TPACK Goes to Sixth Grade: Lessons from a Middle School Teacher in a High-Technology-Access Classroom

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Abstract

This is a qualitative study addressing the question: In what ways does a sixth grade middle school teacher show evidence of behaviors that fit the Technological Pedagogical Content Knowledge (TPACK) framework in the classroom? The researcher observed in this class, interviewed the teacher, and looked for evidence of the interplay between components of the framework. This teacher's class was particularly appropriate for this study because she was an experienced teacher her school district selected to pilot a classroom with many technologies, including one laptop for each student. Applying the TPACK theoretical framework to her classroom helps us better understand how the framework is translated into practice. Findings indicate that the teacher provided a foundation for the use of technology in content (language arts) and pedagogy (project-based learning). The teacher demonstrated technological pedagogical knowledge through well-planned classroom management practices as well as the interplay between components of the framework. Recommendations include the use of the TPACK framework as a lens for classroom observation and the need for additional cases to be used in professional development. (Keywords: TPACK, middle school, technology integration, teacher education)

The Technological Pedagogical Content Knowledge (TPACK) framework represents a new way of thinking about preparing teachers to teach and learn with technology. Although many educators helped to develop ideas that led to the framework, Mishra and Koehler (2006) formulated it in a clear and persuasive manner. In part, TPACK is a conceptual tool that may assist teachers in planning lessons that integrate technology. When applied, the framework requires equal attention to technology, pedagogy, and content as they are used in service of learning objectives. Leaders in teacher preparation for technology integration have helped educators gain a better understanding of the use of the TPACK framework in different content areas (SIGTE leaders and NTLS Program Committee, 2008). Teacher educators argue that TPACK can provide a framework for teacher preparation that leads to effective K–12 student learning in content areas.

In addition to its use preparing teachers, the TPACK framework is becoming an increasingly important tool for researching technology integration in preservice and inservice education. For example, a tally of the presentations in the TPACK strand of the teacher education theme at the 2011 Society for Information Technology and Teacher Education (SITE) conference revealed 32 sessions with 71 presenters. The TPACK framework may help professional developers and teachers make rich connections among technology, the subject matter, and pedagogical choices. However, a review of 20 articles published in peer reviewed print journals from 2006 through 2009 with TPACK in the title or key terms found that contextual information about the studies was limited. Thus, the articles provided a theoretical understanding rather than illuminating its effectiveness in "real-life" K–12 classrooms (Kelly, 2010, p. 3887). Further, in their introduction to the TPACK theme issue of TechTrends, Polly and Bantley-Dias (2009) called for studies in K–12 classrooms that use the TPACK framework based on classroom observations, videotaping of teaching, and analysis of classroom artifacts rather than self-reported data. This study was conceived to help us understand the use of the TPACK framework during teaching—that is, in the real life of a sixth grade teacher and her students. It reports on the work of one teacher, Ms. Marshall, and her sixth grade students' learning about the Renaissance, told through the lens of the TPACK framework.

Theoretical Framework

TPACK (Mishra and Koehler, 2006) builds on Shulman's (1986, 1987) Pedagogical Content Knowledge (PCK) framework. Shulman explained that pedagogical knowledge refers to the broad principles and strategies of classroom management and organization and involves lesson planning and implementation, teaching methods, and assessment. Content knowledge is the knowledge of the subject matter curriculum including key concepts, facts, and procedures. Pedagogical content knowledge refers to how to teach particular content to make it understandable. The intersecting domains of content knowledge and pedagogical knowledge provide the key to successfully teaching in a disciplinary area. Recently, the National Council for Accreditation of Teacher Education (NCATE) affirmed the coupling of content and pedagogy, theory, and practice as a core principal of the redesign of teacher preparation (NCATE, 2010). To this framework, Mishra and Koehler (2006) added the domain of knowledge of technology, which includes the working knowledge and skills needed to use technologies. The key to successful teaching is not
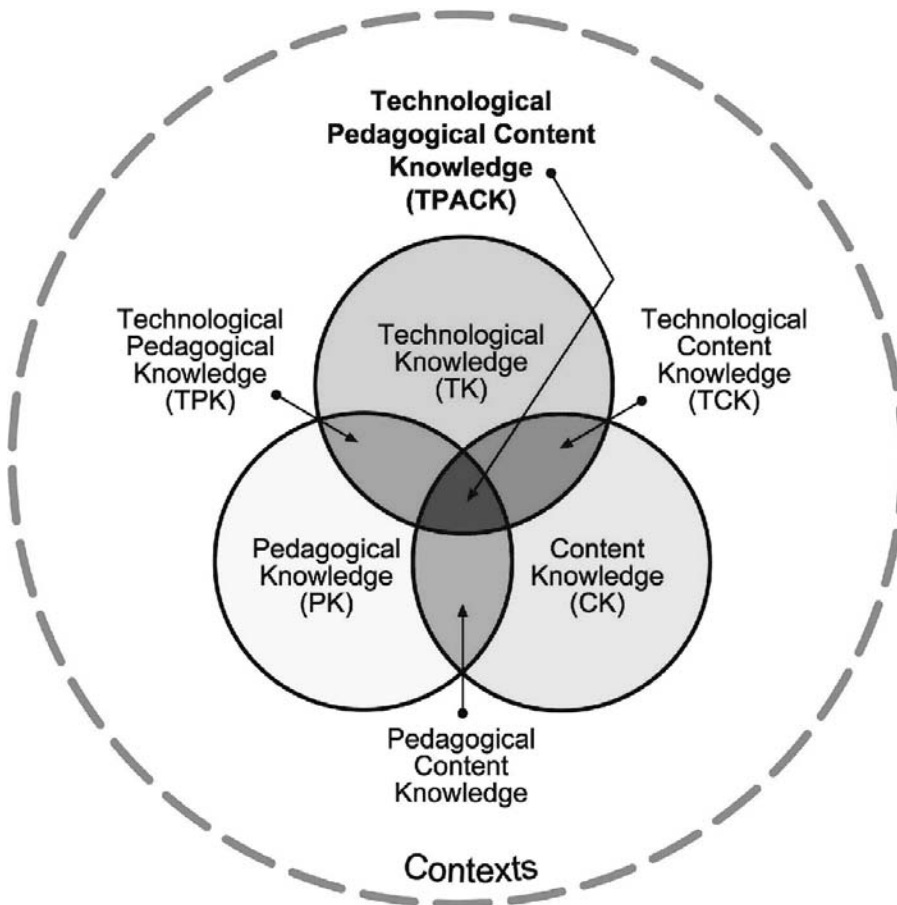
Figure 1. Interweaving technology, content, and pedagogy through the TPACK framework.

than more fundamental issues of how to approach teaching subject matter with these technologies" (p. 49). This point is visually clear in Figure 1, as Mishra and Koehler have placed technology as one of the components and not in the center of the circle. They also have tried to show the complexity of the teaching process by suggesting that the goal is an empowered teacher who has a deep knowledge of the content and who can envision the approach that will help her students best learn this material, and finally use the technologies that can help students achieve the outcomes of the lesson.

As evident in Figure 1, the TPACK framework proposes seven distinct or overlapping categories of teacher knowledge. TPACK is a complex framework, and for the purposes of this study, only three categories will be considered: pedagogical content knowledge (PCK), pedagogical technology knowledge (PTK), and the intersection of all areas or TPACK.

As noted above, PCK is the intersection of pedagogical and content knowledge as described by Shulman. Technological pedagogical knowledge (TPK), added to the framework by Mishra and Kohler, represents the interweaving of technology with general pedagogical strategies. Graham et al. (2009) distinguishes between "technology with pedagogical strategies" and content. With pedagogical strategies, technology such as word processing can be used in many content areas; to put it another way, some technologies are not content specific. In contrast, technological content knowledge represents knowledge of technology uses that are specific to a discipline. For example, science teachers may select probeware to collect data from an experiment. However, Cox (2008) acknowledges the difficulty of trying to limit technology to one unique category and suggested the flexible nature of the TPACK categories.

Teachers also demonstrate technological pedagogical knowledge when they are able to interweave technology into a pedagogical knowledge, such as the adoption of effective classroom

simply achieving competence in the individual areas, but teaching at the intersection of each part of the framework (see TPACK Venn diagram in Figure 1).

Based on her communications with Mishra, Cox (2008) explains that Mishra uses the phrase "dynamic, transactional negotiation" to capture the interactive nature of components of the framework (p. 77). Her expansive definition of TPACK then is "a knowledge of the dynamic, transactional negotiation among technology, pedagogy, and content and how that negotiation impacts student learning in a classroom context" (p. 78).

Priorities in TPACK Planning

Although TPACK begins with the T (technology), the framework does not reflect an intent that technology be the driver of instructional decisions; in fact, it is quite the contrary. Harris et al. (2010) reviewed the literature on teacher planning and the use of digital technology and concluded that effective planning was primarily organized by learning activities and content goals. Consistent with the framework that emphasized the interaction of content, pedagogy, and technology knowledge, they recommended beginning with learning goals and activities in a content area and then selecting and using digital tools and other resources to help teacher and students meet the learning goals. It is important to avoid the errors of the past, when the emphasis was too often on the technology first. Thus, teacher inservices too often emphasized the use of technology in isolation from content area learning outcomes. Mishra, Koehler, and Kereluik (2009) made a similar point when they said that one reason new technologies have failed to transform education is because "most innovations have focused inordinately on the technology rather

management strategies specific to technology use—for example, the institution of effective routines for the distribution of hardware, use of time, expectations for collaboration, and other details of classroom activities. Such practices may be so well developed in experienced teachers' classrooms that a casual observer may fail to note the skill required to achieve efficiency until observing a teacher whose technological pedagogical knowledge is less well developed.

Technological pedagogical knowledge appears to be less visible in the TPACK literature and may also be neglected by teacher educators. Traditionally, pedagogy instruction for aspiring teachers includes lesson planning, assessment, teaching methods, and classroom management but may not identify or explicitly teach classroom management issues introduced by the adoption of a new technology. Although it is well known that beginning teachers expressed concerns about classroom management issues, Bolick and Cooper (2006) found that even teachers with skillful classroom management strategies needed to address issues brought about by the introduction of new technologies in the classroom, such as establishing and maintaining classroom rules and routines, and providing guidelines for interactions among students and the teacher. Academically engaged time, key to learning, is enhanced when transitions between classes or activities are efficient. If experienced teachers have not yet mastered this technological pedagogical knowledge, they may have difficulty assisting their student teachers, increasing the need to address this portion of the TPACK framework in teacher training classrooms.

Lim, Pek, and Chai (2005) provided some guidance on the principles that teacher educators can address with three themes of importance: (a) planning and implementing supporting activities (such as having the teacher initially model the processes for using the technology and developing products together with students); (b) establishing rules and procedures to facilitate smooth-running classroom activities before instruction starts (such as telling the students entering the classroom that they would be working with a partner and where to sit to use the computer); during instruction (directing students to ask a peer for assistance with technology issues), and after instructional activities (giving a 5-minute warning before directing that computers be shut down); and (c) providing teacher support through student helpers and technical aids, including training students to help other students who are experiencing difficulties and access to technical assistance for the teacher.

The recent emphasis on high-stakes testing and accountability has heightened teacher concern about the efficient use of classroom time and may be a barrier to the implementation of technology. Thus, technological pedagogical knowledge and particularly classroom management are of special importance to teachers attempting to address all of the elements of the TPACK framework in an actual classroom setting.

Purpose and Overview

Despite its potential as a useful organizational device for teachers, the TPACK framework has yet to be commonly applied in language that describes K–12 classrooms. Do teachers show evidence of behaviors that fit the framework, and if so, what are they? This article aims to facilitate the transition from theory to application through a case study of Ms. Marshall's practices as they illustrate the use of the framework. As I observed in this class and interviewed Ms. Marshall, I looked for evidence of the interplay among components of the framework. Ms. Marshall's class was particularly appropriate for this study because she was an experienced teacher her school district selected to pilot a classroom with one computer for each student, along with many other technologies. (Although both authors contributed to this study, for the purposes of clarity, "I" refers to the first author.)

My visit coincided with the culmination of a 6-week crosscurricular project on the Renaissance in this sixth grade classroom. Ms. Marshall explained the various student language arts activities in the project, including a newsletter, interview, and poem. I observed Ms. Marshall's classes when she taught students to write poetry about key innovations and figures of the Renaissance. The reading teacher, Ms. Wadman, started the Renaissance project 5 years ago with an emphasis on a study of Shakespeare's life and writing. Students studied lines from a play and wrote insults/riddles to reflect the atmosphere of Shakespearean theater. The final experience was a "fair" held after school for parents. Students lined the halls as parents and friends roamed around to interact with individual students who performed their lines in costume and asked viewers to play a Renaissance game. Over time, other subject-area teachers began to participate in the project. For example, in science, students learned about sound as part of their core curriculum and created Renaissance instruments. In social studies, they wrote a biography of period explorers and inventors. In art class, they researched a piece of art and discovered why it was commissioned, and they created a piece of period art. In math, they created a Renaissance business. In language arts, the students wrote a newspaper article on one of the above ideas, developed questions for an interview with a Renaissance figure, and finally wrote a poem.

Method

The key informant and second author, Ms. Marshall, is an experienced sixth grade teacher who teaches six sections of language arts to 140 students in a high-access pilot program with two laptop carts, each with 15 laptops, 20 Flip cameras, and headsets for each computer. The first author, a professor of educational technology at a university in the southwestern United States, is the observer at a middle school in a small town in the Mountain States (for convenience, this author shall be henceforth referred to as "I"). For a week in May, I observed and audiotaped 10 interviews with Ms. Marshall before and after classes and during lunch and preparation periods. Interviews ranged from 5 minutes

between classes to an hour after school. I video recorded several classroom periods. As part of her role as informant, Ms. Marshall clarified the reasons for her actions and decisions in the classroom, participated in conversations with me about my observations, and responded to my initial interpretations of the integration of technology in the content and pedagogy of the classroom. She did not plan lessons to explicitly emphasize TPACK components or integration, but planned and taught in her normal manner. I composed my interview questions to reveal the dimensions of TPACK, but the stated purpose of the study was to observe an experienced teacher at work in a technology-rich environment, so that the study would be less contrived and more natural.

To provide background for the infusion of technology at this site, I interviewed two of the technology instructional coaches who worked at the middle school. Finally, I examined samples of student work and attended the fair. I had all interviews and observations transcribed and then analyzed them using the constant comparative method (Strauss, 1987). The researcher conducted teacher interviews with a set of questions for each setting. Examples of questions were:

- What language arts activities were included in the Renaissance project?
- How did you integrate technology in each of them?
- Did you align each lesson with standards?
- What role did standards play in your curriculum?

The researcher added questions to the protocols or modified them as initial observations and interviews led to subsequent interviews.

The researcher triangulated teacher interview data with classroom observation data and instructional coach data to confirm the trustworthiness of the findings (Lincoln & Guba, 1985). The researcher read and re-read the transcripts. Guided by the purpose of the study and the TPACK components, the researcher coded the data. As I received

transcriptions of each interview or observation, I read it, wrote notes in the margins, and color-coded by concept. I added and modified codes as additional transcripts became available. Eventually, the researcher combined subcodes into themes. The researcher also noted the frequency of occurrence of paragraphs or thought units illuminating themes. Finally, the researcher employed member checking by sending a draft of the manuscript to the teacher (Ms. Marshall) to check the accuracy of the data and for feedback on the data analysis. She read and commented on drafts of this manuscript, clarifying several points, but she thought the findings accurately represented the situation.

Findings

To answer the research question (In what ways does a sixth grade middle school teacher show evidence of behaviors that fit the TPACK framework in the classroom?), the researcher organized findings around these interwoven components of TPACK: pedagogical content knowledge, technological pedagogical knowledge, and the interplay of all TPACK elements.

Pedagogical Content Knowledge

I coded data around knowledge of content (i.e., knowledge of subject matter, including key concepts, facts, and procedures) and pedagogy, which included subcodes: teaching methods, classroom management, lesson planning and implementation, and assessment. Although the researcher coded content and pedagogy separately, he considered the codes together because he often found them to be interrelated in this classroom. For example, Ms. Marshall addressed them together when she listed these objectives (on a whiteboard for students) for a series of lessons:

- Content objective: I can write four articles reporting what I have learned, including who, what, where, when, why, and how.
- Language objective: I can explain the writing process (used to write the newsletter) to a peer in my own words.

The codes are not necessarily exclusive. The researcher coded the language objective above as both a pedagogical and a content element. One could consider the writing process (prewriting, drafting, revising, editing, and sharing) to be unique to language arts, or alternatively, that this process of writing and thinking is applicable to social studies, science, or any content area and thus more closely related to a general pedagogical learning strategy. Cox (2008) attributes this categorization problem to the sliding nature of the TPACK framework.

The interplay between content and pedagogy was evidenced in the student work on their news articles. Ms. Marshall addressed the content objective as she taught newspaper article writing. However, she also taught the writing process using the writer's workshop model. Here, she orally quizzed them about the sequence of activities they would do for prewriting, drafting, and revising steps they would follow for news article writing. Students also addressed language arts content objectives by creating interviews. Students became journalists. They researched a character they selected in another class, such as social studies; developed the questions and the answers for the interviews; and found another student to assume the character's role and rehearsed their answers.

Finally, Ms. Marshall had students review the key ideas they learned collectively about the Renaissance from their articles and interviews to help them write a poem. Ms. Marshall called this "a treasure hunt for words." She explained, "You will create a poem from sources where poetry doesn't seem to be there." She elaborated, "You will create a found poem by selecting and rearranging words from the Renaissance newspaper headlines or article titles…. You will be finding interesting scraps of language … interesting words that you can eventually turn into a poem."

These three language arts activities helped students focus on the essential content question for this project on the Renaissance: How did the rebirth

of ideas allow for new inventions that would ultimately impact our society today?

Technological Pedagogical Knowledge

Two subcodes supported the theme of pedagogical technological knowledge: (a) Ms. Marshall's approach to teaching students to use computer applications, and (b) her classroom management related to students' technology use.

First, Ms. Marshall used a pedagogical approach that was less teacher directed and that involved more student problem solving. When students used a computer program for the first time, she allowed them to figure it out after minimal direct instruction. This dialog from the middle school classroom 10 minutes before class starts illustrates the point:

> Ms. Marshall: I've been thinking about whether we should have the students create a paper collage of found words for their Renaissance poems, or should we have them use Garage Band? But I've never used Garage Band before. Can you help?
>
> Observer: I've used Audacity for podcasts, and it seems like Garage Band would be similar. Let's look at Garage Band together on the screen. [Pointing to the menus] Oh, they could choose the podcast option. Add a track for male or female voices. Add or create music. I'm not sure that I could help a lot, but it would probably work.
>
> Ms. Marshall: That's the way that I introduce all new technologies. I just try it and have faith that it will work. I know a little about it, but I don't have all of the answers. Some students will figure it out first. I'll ask them to help the others who need help. When I can't answer the questions, I just send the students around to help each other. Let's try it. Today, I'll make it an option. Those who want to try it can. Those who want to create the paper collage version can do that too.

Ms. Marshall expressed this pedagogical approach to introducing a new technology as "Let's try it … students will figure it out." She tried it by giving students a choice—allowing students who wanted to try it to do so. About half tried it; those figuring it out first showed other students how to use Garage Band and answered questions as they arose. In addition to offering students a choice, she encouraged a collaborative approach, with students helping each other.

The second example of pedagogical technology knowledge focused on specialized technology management skills. Findings revolve around two subcodes: classroom management techniques for student use of technology and the arrangement of technology in the classroom.

A few minutes after students entered the classroom, students had the laptops on their desks, opened, and booting. The teacher did not provide any oral directions on how to get the laptop from the cart. Here are seven strategies that Ms. Marshall used, based on my classroom observations and interviews:

1. Students were ready at start of class. Many teachers write an assignment on the board that students begin as they enter the classroom. Building on this strategy, when students entered Ms. Marshall's classroom, they looked at the white board to see if they were using computers and which programs were to be booted. For example, Ms. Marshall wrote these steps on the board when students were to use Keynote to write their newspapers:

   - Get your computer.
   - Open your Renaissance Newspaper.
   - Add any transitions you'd like so it is ready to share.
   - Limit yourself to two transitions or less per page.

2. Ms. Marshall focused student attention. She found that laptops had an advantage over her earlier use of desktops. She noted that with desktop computers, you must work to gain student attention and keep it when you are leading class. Ms. Marshall explained, "I love the laptop [when it doesn't distract students]. You can tell students to close the lid and put them away." Later I observed Ms. Marshall's directions to students during class: "Lids down please. 5 … 4 ... 3 …2-1/2 … 2 … 1-1/2 … 1! Oh, man [you just made it]!"

3. She created aisle space for students to access the laptop carts. Ms. Marshall discussed issues with lost time due to students crowding the aisle to reach the side-by-side computer carts. She repositioned the carts so students had two different paths to the carts, reducing the retrieval and put-away time.

4. Students retrieved the same computer each period. Students had their own folders on shared computers, so each one needed to use the same computer each period. Every computer was numbered with a corresponding number on a slot in the cart. Students from each section were assigned a number that was posted on the board so that if they forgot which computer they were using, they could look at the chart and retrieve the same laptop each day.

5. She taught care of laptops. There were no instances of students breaking or misusing a laptop. When she noticed a student who was not carrying the laptop carefully, she said, "Remember, hold it like a baby. You love it," and she demonstrated this by crossing both of her arms across her chest.

6. She minimized competing noise level in the classroom. When students anticipated they would use technology (such as Brain Pop, which has animated videos) that included audio, they would automatically pick up a headset. Ms. Marshall explains, "The students, they just know—too much noise drives everyone nuts. They sense it at the door. If they have to have noise, they just go and get the headphones and plug them in and move on. It's very seldom that I have to tell students to go get their headphones."

Audio played an important role in the classroom. The teacher wrote a grant to get the headsets so she

could limit the noise and help students who had difficulty reading. For example, she selected a program that read the words to students so they could focus on understanding the text. She explains, "This is a writing class, and my focus isn't reading, but when you're doing research and you're on some of these websites where they have the more difficult words and explanations, hearing it, they would understand it, while reading they won't, so I had a few of them taking notes from a website while they're plugged in…. Some are not following, some are just auditory learners—the visual gets them distracted."

When giving instructions, Ms. Marshall asked students to just wear them around their necks until they were ready to use them. Headsets were located in a box near the door. Although many students used their own headsets, others who forgot them used the provided headsets. Careful planning limited student noise distractions and focused the learning of students with reading or focusing disabilities. Easy access and rules for use enhanced instructional time.

7. Playing music in background provided a classroom setting that allowed students to settle down quickly. When students were working individually in class, Ms. Marshall used the online program Pandora with selections from Jack Johnson and other similar artists in the background. I noticed that students settled down quickly when the music started and focused more thoroughly on the academic tasks, such as writing. When students were rotating from desk to desk writing down words for their poems, the music in the background appeared to be calming.

Technological Pedagogical Content Knowledge

The interweaving of pedagogy, content, and technology were noted as students worked on three activities: news articles, interview, and poem. Students used technology as they researched, created and shared their news articles. Students conducted research to answer the six questions (who, what, where, when, why, and how) using a modified WebQuest (a webpage with directions and a list of links to resource web sites). Students also used a commercial program, Brain Pop, to find information for their reports. Based on their research, students wrote four news articles using the presentation program, Keynote, to write, illustrate and present their articles to the class.

Students created interviews using technology tools. They video recorded their partners in costume. Ms. Marshall taught them to do interviews by watching and critiquing the interviews of news anchors on TV. Ms. Marshall explained, "They spoke with their partners and they practiced their interviews many times before they put on their costumes." They used Flip video cameras to do the recording, and they edited the videos in iMovie. The first time they recorded the interview, the sound did not come out clearly. They had to pay attention to background noise and the voice level of the character. At the Renaissance Fair students from different classes presented their class projects. One part of their language arts presentation was the interview. In the performance area, the school hallway, students set up their laptops on chairs and provided a headset so visitors could hear their interviews.

Technology also played a role as students wrote their poems. Students had a choice in creating the draft of a poem. They could write and rearrange by cutting out each word box and gluing them in order, or they could use a word processor and rearrange them electronically. About half followed each path. They also had the choice of how they would publish their poems. They could create a collage of words on paper, or they could publish their poems by orally recording their voices in Garage Band, adding music they composed to accompany the oral and written presentations of the words. Once again about half of the students selected each path.

During multiple observations, the researcher often observed the following order of presentation in Ms. Marshall's classroom. She began by bringing the student's attention to the activity for that period, e.g., "We're going to go on a treasure hunt for cool words." Following a thorough discussion of the activity, she brought students' attention to the language objective written on the board, discussed each step of the writing process as it applied to this activity and asked students to explain the process, e.g., "…there are five steps to the writing process … you tell [them to] your partner." Next, she discussed the use of the technology to implement part of the process. For example, she gave the students a choice of writing on paper and gluing words in collage form or publishing their poems by creating a podcasts of them and composing music to accompany their reading of the poems.

Discussion and Recommendations

According to Mishra and Koehler (2006), one purpose of a good theoretical framework is to guide observations and the interpretation of the findings. Although, this is an exploratory study, the findings appear to provide some evidence that elements of the TPACK framework were observed in Ms. Marshall's classroom. The discussion is organized around the interweaving of key components.

Pedagogical Content Knowledge

The discussion begins with content and pedagogy because they provide the foundational context for any examination of the implementation of the TPACK framework (Mishra and Koehler, 2006). The Renaissance project set the stage for the integration of technology in the lessons. The pedagogy was project-based learning guided by essential questions, using a writer's workshop approach to teach language arts skills of prewriting, writing, revising, and editing. The content was crosscurricular, but for this study, the focus was the writing strand of language arts.

Table 1. Summary of Management Techniques

Management Technique	Teacher's Action
Teacher gains student attention/eye contact.	Teacher says, "Close lid of laptop."
Students have easy access to laptop cart.	Teacher separates carts for easy student access.
Students locate correct laptops easily.	Teacher places chart on board with students' names and laptop numbers.
Students are ready when class starts.	Teacher writes directions on board regarding whether laptops will be used and the program/project to open.
Students carry laptops carefully.	Teachers reminds students to "hold it like a baby" with arms across chest if they have a tenuous hold on the laptop.
Students minimize noise from audio and video media.	Teacher arranges box of headsets with clear aisle access. Teacher writes directions for use on board, including the activities that need headsets. Teacher establishes rule to not disturb one's neighbors by playing audio or video media without headset.
Students settle down quickly and work.	Teacher uses Pandora to play music in background.
Laptops remain charged.	Each laptop has a numbered slot in the cart with a receptacle for plugging in laptops. Before leaving classroom, each student returns laptop to cart and plug it in.

Technological Pedagogical Knowledge

The findings provide evidence that Ms. Marshall developed special expertise in the management of students and the technologies. She used technological pedagogical knowledge to direct student use of technology in ways that allowed the class to run smoothly without losing time to technology related distractions. The focus remained on learning the content area outcomes.

Teachers must interweave technology with content in ways that help students meet state objectives and perform well on standardized tests. Under these circumstance teachers may be reluctant to use an approach involving technology for several reasons. First they may fear they will lose time on task. Thus, the technology may not fit the pedagogical needs of the teacher. Ms. Marshall maximized time on task by establishing routines such as clearing aisles to the computers, posting technology use directions on the white board so students and laptops were ready when the bell range, and employing charts with names and computer numbers to remove questions and squabbles over which computer to use. Even small steps like students remembering to plug laptops in when they put them away helps to keep them charged and in use (see Table 1 for Summary of Management Techniques). In this classroom, the routines were clear and appropriate, and technologies appeared to be a smooth operation in the classroom with maximization of time on task.

Ms. Marshall's clearly articulated classroom management strategies for student's uses of technology are consistent with effective environments for learning, e.g., establishing rules and routines for smooth running classrooms (Bolick & Cooper (2006), Lim, Pek, & Chai (2005). These classroom management strategies may serve as illustrative examples for beginning and experienced teachers who are developing pedagogical technology knowledge.

Based on the importance that teachers place on classroom management and technology, my sense is that we need many more case studies of teachers at work at various grade levels and of teachers with varying degrees of classroom experience. Such cases would enrich our working knowledge of TPK and particularly classroom management.

Another interweaving of pedagogy and technology was evident in Ms. Marshall's approach to teaching a new computer application: "Let's try it … students will figure it out." Rather than a "sage on the stage" or a direct instruction approach, she employed an inquiry-based stance. Her approach was consistent with other research; for example, Burns (2002) found that teachers who were not experts, but were comfortable with technology did better at integrating technology in the classroom than teachers with more technology expertise. Further, if they introduced the technology to students, but did not teach the program step by step to students, but rather let students figure it out and struggle with it, students were more successful. Ms. Marshall expressed

this pedagogical approach to introducing a new technology "Let's try it … students will figure it out." She tried it by giving students a choice; allowing students who wanted to try it, do so. About half tried it; those figuring it out first showed other students how to use Garage Band and answered questions as they arose. Mr. Thompson, a school district instructional coach, called this approach to technology infusion "jumping into the deep end of the pool." This approach is a good example of the use of technological pedagogical knowledge. It may seem reasonable to assume that the teacher needs a high level of technical knowledge and employ a step-by-step approach to teach students, however, Ms. Marshall did not employ that strategy and it appears that a student-centered problem solving approach and "just jumping in" worked better.

Technological Pedagogical Content Knowledge

At the center of TPACK is the intersection of technology, pedagogy, and content knowledge. This knowledge is employed in the service of learning objectives, often embodied in state standards. Ms. Marshall was able to use project-based learning in ways that helped students meet the state middle school language arts standards. The researcher asked whether the role of state standards hindered her use of project-based instruction with the integration of technology. She replied, "Technology is one more thing I have access to…. I can meet much of my core if I'm being creative in the way that I'm teaching. [In
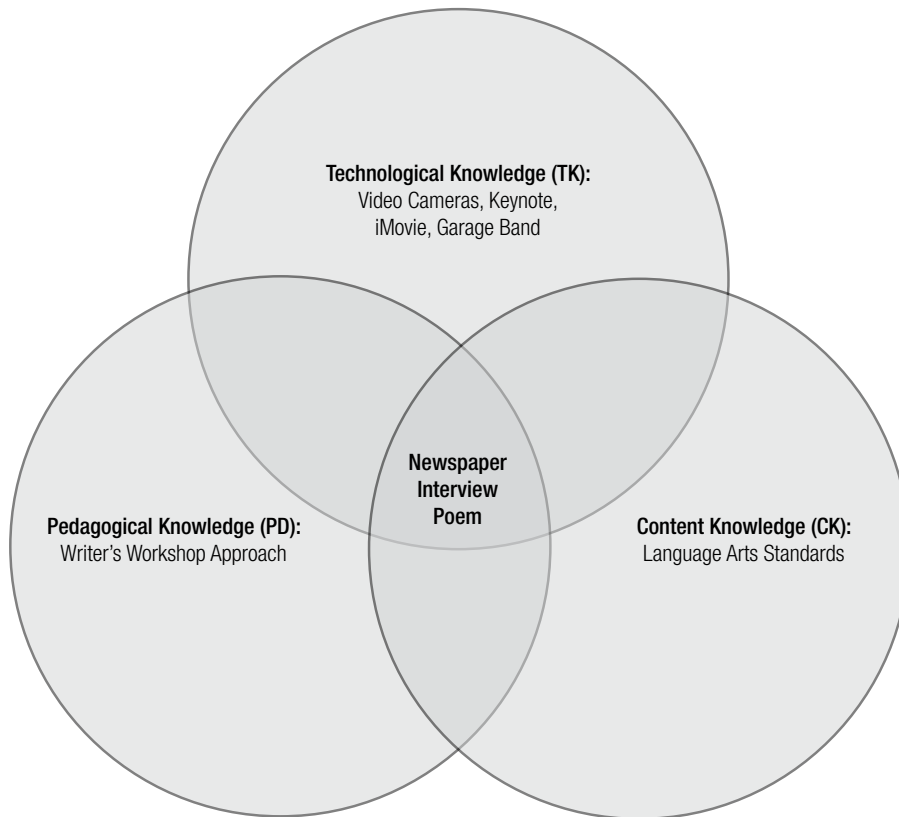
Figure 2. Products: Interweaving technology, pedagogy, and content.

interviewing, included learning the roles of the questioner and the expert or the responder, and practicing the questions and the answers. The video editing skills that students learned when choosing key information and reducing the interview from 10 to 2 minutes were technological content skills. These examples show her interweaving of content, pedagogy, and technology. This interplay appears to be consistent with Mishra's dynamic transactional negotiation (in Cox, 2008). In this project, technology, pedagogy, and content are not separate elements in isolation, but are coordinated in a dynamic two-way (or multiway) interplay. Although the interplay among the components was clear, the researcher also observed that Ms. Marshall's classroom presentation sequence followed the priorities suggested by Harris et al. (2010), in that she started with the learning objectives, addressed the process and activities, and then addressed the technology used to implement appropriate parts of the activity.

Finally, and most important, the teacher employed the technology to enhance student learning of the subject. Ms. Marshall's lessons were aligned to content standards, and she used technology as a tool to enhance the learning both of the content and also the technology skills the students needed to be effective learners. The teacher education community would benefit from more studies on optimal approaches to teaching students technology skills within academic content and learning environments.

This was a qualitative study of one teacher and her classroom. In that sense, the findings are not generalizable, but others who find the management techniques persuasive and the uses of technology to meet content standards helpful may draw on them as resources for inservice and preservice trainings. Also, the study may serve as an instance in which the TPACK framework provided a lens for observing in a classroom and analyzing the findings. As Painter (2011) pointed out, if we think of the teaching process as a beam of light that plays out in the classroom, the prism that allow us to see the colors

this school district] you are left to teach the core in the way you feel is best for your students…. I've been in schools where we've been expected to be on this page in this book when the principal came by.… There is an art to teaching and computers fit into that art."

Figure 2 provides a specific example of the application of the TPACK framework to the language arts portion of the Renaissance Project and of the contributions of each component to the learning outcomes. The student-created products for the Renaissance Project represents the learning outcomes in the center of the diagram. Also, each component is instantiated in the diagram; for example, video editing and other technologies represent technology, language arts standards guide content, and the writer's workshop approach guides pedagogy. However, it is also clear that they are not separate elements in isolation, but are rather coordinated in a dynamic two-way (or multiway) interplay. In this dynamic negotiation, the standards

are implemented through the writer's workshop, and the technologies (e.g., composing music with Garage Band, revising text with Keynote and editing, and sharing through Keynote and iMovie) facilitate the processes of the writer's workshop.

Although, technologies played an important role in the Renaissance Project, the TPACK framework suggests the critical nature of the interweaving of the components rather than an emphasis solely on individual components. In this study, the interplay between the language arts content and the technologies is evident. For example, students learned Keynote skills in the context of writing a newspaper article title with an action verb and keywords, selecting images to convey the concept in an effective manner to go with text, and using references and giving credit to sources. Also, students learned video camera skills in the context of interviewing based on an analysis of newscaster interviews on TV. Content skills, such as

in the beam is TPACK, as it allows us to see the components of the lesson and how they fit together.

Mishra and Koehler (2006) believed that simultaneously addressing content knowledge, pedagogical knowledge, and technology knowledge provided a framework for substantive technology integration in the curriculum. The challenge for future research is to study and report the behaviors of teachers who show evidence that fits the TPACK framework in elementary classrooms, and then to study the utility of such cases as resources for teacher preservice and inservice programs.

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