In-Service Music Teachers' Self-Perceived Sources of Pedagogical Content Knowledge

Author(s): Warren Haston

Source: *Bulletin of the Council for Research in Music Education*, No. 217 (Summer 2018), pp. 45-66

Published by: University of Illinois Press on behalf of the Council for Research in Music Education

Stable URL: https://www.jstor.org/stable/10.5406/bulcouresmusedu.217.0045

Bulletin of the Council for Research in Music Education
Summer 2018 No. 217


# In-Service Music Teachers' Self-Perceived Sources of Pedagogical Content Knowledge

*Warren Haston*
*University of Hartford*
*West Hartford, CT*

## ABSTRACT

*The purpose of this multiple case study was to examine the perceived sources of identifiable pedagogical content knowledge (PCK) used by 5 in-service secondary band teachers. Participants agreed to plan, teach, and video-record a 30-minute band rehearsal early in the second semester of the school year. I viewed each video and created a log of applications of PCK based on previous models. An independent researcher confirmed the identified instances of applied PCK. Without exception, participants confirmed the researcher-identified applications of PCK. The responses from the participants varied: 1 participant reported apprenticeship of observation as the primary source of PCK; 1 reported apprenticeship of observation and methods courses equally; another reported intuition and peers equally; 1 reported peers; and another reported cooperating teacher. Participants recognized the positive impacts this type of metacognition had on their teaching and expressed eagerness to reflect about their PCK in the future.*

Shulman (1986) introduced a teacher knowledge base model and identified four primary sources of teacher knowledge: (a) scholarship in content disciplines, (b) materials and settings, (c) research, and (d) the wisdom of teaching itself (p. 8). Shulman (1986, 1987) defined seven domains of teacher knowledge—content knowledge, pedagogical knowledge, curricular knowledge, pedagogical content knowledge (PCK), knowledge of students, knowledge of educational context, and knowledge of educational outcomes. He 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" (Shulman, 1986, p. 8).

## KNOWLEDGE BASE LINEAGE

Many researchers, pedagogues, practitioners, and policy makers have used Shulman's (1986, 1987) construct to inform their epistemologies. Some researchers have adopted Shulman's typology (Gudmundsdottir, 1990), while others have modified the labels (Ball, 1991; Cochran, DeRuiter, & King, 1993; Grossman, 1990; Sherin, 2002) or used

the model to redefine PCK as teacher pedagogical constructions (Hashweh, 2005) or knowledge of content and students (Hill, Loewenberg Ball, & Schilling, 2008). In an attempt to broaden the definition of PCK in music teaching, Bremmer (2015) posited that use of the body (e.g., positioning, gesture) should be accounted for in any assessment of music teacher PCK. Millican (2008) confirmed the importance of PCK for music teachers, with 214 in-service secondary music teachers ranking PCK as the most important knowledge and skill for professional success.

Grossman (1990) proposed a model of teacher knowledge similar to Shulman's (1986), while incorporating the ideas of several authors. There are four types of knowledge in the model: subject matter knowledge, general pedagogical knowledge, PCK, and knowledge of context. Grossman divided each type of knowledge into subcategories. According to Grossman, PCK is comprised of a teacher's purpose for teaching subject matter, knowledge of students' understanding, curricular knowledge, and knowledge of instructional strategies.

Ball (1991) clarified the purpose of the Professional Standards for Teaching Mathematics, the first such standards published. In doing so, Ball (1991) emphasized the concept of *discourse* and defined it as "the ways in which knowledge is constructed and exchanged in classrooms" (p. 44). This can be viewed as combining Shulman's (1986) PCK, curricular knowledge, and content examinations. Similarly, Cochran et al. (1993) defined pedagogical content *knowing* as "a teacher's integrated understanding of four components of pedagogy, subject matter content, student characteristics, and the environmental context of learning" (p. 266), combining Shulman's content knowledge and PCK and adding consideration for students' contexts. Cochran et al. (1993) base this new concept in a constructivist epistemology, stating that pedagogical content *knowing*: "enables teachers to use their understandings to create teaching strategies for teaching specific content in a discipline in a way that enables specific students to construct useful understandings in a given context" (p. 266). Sherin (2002) combined Shulman's subject matter knowledge and PCK into *content knowledge*. Sherin also divided PCK into knowledge of students' understanding and knowledge of curriculum (similar to Grossman, 1990) and posited that through pedagogical reasoning, teachers modify and/or create new content knowledge complexes. Hashweh (2005) proposed a reconceptualization of PCK, calling it a collection of *teacher pedagogical constructions*, defined in part as resulting "mainly from planning but also from the interactive and post-active phases of teaching" and "from an inventive process that is influenced by the interaction of knowledge and beliefs from different categories" (p. 273). Hashweh (2005) extended the ideas of Shulman of the significance of context and teacher learning in action, believing that PCK is "a collection of teacher pedagogical constructions, as a form of knowledge that preserves the planning and wisdom of practice that the teacher acquires when repeatedly teaching a certain topic" (p. 273). Hill et al. (2008) proposed a revised model of knowledge for teaching, therein relabeling some parts of Shulman's model (but retaining the definitions), while also singling out a specific component of

Shulman's PCK model and labeling it *knowledge of content and students* ("how students learn particular content," p. 378).

Researchers regularly report the difficulties of parsing out the complexities of the teacher knowledge base individually, much less collectively. There is striking agreement in principle about what must be in a model of teacher knowledge (knowledge of the subject, students, curriculum, pedagogy, context), but no unification of labels. For the purposes of this study, with all due respect to the varied models of the teacher knowledge base and the inherent overlap and intertwining of all its components, I retain Shulman's (1986) definition of PCK: "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).

## LITERATURE REVIEW

### *General Education*

Assessment of preservice teacher PCK is much more common than that of in-service teacher PCK. Cavin (2007) examined preservice teachers' technological pedagogical content knowledge (the ability to use technology as a tool for implementation of PCK). Six undergraduate students (five mathematics education majors and one science education major) participated for one semester in microteaching lesson studies that encompassed planning (in groups of three), teaching, and reflecting on mathematics lessons with undergraduate students. Cavin collected data with audio and video recordings, observations, interviews, and course materials and found that the preservice teachers increased the level of their technological pedagogical content knowledge, benefited from serving as students in modeled lessons first, and viewed the use of technology as a pedagogical tool more positively after the semester.

Kellogg (2010) investigated the PCK of preservice elementary teachers with respect to the concepts of area and perimeter. Using a mixed-methods approach, Kellogg found that preservice teachers' knowledge of student thinking was lacking, they were unaware of student misconceptions about the concepts, and they did not effectively use drawings as pedagogical tools.

Özden (2008) asked 28 preservice science teachers to take 1 hour and write a lesson plan on phases of matter for Grade 5 students (without references available), complete a content knowledge test on phases of matter, and participate in interviews about their content knowledge, PCK, difficulties in writing the lesson plan, and anticipated problems teaching the concept. The researcher found that preservice teachers had the requisite content knowledge and that it had a positive influence on PCK. Preservice teachers stated a need to learn more in their training about young students' understanding of science and their educational needs.

O'Hanlon (2010) asked eight preservice mathematics teachers to complete mathematical problems and imagine teaching the specific concepts, including anticipated

student difficulties, how he or she would teach and sequence instruction of the concept, requisite prior student knowledge, how the concept would be incorporated in a lesson, and justification of pedagogical strategies. The participants also completed two plan-teach-reflect lessons with public school children and interviews with the researcher. O'Hanlon found that preservice teachers were lacking in PCK, though differences varied depending on the concept. The researcher noted the teachers' knowledge of instruction improved throughout the school year, they responded to student needs with respect to lesson pacing, and they identified students' prior knowledge that inhibited learning.

### *Music Education*

Investigation of music preservice teacher PCK is limited. Gohlke (1994) investigated the PCK of four preservice music teachers. Through interviews, observations, and program records over a 14-week methods course, Gohlke gathered data about their conceptions of elementary general music teaching, curricular judgment of teaching materials, and lesson planning ideas for teaching specific music concepts to particular grade levels of students. The researcher also asked for the source of this PCK and about the influence of their methods course and apprenticeship of observation on their PCK acquisition. Gohlke concluded her study with several thoughts: (a) that the four preservice music teachers obtained PCK from various sources, but primarily through their apprenticeship of observation; (b) that the methods course influenced their preconceived misconceptions of teaching elementary general music (e.g., participants previously believed it to be a training ground for eventual instrumental teaching jobs); and (c) that their emphasis (vocal or instrumental) influenced their use of PCK (i.e., vocalists focused on the text, genre, and historical context while teaching a song; instrumentalists approached the teaching as if for performance—time signature, key signature, rhythms, etc.).

Ballantyne and Packer (2004) surveyed 76 early career (1–3 years of experience) music teachers in Australia to identify the knowledge and skills those participants perceived as necessary to effectively teach, as well as their perceptions of the effectiveness of teacher education programs in providing said knowledge and skills. The researchers found that preservice teachers need more support to develop their PCK and skills and called for a reconceptualization of music teacher education courses (which include methods courses).

Haston and Leon-Guerrero (2008) identified instances of PCK in teaching videos of six preservice band teachers and asked them to attribute those instances of PCK to particular sources. Haston and Leon-Guerrero (2008) confirmed that there were identifiable instances of PCK application, where "obvious verbal and physical reaction occurred on the part of the pre-service teacher in response to student production of sound," and "where pedagogical approaches were used that were directly embedded in musical actions and concepts" (p. 53). Two participants each cited apprenticeship of observation, methods courses, and cooperating teachers as primary sources of PCK. The current study is a replication of Haston and Leon-Guerrero but with in-service teachers.

Berg and Sindberg (2014) investigated the support structures and obstacles that enabled or inhibited music student teachers' abilities to implement comprehensive musicianship teaching strategies they learned in methods courses. The researchers found that despite their eagerness, some student teachers were not able to use the teaching strategies (PCK) learned in their methods courses due to limited rehearsal time, unwillingness of the cooperating teacher, or performance expectations of the kindergarten-to-12th–grade students. While the study was conducted with student teachers, it is important to recognize that in-service teachers might be equally inhibited by these obstacles and not able to apply PCK strategies and concepts learned in the methods course. The present study is in part an attempt to parse this out.

Millican (2013) is the most closely related music teaching PCK study to the present study. Three expert beginning band teachers independently viewed 14 video clips of beginning band students performing from their band method book and reported to the researcher what he or she would have done to help the students in the videos. Millican asked three questions that essentially became Question 1 of the present study: "What do teachers notice about student performances? What are the ways teachers choose to address performance issues? How might these statements be categorized in order to describe the ways teachers use pedagogical content knowledge in their classrooms?" (p. 47). The expert teachers had a clear mental image of what they expected to hear and would have used modeling, comparisons, and questioning techniques to help students.

## NEED FOR THE STUDY

All of these researchers examined PCK in varying ways, but not the perceived sources of PCK. It might be useful for music teacher educators to know what in-service music teachers say about the acquisition of their PCK, particularly the self-perceived sources of specific PCK. "If educational researchers hope to influence the learning processes of teachers, we must also provide a representation of PCK that accurately reflects teachers' perspectives" (Lee & Luft, 2008, p. 1344). If there is to be any change in music teacher education with respect to PCK, it would be helpful to know what experiences, people, or materials influence the acquisition of PCK. Cochran et al. (1993) called for research into teacher preparation programs, including methods courses: "both theoretical research conducted from the perspective of the construction of knowledge, and applied research conducted with preservice and experienced teachers" (p. 17). Additionally, beyond Millican (2013), in which teachers viewed performances but did not interact with students, I sought to examine teachers' interactions with students and determine the perceived source of the demonstrated PCK.

## PURPOSE AND RESEARCH QUESTIONS

The purpose of this study was to replicate an investigation of preservice teachers (Haston & Leon-Guerrero, 2008) but with in-service teachers. Millican (2008) confirmed the applicability of Shulman's (1986, 1987) teacher knowledge base model to

music education. I examined the perceived sources of PCK used by in-service secondary band teachers. Research questions were:

1. Are there identifiable applications of PCK during in-service secondary band teachers' large ensemble rehearsals?
2. To what source—apprenticeship of observation, intuition, cooperating teacher, methods courses, or other—do in-service secondary band teachers attribute these applications of PCK?

## METHOD

I recruited participants for this multiple case study from a county school system in a southeastern state known for its highly competitive instrumental programs. According to Merriam (1998), case study is likely the best method to offer "intensive descriptions and analyses of a single unit or bounded system" (p. 19). A convenience (nonprobability) sample of five teachers participated. All participants were secondary school band teachers with 4 to 15 years of experience (see Table 1). Participants completed a questionnaire about their instrumental study history. They provided the number of years of participation in secondary and collegiate instrumental ensembles and private study and number of ensemble and private primary instrument teachers. The intent was to further investigate the multiple of sources of PCK and look for any apparent relationships between instrumental study history and self-perceived sources of PCK.

Each participant agreed to plan, teach, and video-record a 30-minute band rehearsal early in the second semester of the school year. Participants submitted the unedited videos for analysis. The school system allowed only one class to be recorded and required that it be early in the second semester. I viewed each video and created a log of applications of PCK based on previous PCK definitions or research models (Gohlke, 1994; Grossman, 1990; Haston & Leon-Guerrero, 2008; Kam Ho Chan & Hin Wai Yung, 2015; Millican, 2013; Shulman, 1986). I applied labels to each application (e.g., subdividing the pulse for steady tempo, technical facility exercise, synthesis-analysis-synthesis), if one or both of the following conditions were met: "(a) obvious verbal and physical reaction on the part of the teacher to student production of sound, and/or (b) pedagogical approaches that were directly embedded in musical actions and concepts" (Haston & Leon-Guerrero, 2008, p. 53). It was not enough for the teacher to display some sort of general pedagogical knowledge (e.g., directed questioning). The knowledge had to apply specifically to the music teaching context and the attempt to help students improve their performance and/or understand a musical concept. Following analysis of all five videos and confirmation of the list of PCK instances (Question 1), each participant viewed his or her video with me and engaged in a retrospective verbal protocol (Question 2). The process was identical to Haston & Leon-Guerrero (2008) and very similar to Kam Ho Chan and Hin Wai Yung (2015). For each identified application of PCK from the video, I asked (1) "Why did you stop the rehearsal?" and (2) "Do you recall where you learned that pedagogical technique?"

**Table 1**
Participant Background Information

| Name (pseudonyms) | Teaching experience | Years in school bands, secondary and college | Private study | Other background information |
|---|---|---|---|---|
| Curtis | 4 years, middle school band | 11 years, 7 directors | 7 years, 3 teachers | Only band director in the school; 10 instrumental teachers, 1 methods course teacher |
| Steve | 15 years, high school band | 12 years, 4 directors | 9 years, 3 teachers | One full-time and one part-time assistant director in the school, both with less experience than him |
| Ellen | 5 years as full-time assistant, high school band | 13 years, 8 directors | 12 years, 5 teachers | Attended world-renowned conservatory |
| Clark | 4 years, middle school band | 8 years, 6 directors | 10 years, 3 teachers | Had one full-time assistant director with less experience than him |
| Bob | 5 years in adjunct/ staff positions | 15 years, 7 directors | 12 years, 4 teachers | Nontraditional; two performance degrees and a masters with certification after 5 years of part-time teaching; private teachers included two principal players in major U.S. symphony orchestras; present study was 2 years after completing certification |

By asking the first question, I not only sought an answer to Question 1 but also wanted it to serve as a member check to increase credibility. A music education researcher and teacher educator not affiliated with me or the participants reviewed each video and my log of applications of PCK. There was 100% agreement on the identification of instances of PCK. Additionally, for transferability and credibility, I engaged in conversations with experienced music teacher educators and researchers throughout the study to seek additional perspectives, engaging in what Lincoln and Guba (1985) called peer debriefing.

## FINDINGS

During the protocol I asked Question 1, "Why did you stop the rehearsal?" Without exception, participants confirmed the researcher-identified applications of PCK.

While they might have used slightly different wording than me (e.g., "tonguing" instead of "articulation"), it is evident that there were identifiable applications of PCK. Confirming results of Haston and Leon-Guerrero (2008), the answer to Question 1 is yes, there are identifiable applications of PCK during in-service secondary band teachers' large ensemble rehearsals. As shown in Table 2, for each participant, some of the PCK applications were corrective, and others were instructive of a new concept.

**Table 2**
Identified Applications of Pedagogical Content Knowledge by Each Participant

| Participant (pseudonyms) | Pedagogical content knowledge applied | Sample quotes (to answer Question 2) |
|---|---|---|
| Curtis | Using the balance pyramid to explain/adjust balance<br>Directed questioning about note length<br>Vocal modeling of correct/incorrect note length<br>Buzzing without a mouthpiece to strengthen muscles<br>Buzzing to address home practice strategies<br>Rhythm work to improve sight reading<br>Counting rhythms to improve independence (no clapping)<br>Written counting system<br>Use of visual aid (rhythms on board)<br>Counting as a means to improve group pulse<br>Counting as a means to improve articulation<br>Counting as a means to improve balance<br>Individual and group assessment of counting<br>Playing rehearsed segments from memory (turn stands around) to allow for better self-assessment (not distracted by the printed music) | "I learned that in student teaching."<br>"My cooperating teacher did that every day."<br>"My college music ed. prof. taught us all how to fix that."<br>"I remember my high school band director using that method to fix pulse." |
| Steve | Restating rules of accidentals<br>Air-playing (blowing air away from instrument and fingering along)<br>Subdivided count-off to start<br>Rehearsed a segment at half-tempo for improved technical execution | "I learned that from my assistant."<br>"The director at [another high school] shared with me at a PD [professional development] meeting how she uses air-playing as a form of rehearsing." |

**Table 2**
*Continued*

| Participant (pseudonyms) | Pedagogical content knowledge applied | Sample quotes (to answer Question 2) |
|---|---|---|
| | Verbal reinforcement of articulation symbols<br>Modeling articulation<br>Direct questioning about enharmonics<br>Directed students to recognize a scalar pattern in the segment being rehearsed (for transfer of knowledge from scale practice)<br>Modeling fingerings<br>Synthesis-analysis-synthesis<br>Pointed out similarities in a pattern to make it more accessible<br>Checked pitch with an electronic tuner<br>Told sax player to drop jaw to lower the pitch<br>Peer modeling of a fingering<br>Embouchure and fingering check to aid bass clarinet player play high notes<br>Explained how to count an entrance on the second 16th note (16th rest followed by three 16th notes) | "I remember recognizing patterns when I was in middle school and I guess I just started pointing that out to my students at some point in my teaching."<br>"Our previous orchestra director suggested I try counting off with subdivision years ago."<br>"I remember learning to play all of the instruments in college and having to mess with my embouchure a lot so I use that with my students now." |
| Ellen | Student use of an electronic tuner<br>Ensemble tuned to Bb (for brass) and A (for woodwinds)<br>Called out a rehearsal number during sight reading (while ensemble was playing)<br>Explained cut time in relation to common time<br>Directed questioning about 3/2 time to transfer knowledge from cut time<br>Vocal modeling<br>Used cued notes to cover a missing part, as an aural aid to the rest of the ensemble<br>Slower tempo for better execution<br>Counted aloud while ensemble was playing<br>Alerted students to unison rhythms<br>Repetition of a segment | "My mentor teacher at the school down the road taught me this in my first year of teaching."<br>"I don't know. It just seems natural to model when rehearsing. I guess I've always known that."<br>"My high school teacher was notorious for repeating corrected sections of music. We called her 'Repeater!'" |

**Table 2**
*Continued*

| Participant (pseudonyms) | Pedagogical content knowledge applied | Sample quotes (to answer Question 2) |
|---|---|---|
| Clark | Posture check<br>Pointed at own eyes to remind students to watch the conductor<br>Pointed at own ears to remind students to listen to pitch<br>Told brass players to alter tongue and oral cavity to adjust pitch on inherently bad notes<br>Use of subdivision to perform a ritardando<br>Modeled a lift in conducting to show style<br>Synthesis-analysis-synthesis<br>Repetition of a segment<br>Transfer of prior knowledge to a new context<br>Rehearsed varied ritardandos to make students watch<br>Made students write performance reminders on their printed music<br>Subdivision of long notes for tempo<br>Air-playing (blowing air away from instrument and fingering along)<br>Percussion accompaniment's effect on soloist's entrance | "My methods teacher insisted that we insist on good posture. It's been one of my things ever since."<br>"I learned all of my conducting from watching my high school band director."<br>"I struggled big time with a ritardando in a Sheldon piece a few years ago. I finally tried subdividing and it worked! Don't think I learned that from anyone, just from the frustration of having tried so many other things." |
| Bob | Work to align articulation<br>Importance of students listening to one another<br>Vowels to shape oral cavity and affect tone color<br>Subdivision in cut time<br>Use of metronome with emphasis on the upbeat to internalize pulse<br>Long tones as exercise to extend brass range<br>Rest-play-rest (to improve brass endurance)<br>Looping one note to improve the beginning of the note<br>Teacher modeling of articulation<br>Directed questioning<br>Student self-assessment<br>Taught dissonance in order to improve consonance | "My trumpet teacher helped me with articulation a lot so I use his techniques with my students."<br>"A colleague I taught marching band with used a metronome on the upbeat in every rehearsal. I started trying it with my students and it works great."<br>"My high school teacher always asked us to critique ourselves before he did. I kind of got tired of it and sometimes just wanted the answer. I'm sure he's laughing somewhere now because I do it with my students all the time!"<br>"I had a lesson with [teacher] and learned most of my articulation tricks from him." |

**Table 2**
*Continued*

| Participant (pseudonyms) | Pedagogical content knowledge applied | Sample quotes (to answer Question 2) |
|---|---|---|
| | First note sound quality for entire phrase<br>Aural image prior to playing<br>Pinching of embouchure resulting in poor tone<br>Opening throat to improve tone and airspeed<br>Analogy of water through a hose<br>Tongue position related to efficient breathing<br>Aural training to aid practice of 16th note passages<br>Practice short, specific segments that need work, then play entire piece<br>Pull out tuning slide to force air support | |

I asked Question 2 about each agreed upon application of PCK ("Do you recall where you learned that pedagogical technique?"). Each participant attributed each application of PCK to one or more sources. I coded answers using categories from Haston and Leon-Guerrero's (2008) study:

> *Intuition* is unattributable PCK or independent creative thought, *apprenticeship of observation* is the internalization of teaching models during time spent as pupils (Lortie, 1975), *methods courses* are required music teacher training program education courses, and *cooperating teacher* refers to contact with cooperating teacher while student teaching (Haston & Leon-Guerrero, 2008, p. 51).

I also included Haston and Leon-Guerro's (2008) *other* category "to account for responses that referred to books or workshops" (p. 53). Additionally, I added the category of *peers or colleagues* to account for several responses from participants who referenced acquiring specific PCK from their teaching peers or colleagues ("Our choir teacher does that all the time" [Curtis]; "My assistant band director taught me that" [Clark]). Sometimes the participants referred to specific people (cooperating teacher), and other times I applied an appropriate label such as apprenticeship of observation to a participant's response (e.g., "My private teacher used that trick all of the time"). The intuition label came about in the 2008 study as a result of comments such as "Not sure where I learned that" and "I just figured that out myself." Four of five participants in the present study had identical and similar responses. See Table 3.

**Table 3**
Self-Perceived Sources of Pedagogical Content Knowledge (in Percentages)

| Participant | Apprenticeship of observation | Intuition | Cooperating teacher | Methods courses | Peers or colleagues | Other |
|---|---|---|---|---|---|---|
| Curtis | 18 | 0 | 45 | 18 | 9 | 9 |
| Steve | 11 | 39 | 0 | 6 | 44 | 0 |
| Ellen | 20 | 33 | 6 | 0 | 33 | 7 |
| Clark | 33 | 28 | 0 | 33 | 6 | 0 |
| Bob | 62 | 10 | 0 | 5 | 14 | 9 |

I reviewed the instances of applied PCK in Table 2 and created subcategories. Table 4 displays the number of instances of each PCK subcategory and the teachers' perceived source(s) of that knowledge.

## DISCUSSION

### *Individual Cases*

Curtis had two main goals in his middle school band rehearsal—(a) individual tone and ensemble balance and (b) sight reading rhythms. Contrary to the other four participants, he overwhelmingly attributed his application of PCK to his cooperating teacher (45%); apprenticeship of observation and methods courses were equal seconds (18% each) and peers or colleagues and other sources were equal thirds (9% each). Intuition accounted for none of the PCK instances. Three of the other four participants relied heavily on intuition. Curtis's cooperating teacher apparently had a substantial effect on his PCK acquisition. It is atypical in this study that none of Curtis's PCK comes from intuition. It is feasible that in this particular lesson that was an accurate self-perception, or it might suggest that Curtis felt compelled to attribute some identifiable source. This could be a lack of self-confidence (unwilling to acknowledge that he could come up with PCK on his own) or an artifact of the question "Do you recall where you learned that particular technique?" Perhaps the question did not allow for self-attributed PCK. Curtis had 10 instrumental teachers and one collegiate methods course teacher. He attributed equal amounts of PCK to these two groups. It is possible his cooperating teacher taught him many of the same things as his instrumental and methods course teachers, but the strong connection Curtis has to his cooperating teacher caused him to attribute nearly half of his PCK to that cooperating teacher. It is equally possible that the cooperating teacher did provide Curtis with all of this new PCK, in which case future researchers should observe and conduct research with that highly influential cooperating teacher in order to gather and disseminate information to help all cooperating teachers, student teachers, and university supervisors.

Steve was able to touch on several things during his high school band rehearsal as opposed to focusing on one or two concepts. He relied heavily on PCK learned from

**Table 4**
PCK Subcategories and Number of Instances

| PCK subcategory | Number of instances | PCK source* | | | | | |
|---|---|---|---|---|---|---|---|
| | | AofO | Int | Coop | MC | PorC | Oth |
| Modeling | 5 | 3 | — | 1 | — | 1 | — |
| Questioning | 5 | 1 | 2 | 1 | 1 | — | — |
| Mouthpiece buzzing | 2 | 2 | — | — | — | — | — |
| Writing on board | 2 | — | 1 | 1 | — | — | — |
| Clapping | 1 | 1 | — | — | — | — | — |
| Counting/ subdividing | 8 | 4 | 1 | 2 | — | 1 | — |
| Playing from memory | 1 | — | — | 1 | — | — | 1 |
| Verbal (definitions, explanations, instructions) | 7 | 2 | 1 | 3 | 1 | — | — |
| Air playing | 2 | 2 | — | — | — | — | 2 |
| Slowing down for practice | 2 | — | 1 | 1 | — | — | — |
| Transfer | 5 | — | — | — | 3 | 1 | 1 |
| Synthesis-analysis-synthesis (whole-part-whole) | 3 | — | — | — | 3 | — | — |
| Electronic tuner | 2 | 1 | — | 1 | — | — | — |
| Embouchure/oral cavity guidance | 7 | 3 | — | 3 | — | 1 | — |
| Peer modeling | 1 | — | — | — | — | 1 | — |
| Repetition | 4 | 1 | — | 1 | 2 | — | — |
| Posture check | 1 | — | — | 1 | — | — | — |
| Exercises to watch the conductor | 2 | — | — | 2 | — | — | 1 |
| Modeled/explained a conducting gesture | 1 | — | — | 1 | — | — | — |
| Write reminders in music | 1 | 1 | — | — | — | — | — |
| Listening/relation of parts or musical lines | 3 | — | 1 | 1 | 1 | — | — |
| Metronome for pulse | 1 | 1 | — | — | — | — | — |
| Long tones | 1 | — | — | — | — | 1 | — |
| Self assessment | 1 | — | — | — | — | 1 | — |
| Dissonance to improve consonance | 1 | — | — | — | — | 1 | — |
| Aural image prior to playing | 1 | 1 | — | — | — | — | — |
| Adjust tuning slide | 1 | — | — | 1 | — | — | — |
| Use of analogy | 1 | — | — | — | 1 | — | — |

*AofO = apprenticeship of observation; Int = intuition; Coop = cooperating teacher; MC = method course; PorC = peers or colleagues; Oth = other. Participants sometimes recalled more than one source for instances of PCK.

his peers or colleagues (44%) and his intuition (39%), very little on apprenticeship of observation (11%), and not at all on his cooperating teacher or other sources. It is apparent that he learned much of his PCK from observing peers (in schools, at conferences, during All-State rehearsals) and relied equally on his intuition as a musician and teacher. It is possible that Steve learned much from his cooperating teacher, ensemble directors, or collegiate methods course instructor and that knowledge was reinforced by peers and colleagues, but the time that had passed since his interactions with the cooperating teacher, directors, and college instructor mitigated any attribution of his PCK to them. It is of course also feasible he learned very little from them and has proactively learned from peers and colleagues and developed intuitive skills. A future individual case study with Steve could elucidate this.

Ellen practiced sight reading for most of her high school band rehearsal and then took some time to rehearse and reread portions of the music. She attributed her PCK equally to peers or colleagues and intuition (33% each), a fair portion to apprenticeship of observation (20%), very little to other or cooperating teacher, and none to methods courses. Ellen attributed much of her PCK to her daily observations of her colleague, the band director. It could be that her PCK from apprenticeship of observation is a result of studying and rehearsing with 13 music teachers. Her strong musicianship skills (acquired through study at a world-renowned music conservatory) and ability to learn from observing others possibly helped her develop the intuitive skills to which she attributed one third of her PCK. She reported a small amount of PCK was from her cooperating teacher and none from her collegiate methods course instructor. She was only 5 years removed from her student teaching experience and was more likely to remember learning specific PCK from her cooperating teacher than Steve, who was 15 years removed, yet she still credited her cooperating teacher for very little PCK in this lesson. This could potentially be different in other lessons or that her strong reliance on her colleague and her intuition caused her to misattribute the source of her PCK. Ellen was the only participant of the five to not attribute any of her PCK to her methods courses. Despite attending a world-renowned music conservatory, she could not recall learning any of the PCK demonstrated in this lesson from her collegiate methods course instructor. Again, this might be different over multiple lessons.

Clark spent time training his middle school band students to watch him for tempi, ritardandos, pitch guidance (pointing to his ears to suggest to students they were out of tune and should listen more closely), phrasing, and breathing. He also employed a synthesis-analysis-synthesis approach to help the ensemble with subdivision and entrances in the correct tempo. He attributed his PCK from this lesson almost equally to apprenticeship of observation (33%), methods courses (33%), and intuition (28%). Clark and Curtis were the only participants to attribute a significant amount of PCK to methods courses (other participants ranked this category at 6% or less). Clark's perceived attributions suggest none of the PCK implemented during this lesson came from his cooperating teacher.

It is conceivable that a future individual case study with Clark could reveal instances of PCK that he attributes to his cooperating teacher. The strategies apparently came from observing his teachers over the years and his collegiate methods course instructor. He also relied on his intuition, perhaps developed through years of apprenticeship of observation and lessons from his collegiate methods course instructor.

Bob rehearsed a middle school band and helped students with various concepts—oral cavity's effect on pitch, subdivision for tempo accuracy, range extension for brass players, and articulation. His PCK attributions were the most disproportionate of all participants—62% for apprenticeship of observation, with no other source higher than 14% (peers or colleagues). He relied on intuition for 10% of the PCK in this lesson, other (specifically, books) for 9%, methods courses for 5%, and cooperating teacher for none. After two performance degrees, Bob completed a master of music education degree with certification. For health reasons Bob decided to not seek full-time employment as a school music teacher. This study, and the recorded lesson, occurred 2 years after the completion of his certification. At least with respect to this recorded lesson, Bob credits his music teachers and teaching colleagues with most of the PCK he applied, while drawing very little from other sources—and none from his cooperating teacher. It is interesting to wonder if Bob's experience with multiple colleagues and private teachers trumped whatever experience he had with his cooperating teacher. It is possible Bob was already well set in his teaching ways (through years of atypical apprenticeship of observation) by the time he student taught. Bob would make for a very interesting future case study.

### *Comparisons Across Cases*

As the primary source of PCK, one participant reported apprenticeship of observation, one reported apprenticeship of observation and methods courses equally, one reported intuition and peers or colleagues equally, one reported peers or colleagues, and one reported cooperating teacher (see Table 3). Three of five participants reported only 0–6% of PCK from methods courses, supporting findings of Hodges (1982) and Leonhard (1988). There was no apparent relationship between years of experience (and therefore time passed since the methods courses) and attribution to methods courses. Four of five participants attributed 0–6% of PCK from a cooperating teacher, contradicting Conway (2002), in which participants highly valued their student teaching experiences. Again, there was no apparent relationship between years of experience (and therefore time passed since student teaching) and attribution to cooperating teacher. Three of five participants reported high attribution for intuition. It is unclear why this was the case. There are no obvious similarities between the three participants to suggest any connections. Perhaps, as noted below, the methods course provided these participants with the intuition to develop their own PCK in the moment, as opposed to providing them specific PCK.

Apprenticeship of observation was the only source with all double-digit percentages of attribution, including the highest percentage in the study, 62% (Bob), furthering the research and findings of Lortie (1975) and many others. Bob received two performance degrees and taught in adjunct roles before his teaching certification. Perhaps these additional years of private study and teaching contributed notably to his PCK acquisition by way of apprenticeship of observation more than for the other participants. Apprenticeship of observation can also result in learning less effective teaching strategies or inappropriately applying observed PCK. "Teaching as you were taught" is a common phrase that can certainly be pejorative and can make it more difficult for teachers to gain new knowledge and skills or develop forward thinking about the profession of music teaching. Two of five participants reported high attribution for peers. Interestingly, these were the only two participants with music colleagues in their school buildings. This could add to the argument against being an isolated, single music teacher in a building—it might inhibit professional growth and development of PCK.

From the perspective of subcodes and subcategories, the most frequently implemented instances of PCK were: counting/subdividing (eight instances), verbal (seven instances), embouchure (seven instances), modeling (five instances), questioning (five instances), transfer (five instances), repetition (four instances), synthesis-analysis-synthesis (three instances), and listening (three instances; all others had one or two instances, see Table 4). These findings are similar to Millican (2013) and Worthy and Thompson (2009). Of these 47 instances, participants attributed 14 to apprenticeship of observation, 12 to cooperating teacher, 11 to methods courses, five to intuition, four to peers or colleagues, and one to other. This perspective (subcodes and subcategories) supports overall findings that two of the participants reported apprenticeship of observation most often and two others reported it the second most (see Table 3).

Table 5 shows the ranges, means, and medians for Haston and Leon-Guerrero's (2008) study with preservice teachers and the present study with in-service teachers. It is interesting to note that the only self-perceived source of PCK that is substantially different is apprentice of observation in favor of in-service teachers and that preservice teachers reported more cooperating teacher and methods course as self-perceived sources. This seems logical, as in-service teachers have more years of learning by observing and are further removed from cooperating and methods course teachers' influence and these experiences are much more recent for preservice teachers.

### *Methods Courses*

Previous researchers (e.g., Ballantyne & Packer, 2004) called for redesigned methods courses in order to provide preservice music teachers more support for the development of PCK and skills. Perhaps, then, it is appropriate to reconsider the framework of PCK in relation to methods courses altogether. Researchers and methods course instructors might consider reframing methods courses as means rather than an ends. That is to say

**Table 5**
Preservice* Versus In-service Teachers

| | Range (%) | | Mean (%) | | Median (%) | |
|---|---|---|---|---|---|---|
| | Preservice | Inservice | Preservice | Inservice | Preservice | Inservice |
| AofO | 19–32 | 11–62 | 26.5 | 28.8 | 25 | 20 |
| Int | 0–40 | 0–39 | 20.4 | 22 | 20 | 28 |
| Coop | 0–56 | 0–45 | 25 | 10.2 | 22 | 0 |
| MC | 12.5–40 | 0–33 | 25.25 | 12.4 | 22 | 6 |
| PorC** | — | 6.44 | — | 21.2 | — | 14 |
| Oth | 0–10 | 0–9 | 1.6 | 3.2 | 0 | 0 |

*Preservice data from Haston and Leon-Guerrero, 2008.
**Peers or colleagues was not part of the Haston and Leon-Guerrero (2008) study.

that methods courses may need only to develop students' musical and teaching intuitions (means) so that they can call upon this intuition to generate new PCK (new to them, even if it is "old" to someone else) in teaching situations, not simply recall PCK learned in the methods course (ends). Dewey (1910/1997) defined intuition as "the funded outcome of long familiarity with like operations in the past" and "the ability to seize what is evidential or significant and to let the rest go" (p. 104) to bring new and immediate insights. Jorgensen (2008) applied this to teaching: "We make rather immediate and instinctual assessments and decisions about what to do based on how the performance is going," and stated that teachers must "develop this ability to grasp holistically what is happening and needs to happen" (p. 239). "They are true judgments because they are based on intelligent selection and estimation, with the solution of a problem as the controlling standard" (Jorgensen, 2008, p. 105). Perhaps the role of methods courses and methods course instructors is to develop preservice teachers' intuition—the skills and knowledge to make intelligent selection and estimation and problem solve based on familiarity with similar situations in the past (referred to earlier as the generation of new PCK). If Hashweh (2005) is correct that PCK can only develop over time anyway, then the methods courses and instructors can *only* help develop intuition, not PCK.

Realistically, methods courses likely provide both numerous types of PCK as well as the intuition to generate one's own PCK in future teaching episodes. If this is true, it is possible that participants in this study relied on intuition without being aware, falsely attributing the source of their PCK to something other than methods courses, when in fact the methods course supplied the intuition to develop new PCK. In the future, I plan to investigate this potential uncoupling of acquisition and generation of PCK in methods courses. Additionally, as in Berg and Sindberg (2014), it is feasible the participants in this study encountered external factors that inhibited their opportunities and/or abilities to implement PCK learned in the methods courses. Future researchers could reframe a study of PCK source attribution with this in mind.

One must also consider that "methods course" inherently includes the professor, the content, how content is delivered, how the course is structured, and how much field experience in authentic context learning experiences is required (Haston & Russell, 2012), among a multitude of variables that are context dependent. It is reasonable to believe that a 1-year methods course sequence would be more beneficial than a one-semester course, and that the inclusion of extensive and varied authentic context learning experiences would result in more PCK or more ability to generate one's own PCK. Frequent teaching episodes and regular feedback (from a variety of sources) will help students convert subject matter knowledge and general pedagogical knowledge into PCK, turning theory into practice.

## IMPLICATIONS AND FUTURE RESEARCH

The current study does not entirely affirm or contradict previous findings (Ballantyne & Packer, 2004; Berg & Sindberg, 2014; Gohlke, 1994; Haston & Leon-Guerrero, 2008; Millican, 2013). It demonstrates the need for additional research in multiple and varied contexts with multiple and varied research designs. The study was also limited to participants teaching in competitive secondary band programs, an artifact of the convenience (nonprobability) sampling, and therefore subject to selection bias and sampling error. The isolated video segments used for the current study may or may not be representative of the overall PCK instances or perceived sources of these participants across longer or more teaching episodes. It would improve credibility for future researchers to collect and analyze several teaching videos with participants. Additionally, Yinger (1986) noted the limitations of retrospective verbal protocol analysis, in particular that the method is reliant upon the participants accurately remembering what he or she was thinking at the time of the teaching episode being investigated. Still, the method is preferable to concurrent reporting, in which participants vocalize their thought processes while making teaching decisions, and is equally limited because it "would lead to incredibly distorted classroom processes even if this complex combination of self-monitoring, reporting, and acting would be psychologically possible" (Yinger, 1986, p. 267; see also Trickett & Trafton, 2009). To answer Question 1, participants had the video stimulus in order to confirm or reject the instances of PCK I identified and aid their retrospective verbal recall. Question 2 was open-ended and required no retrospective verbal recall.

I approached the study from a positivist viewpoint, first seeking to confirm the presence of instances of PCK and then asking specifically about the self-perceived source of said PCK. For Question 1, participants were free to disagree with my identifications of instances of PCK and present new or context-specific information (even though none of the participants did disagree, giving the appearance of a strict, didactic approach). Future researchers might consider having participants identify instances of PCK themselves. This might produce different data than the approach I used here (participants confirmed instances that I identified first). As posted to participants, the second ques-

tion was open-ended: "Do you recall where you learned that pedagogical technique?" Participants were free to offer any answer, unaware of my intention to code their responses into five a priori categories, and in fact their answers lead to the creation of a sixth category. The opportunity to disagree for Question 1, the open-ended Question 2, and the subsequent creation of a sixth category arguably hints toward flexibility, as does my coding and interpretation of the data from the retrospective verbal protocol analysis, but I acknowledge that some may view my approach as positivist. The results are not intended to be widely generalizable or didactic, merely informative of concepts and perspectives teacher educators should ponder.

Participants reflected upon the research process and expressed fascination with thinking about their teaching in this way. "I have never thought about this before. It's very interesting" (Bob). They expressed eagerness to reflect about their PCK in the future and anticipated the positive impacts this type of metacognition will have on their teaching. "I plan to keep thinking about this" (Ellen). "This process of self-reflection and thinking about where I learned things has already changed how I think about my teaching" (Steve). It seems as though the reflective process allowed them to learn more about their teaching and their students' learning, supporting the findings of Sherin (2002).

The categories from Haston and Leon-Guerrero (2008) held true (apprenticeship of observation, intuition, cooperating teacher, methods, and other), with the necessity of adding one category, peers or colleagues. While it is possible that preservice teachers can cite peers or colleagues as sources of PCK, it is not surprising that in-service teachers cited peers or colleagues and precipitated the addition of this category. The in-service teachers certainly had more opportunities to work with and learn from peers or colleagues than did the preservice participants. Wilhelm, Chen, Smith, and Frank (2016) found that in-service teachers' ability to improve student achievement was significantly related to advice seeking from peers. Future researchers might attempt to account for the number of teaching jobs (hence potential peers or colleagues) that in-service teachers have had and investigate the relationship between that and cited sources of PCK. Additionally, as in Haston and Leon-Guerrero (2008, p. 58), "the roles of beliefs, philosophy, socialization, and personal histories" significantly impact teacher educators, preservice teachers, and in-service teachers with respect to PCK.

Knowing that these in-service teachers attributed little or no PCK to his or her undergraduate music teacher educators could meaningfully affect teacher educators' planning, course content, or required preservice field experiences. Conway, Krueger, Robinson, Haack, and Smith (2002) discussed the importance of induction and mentoring. Perhaps music teacher educators could conduct PCK research similar to the present study, become involved in induction and mentoring beyond the undergraduate years, and continue to influence the acquisition of PCK. This type of longitudinal work, both research- and practitioner-based, could influence the pedagogy and philosophies of music teacher educators as well as guide self-reflection for in-service teachers.

New teacher evaluation programs and Teacher Performance Assessment (edTPA) make self-reflection and the reconsideration of PCK an increasingly relevant and important topic for music teacher education research. It is reasonable to expect that more frequent and overt references to PCK delivery and assessment are to come. While policy makers and researchers in other subject areas may also be considering PCK in teacher evaluation, the professionals in the area of science have seemingly published the most about it. For example, Hagevik et al. (2010) detailed how PCK was included in the 2003 National Science Teachers Association Standards for Science Teacher Preparation, including suggestions for how administrators of teacher preparations programs can document it. Park and Oliver (2008) wrote about PCK as one way to examine teachers as professionals, in a way seeking to legitimize the teaching profession. Many other subject areas have standards, including the Common Core State Standards and Core Arts Standards. Many state teacher certification programs and teacher training programs also have detailed requirements and standards. It is possible these entities include the construct of PCK implicitly without using the label as science representatives have chosen to. It might be in the best interest of teacher educators to explicitly use the label, detail how they are delivering to and assessing it of preservice teachers, and advocate for its use by accrediting agencies and state departments of education. Similarly, public, private, and charter school administrators must support the development and assessment of in-service teachers' PCK (Conway, 2002; Conway et al., 2002).

Future researchers might conduct longitudinal studies of teachers with varied years of experience and in various settings. Researchers could revisit participants years later and assess PCK source attribution again. It might prove useful to account for the amount of time passed since participants' last methods courses and mentorship of cooperating teachers as well as the amount and type of professional development as in-service teachers. Similar to researchers in other academic areas, music teacher education researchers could gather data with multiple lesson observations, videos, and reflective journals (Cavin, 2007; Gohlke, 1994; Kam Ho Chan & Hin Wai Yung, 2015; Kellogg, 2010; Lee & Luft, 2008; O'Hanlon, 2010) as well as lesson plan analysis (Lee & Luft, 2008; Özden, 2008; Van der Valk & Broekman, 1999; Vermette & Gattuso, 2014). In-service teachers implement PCK (almost) constantly in their daily work. There is much data for researchers to collect and analyze and a need to develop valid, reliable, trustworthy, and transferrable tools to assess PCK. Part of that assessment must include a consideration of the PCK source in order to improve delivery of PCK (acquisition) or the development of intuition in order to generate one's own PCK.

## REFERENCES

Ball, D. L. (1991). What's all this talk about "discourse"? *Arithmetic Teacher, 39*(3), 44–48.

Ballantyne, J., & Packer, J. (2004). Effectiveness of preservice music teacher education programs: Perceptions of early-career music teachers. *Music Education Research, 6*(3), 299–312. doi:10.1080/1461380042000281749

Berg, M. H., & Sindberg, L. K. (2014). Supports for and constraints on comprehensive musicianship through performance-based student teaching. *Bulletin of the Council for Research in Music Education, 201*, 61–77. doi:10.5406/bulcouresmusedu.201.0061

Bremmer, M. (2015). The role of the teacher's body in music education: Pedagogical content knowledge viewed from an embodied cognition perspective. *International Yearbook for Research in Arts Education, 3,* 48–53.

Cavin, R. M. (2007). *Developing technological pedagogical content knowledge in preservice teachers through microteaching lesson study* (Doctoral dissertation). Available from ProQuest Dissertations and Theses Abstracts. (3301531)

Cochran, K., DeRuiter, J., & King, R. (1993). Pedagogical content knowing: An integrative model for teacher preparation. *Journal of Teacher Education, 44*(4), 263–272.

Conway, C. M. (2002). Perceptions of beginning teachers, their mentors, and administrators regarding preservice music teacher preparation. *Journal of Research in Music Education, 50*, 20–36.

Conway, C. M., Krueger, P. J., Robinson, M., Haack, P., & Smith, M. V. (2002). Beginning music teacher induction and mentoring: A cross-state perspective. *Arts Education Policy Review, 104*(2), 9–17.

Dewey, J. (1997). *How we think*. Toronto, ON: Dover Publications. (Original work published 1910)

Gohlke, L. J. (1994). *The music methods class: Acquisition of pedagogical content knowledge by preservice music teachers* (Doctoral dissertation). Available from ProQuest Dissertations and Theses Abstracts. (9504621)

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York, NY: Teachers College Press.

Gudmundsdottir, S. (1990). Values in pedagogical content knowledge. *Journal of Teacher Education, 41*(3), 44–52.

Hagevik, R., Veal, W., Browstein, E. M., Allan, E., Ezrailson, C., & Shane, J. (2010). Pedagogical content knowledge and the 2003 Science Teacher Preparation Standards for NCATE Accreditation or State Approval. *Journal of Science Teacher Education, 21*, 7–12. doi:10.1007/s10972-009-9155-6

Hashweh, M. Z. (2005). Teacher pedagogical constructions: A reconfiguration of pedagogical content knowledge. *Teachers and Teaching: Theory and Practice, 11*(3), 273–292.

Haston, W., & Leon-Guerrero, A. (2008). Sources of pedagogical content knowledge: Reports by preservice instrumental music teachers. *Journal of Music Teacher Education, 17*(2), 48–59.

Haston, W., & Russell, J. (2012). Turning into teachers: Influences of authentic context learning experiences on occupational identity development of preservice music teachers. *Journal of Research in Music Education, 59*, 369–392. doi:10.1177/0022429411414716

Hill, H. C., Loewenberg Ball, D., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education, 39*, 372–400.

Hodges, C. (1982). Implementing methods: If you can't blame the cooperating teacher who can you blame? *Journal of Teacher Education, 33*(6), 25–29.

Jorgensen, E. R. (2008). *The art of teaching music*. Bloomington: Indiana University Press.

Kam Ho Chan, K., & Hin Wai Yung, B. (2015). On-site pedagogical content knowledge development. *International Journal of Science Education, 37*, 1246–1278. doi:10/1080.0500693.2015.1033777

Kellogg, M. S. (2010). *Preservice elementary teachers' pedagogical content knowledge related to area and perimeter: A teacher development experiment investigating anchored instruction with web-based microworlds* (Doctoral dissertation). Available from ProQuest Dissertations and Theses Abstracts. (3424398)

Lee, E., & Luft, J. A. (2008). Experienced secondary science teachers' representation of pedagogical content knowledge. *International Journal of Science Education, 30*, 1343–1363. doi:10.1080/09500690802187058

Leonhard, C. (1988). Methods courses in music education. In J. T. Gates (Ed.), *Music education in the United States: Contemporary issues* (pp. 191–201). Tuscaloosa: University of Alabama Press.

Lincoln, Y. S., & Guba, E. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage Publications.

Lortie, D. (1975). *Schoolteacher: A sociological study*. Chicago, IL: University of Chicago Press.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*: *Revised and expanded from case study research in education*. San Francisco, CA: Jossey-Bass.

Millican, J. S. (2008). A new framework for music education knowledge and skill. *Journal of Music Teacher Education, 18*(1), 67–78. doi:10.1177/1057083708323146

Millican, J. S. (2013). Describing instrumental music teachers' thinking: Implications for understanding pedagogical content knowledge. *UPDATE: Applications of Research in Music Education, 31*(2), 45–53.

O'Hanlon, W. A. (2010). *Characterizing the pedagogical content knowledge of pre-service secondary mathematics teachers* (Doctoral dissertation). Available from ProQuest Dissertations and Theses Abstracts. (3485930)

Özden, M. (2008). The effect of content knowledge on pedagogical content knowledge: The case of teaching phases of matters. *Educational Sciences: Theory & Practice, 8*, 633–645.

Park, S., & Oliver, J. S. (2008). Revising the conceptualization of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education, 38*, 261–284.

Sherin, M. G. (2002). When teaching becomes learning. *Cognition and Instruction, 20*(2), 119–150.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–21.

Trickett, S. B., & Trafton, J. G. (2009). A primer on verbal protocol analysis. In D. Schmorrow, J. Cohn, & D. Nicholson (Eds.), *The PSI handbook of virtual environments for training and education* (Vol. 1, pp. 332–346). Westport, CT: Praeger Security International.

Van der Valk, T., & Broekman, H. (1999). The lesson preparation method: A way of investigating pre-service teachers' pedagogical content knowledge. *European Journal of Teacher Education, 22*(1), 11–22.

Vermette, S., & Gattuso, L. (2014). High school teachers' pedagogical content knowledge of variability. In K. Makar, B. de Sousa, & R. Gould, (Eds.), *Sustainability in statistics education. Proceedings of the Ninth International Conference on Teaching Statistics* (pp. 1–6). Voorburg, The Netherlands: International Statistical Institute.

Wilhelm, A. G., Chen, I-C., Smith, T. M., & Frank, K. A. (2016). Selecting expertise in context: Middle school mathematics teachers' selection of new sources of instructional advice. *American Educational Research Journal, 53*(3), 456–491.

Worthy, M. D., & Thompson, B. L. (2009). Observation and analysis of expert teaching in beginning band. *Bulletin of the Council for Research in Music Education, 180*, 29–41.

Yinger, R. J. (1986). Examining thought in action: A theoretical and methodological critique of research on interactive teaching. *Teaching & Teacher Education, 2*(3), 263–282.