, 0.5 and 5.5 for Ray and 6.0, 5.5, 3.0, and 5.0 for Tyler. In the experimental classes, the means of informing, extending, refining, and applying tasks were 9.5, 5.5, 6.5 and 4.5 for Ray and 7.5, 6.5, 11.0 and 5.0 for Tyler. In each lesson, two or three inter-task adaptations were provided by the teachers in the comparison classes, whereas the teachers used three to seven inter-task adaptations in the experimental classes.

Before the workshop, the teachers primarily utilized informing or applying tasks with infrequent use of extending and refining tasks. This result is similar to Ayvazo (2007)
who found that the teachers remained primarily at the informing level with the absences of extending and refining tasks in their weaker CK unit. Hastie and Vlaisavljevic (1999) also found that the teachers who are not experts chiefly relied on informing tasks when teaching new content. The investigator hypothesizes that because of the teachers’ weak knowledge of techniques and tactics for badminton, they were unable to use refinement tasks that focus the quality of student performance in the comparison classes. In addition, since the teachers possess a lack of knowledge of task progressions for teaching the content before the workshop, the teachers did not use many extending tasks that change the complexity or difficulty of student performance. In each lesson, the students remained at the informing level for a while and then they were involved in a game without using more diversified tasks before the workshop. In the game, the teachers did not have a specific goal for the game (e.g., moving the opponent players using alternative shots, attacking shots for making a point, and side by side defense position) in the comparison classes. The teachers only provided information about how to score and how to rotate the serve players for playing the game before the workshop.

Following the workshop, the teachers provided more informing, extending, and refining tasks than they did in the comparison classes and all types of tasks were observed in each lesson. This finding is supported by Ayvazo (2007), who found that the teachers utilized all inter-task adaptations in the stronger CK units of instruction. Hastie and Vlaisavljevic (1999) also found that the teachers utilized extension, refinement, and application tasks when they taught their subject matter. In this study, more content development was implemented by the teachers in each lesson after the workshop. The
teachers used more extending or refining tasks followed by informing tasks (i.e., toss and underhand clear to the target) and then the applying tasks were provided at the end of the lesson for the experimental classes. For example, Tyler in the experimental classes provided the initial task (i.e., toss and underhand clear to the target) and extended the task by increasing the distance of the target, allowing students to use a short serve instead of tossing, and changing the direction of the shot. For the experimental classes, Tyler also provided some refining tasks to fix students’ incorrect backswing position or follow-through action and then he provided the applying task (i.e., short serve and underhand clear return game) that allowed students to use underhand clear shots in the game situation. The teachers’ increased use of extending and refining tasks (i.e., mature PCK) were drawn from the development of their knowledge of task progressions and knowledge of techniques and tactics (i.e., mature CK) in the CK workshop. In short, there was more depth of CK after the workshop, which influenced the teachers’ PCK variables.

In terms of the teachers’ use of applying tasks, the means of applying tasks in the experimental classes were not distinct from those in the comparison classes. However, the nature and quality of the tasks distinctively changed after the workshop. Following the workshop, the teachers utilized applying tasks to change the focus of learning from how to do the skill to how to perform the skill in the game. For example, Ray provided an applying task which focuses on teaching a drop shot in the game for the experimental classes on lesson 5. He asked students to practice a combination play in a rally with the specific order (i.e., high serve – smash – underhand drop shot or blocking). This activity helped students in the experimental classes to practice the drop shot in the game situation.
Even though the numbers of applying tasks that the teachers utilized in both groups were similar, the quality of the tasks that enhance student performance was much higher in the experimental classes than in the comparison classes.

Rink (2010) argued that the task progression that includes extending, refining, and applying tasks in a lesson has greater potential to improve student learning than does providing a full game level of application for learners. The student data confirmed this contention by showing more correct trials and fewer incorrect trials in the experimental classes that include the teachers’ content development for badminton skills. Finally, the results of the study also confirmed Ward’s (2009b) PCK continuum model by providing evidence that teachers’ inter-task adaptations (i.e., PCK variable) can be changed from immature (i.e., less diversified inter-tasks) to mature (i.e., more diversified inter-tasks) by developing their CK through the workshop.

**Research Sub-Question 10: How do the teachers’ intra-task adaptations differ between the comparison and experimental classes?**

The purpose of the study was to examine the difference of teachers’ intra-task adaptations between the comparison and experimental classes. Intra-task adaptations were determined as teachers’ development of content within a task toward a small group of students or individuals. Six categories: (a) modifying task complexity, (b) refining or breaking task, (c) restating task, (d) extending task, (e) changing competition conditions and (f) different tasks determined by Ayvazo (2007) were utilized to measure the teachers’ intra-task adaptations for this study. Teachers need to adapt the entire task for individuals
or a small group of students because students’ initial skill levels and the rate of their skill development could differ. In order to modify the tasks for individuals who have different backgrounds, teachers should have a multidimensional understanding of both the subject matter and the students. Assuming that teachers’ adaptations of the tasks for individuals or small groups are an indication of PCK, as asserted by Shulman (1986), the teachers’ intra-task adaptations were tracked as a measure of their PCK in this study.

First, the results showed that the teachers used more intra-task adaptations in the experimental classes than they did in the comparison classes. The means of intra-task adaptations per unit were 5.5 for Ray and 4.5 for Tyler in the comparison classes. The means of intra-task adaptations per unit in the experimental classes were 23.5 for Ray and 18.5 for Tyler. In the comparison classes, the teachers used less than one intra-task adaptation for individual students or small groups per lesson. When the teachers’ presented task was too difficult or easy for some students, they stayed on the task with unsuccessful experiences in the comparison classes. Before the workshop, the teachers could not frequently use intra-task adaptations because they did not know how to adapt the tasks for individual students with different needs. After the workshop, the teachers provided more intra-task adaptations for individual students or small groups based on their understanding of how to sequence the tasks as well as how to make tasks more difficult or easier. The increased number of teachers’ intra-task adaptations in the experimental classes showed their improvement of both CK and PCK.

Second, the results showed that three types of intra-task adaptations (i.e., restating task, refining/breaking task, and extending task) were used in the comparison classes but
four or five types of intra-task adaptations, except changing the competition conditions, were used in the experimental classes. The result is similar to that of Ayvazo (2007), who found that the teachers used more diverse types of intra-task adaptations in their stronger instructional unit. The teachers’ more frequent use of diverse types of intra-task adaptations in the experimental classes validated their improved PCK formed from their development of CK.

Third, most adaptations were restating tasks (i.e., 3.5 for Ray and 2.5 for Tyler) in the comparison classes. In the experimental classes, 12.0 tasks for Ray and 9.0 tasks for Tyler per unit were coded as restating intra-task adaptations. Before the workshop, because some students were not clear about the task that the teachers asked them to do, the students requested the teachers to repeat the entire task. At that time the teachers restated the task in another form. After the workshop, similar to the comparison classes, the most frequently used adaptations for individuals or small groups was a restating task that clarifies the entire task for individuals or small groups. For example, for the entire task, “short serve-underhand return game,” Ray initially stated, “Make a short serve into the diagonal court close form the service line.” For more clarification of the task toward small group of students, Ray restated, “Serve with low and short toward the opponent player’s front court.” In restating intra-task adaptations in the comparison classes, the teachers restated what to do the task, but teachers restated how to do the task well in the experimental classes.

Fourth, the results also showed that the teachers provided more refining/breaking intra-tasks in the experimental classes than they did in the comparison classes. The means
of refining intra-task adaptations in the comparison classes were 0.5 for Ray and 1.5 for Tyler, and 3.5 for Ray, and 7.5 for Tyler in the experimental classes. In the experimental classes, refining/breaking intra-tasks were used with restating tasks as adaptations. The result supports Ayvazo’s (2007) research, who found that refining tasks were frequently used by the teachers who have strong CK as adaptations. In fact, Tyler adapted the entire task (e.g., a forehand overhead stroke to the target) for individual students who performed it incorrectly in the preparation phase by asking them to perform only one critical element (e.g., back scratch position). This adaptation helped individuals to refine their preparation posture.

After the workshop, some extending tasks were observed by Ray. For example, when Ray’s initial whole class task (e.g., a forehand stroke to the down in line) was provided to the whole group, the teachers extended the task for some students who had already mastered the trials by asking them to practice the stroke to the crosscourt line. The results showed that the teachers in the experimental classes provided valuable learning opportunities for individuals by adapting the whole class activities to meet their needs and interests. The increased use of intra-task adaptations can be attributed to the increase in teachers’ CK obtained from the workshop that provided the teachers with a learning opportunity about how to modify the tasks based on their understanding of students’ age, skill level, and characteristics within the entire task. When considering that individual students have different backgrounds (e.g., skill level, skill development, motivation, and previous learning experience), teachers should adapt the inter-tasks for individuals or small groups to enhance their learning in the class. The results supported
the research hypothesis that the improved CK (i.e., task progressions and critical elements of the skills and tactics) positively influenced developing teachers’ PCK (i.e., intra-task adaptations).

**Conceptual Contributions**

In this section, the investigator will situate the results in the context of the assumptions that underlie this study.

**Assumption 1: PCK can be described as a Continuum of Immature to Mature Tasks**

Several studies have examined teacher’ PCK using Shulman’s conceptualization of PCK and found the existence of PCK variations (Chen, 2004; McCaughtry & Rovegno, 2003; Rovegno, 1992; Tsangaridou, 2002) in PE. Rovegno (1992) initially noted the heuristic continuum of PCK development using the words “immature” and “mature” to conceptualize teachers’ PCK but little information about what mature/immature forms of PCK look like in teaching has not been provided. Chen (2005) also used inadequate and adequate PCK for teaching and found that inadequate PCK was linked to weak CK. Ayvazo (2007) also mentioned the existence of PCK on the continuum from immature to mature, based on teachers’ CK. Even though the consensus is that teachers’ PCK varies, unanswered questions remain regarding teachers’ PCK variations. Ward (2009b) conceptualized PCK on the continuum: (a) mature and (2) immature in terms of teachers’ decisions on how to represent the content. His argument was that every teacher can be situated on the continuum from immature and mature, regardless of their teaching
experiences or level of expertise. Under this conceptualization, this study provided
evidence to support the contention that PCK can be placed on the continuum in terms of
the maturity of task representation. The study showed that teachers can be situated in the
immature PCK (i.e., immature task representations with the infrequent use of visual and
verbal representations) with their weak CK and moved to the mature PCK (i.e., mature
task representations with diverse use visual and verbal representations) with strong CK.
From the teacher data, the study conceptually contributed to the support of the contention
that the maturity of task representations varies as a function of PCK.

Assumption 2: PCK can be described as a Continuum of Effective to Ineffective

Instruction

PCK has been considered the most important teacher-related factor influencing
student learning in various subject areas (Shulman, 1986, 1987; Grossman, 1990;
Grossman, Schoenfeld, & Lee, 2005; Hill et al., 2004; Ball, Thames, & Phelps, 2008;
Siedentop, 2002; Rovegno, 2003; Ward, 2009). Yet we still have insufficient empirical
evidence to trace the relationship between teachers’ PCK and student learning and how
they are related. Many researchers have considered students’ correct practice trials as an
indicator of student learning and have found a positive relationship between correct trials
and student learning (Alexander, 1983; Buck et al., 1990; Siedentop et al., 1992;
Silverman, 1984). When considering that students’ existing behaviors can be changed by
teachers’ teaching behaviors as well as new student behaviors can be developed by
teachers’ teaching actions, both students’ and teachers’ behaviors should be examined.
For example, when the teachers select appropriate tasks, use diverse verbal and visual representations of tasks, and adapt the tasks according to students’ characteristics, the rate of students’ correct performances will be significantly increased. Ward (2009b) referred to PCK as a class of teacher’s behaviors that develop on the continuum from ineffective to effective in terms of the results of student learning. The study validated the idea that teachers can be situated in the ineffective (i.e., incorrect student performance) PCK with weak CK, and moved to the effective (i.e., correct student performance) with strong CK. From the student data, the study conceptually contributed to the support of the contention that effectiveness varies as a function of PCK.

Assumption 3: Inter-task adaptations differentiate between Strong and Weaker PCK

Shulman (1987) defined PCK as “the amalgam of CK and PCK derived from teachers’ understanding of how the content should be adapted to learners who have different needs and interests.” Recently, Ball et al. (2008) argued that teachers must be able to anticipate what students are likely to do with the task and whether they will find the task easy or hard. Ball et al. (2008) included teachers’ ability to provide proper task progressions for learners as one of PCK sub-domains. Under this concept of PCK, Hastie and Vlaisavljevic (199), Ayvazo (2007), and Lee (2011) found that teachers who have strong CK implemented more inter-task adaptations in each lesson. The present study also confirmed that teachers possess stronger PCK by using more diversified inter-tasks that provide content development for learners, and that teachers possess weaker PCK by using less content development, primarily relying on informing or applying tasks in each
lesson. The study conceptually supported that inter-task adaptations can be a good indicator to differentiate between teachers’ stronger and weaker PCK.

**Assumption 4: Intra-task adaptations differentiate between Strong and Weaker PCK**

Shulman (1987) defined PCK as “The blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction” (p. 8). Although his initial conceptualization of PCK has been widely accepted by many researchers, there are problems that stem from Shulman’s lack of clarity in conceptualization of PCK. Under the Shulman’s definition of PCK, we cannot show how a teacher’s PCK might be successful for some learners but not for other learners (Ward, 2009b). To determine teachers’ teaching effectiveness from a given example of PCK, it is implicit that PCK leads to student learning (i.e., it is effective) under Shulman’s (1987) definition of PCK. Yet the task progression that a teacher provides might effective for some students but ineffective with other students in the same task. To solve this problem, further examination of PCK in teaching with the functional definition of PCK was needed (Ward, 2009b). Along with the need of functional definition of PCK, Ayvazo (2007) proposed PCK as “the act of selecting content from one’s knowledge base for the purpose of teaching in a specific context” (p. 77). In her postulation of PCK, the adaptation which occurred when teachers select the content forms their CK base. Recently, Ward (2009b) proposed operational definition of 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 understanding of a number of knowledge bases (e.g., understanding of students, of curriculum, of context, of content, and of pedagogy).” The definitions of PCK allow us to include or exclude teaching behaviors under the umbrella of PCK variables. Under Ward’s (2009b) definition, teachers’ ability to adapt the entire tasks for individual students or small groups (i.e., intra-task adaptations) represents their integrated understanding of content, pedagogy, students, curriculum, and context (i.e., PCK). The results of the study indicated that teachers used less appropriate intra-task adaptations (i.e., weaker PCK) with their weak CK but that they used more appropriate intra-task adaptations for individuals or groups (i.e., stronger PCK) after improving their CK. This outcome contributed to the conceptual understanding that the degree of teachers’ PCK can be differentiated by teachers’ use of intra-task adaptations.

**Assumption 5: Improving Teachers’ CK improves their PCK**

Ward (2009b) and Grossman (1990) have argued that PCK is formed mostly through a transformation of knowledge content and pedagogy. Ward argued that when teachers change the content area from one content area to another content area, some of the knowledge bases are influenced by the change of the content. For example, a teacher might use different pedagogical skills for teaching gymnastics than for teaching soccer. A teacher might use a different curriculum (e.g., the objective of the lesson, the length of unit, the instructional model, and assessment) for teaching dance than for teaching volleyball. Ward (2009b) also argued that PCK is influenced by knowledge bases that are filtered through the teachers understanding of content and pedagogy. Lee (2011) in his
dissertation supported that argument, showing with empirical evidence that improving CK is a prerequisite to develop teachers’ PCK.

Ball et al. (2008) empirically examined teachers’ CK and recognized a specific CK for teaching. It was called as “Specialized Content Knowledge (SCK)” which is uniquely needed for teachers (i.e., knowing how to represent a mathematical reasoning for student understanding) and distinguished from “Common Content Knowledge (CCK)” which is basic knowledge for teaching (i.e., knowing how to calculate correct answers in mathematics). Ball et al. argued that SCK is the core knowledge to connect CK with PCK and cannot be spontaneously produced from developing CCK, because these knowledge bases exist independently. Ball et al (2008) suggested that teacher education should be organized to help teachers learn this specialized form of knowledge and skill. In PE, Ward (2009) also proposed two forms of CK: (a) knowing how to perform an activity (i.e., CCK) and (b) knowing what to teach as the activity (i.e., SCK), arguing that learning through performing is only part of the knowledge that is needed for someone to teach the activity. Ward (2009) suggested the emphasis on both CCK and SCK for teachers, arguing that effective teaching entails teachers’ SCK beyond their CCK.

Under these conceptualizations and suggestions of CK, the CK workshop with the knowledge packet was designed to improve teachers’ CCK and SCK. In the knowledge packet, the major rules, the list of critical elements of the skills and tactics, the list of common errors and error corrections, the set of task progressions and badminton notes that provide information about how to set up each task were included. In the CK workshop, the investigator and her assistants modeled each task to the teachers and
evaluated their understanding of the content using a set of questions in terms of skill discrimination, error detection and corrections, task representations and task progressions, and adaptations throughout and at the end of the workshop. Finally, the results of the study supported the argument that teachers’ developed CCK and SCK can influence the development of their PCK behaviors in teaching as well as student learning.

**Methodological Contributions**

Most studies that have investigated PCK have used descriptive and qualitative approaches using interviews, field observations, and field notes (Ayvazo, 2007). Recently studies by Ayvazo and Lee have examined PCK by observing both students and teachers’ behaviors and descriptively providing the results of the functional relationships between CK and PCK as well as PCK and student learning. These descriptive studies contributed to the close examinations on teachers’ PCK variables in teaching, but there was a limitation in finding a causal relationship between teachers’ PCK and student learning. The present study contributed to the methodological practices that can be used to investigate PCK by employing both a behavioral analytic approach and experimental approach in designing research, and in both collecting and analyzing the data.

In a behavior analytic view, teachers and students produce continuous behaviors as individuals at a temporal locus where the past and present ontogenic history of the individuals interact with the environment. The behavior analytic approach enabled the investigator to observe, measure, and analyze the individual teachers’ and students’ behaviors continuously as well as explain contextual variables in their behaviors in terms
Three teachers’ PCK variables (i.e., task maturity, task appropriateness, and task adaptations) were defined and measured in this study. To determine teachers’ task maturity, teachers’ visual and verbal representations were collected. These variables were already utilized by Lee (2011) in his dissertation; however, teachers’ verbal and visual representations were collected within two teaching conditions (i.e., during task representation and during practice) in this study. Teachers’ instruction, descriptions, and analogies/metaphors were collected during task representations, and teachers’ cues and specific congruent feedback were collected during practice.

To measure teachers’ appropriate selections of the tasks, two sub-components of task appropriateness were defined and measured in this study: (a) developmental appropriate and (b) principle appropriate. Under the rationale that teachers should select developmental appropriate activities that are suitable for students’ age and skill levels (Thomas & Thomas, 2008), teachers’ selection of developmental appropriate tasks was measured. Both Ayvazo (2007) and Lee (2011) included this variable as an indicator of PCK. However, in this study, the teachers’ principle appropriate task selection was included as a new variable. I believe that teachers should select the best practices to develop learners’ technical and tactical abilities within realistic and enjoyable learning conditions. Under the rationale that the Play Practice approach can provide students with the best practices that helped them to improve both techniques and tactics through the game and in the game (Launder, 2001), the investigator selected this approach as one of the criteria for determining teachers’ ability to select principle appropriate tasks. Through
the workshop, the teachers learned the theory and practice of Play Practice in order to
develop their ability to select appropriate tasks (i.e., shaping, focusing, and enhancing
play). The study supported the finding that teachers’ appropriate selection of tasks can be
categorized with these sub-components.

In this study, both teachers’ task maturity and task appropriate variables were
examined separately to determine whether teachers have mature PCK while cooperatively
using three components (i.e., maturity, developmental appropriateness and principle
appropriateness). This methodological practice contributed to the examination of the
relationship between the mature tasks and developmental/principle appropriate tasks in
determining teachers’ PCK.

An experimental approach allowed the demonstration of a causal relationship
between teachers’ PCK and student achievement by manipulating teachers’ CK levels.
Using a non-parametric test, the significant difference of student performance between
the comparison and the experimental classes was investigated statistically. Arguing that
the number, type, and quality of practice trials are meaningful measures of engagement
with the skill, rather than simple time on task by Silverman (1985), the percentage of
correct, incorrect, and other trials (i.e., missed, unfair, and non-target performances) were
compared between two groups. The selected students’ trials during practice and game
were collected by three main observers using an event recording in each lesson. To
determine students’ correct and incorrect trials, the observers used either the list of
critical elements of the skills that the researcher developed or the descriptions or
statements of the tasks that the teachers provided. This strategy was accurate and valuable
in that the observers could continue recording student performance regardless of the limitations involved in coding every trial of students for the entire unit. Student data were analyzed descriptively and statistically to compare student performance within different learning environments. The analyzed student data strongly supported the findings of the teacher data as well as the relationship between teachers’ PCK and student learning.

Limitations of the Study

There were some limitations in the research design and the implementation of the study. First, the teachers’ characteristics may have affected the results because the investigator purposefully selected the teachers and the school for the study. For example, one teacher preferred not to use visual tools (e.g., task cards, pictures, diagrams, or videos) to represent the tasks in either group even though the investigator modeled how to use these tools and expected the difference between the groups. In addition, the teacher was involved in the class activity as a player when students did not have a partner for playing a game. This may have influenced the results of the data on teaching behaviors and student performance.

Second, scheduling conflicts with the teacher may have limited the degree of the effectiveness of the CK workshop may have affected the results. Even though the contents of the CK workshop were covered by modeling the tasks for three and a half hours and the intervention was effective, in my opinion it was not sufficient for the teachers to practice teaching. Because of the teacher’s inflexible schedule for the workshops, the teacher had to teach the first lesson in the experimental classes the day
after the workshop, resulting in insufficient time to plan for the lessons and apply knowledge into real teaching. Due to a lack of confidence and preparation, the teacher had difficulties in presenting the tasks (e.g., combination plays with high serve, smash, and underhand drop shot) and organizing the activities after the workshop.

Three, the presence of the observers on site and videotaping of lessons may have affected the results. The students may have reacted because an observer watched their every performance. Moreover, the teachers might have used different teaching strategies with the selected groups than was usual, because their teaching behaviors were observed and analyzed.

Fourth, the research design that allows teachers to teach the same instructional unit repeatedly with different classes may have affected the results of the study. It is difficult to verify the absence of the effects of teacher’s repeated teaching experiences.

Fifth, for this study, the observers attended 10 hour training for three days before starting the data collection. However, the observers had difficulties at times coding all students’ trials during game play because of the fast pace of game.

Sixth, there were some missing data because of several participants’ absences and because one teacher had a shoulder surgery reducing data collection to five instead of six lessons.

Seventh, although a violation of the statistical assumption of independent observations, individual students were used as the unit of analysis rather than classes. Due to the nature of field study, the small number of classes taught by the teacher and meaningful power, individual students were used as the unit of analysis for this study.
Thus, generalization and interpretation of inferential statistical results on student performance should be evaluated with care.

**Implications for Teacher Education**

In this section, recommendations for preservice and inservice teacher education programs are made based on the findings of the study and the investigator’s understanding and conceptualization of how CK and PCK develop and how they are related to each other and to student learning.

The teacher education for preservice and inservice teachers should:

1. *Improve both CCK and SCK with specific practices in order to develop PCK.*

   Ball et al. (2008) argued that SCK is vital knowledge for teaching and thus is a core knowledge domain to connect CK with PCK. Ward (2009b) argued that preservice teachers need to study more in-depth CK mentioning about a lack of time on few subject areas in our PETE programs. Preservice teachers should have more learning experiences to develop their CCK and SCK in their PETE programs that provide a focused way to teach CCK and SCK. For improving inservice teachers’ CK, professional development programs should be organized to help teachers learn this specialized form of knowledge and skill with the knowledge packet and specific practices.

2. *Provide relevant and specific feedback on teaching.* In order to improve teachers’ PCK, it is necessary for teachers to receive sufficient support during the learning process. In this study, providing immediate daily feedback about teachers’ teaching practices was effective to fix their incorrect teaching performances. For
preservice teachers, working with highly qualified teacher educators who have strong CK and PCK for teaching is needed during their teaching experiences. PETE program should need to select the qualified mentors and university supervisors as well as train them in order to promote student teachers’ learning experiences. In addition, the CK workshop should be organized to provide inservice teachers with specific teaching practices and include an effective supporting system with relevant and specific feedback about their teaching performances for promoting inservice teachers’ PCK.

3. **Develop CK using the CK packet.** Ayvazo, Ward, and Stuhr (2009) provided a strong rationale for designing the content courses in the PETE programs at the Ohio State University using a “CK packet.” In the knowledge packet, the major rules, the list of critical elements of the skills and tactics, the list of common errors and error corrections, and the set of task progressions and badminton notes that provide information about how to set up each task can be included. This information in the CK packet for teaching a specific content area can be used by teachers to increase familiarity of the content. Using the CK packet, both preservice teachers and inservice teachers can develop their CK within the approximate teaching environment or the actual teaching environment for teaching a certain content area.

4. **Create opportunities to develop their abilities to analyze the skills.** PETE programs should organize content courses that allow student teachers to develop their abilities to observe, analyze and discriminate students’ performance to a proficiency level. Skill analysis can be performed by either actual teaching experiences or videotaped student’s performance.
LIST OF REFERENCES


Kutame, M. A. (1997). Teacher Knowledge and its relationship to student access in
learning a gymnastics skill. Dissertation Abstracts International, 58/05.


*Educational Researcher, 15,* 4-14.


APPENDIX A

HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD LETTER
February 4, 2011

Protocol Number: 2010B0424
Protocol Title: THE EFFECTS OF IMPLEMENTATION OF CONTENT KNOWLEDGE WORKSHOP ON TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE AND STUDENT LEARNING IN BADMINTON UNIT IN MIDDLE SCHOOL PHYSICAL EDUCATION, Philip Ward, Insook Kim, Weidong Li, Physical Activity and Educational Services

Type of Review: Initial Review—Expedited
IRB Staff Contact: Michael Donovan
Phone: 614-292-6950
Email: donovan.6@osu.edu

Dear Dr. Ward,

The Behavioral IRB APPROVED BY EXPEDITED REVIEW the above referenced protocol. The Board was able to provide expedited approval under 45 CFR 46.110(b)(1) because the research presents minimal risk to subjects and qualifies under the expedited review category(s) listed below.

Date of IRB Approval: February 3, 2011
Date of IRB Approval Expiration: January 9, 2012
Expedited Review Category: 7

In addition, the protocol has been 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 the investigator to promptly report to the IRB any serious, unexpected and related adverse events or potential unanticipated problems involving risks to subjects or others.

This approval is issued under The Ohio State University's OHRP Federally Assured #00006378. All forms and procedures can be found on the ORRP website—www.orrp.osu.edu. Please feel free to contact the IRB staff contact listed above with any questions or concerns.

Shari R. Speer, PhD, Chair
Behavioral and Social Sciences Institutional Review Board
APPENDIX B

LETTER TO TEACHERS
November 11, 2010

Ms. Andrea Jane
Columbus Public school
5736 Lane St.
Columbus, OH 43071

My name is Insook Kim. I am a doctoral student in physical education teacher education working with Dr. Phillip Ward and Dr. Weidong Li at the Ohio State University. Dr. Ward has recommended you as someone who would be very helpful in my studying of teaching because of your experience and competence as a physical education teacher. I am writing to ask if you would be interested in helping me in my study.

My dissertation involves asking you to teach 3 classes your regular badminton lessons in a 6-day badminton unit (grades 6 and 7 if possible but grade 8 is OK). I would then meet with you to talk about some new progressions for teaching badminton in a workshop format. Next, you would teach two more classes (different classes from the first two) using a new 6-day badminton unit. In all you would teach 4 classes badminton. During the lessons I will observe and videotape student performances. I would like to conduct the study if possible during January or February of 2011 at a time that suits you.

Last year we did a similar study with soccer and the teachers reported that they learned a great deal about a different way of teaching. Our purpose in conducting this study is to find better ways to help beginning teachers teach the content of physical education. Your experience and expertise will help us identify the strengths and weakness of the approach we are using.

At this point this is an informal inquiry – if you would like to participate could you please email me back this week and then I will begin a formal request for your assistance through your district offices. If you have questions please feel free to call me at 614-557-6536 or Dr. Ward at 614-688-8435.

I am looking forward to hearing from you.

Sincerely,

Insook Kim
APPENDIX C

TEACHER CONSENT FORM
The Ohio State University Teacher Consent
For Participation in Research

<table>
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<th>Study Title:</th>
<th>The Effects of Implementation of a Content Knowledge Workshop on Teachers’ Pedagogical Content Knowledge and Student Learning in Badminton Unit in Middles School Physical Education</th>
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| Researcher: | PI: Phillip Ward: ward.116@osu.edu - 614-688-8435  
Insook Kim: kim.2477@buckeyemail.osu.edu- 614-557-6536  
Weidong Li: li.832@osu.edu -901-356-1962 |
| Sponsor:    | None |

**This is a consent form for research participation.** It contains important information about this study and what to expect if you decide to participate.

**Your participation is voluntary.**

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

**Purpose:**
The purpose of the study is to examine the effects of implementation of a content knowledge workshop on teachers’ teaching practices and student learning in a badminton instructional unit in middle school physical education. This study seeks to promote your students’ learning by facilitating your knowledge and skills for teaching badminton. This will enhance the quality of physical education experience of your students.

**Procedures/Tasks:**
We are interested in examining the effects of implementation of a content knowledge workshop on teachers’ teaching practice and student learning in middle school physical education. Our focus is primarily on the teacher’s behaviors during the lesson, and thus involves videotaping of teacher and student behaviors to learn more about how teachers’ pedagogical content knowledge can influence on student learning in secondary physical education. We will observe you for two six days of your badminton unit in four classes taught. All of the data collected and the videotapes will remain confidential.

**Duration:**
The investigators will observe this setting during winter quarter (January – March) in the 2010-2011 academic school year.
You may leave the study at any time. If you decide to discontinue participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

**Risks and Benefits:**
Potential benefits of the study include:
- You will improve your badminton content knowledge and apply it to your teaching.
- Your students may receive more quality physical education. No known risk will be presented during this study.

**CHAPTER 1 Confidentiality:**
Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research):
- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;

**Incentives:**
No incentives will be offered.

**CHAPTER 2 Participant Rights:**
You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

**CHAPTER 3 Contacts and Questions:**
For questions, concerns, or complaints about the study you may contact
For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If you are injured as a result of participating in this study or for questions about a study-related injury, you may contact Phillip Ward at 614-688-8435.

**CHAPTER 4 Signing the consent form**

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study. I consent the use of videotapes, I understand how the videotapes will be used for this study.

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

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**Investigator/Research Staff**

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

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The Ohio State University Assent to Participate in Research

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| Researcher: | PI: Phillip Ward: ward.116@osu.edu-614-688-8435  
Insook Kim: kim.2477@buckeyemail.osu.edu-614-557  
Weidong Li: li.832@osu.edu-901-356-1962 |
| Sponsor:    | None |

- You are being asked to be in a research study. Studies are done to find better ways to treat people or to understand things better.
- This form will tell you about the study to help you decide whether or not you want to participate.
- You should ask any questions you have before making up your mind. You can think about it and discuss it with your family or friends before you decide.
- It is okay to say “No” if you don’t want to be in the study. If you say “Yes” you can change your mind and quit being in the study at any time without getting in trouble.
- If you decide you want to be in the study, an adult (usually a parent) will also need to give permission for you to be in the study.

1. What is this study about?
The purpose of the study is to examine the effects of implementation of a content knowledge workshop on teachers’ teaching practices and student learning in a badminton instructional unit in middle school physical education classes. The findings will help your teachers to improve teaching knowledge and skills. As a result of improving your teachers’ teaching knowledge and abilities, you will have more effective and successful PE experience in your PE lessons.

2. What will I need to do if I am in this study?
The study will be conducted in a natural PE learning environment. In this study, any additional work will not be given to you. You need to participate in your regular PE lessons wearing a number jersey to identify you as a study participant.

3. How long will I be in the study?
You will be in the study during winter quarter 2011 (January-March).
4. **Can I stop being in the study?**
   You may stop being in the study at any time.

5. **What bad things might happen to me if I am in the study?**
   Any bad things might not happen to you if you are in the study. You will be in the regular PE lessons as a student.

6. **What good things might happen to me if I am in the study?**
   Your participation in this study will contribute to your PE teachers’ improvement of teaching knowledge and skills. As a result of your teachers’ teaching improvement, you and your friends may have more successful learning experiences in the current and future PE classes.

7. **Will I be given anything for being in this study?**
   Anything will not be given to you for being in this study.

8. **Who can I talk to about the study?**
   For questions about the study you may contact **Insook Kim at 614-557-6536 and Phillip Ward at 614-688-8435.**

   To discuss other study-related questions with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

9. **Signing the assent form**
   I have read (or someone has read to me) this form. I have had a chance to ask questions before making up my mind. I want to be in this research study.

   Signature or printed name of subject
   
   Date and time

   Investigator/Research Staff

   I have explained the research to the participant before requesting the signature above.

   There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

   Printed name of person obtaining assent
   
   Signature of person obtaining assent
   
   Date and time
APPENDIX E

CHILD ASSENT VERBAL SCRIPT
Hello Everyone,

I am Insook Kim and I am a doctoral student at the Ohio State University.

I and my assistants are interested in improving your PE teacher’s teaching practices in badminton as well as facilitating your learning in middle school physical education classes. During your badminton unit, I am going to conduct a study through your PE teacher and your participations. The primary purpose of the study is to investigate the effects of implementation of a badminton workshop to your PE teacher on his teaching practices and your correct trials on tasks that your teacher provides during a 6 days badminton instructional unit. Your participation in this study will contribute to your PE teachers’ improvement of teaching knowledge and skills. As a result of your teachers’ teaching improvement, you and your friends will have more successful learning experiences in the current and future PE classes. If you are involved in the study, any additional work will not be given to you except wearing a number jersey every class to identify you as a study participant. Any bad things might not happen to you. You will be in the regular PE lessons as a student.

I will give the assent form and read it carefully before making up your mind. It is okay to say “No” if you don’t want to be in the study. If you say “Yes”, you can change your mind and quit being in the study at any time without any problems. You will not be receiving anything from participating in this study. If you want to be in this study, please sign it and give it back to me or your teacher. If you decide you want to be in the study, your parent or guardian will also need to give permission for you to be in the study.

If you have additional questions about the study, contact me at my phone or email.

Thank you for your consideration.
APPENDIX F

PARENTAL CONSENT FORM
The Ohio State University Parental Permission For Child’s Participation in Research

Study Title: The Effects of Implementation of a Content Knowledge Workshop on Teachers’ Pedagogical Content Knowledge and Student Learning in Badminton Unit in Middles School Physical Education

Researcher: PI: Phillip Ward: ward.116@osu.edu - 614-688-8435
Insook Kim: kim.2477@buckeyemail.osu.edu-614-557-6536
Weidong Li: li.832@osu.edu – 901-356-1962

Sponsor: None

This is a parental permission form for research participation. It contains important information about this study and what to expect if you permit your child to participate.

Your child’s participation is voluntary.

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to permit your child to participate. If you permit your child to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:
The purpose of the study is to examine the effects of implementation of a content knowledge workshop on teachers’ teaching practices and student learning in a badminton instructional unit in middle school physical education. This study seeks to help your child’s teacher improve their knowledge of teaching. This will enhance the quality of physical education experience of your child.

Procedures/Tasks:
We are interested in how the teacher determines what to teach in physical education and therefore we will observe and videotape the teacher’s teaching practices for 6 days of badminton classes. In the process of videotaping, it is also possible that your child will be videotaped as they go about their regular activity in the physical education class. All videotapes will remain confidential. Due to the potential that your child will be videotaped, we are asking your permission for the participation of your child in this study.

Duration:
The investigators will observe this setting during winter quarter (January – March) in the 2010-2011 academic school year.

Your child may leave the study at any time. If you or your child decides to discontinue participating in the study, there will be no penalty and neither you nor your child will lose
any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

Risks and Benefits:
Potential benefits of the study include:

- Your child’s teacher will improve his/her knowledge and apply it to the teaching.
- Your child may receive more quality physical education.

No known risk will be present during this study.

CHAPTER 5 Confidentiality:
Efforts will be made to keep your child’s study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your child’s participation in this study may be disclosed if required by state law. Also, your child’s records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
- The Ohio State University Institutional Review Board or Office of Responsible Research Practices;

Incentives:
No incentives will be offered.

CHAPTER 6 Participant Rights:
You or your child may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you or your child is a student or employee at Ohio State, your decision will not affect your grades or employment status.

If you and your child choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights your child may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

CHAPTER 7 Contacts and Questions:
For questions, concerns, or complaints about the study you may contact

PI: Phillip Ward: ward.116@osu.edu - 614-688-8435
Insook Kim: kim.2477@buckeyemail.osu.edu -614-557-6536
For questions about your child’s rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

If your child is injured as a result of participating in this study or for questions about a study-related injury, you may contact: Phillip Ward at 614-688-8435.

CHAPTER 8 Signing the parental permission form

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

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

Printed name of subject

Printed name of person authorized to provide permission for subject

Signature of person authorized to provide permission for subject

Relationship to the subject

Date and time

AM/PM

Investigator/Research Staff

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

Printed name of person obtaining consent

Signature of person obtaining consent

Date and time

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APPENDIX H

THE LIST OF QUESTIONS FOR TEACHERS’ UNDERSTANDING OF BADMINTON CONTENT KNOWLEDGE AND EVALUATION FORM
<table>
<thead>
<tr>
<th>Objectives</th>
<th>The List of Questions</th>
<th>Criteria</th>
<th>Evaluation</th>
</tr>
</thead>
</table>
| 1. Teachers will discriminate between correct and incorrect performances. | 1. What was correctly or incorrectly performed?  
2. What are the critical elements of the activity? | 3 out of 3 trials for each skill | O O O O O O O O O O O O O O |
|                                                                           |                                                                                           |          | X O O O     |
| 2. Teachers will identify common mistakes that can be made by students and sources of errors. | 1. What are the common errors made by the students in the activity?  
2. What kind sources of the errors are you expecting? | 3 out of 3 trials for each skill | O O O O O O O O O O O O O O |
|                                                                           |                                                                                           |          | X O O O     |
| 3. Teachers will recommend appropriate solutions to the common mistakes made by students. | 1. What kinds of feedback would you use?  
2. What kinds of cues would you use?  
3. What kinds of tasks would you provide? | 3 out of 3 trials for each skill | O O O O O O O O O O O O O O |
|                                                                           |                                                                                           |          | X O O O     |
| 4. Teachers will represent tasks using a variety of visual and verbal representations. | 1. What kinds of descriptions would you use?  
2. What kinds of analogies or metaphors would you use?  
3. What kinds of demonstrations and physical assistant would you use?  
4. What other visual aids would you use? | 50 % of the tasks | O X O X O O X X O O O O O O |
|                                                                           |                                                                                           |          | O O O O     |
| 5. Teachers will select and organize developmentally appropriate tasks.   | 1. How would teach differently with different age level or skill level?  
2. Do you think that the activity is appropriate for your students?  
3. What tasks would you use for teaching this skill or tactic for the older group? | 4 out of 5 Qs | O X O O O O |
|                                                                           |                                                                                           |          |             |

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6. Teachers will select and organize principally appropriate tasks.

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<tr>
<td>1. How would teach differently using Play Practice assumptions?</td>
<td>2. Do you think that the activity is principally appropriate for your students?</td>
<td>3. How would you organize the tasks to focus on the specific skill in the game?</td>
<td>4 out of 5 Qs</td>
<td>O O O X O</td>
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</table>
APPENDIX I

BADMINTON KNOWLEDGE PACKET
Teaching Badminton

Play Practice (Laundre, 2001; Wendy Piltz, 2010)
Welcome to Badminton Workshop!

You are going to have two days badminton workshops to develop your content knowledge for teaching badminton. Through the participation of this workshop, you will be able to become an expert in teaching badminton and finally your teaching will influence positively your students’ learning. There are six objectives of the workshop.

1. You will be able to discriminate between correct and incorrect performances.
2. You will be able to identify common mistakes that can be made by students and sources of errors.
3. You will be able to recommend appropriate solutions to the common mistakes made by students.
4. You will be able to represent tasks using a variety of visual and verbal representations.
5. You will be able to select and organize developmentally appropriate tasks considering students’ age and skill level.
6. You will be able to select and organize principally appropriate tasks by understanding of three fundamental principles of the Play Practice.

To have more productive outcomes of the workshop, you need to read this knowledge packet independently prior to the workshop. During the workshop, the researcher and some assistant students in the school will model the tasks in the knowledge packet and ask you to answer to the set of questions. When you meet the criteria for the each goal, the workshop will be completed. If you did not meet the criteria, further training will occur and another set of questions will be provided until you meet the criteria.

To develop the content of knowledge packet, the book resources of ‘Play Practice’ written by Alan Launder (2001), ‘Badminton Steps to Success’ written by Tony Grice (1996) as well as the workshop materials under the Play Practice principles by Wendy Piltz (2010) were utilized.
Play Practice

In the knowledge packet as well as during the workshop, six primary activities under the Play Practice principles are included. The definitions of three principles of Play Practice and some example activities using the principles of Play Practice are follows.

**Shaping Play.** The process of shaping play is to manipulate specific variables (e.g., game rules, size and shape of the playing area, the nature of the goal, the number of player and different scoring) that can readily be applied to most sports. The notion of shaping play is to develop far more extreme learning situation using progression in order to layer and scaffolding learning building confidence and competence. Through this process, it is possible to create environment that will more easily improve specific elements of effective performance. For example, if the teacher wants to improve students ‘forehand strokes, the teacher might ask the students to use only forehand strokes using the right side of court to play the game. Shaping of the playing area allows students to use more forehand strokes.

**Focusing Play.** Using targets and minimized/simplified key cues, most important points and simple concepts are presented to the learner. The focusing process is vital because it determines both the quality and the direction of the practice and helps ensure positive transfer from the practice to real game. Moreover, instructors can use this focusing process to point out the similarities and differences between a specific play practice and the real game. For instance, the teacher might ask students to make a continuous rally with forehand overhead stroke - drop shot-underhand clear.

**Enhancing Play.** It is to enhance learning by making improved performance appear to be important and meaningful. It is enhance player commitment and performance by presenting challenges, using time constraints or action fantasy games, handicapping individuals or teams and the freeze replay. Instructor can also change the aspects of the learning environment (e.g., racket, partner, task, court and game) is to maintain students’ interests and engagement. For instance, the teacher might decrease the target areas to challenge students or use the freeze replay strategy during the game.
BADMINTON COURT

COURT & EQUIPMENT

- Court size for singles - 13.4 m long x 5.18 m wide
- Court size for doubles - 13.4 m long x 6.1 m wide
- Net height - 1.55 m
- Shuttlecocks - One type has feathers with a cork base, and the other is synthetic (plastic with a rubber base). * We use the synthetic
- Rackets - Made of lightweight material (e.g. wood/plastic/metal/graphite) * most rackets are now graphite

GAME OBJECTIVE

The objective of the game is to hit the shuttle over the net into the opponent’s court where they cannot reach it or return it in play (i.e. they return it into the net or out of court).
GENERAL RULES

- A player cannot touch the net with a racket or body during play.
- A shuttlecock cannot rest or be carried on the racket.
- If the shuttlecock hits the net and goes into the opponents’ court during play the rally continues.
- A term of service is called an “inning”.
- A player must not reach over the net to hit the shuttlecock.
- A loss of serve is called a “side out”.

SINGLES:

- Players serve and receive in the right service box when the server hasn’t scored or is on an even score and in the left when the server is on an odd score.
- If the receiver faults, the server gets the point and the server serves again from the alternative service court.
- If the server faults, the receiver becomes the server with no point scored by either (I.e. you can only score on your own service).

DOUBLES:

- At the start of each game, and each time the side has the right to serve it shall be played from the right service court.
- Only the receiver (i.e. in the diagonally opposite box) can return the shuttle.
- Once returned, all players can participate anywhere within the double lines on their side of the court.
- The player serving in the right box, continues to do so on their serve when they score an even point, and the left box on an odd point.
- The player receiving at the start of the game will receive in or serve from the right court, when that players side either hasn’t scored or has scored an even number of points.
- The opposite applies to the partners.
• If the receiving side faults, the point goes to the serving side and they serve again
• If the serving side faults, there is no point won and the serve goes to the opposition.
• The right to serve passes consecutively from the initial server to the initial receiver, then to the initial receivers partner, to the initial server’s partner, then to the partner who is due to serve from the right court and then to their partner and so on…
• Either player of the winning side/losing side can serve/receive in any order at the start of the next game

SIMPLIFIED NEW RALLY POINTS SCORING SYSTEM

Scoring System

• A match consists of the best of 3 games of 21 points.
• The side winning a rally adds a point to its score.
• At 20 all, the side which gains a 2 point lead first, wins that game.
• At 29 all, the side scoring the 30th point, wins that game.
• The side winning a game serves first in the next game.

Intervals and Change of Ends

• When the leading score reaches 11 points, players have a 60 second interval.
• A 2 minute interval between each game is allowed.
• In the third game, players change ends when a side scores 11. Points.

Singles

• At the beginning of the game and when the score is even, the server serves from the right service court. When it is odd, the server serves from the left service court.
• If the server wins a rally, the server scores a point and then serves again from alternate service court.
• If the receiver wins a rally, the receiver scores a point and becomes the new server.

**Doubles**

• There is only one serve in doubles. The service passes consecutively to the players.
• At the beginning of the game and when the score is even, the server serves from the right court. When it is odd, the server serves from the left court.
• If the serving side wins a rally, the serving side scores a point and the same server serves again from the alternate service court.
• If the receiving side wins a rally, the receiving side scores a point. The receiving side becomes the new serving side.
• The player of the receiving side who served last stays in the same service court from where he served last. The reverse pattern applies to the receiver’s partner
• The players do not change their respective service courts until they win a point when their side is serving.
• If players commit an error in the service court, the error is corrected when the mistake is discovered

**Serving**

• A coin toss or spin of the racket determines who will serve first.
• The serve travels diagonally across court into the opponents’ service box.
• There are 2 types of serve: a short serve (forehand short service) and a long serve (flick/drive and high serves).
• If, during the serve, the shuttlecock touches the net and lands in the correct court play continues. (Note that this is unlike tennis where “let” is called.) It is however still a fault if the shuttle does not reach the service box.
• The racket must make contact with the shuttle below the waist on a serve.
• If the shuttlecock hits the line it is still considered in bounds.
• Players can only score points when they are serving (you cannot score if you are the receiver).
The server and receiver must stand within their service courts until the serve is made

### THE LIST OF COMMON ERRORS AND ERROR CORRECTIONS

<table>
<thead>
<tr>
<th>Skill</th>
<th>COMMON ERROR</th>
<th>CORRECTION</th>
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<tbody>
<tr>
<td>Serve</td>
<td>You often serve the shuttle into the net.</td>
<td>Angle the racket face slightly more open to direct serve higher.</td>
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<td>You consistently serve the shuttle too high over the net on short serve.</td>
<td>Close the face of your racket to hit a flatter trajectory.</td>
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<td>You consistently serve the shuttle long, out of the singles’ court.</td>
<td>Move your starting position further back so it’s nearer the center of the court.</td>
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<td>You receiver seems to be able to rush and put away your serve.</td>
<td>Mix up your serves, both in their types and in their direction or placement.</td>
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<td>You swing and miss the shuttle altogether on serve.</td>
<td>Suspend a shuttle form a string and hold it at knee level. Shorten your swing and grip or drop the shuttle from a lower height.</td>
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<td>You return long serve too short or near midcourt.</td>
<td>Direct your return of the long serve to the four corners of your opponents’ court.</td>
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<tr>
<td>Forehand and Backhand</td>
<td>Your strokes lack power.</td>
<td>Increase your racket speed at the top of your swing and shift your weight forward as you swing.</td>
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<tr>
<td>Overhead Strokes</td>
<td>You lack arm extension.</td>
<td>Throw your racket upward as it attempting to scrape the ceiling.</td>
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<td>Your contact point is inconsistent.</td>
<td>Move quickly to get behind the oncoming shuttle and keep your racket up.</td>
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<td>You have no deception.</td>
<td>Turn sideways and point your non-dominant shoulder toward the net before your forehand and point your dominant shoulder toward the net before your backhand.</td>
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<tr>
<td>Drop Shot</td>
<td>You lack racket control.</td>
<td>Practice the drop shot from backcourt and at the net.</td>
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<td>You are telegraphing your drop shot.</td>
<td>Extend your racket arm completely as you reach up to make contact.</td>
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<td></td>
<td>Your preparatory position is poor.</td>
<td>Move quickly to get into the proper hitting position and make contact as soon as possible but under control.</td>
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<td>Your reaction and movement on the court are slow.</td>
<td>Practice your foot work.</td>
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<tr>
<td>Smash</td>
<td>You have an incorrect grip.</td>
<td>Use the handshake or pistol grip for both the forehand and backhand smash but the</td>
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<tr>
<td>You lack balance.</td>
<td>Keep your left arm extended for balance.</td>
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<td>---------------------------------------------------</td>
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<tr>
<td>Your arm swing and resulting smash are poorly timed.</td>
<td>Spend more time on your smash and practice your stroking actions so you make contact at the correct time.</td>
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**Drive**

<table>
<thead>
<tr>
<th>You lack full arm extension at contact and hold shuttle too close to your body.</th>
<th>Make contact well away from the body so your swing is not restricted.</th>
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</thead>
<tbody>
<tr>
<td>You sometimes hit drives with too much wrist flexion; wrist snap is a misnomer; forearm rotation is more correct.</td>
<td>Move quickly to get into the proper hitting position and make contact at the proper time.</td>
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<tr>
<td>You have a lack of pace on your returns.</td>
<td>Lead with your elbow bent and your forearm parallel to the floor. Extend your arm and snap the racket through.</td>
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**Doubles**

<table>
<thead>
<tr>
<th>You lack confidence or success on your short serve.</th>
<th>Practice your short serve with both forehand and backhand deliveries.</th>
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<tbody>
<tr>
<td>Partners do not cooperate or try to complement each other’s strengths and weaknesses.</td>
<td>Work together. You should discuss strategy before play.</td>
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<tr>
<td>You have indecision about who should make the return.</td>
<td>Try to consistently be in proper position. The partner who has the shuttle on her forehand should hit returns down in the middle.</td>
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<tr>
<td>Too many of your returns are hit upward.</td>
<td>When in doubt, smash!</td>
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<tr>
<td>Skills or Tactics</td>
<td>Preparation</td>
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</table>
| **1. Forehand Short Serve** | - Up and back stance  
- Racket arm in backswing | - Push or guide shuttle  
- Low, close to net | - Cross racket over in front of opposite shoulder |
| **2. Backhand Short Serve** | - Square stance  
- Racket arm in backswing | - Push or guide shuttle  
- Low, close to net | - Cross racket over in front of same shoulder |
| **3. Forehand Long Serve** | - Up and back stance  
- Racket arm in backswing | - Use wrist action  
- High and Deep | - Cross racket in front of and over opposite shoulder |
| **4. Forehand Overhead** | - Sideway hitting stance  
- Both arms up | - Reach high to hit  
- Pronate forearm | - Cross racket to opposite side of your body |
| **5. Backhand Overhead** | - Sideway to backward hitting stance  
- Both arms up with forearm parallel to the floor | - Reach high to hit  
- Supinate forearm | - Push forward with rear foot to propel your back toward center court |
| **6. Forehand Underhand** | - Racket arm up with palm pointed upward | - Drop racket down and swing it up to contact shuttle at high as possible  
- Pronate forearm | - Continue swing up with shuttle’s flight |
| **7. Backhand Underhand** | - Hold racket arm up, palm down | - Drop racket down and swing it quickly up to contact shuttle at high as possible  
- Supinate forearm | - Continue swing up with shuttle’s flight |
| **8. Forehand Drop** | - Hold arm up with racket head up | - Forward swing to contact high  
- Blocking the shuttle, not hit | - Continue in line with shuttles’ flight |
| **9. Backhand Drop** | - Hold arm up  
- Put weight slightly on front foot | - Drop racket down and lift to contact shuttle as high as | - Short swing up with shuttles’ flight |
### 10. Forehand Smash
- Hold racket arm up with racket head up
- Turn shoulders with feet up and back
- Forward swing up to contact high as possible
- Throw racket out and upward with racket face down
- Swing down and across body

### 11. Backhand Smash
- Hold racket arm up and parallel to floor
- Forward swing as high as possible with racket leading
- Throw racket out and upward with racket face down
- Swing in the line with flight of shuttle

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<tr>
<th>Tactics</th>
<th>Critical Elements</th>
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<td>- Starting close to service line</td>
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<td><strong>2. Playing Downward Shots Where ever Possible (Doubles)</strong></td>
<td>- Adopting the attacking position</td>
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<td><strong>3. Side by side or Up and back position</strong></td>
<td>- Decide the position before the game</td>
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## THE SET OF TASK PROGRESSIONS

<table>
<thead>
<tr>
<th>Skills</th>
<th>Task Progressions</th>
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</table>
| Serve       | *Task 1:* Forehand long serve to the target area from each side  
*Task 2:* Forehand short serve to the target area from each side  
*Task 3:* Backhand short serve to the target area from each side  
*Task 4:* Alternative serves and return game with a partner  
*Task 5:* Alternative serves and four corners target returns with a partner  |
| Overhead Strokes | *Task 1:* Overhead toss to yourself (forehand)  
*Task 2:* Overhead toss to yourself (backhand)  
*Task 3:* Overhead toss to yourself (alternative hitting forehand and backhand)  
*Task 4:* Wall rally drill using forehand and backhand overhead strokes  
*Task 5:* High serve and overhead forehand return to the target area  
*Task 6:* High serve and overhead backhand return to the target area  
*Task 7:* High serve and overhead alternative returns to the target area  
*Task 8:* Forehand overhead rally in the right side  
*Task 9:* Backhand overhead rally in the left side  
*Task 10:* Forehand and backhand overhead rally in the whole court.  |
| Underhand Strokes | *Task 1:* Underhand toss to yourself (forehand)  
*Task 2:* Underhand toss to yourself (backhand)  
*Task 3:* Underhand toss to yourself (alternative hitting forehand and backhand)  
*Task 4:* Wall rally drill using forehand and backhand underhand strokes  
*Task 5:* Toss and forehand underhand clear return to the target area  
*Task 6:* Toss and backhand underhand clear return to the target area  
*Task 7:* Toss and forehand or backhand underhand clear return to the target area  
*Task 8:* Short serve and underhand return game  
*Task 9:* Short serve and underhand alternative forehand and backhand return game  |
| Drop Shot   | *Task 1:* Toss and underhand down the line drop shot to the target area  
*Task 2:* Toss and underhand crosscourt drop shot to the target area  
*Task 3:* Haripin drop shot rally at the net  
*Task 4:* Serve and overhead drop shot return game  
*Task 5:* Short serve – underhand clear – overhead drop shot combination  
*Task 6:* High serve – overhead return – crosscourt drop shot combination  |
| Smash       | *Task 1:* High serve and smash return to the target (down the line)  
*Task 2:* High serve and smash return to the target (cross court)  
*Task 3:* High serve-smash – underhand drop shot/blocking combination  
*Task 4:* High serve-smash – a blocked drop shot – underhand clear  
*Task 5:* Short serve-underhand clear-smash – a blocked drop shot  |
| Singles     | *Task 1:* Continues rally with three shots (short serve – underhand clear return – drop shot or smash – underhand clear return)  
*Task 2:* Continues rally with six shots (straight clear – straight return clear – crosscourt clear – straight return clear – crosscourt drop shot – net drop shot)  
*Task 3:* Continues rally with six shots (straight clear – crosscourt drop shot-net drop short return-crosscourt drive – straight clear – crosscourt smash)  
*Task 4:* Single game using only shaded areas.  |
| Doubles     | *Task 1:* Short serve and push return to the target area (midcourt)  |

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Task 2: Short serve and net drop shot to the target area (forehand side alley)
Task 3: High serve – Smash return – blocked drop shot by rotating side by side position or up and back position
Task 4: Clear – smash – block continues rally
Task 5: Short serve – push return rally
Task 6: Double games using only the side alleys
## THE SET OF TASKS IN A 6-DAYS BADMINTON UNIT

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<td><strong>Task 2</strong>: Backhand short serves to the target area</td>
<td></td>
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<tr>
<td><strong>Task 2</strong>: Forehand long serve to the target area</td>
<td></td>
</tr>
<tr>
<td><strong>Task 3</strong>: Alternative serves and return game with a partner</td>
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<td><strong>Task 3</strong>: High serve and overhead drop shot to the target (down the line or cross court)</td>
<td></td>
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<tr>
<td><strong>Task 4</strong>: Earning a point with drop shot in a game</td>
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<td><strong>Task 2</strong>: Short serve and net drop shot to the target area (forehand side alley)</td>
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Badminton Notes

LESSON 1

Warm Up: Racket handling activities (5 min)

Skill Practice (Serve): 20 min
- Task 1 (Grip and Ready position): The student holds the forehand and backhand grips correctly and practices a ready position by a teacher’s signal.
- Task 2 (Forehand short serves to the target area): The student stands close to the centerline and close behind the short service line on the court and serve 30 forehand short serves from each side to the target (just past the short service line for short serve)
- Task 3 (Backhand short serves to the target area): The student stands close to the centerline and close behind the short service line on the court and serve 30 backhand short serves from each side to the target (just past the short service line for short serve)
- Task 4 (Forehand long serve to the target area): The student stands close to the centerline and close behind the short service line on the court and serve 30 forehand long serves from each side to the target area (doubles’ back service line)

Game Practice (Serve): 15 min
- Alternative serves and return game with a partner: One partner sets up the other by hitting a short or long serve to the partner’s forehand side close to the net. The receiving partner returns each serve with any shots. This is a game in which the server earns a point when the reviver missed the return shot to the target area and the receiver gets a point when the server missed hitting the serve or the receiver returned the correct serve to the opponent court. The jobs should be rotated after 15 trials.

LESSON 2

Warm up: Racket handling activities and serve practices (5 min)

Skill Practice (Overhead stroke): 20 min
- Task 1 (High serve and forehand or backhand overhead clear return to the target area): One partner sets up the other by hitting a high, deep, friendly underhand serve to the partner’s forehand side or backhand side close to the
net. The receiving partner returns each serve with a forehand or backhand overhead strokes to the target area (doubles’ back service line)

- **Task 2 (Forehand overhead rally in the right side of court):** One partner sets up the other by hitting a high, deep, friendly underhand serve to the partner’s forehand side close to the net. The receiving partner returns each serve with a forehand strokes. This is a rally in which both partners should attempt to execute as many return forehand clears as possible using their right side of court.

- **Task 3 (Backhand overhead rally in the left side of court):** One partner sets up the other by hitting a high, deep, friendly underhand serve to the partner’s backhand side close to the net. The receiving partner returns each serve with a backhand strokes. This is a rally in which both partners should attempt to execute as many return backhand clears as possible using their left side of court.

**Game Practice (Overhead stroke): 15 min**

- **Overhead stroke rally with a partner:** One partner sets up the other by hitting a long serve to the partner’s forehand or backhand side close to the net. The receiving partner returns the serve with overhead storks. The rally is continued with overhead storks. This is a game in which the player earns a point when the partner missed the shot.

### LESSON 3

**Warm up:** Overhead stroke rally with a partner (5min)

**Practice Skill (Underhand stroke): 20 min**

- **Task 1 (Toss and forehand underhand clear return to the target area):** One partner sets up the other by throwing friendly, overhead tosses to the partner’s forehand side close to the net. The receiving partner returns each serve with a forehand or backhand underhand strokes to the target area (doubles’ back service line)

- **Task 2 (Toss and backhand underhand clear return to the target area):** One partner sets up the other by throwing friendly, overhead tosses to the partner’s backhand side close to the net. The receiving partner returns each serve with a forehand or backhand underhand strokes to the target area (doubles’ back service line)
Game Practice (Underhand Stroke): 15 min
- Task 1 (Short serve and underhand forehand or backhand return game):
  One partner sets up the other by hitting a short serve to the partner’s forehand or backhand side close to the net. The receiving partner returns each serve with a forehand or backhand underhand strokes. This is a game in which the server earns a point when the reviver missed the return shot to the target area and the receiver gets a point when the server missed the serve or the receiver returned the correct serve to the target area. The jobs should be rotated after 15 trials.

- Task 2 (Short serve –forehand or backhand underhand clear – overhead clear combination):
  A player sets up the other by hitting a short serve to the partner’s forehand or backhand side close to the net. B or D player returns each serve with a forehand or backhand underhand clear. C player returns the forehand or backhand underhand clear with an overhead clear. This is a rally in which A and C play against B and D player. The point will be earned when the opponent player missed the shots or target shots. Each player’s jobs should be rotated after 10 trials.

LESSON 4

Warm up: Overhead and underhand stroke rally with a partner (5min)

Skill Practice (Smash): 20 min
- Task 1 (High serve and smash return to the down in line):
  A player sets up the other by hitting a high serve to the partner’s forehand or backhand side close to the net. B player returns each serve with a forehand or backhand smash to the target area (down line). Each player’s jobs should be rotated after 10 trials.

- Task 2 (High serve and smash return to the cross court):
  A player sets up the other by hitting a high serve to the partner’s forehand or backhand side close to the net. B player returns each serve with a forehand or backhand smash to the target area (cross court). Each player’s jobs should be rotated after 10 trials.

Game Practice (Smash): 15 min
- Task 1 (earning the point with a smash):
  A player sets up the other by hitting a high serve to the partner’s forehand or backhand side close to the net. B
player returns the serve with a forehand or backhand smash. This is a rally in which A and C play against B and D. This is a double game in which the player earns a point when the opponent players missed only smash shot.

LESSON 5

Warm up: Rally with a partner (5 min)

Skill practice (Drop Shot): 20 min

- Task 1 (High serve – overhead drop shot to the down in line): A player sets up the other by hitting a high serve to the partner’s forehand or backhand side close to the net. B player returns each serve with a forehand or backhand overhead drop shot to the target (down in line). Each player’s jobs should be rotated after 10 trials.

- Task 2 (High serve – overhead drop shot to the cross court): A player sets up the other by hitting a high serve to the partner’s forehand or backhand side close to the net. B player returns each serve with a forehand or backhand overhead drop shot to the target (cross court). Each player’s jobs should be rotated after 10 trials.

Game practice (Drop shot): 15 min

- Task 1 (High serve-smash – underhand drop shot/blocking combination): A player sets up the other by hitting a short serve to the partner’s forehand or backhand side close to the net. B or D player returns each serve with a forehand or backhand smash. C player returns the forehand or backhand smash with an underhand drop shot. This is a rally in which A and C play against B and D player. The point will be earned when the opponent player missed the shots or target shots. Each player’s jobs should be rotated after 10 trials.

LESSON 6

Warm up: Rally with a partner (5 min)

Skill Practice (Double Strategies): 20 min

- Task 1 (Short serve - push return to the target area): A player sets up the
other by hitting a short serve to the B player’s forehand or backhand side close to the net. B player returns the serve with a forehand or backhand push to the target area (midcourt). The point will be earned when the opponent player missed the shots or target shots. Each player’s jobs should be rotated after five trials.

- **Task 2 (Short serve and net drop shot to the target area):** A player sets up the other by hitting a short serve to the partner’s forehand or backhand side close to the net. B player returns each serve with a forehand or backhand drop shot to the target area (forehand side alley). Each player’s jobs should be rotated after 10 trials.

- **Task 3 (high serve – smash return – blocked drop shot – underhand clear by rotating side by side position or up and back position):** A player sets up the other by hitting a high serve to the partner’s forehand or backhand side close to the net. B player returns the serve with a forehand or backhand smash. C player returns the forehand and backhand smash with a blocked drop shot drop shot. D player returns the drop shot with an underhand clear. This is a rally in which A and C play against B and D. Each player’s jobs should be rotated after 5 trials.

**Game Practice (Double Strategies): 15 min**

- **Task 1 (any combination shot):** This is a double game in which A and C play against B and D. The point will be earned when the opponent player missed the shots or target shots.
APPENDIX J

UNDERSTANDING OF DEFINITION (TEACHER VARIABLES)
Maturity of Task Representation

*Maturity* referred to the degree to which a task is well represented to the students. A mature task includes cues, descriptions, analogies, metaphors, or demonstrations that make comprehensible to learners.

*Immaturity* of task representation was referred as the degree which a task is simply or poorly represented in an unsophisticated manner. Immature tasks may not include visual and/or verbal explanation of critical elements of the skill and unclear task statement without mentioning about criterion, situation and behavior.

Verbal Representations

Five sub categories of the verbal representations were included: (a) instructions, (b) descriptions, (c) analogies and metaphors, (d) cues, and (e) specific congruent feedback. Each sub category was defined as follows:

- **Instructions**: “Teacher is verbally describing to the students how to do a skill, or is using a verbal prompt to direct students in attempting a skill or activity” (Hawkins & Wiegand, 1989, p. 279).

- **Descriptions**: Descriptions are the teacher’s verbal explanation or illustration on what a particular skill (activity) looks like (Lee, 2010).

- **Analogies and metaphors**: While analogies are used by teachers to explain the skills using similar or different examples, metaphors are used by teachers to describe the content in the imaginative ways using different names with the same characteristics (Lee, 2010).
• **Cues**: Cues are shortening technical, visual or metaphoric words that related to
the information about the performance of the movement provided by teachers
(Kutame, 1997; Rink & Werner, 1989; Rink, 2006).

• **Specific congruent feedback**: Specific congruent feedback is “the degree to which
teacher feedback during activity is congruent with (matched to) the focus of the
task” (Rink, 2006, p. 372). For example, the teacher explains and emphasizes the
follow through in the forehand clear shot in badminton. The teacher looked
around the class and provided specific congruent skill related feedback such as
“Continue swing up with shuttles’ flight” when recognizing some students’ wrong
performance.

**Visual Representations**

Three sub categories of the visual representations were included: (a)
demonstrations, (b) gestures, (c) task cards, pictures, diagrams, and video clips, and (e)
physical assistance identified by Lee (2010). Each sub category was defined as follows:

• **Demonstrations**: Demonstrations are “modeling desired performance executed by
teacher, student(s), and/or visual aids” (Rink, 2006, p. 372).

• **Task cards/pictures/diagram/video clips**: To help students’ understandings about
what to perform and how to perform, teacher might use task cards, pictures,
diagrams and video clips the visual ways.

• **Physical assistance**: Physical assistance is “physically moving the player’s body
to the proper position or through the correct range of motion of a skill” (Lacy &

**Developmental or/and Principle Appropriate Tasks**

*Developmental appropriate* refers to “the task that teacher provided was suitable students’ age and skill level.

*Principle appropriate* activities refers to “the task that teacher provided was principally appropriate activities that underpin Play Practice which teaches sport through the game and in the game using three fundamental process including shaping play, focusing play and enhancing play in the pragmatic and goal-directed methods (Launer, 2001). Four combinations of developmental and principle appropriate tasks were used. Each sub category was defined as follows:

- **Developmental Appropriate & Principle Appropriate - #4**: The task that teacher provided was not only developmental appropriate activities that are suitable for students’ age and skill levels but also principle appropriate activities that underpin Play Practice which teaches sport through the game and in the game using three fundamental process including shaping play, focusing play and enhancing play in the pragmatic and goal-directed methods.

- **Developmental Appropriate & Principal Inappropriate - #3**: The task that teacher provided was developmental appropriate activities that are suitable for students’ age and skill levels but it was not principle appropriate activities that did not use three fundamental principles of Play Practice.

- **Developmental Inappropriate & Principle Appropriate - #2**: The task that teacher provided was developmental inappropriate activities without considering a
student’s age and skill levels but it was principle appropriate activities that used three fundamental principles of Play Practice.

- Developmental Inappropriate & Principle Inappropriate - #1: the task that teachers provided was NOT developmental appropriate without considering a student’s age and skill level as well as principle inappropriate without using three fundamental principles of the Play Practice.

**Maturity of Task Representations & Appropriateness of Task Selections**

The eight combination scales of combined maturity of task representations, developmental appropriate task selections and principle appropriate task selections were developed. Each sub category was defined as follows:

- **Mature & developmental/principle appropriate - #4**: The teacher represented developmental and principle appropriate tasks with diverse uses of verbal and visual representations as well as the consistent uses of Play Practice assumptions.

- **Mature & developmental/principle inappropriate - #3**: The teacher represented the content with diverse uses of instructional cues, descriptions, analogies, metaphors, or demonstrations but the selected tasks were not suitable for students’ age and skill level without consistent uses of Play Practice assumptions.

- **Mature & developmental appropriate & principle inappropriate - #3-D**: The teacher represented the content with diverse uses of verbal and visual representations but the selected tasks were developmental appropriate without uses of Play Practice assumptions.
• *Mature & developmental inappropriate & principle appropriate - #3-P:* The teacher represented the content with diverse uses of verbal and visual representations but the selected tasks were used with consistent uses of Play Practice assumptions but they were not suitable for students’ age and skill level.

• *Immature & developmental/principle appropriate - #2:* The teacher represented the content with simple or poor uses of verbal and visual representations and the selected tasks were suitable for students’ age and skill level with consistent uses of Play Practice assumptions.

• *Immature & developmental appropriate & principle inappropriate - #2-D:* The teacher represented the content with simple or poor uses of verbal and visual representations but the selected tasks were suitable for students’ age and skill level without consistent uses of Play Practice assumptions.

• *Immature & developmental inappropriate & principle appropriate - #2-P:* The teacher represented the content with simple or poor uses of visual and verbal representations but the selected tasks used Play Practice assumptions but they were not suitable for students’ age and skill level.

• *Immature & developmental/principle inappropriate -#1:* The teacher presented the content with simple or poor uses of verbal and visual representations as well as the selected tasks were not suitable for students’ age and skill level without consistent uses of Play Practice assumptions.
**Task Adaptations**

Task adaptations were recorded with two levels: (a) inter-task adaptation (i.e., task development between tasks for entire class), and (b) intra-task adaptation (i.e., task development within tasks for small groups or individuals).

**Inter-task adaptation** refers to a teacher’s inter task development between tasks toward whole class was measured according to the following four categories: (a) informing task, (b) extending task, (c) refining task, and (d) applying task.

- **Informing Task:** This category refers to the initial task in the progression of a skill. For example, the teacher could start to teach the forehand overhead stroke with having students toss the shuttle upward placing the shuttle overhead for a forehand overhead stroke.

- **Extending Task:** This refers to the task that changes the complexity or difficulty of student performance. For example, the teacher could have students hit the shuttle using forehand overhead stroke coming from the opponent.

- **Refining Task:** This category refers to the task that focuses the quality of student performance. For example, the teacher could emphasize students’ correct execution saying “rotate your upper body and reach high to hit” as they practice.

- **Applying Task:** This category refers to the task that changes the focus of learning from how to do the skill to how to use the skill in the game situation. For example, the teacher could have five students play a serve and overhead return game by rotating positions after three attempts.
**Intra-task adaptation** refers to a teacher’s adaptations within tasks toward small group of students or individuals were recorded according to the following six categories: (a) modifying task complexity, (b) refining or breaking task, (c) restating task, (d) extending task, (e) changing competition conditions and (f) different tasks.

- **Modifying Task Complexity:** This category refers to modifications made by the teachers under the following conditions (Avyazo, 2007): (a) space (e.g., changing the dimensions of the playing area changes the complexity of games); (b) equipment (e.g., using a lighter shuttle in badminton decreases the difficulty of the task); (c) number of participant (e.g., increasing the number of participants results in the increase of complexity); and (d) rules (e.g., using a single court for playing doubles in badminton reduces the difficulty of the game).

- **Refining or Breaking Task:** The teacher simplifies the task by asking the student to perform only one or two elements of it for the quality of performance without changing the task (Rink, 2006). For example, when teaching the ‘wall rally drill’ for badminton overhead stroke, the teacher could emphasize a high, deep return to have enough time to prepare before each shot.

- **Restating Task:** The teacher repeats the entire task in other forms than the ones used when the task was delivered to the entire class. For example, the teacher restated that “Make a serve with long and deep into the diagonal court corner rather than saying “Serve toward the opponent receiver’s deep court” in badminton.

- **Extending Task:** The teacher expands the task’s complexity by adding more
elements to the skill that is being practiced. For example, the teacher could extend the task by asking the students to hit the unexpected shuttles while the entire class practices the expected shuttles from the feeder in badminton.

- **Different task:** The teacher assigns a different task to small group of students or individuals, than the one that is performed by the entire class. For example, changing a long serve task practiced by entire class to a short serve task performed by a single student.

- **Competition Condition:** The teacher moves the students from noncompetitive to competitive situations and vice versa (Rink, 2006). For example, practicing the long serves to the target area, and then practicing it under timed conditions.
APPENDIX K

UNDERSTANDING OF DEFINITION (STUDENT VARIABLES)
Correct or Incorrect Trial on the Skills

When a student’s trial met the partial critical element outcomes that a teacher stated or the object criteria (i.e., three out of five critical elements of the skill), it was coded as a correct trial. When a student’s trial did not meet the partial critical element outcomes that the teacher described or the full object criteria (i.e., less than three out of five critical elements of the skill) that the researcher developed, it was coded as an incorrect trial.

If the teacher did not mention about critical elements of the skill or the teacher’s presentation of the critical elements of the skill was not appropriate, the observers used the checklist of the object critical elements of the skills to measure the students’ correct or incorrect performances. The observers coded their performance as a correct trial when they demonstrated at least three out of five object critical elements of the forehand overhead stroke that are already developed by the researcher. If the student demonstrated less than three out of five object critical elements of the skill, it was coded as incorrect trial.

Correct or Incorrect Trial on the Tactics

When a student’s trial met either the partial critical elements that the teacher stated or the full object criteria (i.e., all the critical elements of the tactic) that the researcher developed, it was coded as a correct trial. When a student’s trial did not meet the partial critical element outcomes that the teacher described or the full object criteria (i.e., no critical element or one out of two critical element outcomes of the tactic) that the
researcher developed, it was coded as an incorrect trial. If the student did not demonstrate two critical elements of the tactic, it was coded as an incorrect trial.

**Other Trials**

*Unfair Opportunity.* When a student missed hitting the shuttle due to an unhittable shuttle made by the partner, the observers coded it as an unfair opportunity. During the practice and game play sections, students’ unfair opportunities were observed and coded.

*Missed Opportunity.* When a student missed hitting the shuttle due to the mistakes made by the student, the observers coded it as a missed opportunity. During the practice and game play sections, students’ missed opportunities were observed and coded.

*Non-target Performance.* When a student made the skill or tactic performance that the teacher did not ask during the practice sections, the observers coded it as a non-target performance. Students’ non-target performances were observed and measured only during the practice section.
APPENDIX L

WRITTEN TEST (TEACHER VARIABLE)
Written Test (Teacher Variables)

Please mark one of the following letters next to each statement: “M” for Maturity, “IM” for immaturity, “DA” for developmental appropriateness, “DIA” for developmental inappropriateness, “PA” for principal appropriateness, and “PIA” for principal inappropriateness.

1. “You are going to be performing a log roll; logs are long and straight, so in the log roll you need to stay really straight like a log with your arms together and extended and your legs together and straight, watch Susan’s demonstration of the log roll” ____ (M)
2. “Now I want you to perform a log roll, ready, go” ____ (IM)
3. The teacher provided a log rolling activity to 3rd graders as a warm up activity using mats to prepare for the gymnastics unit ____ (DA)
4. The teacher provided a log rolling activity to 9th graders without any mats in gymnastics unit ____ (DIA)
5. The teacher had students to practice a forehand overhead stroke with a partner with a specific target area in the opponent court ____ (PA)
6. The teacher had students to practice a inside pass in soccer with a partner in a stationary area ____ (PIA)

Please mark one of the following letters next to each statement: “I” for instructions, “D” for descriptions, “AM” for analogies and metaphors, “C” for cues, “S” for specific congruent feedback, “DM” for demonstrations, “G” for task cards, pictures, diagrams or video clips, and “P” for physical assistance.

1. “We are going to do 3 vs. 3 passing game using chest pass and bounce pass for 2 minutes” ____ (I)
2. “Critical elements of set shot in basketball are have your elbow in, guide your non-dominant hand, and follow through with your elbow and wrist” ____ (D)
3. “We are going to do racket control like pancake flip” ____ (AM)
4. “Bend your knees” ____ (C)
5. “Way to follow through low to high” ____ (S)
6. The teacher showed desired or undesired lay-up shot, or asked students to show it to the class in basketball ____ (DM)
7. Patting on students’ shoulders ____ (G)
8. Teacher could show students task cards that included critical elements of forearm pass in volleyball ____ (G)
9. When teacher taught a basketball unit, she could show one of OSU basketball games to students to motivate them at the beginning of the unit ____ (G)
10. Teacher corrected students’ arm movement of set shot in basketball through physical touches ____ (P)

Please mark one of the following letters next to each statement: “I” for informing task, “RC” for refining task toward a whole class, ‘EC’ for extending task toward a whole class, ‘A” for applying task “M” for modifying task difficulty, “R/B” for refining or breaking tasks, “D” for different tasks, “R” for restating tasks, “E” for extending tasks, and “C” for competition of condition.

1. “Use only half court for practicing forehand overhead strokes” ____ (M)
2. “Now, focus on hitting the shuttle at the highest point” ____ (R/B)
3. The teacher is restating that students should make a serve to the opponent service box instead of saying that “Serve toward diagonally” ____ (R)
4. “Move from the service line to the base line to hit the ball in tennis” ____ (E)
5. The teacher asks three of the students to practice “Wall Rally”, whereas the rest of students are asked to practice a forehand stroke with a partner in the court ____ (D)
6. With a partner, scoring the long serves to the target area, and then scoring it under timed conditions ____ (D)
7. The teacher starts to teach forehand overhead stroke having all students toss the shuttle upward placing the shuttle overhead for a forehand overhead stroke ____ (I)
8. The teacher has all students hit the shuttle using forehand overhead stroke coming from the opponent after the self practice ____ (E)
9. The teacher emphasizes all students’ correct execution saying “rotate your upper body and reach high to hit” as they practice____ (RC)
10. The teacher assigns all students into several groups with five players and asks five players to play a serve and overhead return game by rotating positions after three attempts ____ (A)
APPENDIX N

WRITTEN TEST (STUDENT VARIABLE)
Written Test (student variable)

Please mark one of the following letters next to each statement: “C” for correct trial, “I” for incorrect trial, “UO” for unfair opportunity, “MO” for missed opportunity, and “NT” for non-target performance.

1. The student performed a forehand overhead stroke with the following elements (e.g., side way hitting stance in preparation, rotate upper body and reach high to hit in execution and cross racket to opposite side of the body in follow-through) ____ (C)
2. The student performed a backhand overhead stroke with the following elements (e.g., sideways to backward hitting stance in preparation, little rotate upper body and half of arm extension in execution and stopped swing after hitting in follow-through) ____ (I)
3. The student performed a backhand overhead drop shot with the following elements (e.g., hold racket arm parallel to floor in preparation, backswing places wrist in cocked position and contact as high as possible in execution, and swing toward net in follow-throw) ____ (C)
4. The student performed a forehand smash with the following elements (e.g., back scratch position in preparation, throw racket upward with racket face up in execution and swing low to high ____ (I)
5. The student did not return to the center court during the practice of singles’ play when the teacher asked the students to return to the center court after the shot. ____ (I)
6. When the teacher asked the students to adopt attacking position and make a downward shot in doubles, the student demonstrated these elements during the practice of doubles’ play. ____ (C)
7. The student missed returning the shuttle because the opponent player made an error in service ____ (UO)
8. The student made an error to miss hitting the shuttle that directly comes to the student ____ (MO)
9. The student performed a forehand overhead stroke with correct movements when the teacher asked to practice the serve to the target area ____ (NT)
10. The student could not return the shuttle because the shuttle was landed out of court (UO)
11. The student was asked to adopt attacking position in offense but the student were in the back court to return the shuttle (NT)
APPENDIX N

TREATMENT INTEGRITY CHECKLIST FOR THE WORKSHOP
<table>
<thead>
<tr>
<th>Questions</th>
<th>Serve</th>
<th>Overhead Stroke</th>
<th>Underhand Stroke</th>
<th>Smash and Drop shot</th>
<th>Singles</th>
<th>Doubles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. When the investigator introduces the tasks, she delivered clear instructions and descriptions of the skill.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>2. During the workshop, the investigator frequently used analogies or metaphors.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>3. When modeling the activities, the investigator frequently used appropriate cues.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>4. When modeling the activities, the investigator provided the students with specific congruent feedback.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>5. When the investigator demonstrates a new task, she clearly mentioned the critical elements of the skill.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>6. During the workshop, the investigator used either video clips, task cards, pictures, diagrams or video clips.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>7. During the student practice, the investigator provided students with physical assistance.</td>
<td>✓</td>
<td>✓</td>
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<td>8. During the workshop, the investigator checked whether the teachers understand the goals of each task and how to set up the tasks with students.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>9. The selected tasks were well organized by the investigator with appropriate uses of equipments.</td>
<td>✓</td>
<td>✓</td>
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<td>10. The investigator asked several questions to the teachers about possible ways to modify the tasks depending on students’ age and skill</td>
<td>✓</td>
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</table>
11. The investigator introduced the expectations, procedures and the main concepts of the Play Practice approach as the beginning of the workshop.
APPENDIX O

TREATEMENT INTEGRITY CHECKLIST FOR THE TEACHERS
<table>
<thead>
<tr>
<th>Task</th>
<th>As taught</th>
<th>Partially correct</th>
<th>Different task but consistent with workshop</th>
<th>Different task and not consistent with workshop</th>
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