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PEDAGOGY

Effects of a Content Knowledge Intervention on Instruction and Learning: A Pilot Study

Emi Tsuda, Phillip Ward, Jacqueline D. Goodway

Abstract

The purpose of this pilot study was to examine the effects of improving a physical education teacher's content knowledge and, in turn, the teacher's instructional effectiveness and student learning in an upper elementary physical education setting. Four classes were randomly assigned to either a comparison condition (n_{4th} = 9 students; n_{5th} = 17) or an intervention condition (n_{4th} = 7; n_{5th} = 10). The teacher taught both conditions. The teacher first taught two classes in the comparison condition in a manner that he had taught for the past five years. Following the completion of the teaching, he received a content knowledge workshop. After the workshop, the teacher taught two classes in the intervention condition. Assessment of the teacher following the workshop showed that he obtained higher content knowledge scores than prior to the workshop. These improvements in content knowledge positively impacted his enacted teaching with more appropriate task selection and better instruction. Student learning also significantly improved in the intervention condition, not in the comparison condition, from pre- to posttest. The findings of this study extend the research demonstrating the effectiveness of improving the content knowledge of teachers in

Emi Tsuda, College of Physical Activity and Sport Sciences, West Virginia University. Phillip Ward, Department of Human Sciences, The Ohio State University. Jacqueline D. Goodway, Department of Human Sciences, The Ohio State University. Please send author correspondence to emi.tsuda@mail.wvu.edu

impacting student learning, in this case in the upper elementary grade band.

Improving a teacher's pedagogical content knowledge (PCK) is central to enhancing the quality of instruction and student learning (Shulman, 1987; Ward & Ayvazo, 2016). PCK is typically conceptualized as including five areas of knowledge: students, content, context, pedagogy, and curriculum (Ward & Ayvazo, 2016). Lack of content knowledge is often argued as a significant weakness in the PCK of teachers (Hastie & Vlaisavljevic; 1999; Ingersoll et al., 2014; Tsangaridou, 2002). Yet, despite this, a number of studies have demonstrated that improving the content knowledge of teachers leads to improved student learning and that this can be done in a time-efficient manner (Iserbyt et al., 2017; Kim, 2016; Kim et al., 2018; Ward & Ayvazo, 2016).

Ball et al. (2008) defined two categories of content knowledge: common content knowledge (CCK) and specialized content knowledge (SCK). Ward (2009) further refined these categories for physical education defining CCK as knowledge of rules, etiquette, and safety, techniques, and tactics of sports, and SCK as knowledge related to content representations, instructional tasks, and student's error detection. The National Standards for initial licensure in physical education recognize the importance of teachers being able to develop strong content knowledge with two substandards. Standard 1.a states, "Describe and apply CCK for teaching PreK–12 physical education" and Standard 1.b states, "Describe and apply SCK for teaching PreK–12 physical education" (SHAPE America, 2017).

Studies have demonstrated support for the importance of CCK and SCK regarding PCK (Iserbyt et al., 2017; Sinelnikov et al., 2015; Ward et al., 2015). Experimental studies have shown that improvements in content knowledge and, in particular, SCK have positively impacted teacher instruction, including task selection (e.g., sequences of tasks and appropriateness of tasks) and instruction (e.g., task presentation and feedback), which resulted in better student learning outcomes (Iserbyt et al., 2017; Sinelnikov et al., 2015; Ward et al., 2015).

However, there are at least two critical gaps in this line of research. The first is that prior intervention studies that focused on

improving the PCK of teachers did not evaluate the teachers' CCK and SCK prior to and following the content knowledge workshop using knowledge tests (Iserbyt et al., 2017; Sinelnikov et al., 2015; Ward et al., 2015). In these studies, a workshop to train teachers to deliver specific CCK and SCK to a particular grade level and content area was implemented. Researchers then investigated if the content taught in the workshop appeared in the instruction of teachers in subsequent lessons. However, none of these studies documented whether the intervention brought changes in a teacher's understanding of the content (i.e., CCK and SCK). Thus, inferences between the outcomes of the workshop and the teacher's ability to apply the knowledge in practice can be questioned because there is no direct measure of the impact of the workshop as an intervention.

A second gap in the literature is that the majority of studies in this line of content knowledge intervention studies were conducted in secondary physical education settings (Iserbyt et al., 2017; Sinelnikov et al., 2015; Ward et al., 2015). Only one study has been conducted in a lower elementary context (Chang, 2014), and there are no studies in upper elementary settings. Examining the impact of improving a teacher's content knowledge and the subsequent results on student learning in an upper elementary context is essential considering the uniqueness of this age group for psychomotor learning. From a developmental perspective, upper elementary school students are in the transitional motor skill phase (Goodway et al., 2019). This stage is a critical stepping stone to lead learners' motor skill performance from isolated and decontextualized environments to the more dynamic and context-specific environments that are inherent in sports and games (Belka, 2004; Goodway et al., 2019). If we, as teachers, fail to assist children in this transitional motor skill phase, children may experience failure in sport-specific skills and could drop out of engaging in sports or physical activity (Belka, 2004; Goodway et al., 2019).

Rink's (2012) four-stage games model provides a promising framework to teach children who are in the transitional phase of motor development. In Stage 1, the focus is on attaining individual skills and developing the ability to control an object. Stage 2 focuses on using skills in combination with each other and relating movement to others in cooperative ways. In Stage 3, basic offensive and

defensive strategies are introduced, and in Stage 4, the focus is on modified games with changes in the rules, boundaries, and number of players, leading to playing of the full game. Among the four stages, Stages 2 and 3 are especially important to provide children who are in the transitional motor skill phase step-by-step development of their skills (Rink, 2012). However, at present, no research has examined the efficacy of Rink's stages of game development.

In addition to Rink's (2012) stages of game development, the concept of content development is critical in providing students step-by-step learning experiences. Content development is defined as sequencing movement tasks in a manner that has the potential to facilitate learning (Rink, 2012). The assumption underpinning the concept of content development is that beginning levels of the skills need to be mastered before more complex versions of those skills can be learned. Based on this assumption, Rink conceptualized content development tasks with having four functions: informing, extending, refining, and applying. An *informing* task is the first task in a sequence to teach specific content. An *extending* task increases or decreases the complexity of the task relative to a previous task. A *refining* task focuses on the quality of the performance such as improving the technique. An *applying* task has two different functions: to assess a student's ability or to apply their performance in a context such as a game. All tasks in the development are referenced relative to the initial informing task.

This study aims to address two gaps in the literature (i.e., the lack of content knowledge experimental study in upper elementary contexts and evidence in support of Rink's stages of game development). The purpose of this pilot study was to examine the effects of improving the tennis content knowledge of a teacher on his CCK and SCK and on his instruction and student learning in an upper elementary physical education setting. Three research questions guided the study: (a) What is the impact of a content knowledge intervention consisting of a content knowledge workshop and accompanying knowledge packet on a teacher's CCK and SCK? (b) What are the differences in the teacher's PCK (i.e., task selections and instruction) between the comparison and the intervention conditions? and (c) What are the differences in students' tennis skill performance

between the comparison and intervention tennis units? This study serves as a pilot study to ensure the feasibility of the study approach.

Method

Settings

The institutional review board of the university approved the study, the teacher consented to the study, and parental permission and assent were secured from the children. The study was conducted in an elementary school with one physical education teacher and four classes of students in a suburban, Midwestern city in the United States. Students typically received physical education twice a week for 30 min in each lesson. Tennis was selected as the content area because tennis is a common lifelong physical activity (SHAPE America, 2014) and is a new content area that has increasingly been introduced in elementary school contexts, in this study the fourth and fifth grades (United States Tennis Association [USTA], 2016).

Participants

Teacher

The teacher was male and had been teaching physical education in elementary school for 19 years. While he had little to no experience in playing tennis, he had taught tennis in elementary schools for 5 years. He had participated in a professional development training session from the USTA prior to teaching tennis in his physical education classes. He rated his confidence level of teaching tennis as 4 on a scale of 1 (*low*) through 5 (*high*).

Students

Forty-three students from two classes in fourth grade and two classes in fifth grade participated in the study. One class from each grade was randomly assigned to the comparison condition (n = 26; n_{4th} = 9 [girls = 3]; n_{5th} = 17 [girls = 10]) and the intervention condition (n = 17; n_{4th} = 7 [girls = 2]; n_{5th} = 10 [girls = 3]).

Study Design and Procedures

An experimental research design with a comparison condition and an intervention condition with students nested within intact classes (n = 4) was used to drive the study. The same teacher taught

both conditions. The teacher first taught the comparison condition in a manner that he "typically" teaches. The pretest of students' tennis skill performance was conducted prior to the first day of the unit (2 days prior in both classes), and the posttest was executed after the last day of the unit (12 days [fourth grade] and 5 days [fifth grade] after the unit completion). Then the teacher received a content knowledge workshop. Prior to and following the 2-hr training, the teacher spent 30 min completing the pre- and posttests (a total 1 hr of testing). The pretest was conducted at the beginning of the training and the posttest was conducted once all the content had been covered. Emi Tsuda was present in all the classes taught by the teacher. The data of task selection and instruction were collected during the teacher's enacted teaching in the 3-day tennis unit. A video camera was not utilized to record classes, because not all the students in the class provided permission to participate in the study. The teacher wore a wireless microphone to record his voice. Voice-recording started when the teacher began a lesson and finished when all the students were out of the gymnasium. After all the procedures were completed, interobserver agreements were established for all the variables with the exclusion of two components of instruction: clarity of task presentation and demonstration. Following the workshop, the teacher taught the intervention condition to the two classes. As with the comparison condition, the pretest of students' tennis skill performance was conducted prior to the first day of the unit (8 days [fourth grade] and 5 days [fifth grade] prior), and the posttest was executed after the last day of the unit (7 days after in both classes).

To address the issue of teacher knowledge gains, this study was conceptualized in terms of two levels of analysis. The first level focused on the pre-to-post learning gains that occurred from the content knowledge intervention designed to improve the teacher's CCK and SCK. The second level was a comparison of teacher instructional behavior and student learning that occurred in the comparison and the intervention conditions. Table 1 indicates the summary of the independent and dependent variables of the study, along with the timelines.

Table 1
Timeline, and Independent and Dependent Variables of the Study

Timeline	1	2	
comparison condition 3-day tennis unit	**The CK intervention**	**Intervention condition 3-day tennis unit**	**3**
Level 1 analyses			
IV	–	The CK workshop using the knowledge packet	–
DV	–	The teacher's CCK and SCK across the CK intervention	–
Level 2 analyses			
IV	The teacher's task selection and instruction	–	The teacher's task selection and instruction
DV	Student skill learning	–	Student skill learning

Note. IV = independent variable; DV = dependent variable.

Level 1 Analysis: A Content Knowledge Intervention

Independent Variables

The Level 1 analysis looked at the impact of the upper elementary tennis content knowledge intervention on the teacher's CCK and SCK. The intervention consisted of the content knowledge workshop and upper elementary tennis knowledge packet. During the workshop, the teacher was actively led through the knowledge packet content, which ensured his understanding.

The Upper Elementary Tennis Knowledge Packet. A knowledge packet is a body of knowledge that defines and explicitly de-

scribes the content to be taught to a specific grade level (Ward et al., 2015). The knowledge packet in this study was designed for a physical education teacher with some experience in teaching tennis to Grades 4 to 5 students (Tsuda et al., 2018). The knowledge packet was underpinned by two premises. The concept of content development (Rink, 2012) and the stages of game development (Rink, 2012), both discussed in the introduction. There were five components in the knowledge packet: (a) introduction, (b) equipment modification, (c) concepts of task development, (d) content map, and (e) task description (Ward et al., 2015). The content validity of the knowledge packet was secured through two steps. First, a tennis expert developed the knowledge packet in alignment with recommendations provided by the International Tennis Federation (ITF, 2007) and the National Standards for K–12 Physical Education (SHAPE America, 2014). Second, another tennis expert checked the content, and revisions were made based on feedback.

The Content Knowledge Workshop. The content knowledge workshop aimed to prepare the teacher to implement the tasks in the knowledge packet. The training lasted 2 hr and was completed within a day. Four goals of the workshop were that the teacher (a) knows the basic rules, critical elements of techniques, and tactics needed to teach upper elementary tennis (CCK); (b) can perform the tennis skills to teach upper elementary tennis (CCK); (c) knows and can deliver the tasks and task progressions in the knowledge packet (SCK); and (d) can detect errors of students and correct them (SCK). During the workshop, the teacher completed pretests (30 min); Tsuda introduced and explained the rationales of the knowledge packet (20 min); Tsuda explained equipment, rules, techniques, and tactics of tennis (20 min); Tsuda explained and practiced the tasks on a content map (70 min); the teacher completed the posttest (30 min); and the teacher created a block plan (10 min). The total time for the workshop was 2 hr. Treatment integrity was secured through a rehearsal of the workshop and use of a checklist during the workshop that ensured all the elements were covered. Table 2 illustrates the contents, timeline, and pedagogy of the content knowledge workshop.

Dependent Variables for the Workshop

The teacher's content knowledge changes were evaluated through four tests: (a) rules, techniques, and tactics (CCK); (b) skill performance (CCK); (c) knowledge of task sequences (SCK); and (d) knowledge of student errors (SCK). The teacher took the tests before and after the content knowledge workshop.

Knowledge of Rules, Techniques, and Tactics. The teacher completed 15 open-ended questions examining knowledge of rules, techniques, and tactics in tennis. The questions were aligned with the knowledge packet. Each question was valued 1 point, with a total of 15 points. Content validity was established in two ways. First, a tennis expert developed the test based on the National Standards (SHAPE America, 2014), tennis textbooks (Brown, 1989; Bollettieri, 2001), and ITF (2007) and USTA (2016) guidelines. Second, two graduate students with experience in tennis and in developing similar tests checked the content and clarity of the test. Based on their feedback, refinements were made on two questions for clarity.

Skill Performance. A tennis skills test to evaluate the teacher's tennis performance was created. This same assessment was used in the measurement of students' tennis skill performance with the assumption that a teacher needs to be able to perform skills at a minimum of the level that is going to be taught. The test was also developed to meet the expected learning outcomes identified in the grade level outcomes in the National Standards (SHAPE America, 2014). The stages of game development (Rink, 2012) underpinned the test. The test included three tasks (Stage 1 to 3 tasks) for both forehand and backhand. There were three trials for each task: a practice trial and two coded trials. Each task had two to seven technical criteria, with a 1 representing when a criterion was present and 0 representing when a criterion was absent. This assessment was scored between 0 and 60 points. The test used the developmentally appropriate equipment (i.e., a red ball, a 25-in. racquet, and a quarter size of the full-size tennis court). Content validity of the test was secured in three ways: First, a tennis expert developed the test referring to preexisting assessments (Brown, 1989; Strand & Wilson, 1993; Ulrich, 2016), and second, another tennis expert checked the content and clarity of the test. Third, a pilot test was conducted with six elementary school students.

Table 2
The Contents, Timeline, and Pedagogy of the Content Knowledge Workshop

Time	Topic	Content	Pedagogy
30 min	Pretest	• The test for the knowledge of rules, techniques, and tactics • The test for the knowledge of tasks • The test for the knowledge of student errors • The test for the skill performance	N/A
20 min	Introduction & rationales of the knowledge packet	• Organization of the knowledge packet • Grade level outcomes of striking with a short-handled implement in the National Standards in the upper elementary age band • Two underlying concepts of the knowledge packet (i.e., the stages of game development & the concept of content development) • The four goals of the teacher training	Tsuda verbally explained the content to the teacher in a conversational style. Tsuda frequently asked the teacher if he had a question. However, the teacher did not ask any questions, because he had no problem of understanding of the content.
20 min	Equipment, rules, techniques, and tactics	• Equipment: racquet, court, ball sizes • Rule: one bounce, name of the lines, and on the line still counts • Techniques: forehand and backhand (four critical elements) • Techniques: footwork (four critical elements) • Tactics: ready position, aim weakness, open court, and cross-court rally	Tsuda explained the content and demonstrated the skills to the teacher. After that, Tsuda and the teacher practiced each skill together. The researcher asked questions of the teacher to check for understanding (e.g., "Could you tell me what the critical elements for forehand ground stroke are?").

Table 2 (cont.)

Time	Topic	Content	Pedagogy
70 min	Content map & tasks	• Overall picture of the content map • Tasks 1–14 including the five components of the task: (a) purpose of task as related to aspects of skilled performance, (b) task description, (c) equipment needed, (d) teaching cues, and (e) student common errors	The researcher explained the content. Emi Tsuda explained the contents in a conversational style. Tsuda and the teacher practiced the task together. Tsuda frequently asked the teacher if he understood the task. During the practice, Tsuda and the teacher also discussed the best way to implement each task in the context considering a size of the gym and a number of the students in his class.
30 min	Posttest	• The test for the knowledge of rules, techniques, and tactics • The test for the knowledge of tasks • The test for the knowledge of student errors • The test for the skill performance	N/A
10 min	Block plan	• Create a block plan	The teacher was asked to write a block plan. After that, Tsuda asked the rationale to the teacher, and feedback was provided based on his comments.

Knowledge of Tasks and Task Sequences. A content map to assess knowledge of tasks and task sequences was used (Ward et al., 2017). A content map is a graphic organizer of SCK that defines the content to be taught and has been established as a valid and reliable tool for measuring SCK. In this study, the focused content was forehand and backhand groundstrokes and footwork of tennis. Tsuda coded the content map in three aspects: (a) Rink's (2012) content development categories (the depth of the content development was calculated by the formula [E + R + A] / I; Ward et al., 2017), (b) Rink's four stages of game development, and (c) appropriateness of task sequences (see Table 3 for definitions).

Table 3
The Definitions of the Categories for Task Selection

Category	Definition
	Alignment With Content Map
Aligned with the CM	A task matched with the task on the CM.
A goal of the task was consistent with the CM	A primary goal of the task was consistent with a task on the CM, but a different task was implemented.
Not aligned with the CM	A task was not on the CM.
	Content Development
Informing	The first task in a sequence to teach specific content.
Extending	A task increases or decreases the complexity of the task relative to a previous task.
Refining	A task focuses on the quality of the performance such as improving the technique.
Applying	An applying task can be used to assess a student's ability or to apply their performance in a context such as a game.

Table 3 (cont.)

Category	Definition
	Stages of Game Development
Stage 1	Focus on the ability to control the object or body which also includes the changes from stationary to moving objects/moving receivers.
Stage 2	Skills are combined; rules that limit the way an action can be performed are emphasized; skills are practiced in cooperative relationships.
Stage 3	The focus is removed from the execution of the skill to simple offensive and defensive roles with the use of the skill.
Stage 4	Complex game play. For most games, Stage 4 begins when offensive and defensive players become specialized.
	Appropriateness of Task Sequences
Appropriate	The task progression from one task to another was characterized by small step-by-step instructional progressions.
Inappropriate	The task progression from one task to another was not characterized by a small step-by-step progress, not a big step up from a prior task.

Note. CM = content map.

Knowledge of Common Errors of Students. The teacher's understanding of potential student errors and how to correct those errors was assessed through a test with 10 open-questions that was developed and implemented based upon the knowledge packet. Each question consisted of two parts: to detect an error and to correct it. A total score for this assessment was 20, and each answer was scored as 1 point (10 questions × 2 parts = 20 points). Tsuda secured content validity in three ways: First, a tennis expert developed the test based on the knowledge packet, which had previously been validated. Second, two graduate students checked the content and clarity of the test. Third, based on their suggestions, refinements were made on three scenarios in the test for clarity.

Level 2 Analysis: A 3-Day Tennis Unit

Independent Variables

The independent variable of the tennis unit was the teacher's PCK (task selection and instruction), and the dependent variable was students' learning. The teacher taught a 3-day tennis unit for both the comparison condition and the intervention condition. In the instruction of the comparison condition, the teacher was asked to teach the tennis unit in the way he had typically taught in the past. The teacher determined what tasks to do and how to instruct lessons. The intervention condition consisted of the same teacher being asked to teach another 3-day tennis unit to two classes, using the knowledge learned through the knowledge packet and the content knowledge workshop. All the lessons in both the comparison condition and the intervention condition were video recorded. The teacher's PCK was coded and the differences were compared between the comparison condition and the intervention condition through the video data. Tables 3 and 4 demonstrate the definitions of a criterion for each subelement for task selection and for the instruction of the teacher, respectively.

Table 4
The Definitions of Categories for Instruction

Category	Definition
	Clarity of Instruction
Clear	A teacher described the task clearly, and little confusion is seen among students.
Unclear	A teacher did not describe the task clearly and students were confused with what they were expected to do.
	Demonstration
Complete demonstration	A correct complete model of the desired movement and that movement met all the critical elements of Stage 1 and 2 tasks.
Incomplete and/or incorrect demonstration	An incorrect model of task performance by using incorrect critical elements and/or partial elements of the whole demonstration.

Table 4 (cont.)

Category	Definition
	Cues
Accurate and appropriate	All cues presented were correct and appropriate.
Accurate but inappropriate	All cues presented were correct but were inappropriate.
Feedback	
Congruent feedback	A cue provided was congruent with a student's error.
Incongruent feedback	A cue provided was not congruent with a student's error.

Dependent Variable

Students' tennis skill performance was assessed through the same instrument that assessed the teacher's tennis skill performance. All performances of the tennis skill test were video recorded. Students were assessed in groups of one to three students, depending on the availability of students and time.

Coder Training and Interobserver Agreement

Coder training was conducted in three steps for analysis of the tests measuring the teacher's CCK, SCK, PCK, and the students' learning. First, Tsuda explained the definitions of each variable. Second, two graduate students coded and analyzed 10% of the data together until reaching 100% of the agreement with Tsuda. When disagreement occurred among the graduate students, they discussed until 100% of the agreement was secured. Third, the graduate students analyzed another 10% of the data independently until they acquired a 95% agreement with Tsuda. After the completion of the training, the graduate students analyzed 100% of the teacher's CCK and SCK data because there was only one teacher's data, and the interobserver agreement was 95%–100% across four tests. For the teacher's PCK data (instruction and task analysis), 33% of the data were analyzed by the graduate students. The result of the agreement

was 91.07% for task selection and 92.50% for instruction. For the students' performance, the graduate students analyzed 33% of the data, and the interobserver agreement was 94.10%.

Data Analysis

The teacher's variables (CCK, SCK, and PCK) were analyzed through descriptive statistics because there was data for only one teacher. For the student variable, nonparametric statistics were used because the data did not meet the assumptions of parametric statistics. The Mann–Whitney U test analyzed the mean scores of the pretest of tennis skill performance between the comparison condition and the intervention condition. Two Wilcoxon signed-rank tests were used in the examination of the differences between student tennis skill performance scores pretest and student tennis skill performance scores posttest for each condition. Effect sizes were calculated with the formula $r =$ (Rosenthal, 1991; $r = .10$ [small], $r = .30$ [medium], and $r = .50$ [large]). SPSS 22 was used in the analysis of the data.

Results

Level 1 Analysis: The Content Knowledge Intervention

Table 5 illustrates the results of the pre- and posttests of the teacher's CCK and SCK and detailed analyses of the content map written by the teacher. Overall, the teacher improved both CCK and SCK after receiving the workshop. Specifically, the teacher improved his skill performance and the knowledge of student errors.

Level 2 Analysis: The 3-Day Tennis Unit

The Teacher's PCK

Table 6 shows the results of the teacher's task selection and instruction in the two conditions. The teacher used more (a) tasks from the knowledge packet, (b) appropriate task sequences, (c) extension tasks, and (d) Stage 2 and 3 tasks after the workshop in the intervention condition than in the comparison condition. Regarding instruction, the teacher demonstrated more complete demonstrations, accurate

Table 5
The Results of Common Content Knowledge (CCK) and Specialized Content Knowledge (SCK) on the Pre- and Posttest of the Teacher

Test content	Test (total score)	Pretest (% correct)				Posttest (% correct)			
CCK	Rules, techniques, and tactics (15)	14 (93.3%)				14 (93.3%)			
	Skill performance (60)	38 (63.3%)				57 (95%)			
SCK	Content development (the index score)	5.33 (N/A)				6 (N/A)			
	Student errors (20)	11 (55%)				17 (85%)			
	Detailed analyses of content development on the content map								
Content development	Task development	***I***	***E***	***R***	***A***	***I***	***E***	***R***	***A***
		3	16	0	0	3	17	0	1
	Task sequences	***Appropriate***		***Inappropriate***		***Appropriate***		***Inappropriate***	
		11		5		13		7	
	Stages of game development	***1***	***2***	***3***	***4***	***1***	***2***	***3***	***4***
		17	2	0	0	13	7	1	0

Note. The score in the parentheses is the total score of the assessment; I = informing; E = extending; R = refining; A = applying; N/A = not applicable.

Table 6

The Mean of Teacher's Task Selection in the Comparison and Intervention Conditions in the 3-Day Unit

Task selection														
	Alignment			Task sequences		Content development				Index score	Stages of game development			
Class	A	C	N	A	IA	Informing	Extending	Refining	Applying		1	2	3	4
Comparison	4.17 (4-4.5)	0.83 (0.5-1)	1.83 (0-3.5)	4.17 (3-4.5)	1.67 (1-2.5)	1.17 (1-1)	4.67 (3-5.5)	0.83 (0-2)	0.33 (0-1)	5.12	6.00 (2.5-8.5)	0.5 (0-1.5)	0.00 (0)	0.33 (0-1)
Experiment	7.83 (6.5-9)	0.67 (0-1.5)	0.00 (0)	6.83 (5.5-8)	0.33 (0-1)	1.33 (1.5-3.5)	4.67 (3.5-6.5)	0.83 (0-1.5)	1.67 (1-2)	5.39	4.66 (2-7.5)	2.50 (2-3)	0.83 (0-1.5)	0.50 (0-1.5)

Instruction											
	Clarity		Demonstration			Cues				Feedback	
Class	Clear	Unclear	CD	ID	ND	AA	AI	IA	N	Congruent	Incongruent
Comparison	7.16 (5-8.5)	0 (0)	4.16 (2.5-5)	1.50 (0-2.5)	1.16 (0-2.5)	2.83 (0-5)	0 (0)	0 (0)	4.00 (3.5-5)	5.83 (5-8)	0 (0)
Experiment	8.5 (6.5-10.5)	0 (0)	6.17 (2-9.5)	0.67 (0.5-1)	1.50 (0-3.5)	5.67 (4.5-7.5)	0 (0)	0 (0)	2.83 (2-3.5)	10.66 (9.5-12.5)	0 (0)

Note. Task selection (A = aligned with the content map; C = a goal of the task is consistent; N = not aligned with the content map; A = appropriate; IA = inappropriate). Instruction (CD = complete demonstration; ID = incomplete demonstration; ND = no demonstration; AA = accurate and appropriate; AI = accurate but inappropriate; IA = inaccurate; N = not given).

and appropriate cues, and congruent feedback in the intervention condition than in the comparison condition.

Student Learning

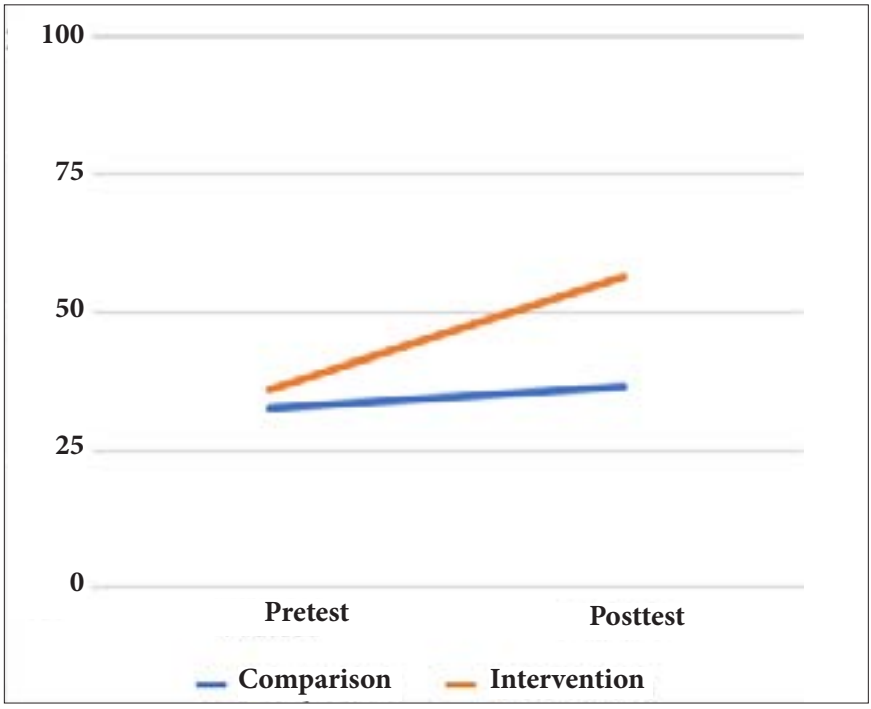
Figure 1 shows the results of the pre- and posttest student performance tennis skills test of the students in the two conditions. There were no statistically significant differences at the pretest between the comparison condition (M = 19.61, SD = 6.90) and the intervention condition (M = 21.63, SD = 9.22; U = 168.00 [Z = -.73], p = .46, r = -.11). No statistically significant change from the pre- to posttest was observed in the comparison condition (Z = -1.01, p = .30, r = -.19; M = 21.96, SD = 9.90). In the intervention condition, there was a statistically significant difference from the pre- to posttest (Z = -3.23, p = .001, r = -.83; M = 33.86, SD = 4.73) for student performance on the tennis skills test.

Discussion

The Intervention Was Effective in Improving the Teacher's Content Knowledge

The teacher improved his CCK and SCK after the intervention, in comparison to the pretest results, with the exception of CCK in rules, techniques, and tactics. The lack of improvement in rules, techniques, and tactics of CCK may have been due to ceiling effects because the teacher scored high on the pretest (14 out of 15 points) and little room was left for improvement. The teacher's skill test score changed from 63% to 95%, which indicates that although limited time (10 min) was allocated to practice tennis skills in the workshop, the teacher already had the skill set to further advance his performance in tennis needed to teach upper elementary students. Regarding SCK, the teacher developed more appropriate task sequences in the content map with the use of more Stage 2 and 3 tasks in Rink's (2012) stages of game development. The teacher's knowledge of student errors also enhanced after the intervention. Overall, the results of the Level 1 analyses showed that the content knowledge intervention was effective in improving the teacher's CCK and SCK. The findings provided the first evidence of the teacher's CCK and SCK changes that were measured.

Figure 1
Changes in Percentage From Pre- to Posttest in the Student Tennis Skill Performance Test in the Comparison and Intervention Conditions



Strengths of the content knowledge intervention were that the training covered all the elements of the knowledge packet and Tsuda went over every task by practicing and discussing how to best implement each task with the teacher. During that time, cues and student common errors were also provided to the teacher. A weakness of the content knowledge intervention was that the knowledge packet was given to the teacher right before the content knowledge workshop. It is suggested that in future interventions, teachers be given the knowledge packet beforehand so that they have some time to study it and the workshop time can be used in the most meaningful way.

Positive Changes in the Teacher's Enacted Teaching and Student Learning

Changes in Enacted Teaching

The teacher's task selection was better in the intervention condition than in the comparison condition. The teacher's task selection in the intervention condition was characterized by the use of more appropriate task sequences in Stages 1 to 3 of game development (Rink, 2012), while the teacher primarily utilized Stage 1 tasks in the comparison condition. The use of Stage 2 and 3 tasks in the intervention condition created a more continuous task progression toward more game-like contexts (Belka, 2004). Similarly, the teacher's quality of the instruction component of PCK was higher in the intervention condition than in the comparison condition. The teacher provided more complete demonstrations, more accurate and appropriate cues, and more congruent feedback; no differences were observed in the clarity of the task presentation because the teacher demonstrated clear task presentation 100% of the time in both conditions. The results from this study support other research with mostly older grade levels (Kim et al., 2018) and suggest that the teacher's changes in CCK and SCK after the content knowledge intervention were successfully translated into the teacher's actual teaching, PCK.

In those prior experimental studies, continuous coaching was provided to teachers after an intervention. In an attempt to have more social validity mirroring the real conditions of teachers, this study did not give follow-up feedback to the teacher. This study produced the first evidence that if the intervention was successful in changing a teacher's CCK and SCK, then a teacher can also improve their PCK without further support, which is more ecologically feasible in a real-life context and allows for the implementation of the intervention in a larger scale.

Changes in Student Learning

At the pretest, no statistically significant differences were detected between the two conditions in students' skill levels, indicating that the students from the two conditions were at a similar skill level prior to the tennis unit. In the comparison condition, there were no significant score changes from the pre- to posttest. This may be due to the biased use of Stage 1 tasks, which provided few opportunities

for students to learn critical elements of the forehand and backhand and practice those skills in more dynamic and game-like contexts, which are expected learning outcomes in fourth and fifth grades (SHAPE America, 2014).

In contrast, a statistically significant change from the pre- to posttest in tennis skill scores occurred in the intervention condition. Greater use of Stage 2 and 3 tasks in Rink's stages of game development, and appropriate sequences of those tasks to provide the students step-by-step learning experiences as discussed, which was the most notable differences in the two conditions, may have accounted for these results. Collectively, the changes seen among students were consistent with those in prior studies that have used similar content knowledge interventions to improve PCK of teachers and that resulted in subsequent improvement in student learning (Iserbyt et al., 2017; Sinelnikov et al., 2015; Ward et al., 2015).

Limitations

This study has four major limitations. First, while the CCK and SCK (excluding a content map) assessments were content validated, they were not validated through construct validity. Construct validity could not be secured because there are no other extant tests of CCK and SCK with which to compare the results. Future studies might use CCK and SCK tests validated by a Rasch analysis. Second, while this was a pilot study, the sample size for both the teacher analysis and the student analysis was small. Future studies can use larger sample sizes to enhance the generalizability of the study. Third, the use of a more extended unit (5 to 10 days) could promote greater student learning. While the 3-day unit may be ecologically valid, it is too short to assist students in learning more advanced content (i.e., Stage 3 tasks), as even the students in the intervention condition were only able to achieve 60% of the test score on average. Last, this study did not explore the retention of the intervention effect of the teacher's instruction. Future studies can analyze teachers' instruction after 6 months or longer to see if teachers still teach in the way that theytaught the intervention condition.

Conclusion

This study provides the first evidence in the line of content knowledge intervention studies in an upper elementary context. The

results demonstrate that the intervention is sufficient in developing teacher CCK and SCK, which can improve a teacher's PCK and correspondingly students' learning. Also, the study produces the first evidence of the efficacy of the framework of Rink's stages of game development. The use of Stage 2 and 3 tasks can assist students in meeting the expected learning outcomes in upper elementary levels.

Based on the findings, there are three recommendations for pre- and in-service teacher education programs. First, teacher education programs should focus on developing teachers' CCK and SCK, which could produce corresponding improvements to PCK. This is especially important because recent studies have found that K–12 physical education and extracurricular experiences spend too little time developing CCK and SCK (Tsuda et al., 2019; Ward et al., 2017). Second, teacher education programs should utilize instructional materials such as a knowledge packet to help teachers learn the appropriate content. Having this type of packet enables teachers to implement developmentally and principally appropriate tasks right away. Finally, teacher education programs should utilize evidence-based approaches to prepare teachers on how to teach games. Rink's (2012) stages of game development are one such approach that helps teachers to develop appropriate tasks and task sequences that produce student learning outcomes. In conclusion, the pilot study was successful in demonstrating the appropriateness of the research design and approaches for conducting a larger scale study.

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