A Post-Intentional Phenomenological Case Study of Pedagogical Awareness of Technology Integration into Secondary Science Teaching

A Dissertation

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Abstract

Pre-service teachers continue to matriculate through content and methods courses without sufficient attention to how these disciplines merge in the practice of teaching with technology. Consequently, a disconnect exists between learning what to teach and the act of teaching with technology. In order to develop this proficiency, Niess (2005) and others (Beck and Wynn, 1998; Becker, 2001; Duhaney, 2001; Flick and Bell, 2000) suggest investigating the pedagogical decisions that teachers make and how technology integration must inform those decisions. Using Vagle’s (2010) post-intentional phenomenological approach, this study examined the practice of two pre-service science teachers and the tentative manifestations of their pedagogical awareness of technology integration in secondary science student teaching. This study investigated the what, how and why surrounding the pedagogical decisions with technology and how these pre-service teachers came to understand the impacts to their teaching. Additionally, this study examined the challenges that existed in identifying the participants’ pedagogical awareness of technology integration into teaching. Utilizing Mishra & Koehler’s (2006) framework of technological pedagogical content knowledge (TCPK), the participants provided insight into their perception of how their TPCK changed throughout student teaching through observed lessons, interviews and the reflexive phenomenological practice of bridling. Single-case and cross-case analysis indicated that the participants
perceived a deeper understanding in their TPCK, greater student engagement through student-centered technology integration and greater comfort levels with technology integration in their teaching. This study also indicated existent challenges in how preservice teachers decipher their own pedagogical awareness from that of their cooperating teachers. These results have implications for science teacher preparation, cooperating teachers and student teaching supervisors as these constituents conglomerate into more effective science teacher preparation. Situating pre-service teachers in the reflexive practice of bridling provides both time and space to investigate their pedagogical understandings that inform the practice of teaching.
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Chapter I: Introduction

Rationale

Pre-service teachers continue to matriculate through content and methods courses without sufficient attention to how these disciplines merge in the practice of teaching with technology. Consequently, a disconnect exists between learning what to teach and the act of teaching with technology. In a study on preparing science and mathematics teachers with technology, Niess (2005) suggests that teachers might not teach the subject to their students in the same way that they learned the content in their coursework; “learning subject matter with technology is different from learning to teach that subject matter with technology” (p. 509). In order to develop proficiency with technology integration, researchers - (Beck and Wynn, 1998; Becker, 2001; Duhaney, 2001; Flick and Bell, 2000; Niess, 2005) have suggested investigating the pedagogical decisions that teachers make and how technology integration must inform those decisions. In order to advance this work in science, additional research must be done to understand the knowledge bases of technology, pedagogy, and content (Technological Pedagogical Content Knowledge) and how they foster effective instruction in science classrooms. Pre-service science teachers must develop a deeper “overarching conception” of what science teaching with technology looks like (Niess, 2005). Inquiry into effective
technology integration also requires an acknowledgement of the current status and barriers to technological affordances in the K-12 classroom.

Grants and funding have saturated K-12 institutions in an effort to ameliorate the technological affordances available to teachers, yet many educators still feel inadequate in using technology in the classroom. Studies suggest (Laffey, 2004; McCannon & Crews, 2000) that teachers “lack the confidence in using technology in ways that construct knowledge beyond the level of recall” indicating that pre-service teachers “have had poor modeling of methods classes in their training programs demonstrating how learning science can be enhanced using technology while following standardized curricular mandates” (Bhattacharyya & Bhattacharyya, 2009, p. 114). While states are requiring explicit technology training in their teacher preparation programs (Kent & McNerney, 1999), the Office of Technology (OTA) reported that only three percent of teacher education graduates felt “very well prepared” to use technology in the classroom (Doering, Hughes, & Huffman, 2003). According to a 2000 report from the U.S. Department of Education, “new teachers entering the profession are still not being adequately prepared to teach with technology” (U.S. Department of Education, 2000, p. 14). Work must be done to increase the technological and pedagogical capacities of new teachers as they enter the teaching profession (Donna & Miller, 2011).

In a 2000 report from the National Center for Education Statistics (NCES), 53% of teachers reported feeling “somewhat prepared” to use technology for classroom
instruction. As of 2003, the U.S. Department of Education identified an increase to 85% of teachers who reported feeling “somewhat well-prepared (U.S. Department of Education, 2003) to teach with technology. These statistics, while they reflect a federal investment in professional development for teachers, also raise concern that teachers still do not feel adequately prepared to integrate technology to the depth and potential that is possible (Ertmer, 2005). The lack of technology integration can be evidenced by a study of 90,000 teachers in Michigan who, as part of a $110-million effort to establish a 1 to 1 computer to teacher program, reported that only a few teachers used tech tools such as spreadsheets, presentation software, or digital imaging to enhance their lessons (Ertmer, 2005; Newman, 2002). Findings also indicated a lack of deeper, more constructivist means of technology integration (Ertmer & Ottenbreit-Leftwich, 2010). Additionally, research supports that when technology is used, “it is typically is not used to support the kinds of instruction (e.g., student-centered) believed to be most powerful for facilitating student learning” (Cuban, Kirkpatrick, & Peck, 2001; Ertmer & Ottenbreit-Leftwich, 2010, p, 256; International Society for Technology in Education, 2008; Partnership for 21st Century Learning, 2007). There appears to be a discrepancy between what is expected of teachers and what is actually happening in the classrooms.

These findings raise awareness and posit a challenge to modify teacher preparation programs to better prepare teachers to integrate technology and to develop a clearer understanding of how and why “high-tech” constructivist tools should be
embedded into science teaching. Studies show (Ertmer, 2003; Ertmer & Ottenbreit-Leftwich, 2010; Rosaen, Hobson, & Kahn, 2003) that “few teacher education programs currently model systemic and sustainable technology integration in science classrooms, and as a result both pre-service and in-service teachers often hesitate to use such approaches in their instruction” (Bhattacharyya & Bhattacharyya, 2009, p. 115). It is critical that teacher educators and K-12 cooperating teachers model effective uses of technology in the classroom so that pre-service teachers can move beyond the ways in which they were taught—something that Lortie (1975/2002) refers to as the “apprenticeship of observation”—and become more innovative, constructivist and engaging educators. Many pre-service teachers, by default, enact Lortie’s notion by teaching the way they were taught through observation and experience, instead of modifying and improving their instruction towards more effective methods—something that the changing technology necessitates.

Work must be done to bridge the gap from institutions of teacher preparation to the K-12 classrooms with the use of integrating a technology-oriented pedagogy of practice. Pre-service teachers that effectively implement technologically-rich teaching practices can facilitate learning, increase motivation and produce engagement on behalf of the learners, as they, alongside of their teachers construct this knowledge through hands-on, authentic, contextual learning (Doering, Hughes, & Huffman, 2003).
Statement of the Problem

Becker (2001), Ertmer (2005), and Ertmer & Ottenbreit-Leftwich (2010) have identified that although the number of teachers who feel as though they are adequately prepared to integrate technology into teaching has increased, the teachers’ level of self-identified adequacy might be misguided due to simplistic forms of technology integration like PowerPoint and internet research. Consequently, many teachers never experience the benefits of rich, transformative technology integration embedded in good teaching. Researchers have identified that “low-level technology uses tend to be associated with teacher-centered practices while high-level uses tend to be associated with student-centered, or constructivist, practices” (Ertmer, 2005, p. 5). Consequently, research must be done with pre-service teachers in order to help them—situated in the experience of student teaching to identify their pedagogical awareness and philosophical underpinnings that accompany either their teacher-centeredness or student-centeredness and push them towards enabling “students to construct deep and connected knowledge, which can be applied to real situations” (Ertmer & Ottenbreit-Leftwich, 2010, p. 257). Further research investigating the pedagogical awareness surrounding the how, what and why of technology integration in science teaching (Bhattacharyya & Bhattacharyya, 2009; Niess, 2005; Tondeur, Hermans, van Braak, & Valcke, 2008) will provide further support for future and current educators—and hopefully aid in their comfort levels of technology integration in the classroom. This study, unlike others in field, attempts to investigate
these pedagogical decisions from a post-intentional phenomenological perspective.
Research must be conducted to identify how pre-service teachers come to understand
their pedagogical awareness through the student teaching process and therefore,
understand how a technological pedagogical content knowledge (TPCK) perspective will
help them gain a more student-centered approach to teaching. Consequently, teacher
educators may be able to more effectively equip pre-service teachers in their preparation
phases of coursework.

Goals of the Study

This study seeks to explore the pre-service science teachers’ decisions,
implementation and reflection on technology integration into their science teaching. The
following research questions guide the study:

1) In what ways do pre-service teachers come to identify the tentative
manifestations of their own pedagogical awareness of good teaching and
learning through the implementation of technology in the secondary science
classroom?

2) What challenges exist in identifying how and why the tentative manifestation
of or intentional relationship with pedagogical awareness changes throughout
teaching?
Potential Significance of the Study

The rationale for this study comes from the researcher’s desire to facilitate greater pedagogical awareness of technology use into science education such that pre-service teachers and their students experience greater engagement and motivation to teach, learn and interact with science. This phenomenological case study creates the time and space for both the researcher and the pre-service teachers to evaluate pedagogical decisions in the K-12 classroom and how their tentative manifestations present themselves to the student teachers. Through a closer look at how and why these decisions are made, teacher education faculty and pre-service teachers will gain insight into how and when to integrate technology into the secondary science classroom.

Overview of the Following Chapters

Chapter II provides an overview of the relevant literature supporting the conceptual framework of technology integration into science teaching—technological pedagogical content knowledge (Mishra & Koehler, 2006) as well as investigating elements of effective teaching with technology. Chapter III introduces the methods and methodology used and provides an overview of Vagle’s (2010a; 2010b) post-intentional phenomenological approach used in the study. Furthermore, the study’s participants, data collection methods and potential limitations are presented. Chapter IV will present each of the pre-service teachers’ efforts towards integrating technology into science teaching and how each of the teachers (as well as researcher) came to understand the pedagogical
awareness in the student teaching experience using the phenomenological method of bridling and through post-observation interviews. Supporting information regarding their school contexts, decision-making processes, and their perception of TPCK evidenced by teaching practices is also presented. Excerpts and bridling responses from the twenty-one lessons will be highlighted to provide insight into the pedagogical awareness of the participants. Chapter V will present both single-case and cross-case analyses of the participants illuminating manifestations of the phenomena that arose from bridling entries, classroom observations as well as interviews conducted after classroom observations. Finally, chapter VI will identify conclusions of the study, implications for teacher preparation and suggestions for further research in technology integration into science teaching. Specific attention will be given to how this study informs the practice of teacher preparation faculty for greater technology integration into science teaching.
Chapter II: Literature Review

This literature review identifies critical elements explored in this study regarding technology integration into science classrooms. The first portion of this chapter identifies the growing need and influence of technology in the classrooms and how teacher preparation programs are responding to this growing demand. In an effort to identify and build a case for effective technology integration into science teaching, elements of good teaching are investigated through the lens of teacher preparation. The next section of this chapter then positions Shulman’s work (1987) on Pedagogical Content Knowledge in a foundational capacity that facilitates Mishra and Koehler’s (2006) conceptual framework of Technological Pedagogical Content Knowledge (TPCK). Additionally, McCrory (2008) identifies the knowledge bases of TPCK and how pre-service teachers need to identify the where, what and how of their technology integration in order to facilitate effective instruction with technology. The next section identifies helpful considerations for implementing technology in teaching and learning. If educators seek to integrate technology effectively in their instruction, it is critical that they locate themselves in relation to the barriers of implementation identified by various researchers (Ertmer 2003, Ertmer & Ottenbreit-Leftwich, 2010). Lastly, existing research on technology into science education is presented in order to situate the implications and findings of this study.
State of Technology Integration

The presence and availability of technology in classrooms is increasing in accordance with the policy demands that technology instruction must be established and supported in the K-12 schools (Hughes, 2004). In response to these societal turns towards technology—evident in programs like Preparing Tomorrows Teachers to use Technology (PT3), the National Educational Technology Standards (NETS) and other initiatives (Clausen, 2007) -- Niess (2005) proposed that “education must shift to incorporate computer-based, electronic technologies integrating learning with these technologies within the context of the academic subject areas” (p. 509). While efforts to bring technology into the schools continue to grow, teachers are left with the dilemma of what and how to integrate this technology as they are “often expected to integrate technology without having a working definition of the concept” (Dias, 1999). Teachers still feel unprepared to successfully implement technology in their teaching (Rakes, Fields, & Cox, 2006).

While Kent and McNergney (1999) report that over 32 states require explicit technology training in their teacher certification programs, the Office of Technology (OTA) confirmed that only 3% of teacher education graduates felt “very well prepared” to use technology in their classroom (Doering et al., 2003). An additional survey claimed that only 11.3% of the nation’s teachers felt that they had advanced technology integration skills for their daily teaching (Doering et al., 2003). Ertmer (2005) and others
(Dede, 2008; Ertmer & Ottenbreit-Leftwich, 2010; Lai, 2008; Law, 2008; Thomas & Knezek, 2008) purport that pre-service preparation and professional development must help teachers “understand how to use technology to construct deep and connected knowledge, which can be applied to real situations (e.g., Jasper Woodbury Problem-Solving)(Ertmer & Ottenbreit-Leftwich, 2010, p.257). This requires a dramatic shift from teachers such as those represented in the Speak Up 2007 national survey. This survey claimed that “51% of the teachers reported that their primary use of technology to “facilitate student learning” comprised (a) asking students to complete homework assignments using the computer and (b) assigning practice work at the computer” (Project Tomorrow, 2008). Teachers must be encouraged to both model for and expect their students to learn with and through the technology.

There appears to be a discrepancy between what is expected of pre-service teachers and what is actually happening in their classrooms. While reports indicate that the accessibility to computers is high—up to 98% of schools are providing students with internet-connected computers (Bhattacharyya & Bhattacharyya, 2009; Parsad & Jones, 2005; Wells & Lewis, 2006), teachers and students are still integrating technology with “low-level productivity tasks” like word processing, basic Internet searches, and electronic presentations (Lanahan, 2002). Work must be done to shift the practicing paradigm from low-level productivity tasks to higher-level constructivist, generative tasks so that students can experience how technology enhances the science content.
Doering et al. (2003) provide suggestions to revitalize the technology integration in the classrooms—“we believe that in order to help preservice teachers feel well prepared to use technology, the experiences within technology education courses need to be generative. In other words, we need to provide instruction that will scaffold students’ pedagogy within the classroom toward more authentic, learning-centered activities for the students” (p. 343). Teachers must experience pedagogical implementation that fosters teaching with and through the technology (Carr, Jonassen, Litzinger, & Marra, 1998). This paradigm of curriculum requires that pre-service, in-service and education faculty evaluate what teaching and learning means and how it is executed in the classroom for their students. In order to understand this new paradigm, one must first examine elements of effective instruction.

**Framework for effective teaching.** Good teaching exists as a multi-faceted, deep-rooted response to who we are as teachers and how one sees the purposes of education lived out in the classroom. This study operates under the belief that good teaching rests on three pillars—the knowledge, skills and dispositions that a teacher candidate possesses and how they are implemented into classroom practice. To facilitate this work of identifying the elements of good teaching, Darling-Hammond and Bransford (2005) outline a framework (Figure 2.1) for teaching and learning that undergirds the aforementioned knowledge, skills and dispositions. Darling-Hammond and Bransford (2005) propose that teachers must possess:
1) knowledge of learners and how they learn and develop within social contexts,  
2) conceptions of curriculum content and goals: an understanding of the subject matter and skills to be taught in light of the social purposes of education, and  
3) an understanding of teaching in light of the content and learners to be taught, as informed by assessment and supported by classroom environments

Figure 2.1 Darling-Hammond & Bransford’s Model of Effective Teaching (2005, p. 11)

As an outcropping of Dewey’s belief that teachers mediate for the needs of the child and the demands of the curriculum (Dewey, 1902), Darling-Hammond and Bransford’s framework for teaching and learning is structured by two conditions—“first, the fact that teaching is a profession with certain moral as well as technical expectations
and, second, the fact that, in the United States, education must serve the purposes of the democracy (Darling-Hammond & Bransford, 2005, p. 10). This premise that teaching exists for the moral development amidst a democratic society is supported by Palmer’s (1998) work on the disposition exemplified in good teaching. Palmer’s conviction claims that teachers are called to the practice of teaching. He supports this calling by arguing for a transferrence of the entire lived-experience into one’s practice—“as I teach, I project the condition of my soul onto my students, my subject, and our way of being together (p. 2). He posits that “good teachers possess a capacity for connectedness. They are able to weave an intricate web of connections among themselves, their subjects, and their students, so that students can learn to weave a world for themselves” (Palmer, 1998, p. 11). As a result, Palmer believes that a teacher’s ability to teach hinges on their students’ ability, receptivity and creativity to learn.

I have no question that students who learn, not professors who perform, is what teaching is all about: students who learn are the finest fruit of teachers who teach…teachers possess the power to create conditions that can help students learn a great deal—or keep them from learning much at all. Teaching is the intentional act of creating those conditions, and good teaching requires that we understand the inner sources of both the intent and the act. (Palmer, 1998, p. 6)
What Palmer has identified through his own teaching experience is the moral obligation to partner with students in this educational dialogue, thus emphasizing a much needed adjustment towards student-centered teaching practices. Far too often educators and policy makers assign students with the role of passive recipient instead of active participant, thus conveying more of a educational monologue than an interactive dialogue. This type of engagement implicates the need for teachers to not only know their subject matter, but also their students and how the intersection of these two foster curricular decisions to achieve learning outcomes. Vagle (2008) also identifies a tension that arises though as teachers try to establish connectedness in the classroom—“one of the challenges the pedagogue faces is determining how to stand close enough to the child to want what is best for the child, and to stand far enough away from the child to know what is best for the child” (van Manen, 1991, p. 97). Inherent in good teaching is the sense that good teachers know their students and that good instruction occurs not in a vacuum, but rather through relationships and collaboration. Vagle elicits the power of effective pedagogy in this collaborative process when he defines pedagogy as “the coordinated relationship between teacher and student requires something more than language, such as diagnosing and strategizing. It requires a language that burrows deeper into what it means to become pedagogical” (Vagle, 2008, p. 53).

Most teachers hope to provide fun, engaging, thought-provoking lessons each time they interact with their students. Far too many times though, these lessons digress to
a monologue of expert knowledge transmitted to novice receptacles and many times through the vehicle of electronic presentations (Bonwell & Eison, 1991; Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Thomas, Pedersen, & Finson, 2001; Tobin, Briscoe, & Holman, 1990). This is due, partially, to the multi-facetedness of a teacher’s job, their responsibilities, stresses and lack of time for planning and preparation (Patchen and Cox-Petersen, 2008; Roehrig et al., 2007). Work must be done to further develop pre-service teachers’ abilities of integrating technology to assist in the classroom practices of teaching and learning.

**Pedagogical content knowledge.** Shulman’s (1987) work on Pedagogical Content Knowledge (PCK) may also be examined to identify a perspective of characteristics of good teaching. Shulman analyzed the new reform suggestions made by his contemporaries in response to determining whether or not a “knowledge base for teaching” could be established. As a result, he organized his thinking into a conceptual framework called Pedagogical Content Knowledge (PCK) that “represents 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, 1987, p. 8). PCK helps provide a framework for all teachers—pre-service, teacher preparation faculty and in-service teachers with which to hang their instruction and training on. Shulman pushed the boundaries of the “instructional paradigm” as he proposed the importance of a two-fold
approach towards teacher preparation “emphasizing teaching as comprehension and reasoning, as transformation and reflection” (Shulman, 1987, p. 13). He shed further light on the practicality of implementing PCK by saying:

the key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and backgrounds presented by the students. (Shulman, 1987, p. 15)

Shulman proposes the idea that it is equally important to understand the components by their definitions as well as their interactive applications. He defined content knowledge (CK) as the teacher’s knowledge about the subject matter that is taught and learned by the students. Pedagogical Knowledge (PK) was defined as the teachers’ rich knowledge about the processes, methods, or practices of teaching and learning that facilitate student learning. Consequently, Shulman urged the pedagogue to experience the convergence of both content and pedagogy as a way of transforming the subject matter for teaching. “This transformation occurs as the teacher interprets the subject matter, finds multiple ways to represent it, and adapts and tailors the instructional materials to alternative conceptions and students’ prior knowledge” (Koehler & Mishra, 2005, p. 64). It is critical that teaching and learning move beyond the just mastery of content so that educators can begin dialoguing about the most effective learner-
appropriate strategies that exist in order to present relevant content in ways that facilitate engagement and achievement. It is from Shulman’s PCK model of good teaching that technology integration models have been extended.

**Technological pedagogical content knowledge.** As the wave of digital literacies and technological developments began to invade the educational spaces, Mishra and Koehler (2006) extended Shulman’s Pedagogical Content Knowledge framework into a new instructional and theoretical framework—Technological Pedagogical Content Knowledge (TPCK) (Figure 2.2) as they sought to integrate technology into the conversation.

![Figure 2.2 Mishra & Koehler’s TPCK framework (2006)](image)

As supported by Mishra & Koehler (2006), effective teaching can stem from the acknowledgement and enactment of a well-developed understanding of technology,
pedagogy, and content. Technological Pedagogical Knowledge (TPK) supports an understanding of how “teaching and learning change when particular technologies are used” (Harris, Mishra, & Koehler, 2007). Technological Content Knowledge (TCK) includes an understanding of how technology and content impact and limit one another (Harris, Mishra, & Koehler, 2007). When PCK, TPK, and TCK converge in the act of effective teaching, instructors can transform learning objectives into contextually rich learning experiences. This is possible with strong influences of pedagogy, content and teaching with and through the technology. Mishra and Koehler have argued “developing TPCK requires the design of a coherent curricular system (Brown & Campione, 1996), not a collection of isolated parts that focus on just one of the three knowledge bases at a given moment (Koehler & Mishra, 2005b). This illustrates the need for all three legs of this proverbial TPCK tripod to support the instruction of science teachers so much so that one of the components may be reduced or weakened in isolation resulting in the collapse of the TPCK framework. “Teachers need to develop fluency and cognitive flexibility not just in each of these key domains—content, technology, and pedagogy—but also in the manners in which these domains interrelate, so that they can effect maximally successful, differentiated, contextually sensitive learning” (Harris, Mishra, & Koehler, 2007). It is through an intentional development of all three of these key domains that effective integration of technology holds the potential to enhance learning.
In this seminal work, Mishra and Koehler push educators to move beyond using technology as “low-tech” presentation tools, and consider rather what Jonassen, Doering and others claim as teaching “with and through the technology” (Carr, Jonassen, Litzinger, & Marra, 1998). “It is becoming increasingly clear that merely introducing technology to the educational process is not enough to ensure technology integration since technology alone does not lead to change. Rather, it is the way in which teachers use technology that has the potential to change education” (Carr et al., 1998 in Mishra & Koehler, 2005, p. 132). The pedagogical infrastructure that girds this approach to science teaching requires thoughtful, pre-meditated considerations of which integrations of technology are appropriate for each learning context and nullifies the concept of just adding technology to existing practices for the sake of reporting its use. With that in mind, Mishra and Koehler propose the idea that technology must be viewed as a “knowledge system (Hickman, 1990) that comes with its own biases, and affordances (Bromley, 1998; Bruce, 1993) that make some technologies more applicable in some situations than others” (Koehler & Mishra, 2005a, p. 132)—thus supporting the importance of how TPK and TCK inform the pedagogical decisions made in the classroom. When the use of technology is explicitly considered in tandem with instructional design, the compartmentalized, “technocentric” notion of technology as an add-on or separate and individualistic entity from instruction is eliminated.
**McCrory’s integration of TPCK in science.** McCrory (2008) investigated effective uses of technology in science education through the TPCK framework. McCrory (2008) suggests science classrooms are “a natural place for technology use since so much of science today depends on technology” (p. 193). She posits an assumption that “technology should be used to do things that would otherwise be difficult or impossible to do, not to replicate the same things ordinarily done; and that technology has a place in science classrooms when it is integral to the science being taught or when it solves a particular pedagogical problem” (p. 193). Her approach to effective technology integration in science is strongly connected to Mishra and Koehler’s TPCK framework as a means to develop a teacher’s awareness of “where [in the curriculum] to use technology, what technology to use, and how to teach with it” (McCrory, 2008, p. 195). McCrory (2008) advocates for teachers to contemplate a TPCK framework in light of the where, what and how of technology integration in order to build their knowledge base for effective instruction. McCrory (2008) indicates that teaching and learning with technology can be a newfound, iterative experience that requires reflection and particular knowledge bases.

In the process of building a scenario for teaching with technology, and then reflecting on what happened when the class is over, a teacher develops knowledge that he can use the next time he uses the technology. It is very context- and content-specific knowledge, depending on the technology available, the students,
and the subject matter. It is TPCK. (p. 199).

McCrory (2008) continued to identify that in the where, what and how of technology integration that technology for science teaching can be classified into three categories: 1) technology that is unrelated to science but is used in the service of science; 2) technology designed for teaching and learning science; and 3) technology designed and used to do science. She argued that science teachers reserve the right to implement all three of these categories at appropriate times. It is through this reflective practice on TPCK and its nuanced presence in the classroom that teachers may be able to further develop their understanding of how TPCK is enacted in the act of teaching and how it fosters more effective instruction.

**Implementation of Technology Integration**

In an effort to establish standards and professional accountability for teachers, the International Society for Technology in Education worked to create teacher performance objectives that promoted technology integration into teaching. Extending their work from 2000, the 2008 National Education Technology Standards for Teachers (NETS-T) urged teachers to become “facilitators of collaborative student learning through a wide variety of media-rich, interactive, and authentic learning experiences” (International Society for Technology in Education, 2008), thus supporting the need for teachers to familiarize themselves with TPCK and its nuanced means of integration in the classroom. This development urged educators to re-conceptualize the framework of good teaching as
teachers “become comfortable as co-learners with their students” (ISTE, 2008) when using technology. This push for technology integration fosters collaboration between the learner and instructor that transcends isolationism that has permeated science education (Reiser & Dempsey, 2007).

Educators must maintain a focus not just on the technology used in the integration, but also on the learning outcomes for which the technology was designed without succumbing to the pressure of what Gillespie (1998) refers to as “using new technology in old ways” (p. 45). Ertmer and Ottenbreit-Leftwich (2010) challenge the idea that teachers’ uses of technology are not often linked to learning outcomes and urge educators to integrate technology in ways that support instruction (e.g., student-centered) believed to be “most powerful for facilitating student learning.”

It is time to shift our mindsets away from the notion that technology provides a supplemental teaching tool and assume, as with other professions, that technology is essential to successful performance outcomes (i.e., student learning). To put it simply, effective teaching requires effective technology use.


Educators must be cautious to place an imbalanced pressure on technology as a either a stand-alone or a tack-on approach as well (Project Tomorrow, 2008). Technology integration needs to be informed by all aspects of the knowledge bases inherent in TPCK. Hooper and Hannafin (1991) provide a good reminder—
Although technology undoubtedly influences the manner in which instruction is delivered, it is unlikely that cognitive processing will be singularly determined through technology alone. Perhaps the underlying problem with “technocentric” perspectives is the attempt to optimize the capabilities of technology rather than learners. (p. 70)

Educators must have a thorough and contextual understanding of the technology that is implemented into their classrooms so as not to overemphasize the technology, but rather teach with what Jonassen terms “with and through” the technology as they “promote the development of higher-order cognitive skills rather than the transfer of content” (Carr et al., 1998; Gillespie, 1998). Integrating technology in a with and through approach accesses the pedagogical decisions that support subject matter content knowledge while capitalizing on the affordances the technology offers.

**Teacher preparation and technology integration.** The responsibility of instilling an integrated mindset of teaching and learning with technology into the educational philosophies of pre-service teachers is largely dependent on the work of teacher preparation programs and cognate faculty. Pre-service teachers who are digital natives with strong technology knowledge, hold the potential to develop a TPCK that “is an extension and application of an already existing and naturally evolving skill set” (Brupbacher & Wilson, 2009). Pre-service teachers who lack substantial technology knowledge must continue to develop a foundation and comfort level of integrating
technology into their classroom. The work for teacher preparation faculty is to help all pre-service teachers recognize this necessary skill set and help pre-service teachers implement it in their classroom practice. Koehler and Mishra (2005) reiterate this knowledge base—

This framework requires a shift in the roles of both students and teachers. The student becomes a cognitive apprentice, exploring and learning about the problem in the presence of peers (who may know more or less about the topic at hand). The teacher, on the other hand, must shift from being the “knowledgeable other” towards becoming a facilitator, who manages the context and setting, and assists students in developing an understanding of the material at hand. (p. 96)

Teacher education faculty must analyze their TPCK influences in instruction so that pre-service teacher education students learn from this constructivist approach. This self-evaluation allows pre-service teachers to initiate the construction of their own knowledge, as well as contemplate the benefits that surround the successful integration of the TPCK model (Koehler & Mishra, 2005). Following Mishra & Koehler’s (2005) suggestions would also allow teachers to encounter the constructivist approach that they will hopefully require of their students in the K-12 setting. However, more work still needs to be done with pre-service science teachers so that the “what” teachers need to
know can be translated into “how” they are supposed to learn and practice it with and through the lens of a TPCK framework.

**Barriers to technology integration.** In order to experience the relative advantage that technology offers, the barriers that teachers encounter when integrating technology must be considered. Ertmer (2005) proposed that a gap in the research exists on the influence of teachers’ beliefs on classroom instruction with regards to technology integration. In an attempt to determine these influences, Ertmer identifies that overcoming teachers’ pedagogical beliefs constitutes a Barriers Model for technology integration. Ertmer continued by claiming that “although it is not clear whether beliefs precede or follow practice (Guskey, 1986), what is clear is that we cannot expect to change one without considering the other” (Ertmer, 2005, p. 36). It is paramount, then to “consider how teachers’ current classroom practices are rooted in, and mediated by, existing pedagogical beliefs” (Ertmer, 2005, p. 36). While it is not necessary to solidify beliefs prior to exposing teachers to technology, Ertmer suggests that progress is most tenable if the integration parallels their most immediate felt needs in the classroom.

Ertmer’s Barriers Model necessitates a pause in the technology discussion to ascertain one’s fundamental teaching philosophy that drives one’s pedagogy. It is suggested though, that while one’s philosophy might be precursive to one’s pedagogy, this enactment of integration also lies at the heart of Mishra and Koehler’s reason for developing the TPCK model in the first place. Teachers need to identify their standing in
the TPCK model and use that awareness of their understanding as they attempt to break
down the barriers that stand in the way of true integration—something that would
position them closer to the core of the TPCK framework.

**Technology Integration into Science Teaching**

Substantial research has been conducted on teacher’s beliefs related to technology
implementation (Bhattacharyya & Bhattacharyya, 2009; Borko & Putnam, 1996; Niess,
2005), student-centered practices with technology (Kanaya, 2005; Tangdhanakanond,
Pitiyanuwat, & Archwamety, 2006), and technological barriers (Ertmer, 2003; Ertmer &
Ottenbreit-Leftwich, 2010) that exist with regards to implementing technology into
teaching. Conversely though, as other researchers contend (AACTE Committee on
Innovation and Technology, 2008), more work must be done to investigate teachers’
beliefs from teacher preparation programs (Guzey & Roehrig, 2009; Niess, 2005) with
regards to TPCK. Consequently, additional research is needed to explore how these
TPCK understandings present themselves in science education—something that this
study attempted to do.

While a limited research base on the influences of TPCK and science educators’
pedagogical decisions exists, there is sufficient evidence of benefits for technology in the
science classroom. For example, in their study on inquiry in the middle school science
classroom, Novak & Krajcik (2006) found that “utilizing technology tools in inquiry-
based science classrooms allows students to work as scientists” (p. 76). ChanLin (2008)
and Pedroni (2004) also found that technology integration in the science classroom promoted scientific thought processes of inquiry, problem-solving and critical thinking.

In their study on science teachers’ TPCK, Guzey & Roehrig (2009) proposed that this appropriate and effective use of technology leans heavily on teachers’ familiarity, fluidity, depth and application of TPCK—something that affords them the structure to perceive which technology tool is best, how to integrate it pedagogically, and how to construct the framework to support the science content. Guzey & Roehrig (2009) indicated that “when educational technology tools are used appropriately and effectively in science classrooms, students actively engage in their knowledge construction and improve their thinking and problem solving skills” (p. 27).

In her study investigating science teachers’ uses of technology and TPCK, McCrory (2008) suggests that science teachers need extensive content knowledge in order to support the conceptions and misconceptions that science students encounter while interacting with the material. Moreover, McCrory (2008) proposes that teachers who possess deep levels of both content knowledge and pedagogical knowledge inherent in Mishra & Koehler’s (2006) TPCK framework are positioned to integrate student-centered, inquiry-based technology tools in their practice. The enactment of these knowledge bases will situate teachers “in knowing where to use technology, what technology to use, and how to teach with it” (McCror, 2008, p. 195), and thus help them identify the tentative manifestations situated in the phenomena of pedagogical awareness.
If pre-service science teachers are going to be successful with effective technology integration, teacher preparation must provide both time and space to evaluate their practices. In his study of preparing pre-service teachers for integrating technology into math and science, Niess (2005) suggests that too often pre-service teachers experience a disconnect between their preparation and their teaching in the field. They learn about learning and teaching outside both the subject matter and technology. In fact, pre-service teachers often learn about teaching and learning with technology in a more generic manner unconnected with the development of their knowledge of the subject matter. (p. 510)

As pre-service teachers prepare to enter the classroom, they must be reminded to consider how the science content and the integration of technology affect the subject matter and the pedagogical decisions that accompany the teaching and learning of that subject matter (Niess, 2005). Through creating reflexive teaching habits, teachers must “recognize the importance that learning to teach is a ‘constructive and iterative’ process where they must interpret ‘events on the basis of existing knowledge, beliefs and dispositions’ (Borko & Putnam, 1996, p. 674 in Niess, 2005, p. 511).

In their study presenting taxonomies for comprehensive categorization schemes on PCK in science education, Veal & MaKinster (1999) identified the need for pre-service science teachers to attend to three areas of development—general PCK, domain-specific PCK and topic-specific PCK. While their work preceded Mishra & Koehler’s
(2006) work on TPCK, it highlighted the need for pre-service teachers to develop teaching strategies inherent in these three areas. Veal & MaKinster (1999) indicated that as teachers develop their professional knowledge and skills, they cultivate subject-specific strategies in the area of science, more detailed domain-specific strategies for subject matter (physical science versus biology) and even more detailed topic-specific strategies unique to particular domains (heat and temperature within physical science and biology) within science. With an instructional paradigm for prospective science teachers, adding TPCK to this taxonomy compounds the level of complexity as well as nuanced knowledge bases embedded in each one of the hierarchical taxonomies.

In support of developing science teachers’ PCK, van Driel, Verloop & de Vos (1997) also examined the intersection of pedagogy and content necessary for effective topic-specific science instruction. They found that “familiarity with a specific topic in combination with teaching experience positively contributes to PCK” (p. 681). Their study also presented that “teachers, when teaching unfamiliar topics, have little knowledge of potential student problems and specific preconceptions, and have difficulties selecting appropriate representations of subject matter” (p. 679). Their work on science and PCK supports the need to further research and develop the content knowledge of pre-service science teachers, as well as the technology integration that accompanies that PCK development.
This study attempts to extend the work on technology integration in science education by providing time and space for pre-service teachers to investigate and examine what McCrory (2008) illuminated as the “where, what and how” decisions in the teaching of science with technology. Framed within a post-intentional phenomenological case study approach, this study provides preliminary insight into how teachers come to understand the tentative manifestations of their pedagogical awareness of technology integration into science education through reflexive bridling. While post-intentional phenomenology does not claim to draw hard and fast conclusions as a result of entering into this type of work, this study seeks to add salient meaning to the ongoing research. The following chapter provides an overview of both the methods and methodological approach of post-intentional phenomenology.
Introduction and Overview

In order to provide the necessary framework for the methodology presented in this study, the following section will provide a rationale for the chosen research paradigm, theoretical perspectives and underpinnings that inform the research inquiry, inherent assumptions that accompany the study’s infrastructure, as well as the methodology that will be used to explore the integration of technology into science teaching.

Paradigms explored. Teaching is a complex entity and it must be argued that it is not possible to isolate its practice to simplistic, component parts. In an effort to identify how the lived experience of pre-service teachers shapes their teaching practice, it is not necessary to operate in a post-positivistic paradigm that tests hypotheses or controls for variables, but rather to recognize that reality is socially, culturally and historically constructed (Lincoln & Guba, 1985). Thus, teaching may be analyzed through the social constructivist or interpretivist paradigm situated in qualitative research. Qualitative studies are “naturalistic to the extent that the research takes place in real-world settings and the researcher does not attempt to manipulate the phenomenon of interest” (Patton, 2002, p. 39). Qualitative research, being rich in detail and thick description may also be “epistemologically in harmony with the reader’s experience” (Stake, 1978). Maxwell (2005) promotes the use of qualitative studies to achieve intellectual and practical goals that center on understanding the meaning and context, unanticipated phenomena and
influences, process rather than the product, and developing causal explanations. Inherent in the social constructivist paradigm is the assumption that “reality is socially constructed, that individuals develop subjective meanings of their own personal experience, and that this gives way to multiple meanings” (Bloomberg & Volpe, 2008, p. 8). This sheds light on the effort of interpretative qualitative researchers like Lincoln to ascertain these complex meaning structures inherent in the paradigm itself. Lincoln and Guba (1998) propose the notion that the constructivist researcher is a “passionate participant”—one who must come to recognize how their own lived experience shapes and effects their interpretation of the lived experience of others—an issue that will be addressed further in the methods section. Qualitative research offers the necessary time and space to contemplate the varied meanings and processes rather than just the product itself.

Methodology

A multi-case study design was used to explore the pedagogical awareness of pre-service science teachers and the integration of technology into their teaching. Yin (1984) defines case study research as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used” (Yin, 1984, p. 23). This research methodology allows for a descriptive analysis of the phenomena at hand—pedagogical awareness—and how the context of the classroom
when bounded by both time and place (Creswell, 1998; Merriam, 1998) can facilitate an 
evaluation of the phenomenon. This study occurred in the spring semester (January to 
May) of the researcher’s college and at the pre-service teachers’ student teaching 
placements in both the middle and high school life science classrooms. As a method and 
means of qualitative research, case studies are holistic, contextually sensitive and 
constitute a specific way of “collecting, organizing, and analyzing data” (Patton, 2002, p. 
447). Case study research can be both an analysis process as one gathers 
“comprehensive, systematic, and in-depth information about each case of interest” 
(Patton, 2002, p. 447), as well as the product of analysis that results from the case study 
itself. While some researchers use either the process or product approach, this study 
utilized both as Patton proposes as a way of understanding the “idiosyncratic 
manifestations of the phenomenon of interest” (Patton, 2002, p. 450). In an attempt to 
more clearly articulate the “phenomenon of interest,” an introduction to phenomenology 
is presented.

**Introduction to phenomenology.** In order to investigate effective integrations of 
technology into the secondary science classroom, it is necessary to evaluate the 
significance and meaning that resides within the pedagogical framework of the pre-
service teacher. To move beyond what can be read as a vague generalization of “teacher 
reflection,” I would argue that an analysis of pedagogy must take place from both the 
philosophical and practical standpoints of both retrospective and introspective thinking
on a teacher’s teaching. This investigation to find significance and meaning amidst the work of pre-service teachers leaned on the underpinnings of phenomenological research that sought to find essential meanings in particular phenomenon as well as Schon’s call to “create or revitalized a phenomenology of practice that includes, as a central component, reflection on the reflection-in-action of practitioners in their organizational settings (Schon, 1987, p. 321). This act of reflecting on the “reflection-in-action” enables a deeper level of metacognitive reflection—a reflexive act of the lived experience and inherent assumptions of the pre-service teachers and the researcher’s practice.

Sokolowski (2000) claims that phenomenology is “the study of human experience and the ways things present themselves to us in and through such experience” (p. 2). Dahlberg et al., (2008) posit phenomenology as “the study of phenomena—the study of what shows itself in acts of knowledge” (p. 24). Sokolowski (2000) further clarifies this notion of phenomenon:

They (phenomenon) are ways in which things can be. The way things appear is part of the being of things; things appear as they are, and they are as they appear. Things do not just exist; they also manifest themselves as what they are. (p. 14)

Altogether, phenomenology “insists that parts are only understood against the background of appropriate wholes, that manifolds of appearance harbor identities, and that absences make no sense except as played off against the presences that can be
achieved through them” (Sokolowski, 2000, p. 4). Defined as such then, phenomenology is “reason’s self-discovery in the presence of intelligible objects” (Sokolowski, 2000, p. 4). Understanding cannot be achieved then without identifying how one comes into relationship with a phenomenon at hand.

Articulating a ground level scope of this research would then project that the phenomenon at hand referenced the various degrees to which pedagogical awareness was present. This awareness could be conceived as the metacognition that surrounded the practices of teaching or the act of learning to teach, the “in knowing” of how one was situated in the process of teaching and learning, or of evaluating the effectiveness of particular pedagogical practices. Positioned within this framework of phenomenology is the philosophical principle of “intentionality”—a core tenet of both the philosophy and methodological approach. This intentionality explores “the ‘consciousness of’ or ‘an experience of’ something” (Dahlberg et al., 2008). Sokolowski helps to distinguish the difference that exists between the common use of intentionality and the philosophically informed phenomenological use of intentionality. “The phenomenological notion of intentionality applies primarily to the theory of knowledge, not to the theory of human action” (Sokolowski, 2000, p. 8). With this in mind, phenomenologists are not referring to the common place notion of “intending” to do something like cut the grass or fold the laundry, but rather that intentionality refers to the relationship that exists with an object,
such as being in love, in pain, or in struggle. In an effort to conceptualize the notion of intentionality, Freeman & Vagle (2009) provide the following assistance.

Merleau-Ponty (1964) describes intentionality as the invisible thread that connects humans to their surroundings meaningfully whether they are conscious of that connection or not. Sartre (in Moran & Mooney, 2002) has described intentionality as the ways in which we meaningfully find ourselves “bursting forth toward” (p. 383) the world. Regardless of how it is described, intentionality is a difficult concept to grasp. Part of its confusion lies in the strength of the image of the autonomous meaning-making agent orienting to the world with purpose and intent…Intentionality is neither consciousness nor in the world. It is the meaning link people have to the world in which they find themselves. People in everyday contact with the world bring into being intentionality but not in the sense of choice or intent. (p. 3)

Consequently, this “epistemological dilemma” rests in the required dichotomy of a subject-object relationship. With regards to this study—the phenomenon of pedagogical awareness was situated amidst the subject of pre-service secondary science teachers and the object of effective integration of technology for science learning.

*Natural versus phenomenological attitude.* Identifying a phenomenon hinges on detecting the “attitude” with which one is operating within—the natural attitude or the phenomenological attitude. Sokolowski defines the natural attitude as “the focus we have
when we are involved in our original, world-directed stance, when we intend things, situations, facts, and any other kinds of objects (2000, p. 42). This perspective marks the starting place for observation and questioning. Edmund Husserl, the father of descriptive phenomenology, claimed that the natural attitude is “the everyday immersion in one’s existence and experience in which we take for granted that the world is as we perceive it, and that others experience the world as we do” (Dahlberg et al., 2008, p. 33). If one moves beyond the natural attitude and enters a mindset of interpretation and analysis, one has begun operating in the phenomenological attitude. This process of moving from a participant observer in the natural attitude to a detached observer in the phenomenological attitude requires what Sokolowski (2000) coins as the “phenomenological reduction—a term that signifies the ‘leading away’ from the natural targets of our concern, ‘back’ to what seems to be a more restricted viewpoint, one that simply targets the intentionalities themselves” (p. 49).

Sokolowski (2000) defines the phenomenological attitude as “the focus we have when we reflect upon the natural attitude and all the intentionalities that occur within it. It is within the phenomenological attitude that we carry out philosophical analyses” (p. 42). It is through the phenomenological reduction and attitude where the researcher suspends ones beliefs in the form of mental “brackets” or parenthetical phrases about observations that derive meaning or analysis about the intentionalities or phenomenon at hand (Sokowloski, 2000). These brackets allow the researcher to “consider it precisely as
Situated within these mental bracketing exercises, a researcher identifies through the phenomenological attitude how the technological and pedagogical awareness of a teacher exists in the natural attitude of teaching and learning science.

**Historical underpinnings of phenomenology.** Phenomenological roots can be traced back to the turn of the 20th century with Edmund Husserl’s creation of descriptive phenomenology and his Theory of Intentionality. Husserl’s doctrine of intentionality assumes that meanings must transcend time and space; theories, knowledge and thoughts can be reduced to the essence of the phenomena itself (through bracketing); and when a person is describing the particulars of the phenomenon, the person is finding meaning in, not giving meaning to the phenomenon as it is in relationship with. Through these developments, Husserl purported that the key to descriptive phenomenology is finding the essence of the phenomenon under study. Husserl also felt that “science begins with and extends from a lifeworld perspective. He saw phenomenology as the key to an explicit and reflective basis of science in the lifeworld” (Dahlberg et al., 2008, p. 37). It is through a Husserlian influence on the “essence of” and “intentionality with” that the pre-service teacher’s intentions with technology integration into science teaching must be evaluated.

As an extension of Husserlian phenomenology, Martin Heidegger worked to further establish understanding within interpretative phenomenology with his work on
“being” (Sokolowski, 2008). As a predecessor to Hans-Georg Gadamer, Heidegger worked to expand the “notion of hermeneutics from the study of texts and records to the self-interpretation of human existence as such” (Sokolowski, 2000, p. 224). It was through this movement that Heidegger extended the work of intentionality into how people come into relationship with experiences through “threads of meaning.” Heidegger continued to isolate the essence of “being” through the ‘ontological difference’ present in the phenomenological perspective as “the difference between a thing and the presencing (or absencing) of the thing” (Sokolowski, 2000, p. 50). Heidegger brought clarity to the notion that understanding one’s “being” must occur within the phenomenological attitude in response to what is observed in the natural attitude. Merleau-Ponty also provided clarification on the “meaning threads of intentionality” by drawing connections between the mind and the body. Merleau-Ponty explicated that significant meaning was derived from the bodily-lived experience and intentional relation with our bodies and the world and our world and our bodies (Vagle, 2010a; 2010b).

**Post-intentional phenomenology.** Building on Husserl’s Descriptive Phenomenology and Heidegger and Gadamer’s Interpretative Hermeneutical Phenomenology, Vagle introduces a Post-Intentional Phenomenology that capitalizes on the influence of coming into intentional relations with the phenomenon at hand and creates a foundation for studying the intentionality that surrounds how people “find themselves in” significant meaning making (Vagle, 2010a; 2010b). Vagle extends past
the notion that phenomenon contain essences in and of themselves that can isolated and centralized. He proposes that “intentionality is shifting and forever partial” (Vagle, 2010b, p. 34). Vagle (2010b) continues to discuss the concept of gaining understanding through a fluid phenomenological investigation.

Whatever understanding is opened up through an investigation will always move with and through the researcher’s intentional relationships with the phenomenon—not simply in the researcher, in the participants, in the text, or in their power positions, but in the dynamic intentional relationships that tie participants, the researcher, the produced text, and their positionality together.

(p. 35)

Consequently, “a post-intentional phenomenological research approach resists a stable intentionality, yet still embraces intentionality as ways of being that run through human relations with the world and one another” (Vagle, 2010b, p. 36). This instability with regards to intentionality implies what Vagle claims as “tentative manifestations”—intentions that are morphing, changing, fleeting, and expanding through investigation. One could argue then, that the presence of pre-service teachers’ pedagogical awareness displays a sense of tentative manifestations as one becomes more (and possibly less) aware of the pedagogical affordances that accompany good teaching. These manifestations presented themselves to the pre-service teachers in many ways—enacted
lessons, peer consultation, mentor feedback, student acknowledgement, teacher satisfaction, and many more.

As a means of researching a “re-framed phenomenology of practice” that extends on the work of other phenomenological researchers (Dahlberg et al., 2008; Dahlberg, Drew, & Nystrom, 2001; van Manen, 1997), Vagle (2010a; 2010b; Vagle, Hughes, & Durbin, 2009) proposes a five-component process for conducting post-intentional phenomenological research. The process is as follows:

1) Identify a phenomenon in its multiple, partial, and varied contexts.

2) Devise a clear, yet flexible process for collecting data appropriate for the phenomenon under investigation.

3) Make a bridling plan.

4) Read and write your way through your data in a systematic, responsive manner.

5) Craft a text that captures tentative manifestations of the phenomenon in its multiple, partial and varied contexts.
Using Vagle’s post-intentional approach, the phenomenon being studied is the identification of the tentative manifestations of a pre-service teacher’s pedagogical awareness of good teaching and learning through the implementation of technology in the secondary science classroom. Challenges exist to identify how and why the manifestation of pedagogical awareness alters throughout teaching and what pre-service teachers do to accommodate for these changes. Regardless of an unavoidable ebb and flow, these tentative manifestations speak to the metamorphosing nature of teaching and the challenges that exist within the discipline itself. Through this study, the pre-service teachers were introduced to the post-intentional phenomenological approach and how it illuminated the tentative manifestations of the varied contexts and presence of pedagogical awareness within their teaching. As a methodological commitment to foster practitioner’s reflexivity (Schon, 1987; Vagle, 2010a), both the pre-service teachers and the researcher participated in a reflective, cognitive process called bridling. Proposed by Dahlberg et al., (2008) bridling has three main tenets:

1) ‘Bridling’ covers the Husserlian concept of “bracketing” by restraining of one’s pre-understanding in the form of personal beliefs, theories, and other assumptions that otherwise would mislead the understanding of meaning and thus limit the research openness.
2) Bridling covers an understanding that not only takes care of the particular pre-understanding, but the understanding as a whole. As such, ‘bridling’ means an open and alert attitude of actively waiting for the phenomenon to show up and display itself.

3) ‘Bridling,’ because of its focus on the whole event of understanding, is pointing forward. While ‘bracketing’ is directed backwards, putting all energy into fighting pre-understanding and keeping it in check ‘back there,’ not letting it affect what is happening ‘here and now,’ ‘bridling’ has a more positive tone to it as it aims to direct the energy into the open and respectful attitude that allows the phenomenon to present itself. (Dahlberg et al., 2008, p. 129-130)

As a result, this bridling encapsulates the metaphor of tightening and slackening the reins of intentionality in order that a phenomenon may tentatively manifest itself to the researcher. Dahlberg et al., (2008) reiterate the importance of identifying pre-understandings.

It is important that pre-understanding is recognized, reflected upon and ‘bridled’ during the search for meaning, essences, interpretations and comprehensive understandings. Researchers who are not aware of their pre-understandings and neglect its associated problems risk obtaining results that are primarily a reflection of their past experiences or unrecognized
beliefs. Research is then likely to merely confirm what is already known, and no new understanding is reached. (p. 135)

It was critical then to provide opportunities for the study’s participants (pre-service teachers and researcher) to bridle through their pre-understandings in ways that fostered deeper, more substantial, invasive understandings of this pedagogical awareness. Albeit difficult to delve past the superficial ‘reflective practice’ of good teaching, the constituents had to be prepared for new understandings to surface as a result of the reflexive bridling process. This bridling process was both one of mental reflection as well as one of written reflection.

Methods

A post-intentional phenomenological multi-subject case study approach was used to investigate the pedagogical awareness of technology integration with pre-service science teachers. Creswell (1998) identifies five qualitative traditions of inquiry: biography, phenomenology, grounded theory, ethnography, and case study. While Creswell (1998) identifies both phenomenology and case study as two separate traditions, this study attempted to utilize the benefits of both of the traditions. Consequently, this study explored the tentative manifestations of the lived experience inherent in post-intentional phenomenology while giving specific attention to the “particularity and complexity…within important circumstances” (Stake, 1995, p. xi) inherent in case study design. While there is some discrepancy as to whether a case study is a qualitative
approach or a method (Hamel, Dufour, and Fortin, 1993) the argument can be made that
the method informed the approach.

While case study was enacted as both the approach and the method, the analysis
of how the phenomena tentatively manifested itself was conducted using a hybrid method
of single-case and cross-case analyses (Glaser & Strauss, 1967; Patton, 2002), as well as
the “whole-part-whole” analysis (Dahlberg et al., 2008; Vagle, 2010a; van Manen, 1997)
inherent in phenomenological research. In an effort to honor the methodological
convictions of phenomenological work and carry out the whole-part-whole analysis, I
intentionally enacted a single and cross case analysis on the phenomena of pedagogical
awareness. Cross-case analysis provided the means of “cutting across” individual
experiences of the participants single cases in search of patterns and themes that emerged
(Patton, 2002)—what is referred to in this study as “tentative manifestations.” In post-
intentional phenomenology, like all other phenomenological work, the unit of analysis is
the phenomena under investigation. The initial “whole” analysis was conducted by
identifying the tentative manifestations inherent in each of the single case analyses. The
intermediary “part” analysis was guided by the cross-case analysis that investigated the
unique manifestations of the pedagogical awareness across each of the participants.
Finally, the secondary “whole” analysis was conducted as the researcher theorized
implications from the study—constituting a new “whole.”
Teacher Preparation Program. This term-bound post-intentional phenomenological case study stemmed from the literature calling for teacher preparation programs to establish effective technology integration in their teacher candidates. Throughout the course of the study, each of the participants was enrolled in the same undergraduate teacher preparation program at the college where they attended. Additionally, each of the participants was previously enrolled as a non-education major before each of them decided to pursue secondary life science education and the licenses associated with life science for grades 9-12 and general science for grades 5-8. As a result, both Molly and Lily completed their B.S. in Secondary Life Science Education from the partnering institution over a five-year period of time and participated in their student teaching during their final undergraduate semester. Throughout their undergraduate tenure, Molly and Lily matriculated through department-specific education classes together, taking courses from the same instructors, experiencing the same philosophies, pedagogies, and perspectives on teaching and learning characteristic of the Teacher Education Department (TED) to which they belonged. This TED focuses on a constructivist teaching approach, centered on the development of the knowledge, skills and dispositions necessary for successful teaching and learning.

Participants and participant selection. This study continued a dialogue between the researcher and two secondary life science teacher candidates (Molly and Lily--pseudonyms) during their student teaching in the spring of 2012. Each of the participants
were selected from a cohort of student teachers from a private, Midwest 4-year college working toward their secondary science teaching license and who were placed in middle and high school science student teaching placements during the academic year. On the other hand, each participant possesses her own life circumstances that have shaped who she has become up until this student teaching experience. Additionally, each participant experienced different sophomore and junior level practicum and student teaching school placements that accompanied and supported their coursework. Consequently, their personalities, background information and placements shaped their teaching philosophy and the inculcation of their thoughts on teaching and learning—leading to their individualistic approach to teaching that was exhibited in their student teaching.

**Bridling plan.** In an effort to provide maximum opportunities for bridling, the researcher himself began bridling at the start of the study about his inclinations that arose about tentative manifestations of the phenomenon itself as well as investigated the interactions with the pre-service teachers on good teaching and learning. Throughout the 15-week study, the researcher conducted ten teaching evaluations of the pre-service teachers in their respective middle school and high school placements. Preceding and following each visit, the researcher and participants were asked to bridle about the phenomenon in question, paying close attention to whether or not pedagogical awareness was identified as well as periodic bridling prompts (10 total) given by the researcher. The pre-service teachers had opportunities to bridle about their lesson plans, peer focus
groups of pre-service teachers, student teaching journal entries, lesson plan reflections
and site visits by the researcher. At the conclusion of the 15-week study, the pre-service
teachers were also asked to participate in a short bridling activity where they bridled
about their student teaching experience in its entirety. By looking through an extended
lens, the pre-service teachers may have come to realize that separation from the
experience created an even more complex phenomenon or alternative tentative
manifestation than they had already acquired. As a result of this bridling plan, both the
researcher and the participants were given the opportunity to step back and acknowledge
the teaching and learning that had transpired in the science classroom as a result of
integrating technology during their student teaching experience. It was the hope of the
study to provide “meanings of intentionality” that captured the tentative manifestations
surrounding the pedagogical awareness in technology integration for science teaching and
learning.

**Data collection.** This qualitative study’s focus on pedagogical awareness
explored what pre-service teachers did, thought and said through teaching middle school
and high school science. Throughout the course of the pre-service teachers’ student
teaching experiences, many points of inquiry were explored in order to get a more
stippled picture of what went on in the minds of pre-service teachers.

**TPCK framework identification.** It was critical for the pre-service teachers to
establish their understanding of Technological Pedagogical Content Knowledge proposed
by Mishra and Koehler (2006) before starting this phenomenological case study. To raise their awareness and metacognition of their teaching, the pre-service teachers located themselves on the TPCK framework diagram (Appendix A) and then provided a rationale as to why they located themselves where they did based on their perception of their understanding of the elements of TPCK. The purpose of this exercise was two-fold: 1) it alerted the teacher’s consciousness towards their present location and 2) provided the opportunity for the pre-service teacher to reflect and identify what potential areas of growth exist in order for them to center themselves on the framework diagram. The participants also completed this self-placement TPCK framework identification at the completion of their first and second student teaching placements in order to gain deeper understandings of the tentative nature of their pedagogical awareness and how it morphed, changed and shifted as a result of their experiences.

**Observations.** Each of the lessons and post-lesson interviews were videotaped and uploaded to a video annotation website for further review, reflection and bridling prompts. An eleventh lesson was initiated and recorded by Lily during her second placement in an attempt to showcase her follow-up to lesson 10 using a mobile computer lab enabling students to calculate and analyze lab results. Since the researcher was not present for this eleventh lesson, no follow-up interview was conducted. The participants were emailed hyperlinks to the ten or eleven lessons and asked to review their lessons in order to identify four lessons they would further critique. The participants were
encouraged to identify two lessons they felt demonstrated effective teaching and learning and two lessons that, if given the opportunity, they would revise, reorganize or re-teach in order to provide more effective teaching and learning. The participants were then asked if they would review each of the four lessons and annotate the what, when, where, why and how of what they did in the classroom—thus identifying their pedagogical awareness of their science teaching. Following the annotation exercise, participants were asked to bridle about why they chose each of the lessons and what they gained from the review experience. These lesson rationales can be found in the text to follow. Each of the participants, without the request of the researcher, volunteered to annotate all ten lessons in order gain a clearer picture of which four lessons stood out to them as effective and ineffective lessons throughout their student teaching experience. This action indicated the awareness of inherent professional development on behalf of the student teachers as well as their desire to become more reflexive in their teaching.

Once each of the participants had annotated and briddled about their four lessons, the researcher annotated their videos with his own thoughts and ideas towards their teaching. This exercise was done after each of the participants had completed their annotations in order to not influence the participant’s own reflective practice.

Post-observation interviews. Following each of the observations, an informal interview occurred with the student teacher, the researcher, and the cooperating teacher (if time allowed). These semi-structured interviews focused on the pre-service teacher’s
perception of lesson preparation and execution, identification of good teaching and learning, and their uses of technology integration. The researcher focused particular attention to comments focused on pedagogical awareness as well as technology integration into the science content areas as the following questions were asked in the post-observation interview.

1) How do you think your lesson went overall?
2) How do you think technology affected your lesson?
3) Do you think technology was utilized in an effective way?
4) Are there other areas in which technology integration would enhance your material?
5) Do you think technology enhanced, retracted or remained neutral to the science content in this lesson?

These interviews were videotaped and salient comments regarding the tentative manifestations were transcribed and bridled about by the researcher so they were available for further exploration in the cross-case and whole-part-whole analysis.

**Bridling entries.** As mentioned earlier in the methods section, the pre-service teachers participated in a bridling plan (Dahlberg et al., 2008) throughout the entire study in an effort to solicit pedagogical awareness embedded in their student teaching experiences. The students were asked to respond to prescribed and spontaneous prompts following the TPCK framework diagram, after each of the ten post-observation
interviews as well as a summative bridling entry after each of the placements. The pre-service teachers also had the flexibility to bridle independently of prompts thus creating time and space to process through perplexing issues from the classroom, pedagogical changes and developments, or issues that arose as a result of student teaching. The participants also reviewed the videos of their observed lessons and provided bridling responses to each of their lessons—paying particular attention to their pedagogical awareness of technology integration. Finally, in order to gain a clearer picture of their pre-understandings regarding science, technology and teaching, the participants bridled their responses to the list of prompts found in Appendix B.

At the conclusion of the semester, the pre-service teachers were given time and space to bridle about the entire teaching, learning and research experience. It was the goal of the researcher to identify threads of commonality among the tentative manifestations of issues, concerns and developments surrounding the pedagogical awareness that accompanied technology integration into science teaching.

**Limitations to the study.** Every study—quantitative or qualitative has limitations that must be acknowledged and brought forward with a level of transparency that aids in gaining credibility. While this study sought to identify the pedagogical awareness of the pre-service teachers through their lived experience, it is difficult to truly ascertain the true lived experience of another without constant, holistic surveillance and monitoring. It was through hopeful anticipation that the researcher received a clear mosaic of the lived
experience through the data collection methods presented above. Much of the impact of
the study rested on the shoulders of the pre-service teachers and their willingness to share
their normal teaching practices with regards to integrating technology. With that said, the
implications for the study were also dependent on the level and extent to which the pre-
service teachers’ pedagogical awareness surfaced from their routine uses of technology
integration. It must be acknowledged that while the participants indicated the level or
frequency of technology was reflective of their normal implementation in each
placement, the pressure to produce technologically-saturated appearances, more frequent
uses or desired uses of technology in their teaching could have occurred. Additionally,
the perception of the participants’ TPCK and the integration of technology cascaded from
their cooperating teachers and their beliefs of how technology integration impacts
instruction—thus creating another influence in the study’s results.

Another limitation was positioned within the fact that the researcher was also the
academic advisor and instructor for the pre-service students. While some would view
this as a limitation, the researcher believes the strength of these established relationships
fostered more authentic interactions and invested interest on behalf of the pre-service
teachers. One final limitation that needs to be identified related to the sample size was
the selection of the pre-service teachers for the purpose of the study. While it would have
been more ideal to have selected a random sample from a superfluous group of science
students, these two research subjects were selected because they were the two secondary
life science teachers approved for student teaching in the spring of 2012 at the researcher’s institution. The researcher pleads with the reader to see this not as a matter of convenience, but rather of one built on strong relationships, invested interest and transparency.
Chapter IV

This chapter presents the cases for the two participants in this study—Molly and Lily (pseudonyms). Each case includes the experiences and circumstances that shaped the tentative manifestations of their pedagogical awareness of technology into their student teaching experiences. First, an introduction to each of the participants will be presented. Second, the participants’ understanding and rationale of the Technological Pedagogical Content Knowledge (TPCK) framework will be introduced as a means to better understand their approach to teaching and learning. Their understanding of their location within the framework will be situated amidst the student teaching placement in which it was identified. Details regarding each of their student teaching placements will follow to provide a greater understanding of their learning environments. Finally, a brief overview of each of their lessons and the technology they integrated will be presented.

As stated in Chapter 3, each of the participants completed three self-evaluations on their perception of understanding of Shulman’s PCK framework and Mishra and Koehler’s TPCK framework. The evaluations were completed prior to the start of their student teaching, after their first placement and at the conclusion of their second placement. Each of the participants provided a rationale as to why they perceived their location on the PCK and TPCK frameworks as they did. Additionally, each of the participants reviewed the videos of each of their observed lessons and provided annotations towards McCrory’s (2008) suggestions of identifying the what, how and why
of their pedagogical awareness. Finally, each of the participants provided bridling responses to the questions in Appendix B as well as bridling throughout the study to help capture their understanding of their pedagogical awareness.

Molly’s Case

Molly was a diligent, caring individual who had a calm, collected disposition for teaching. Her shy, reserved, yet respectful demeanor earned her veneration in the eyes of her peers, instructors and consequently, her students. Molly was very conscientious, polite and sincere in her approach with people, which lent itself well to her dependable and consistent approach in the classroom. She completed her BS in Life Science Education and planned to pursue a teaching position in secondary life science. Her desire to teach in the biological sciences stemmed from her passion for the natural world and her desire to transmit that interest to her students.

Molly’s initial understanding of PCK and TPCK. Prior to her first student teaching experience, Molly identified where she perceived herself in both Shulman’s PCK model as well as Mishra & Koehler’s TPCK model. Using Shulman’s PCK model, Molly positioned herself at the intersection of pedagogy and content knowledge slightly toward the content side, referencing the need to connect theory she had learned in class with the opportunity to practice in her upcoming student teaching experience (see Figure 4.1). Molly provided the following rationale for her decision,

I believe this is where I am currently because I feel generally comfortable with
and competent of much of the content (though I do still often need to do research before lessons), and I am just getting going on the pedagogical part. I have learned the theory, but only this year have I been putting it into practice.

Using Mishra & Koehler’s TPCK framework, Molly positioned herself at the intersection of content, pedagogy & technology (see Figure 4.2), slightly favoring content knowledge again. She shared a willingness to learn and expand her knowledge base with regards to technology, indicated a lack of exposure to classroom-based technologies as a reason for her limited understanding. Molly provided the following rationale for her decision.

I aligned it [her location on the diagram] about where my CP [pedagogical content] knowledge is, but included my T [technological] knowledge. I can do most basic things, but I have never been very technology-savvy. I am open and able to learn new things, but my current knowledge is limited.
Molly’s first student teaching placement. Molly’s first placement took place at a Midwest, mid-sized, suburban public high school composed of students from a middle to upper-middle class socio-economic status. The high school services approximately 900 students, 8.1% of whom are eligible for free or reduced priced lunch. The ethnicity composition of the students is as follows: 1.1% Black; 0.5% American Indian/Alaskan Native; 1.9% Asian/Pacific Islander; 2.3% Hispanic; and 94.3% White. Molly taught five biology courses—three days per week for 40 minutes and two days per week for 48 minutes. Over the course of her ten-week placement, Molly taught and collaborated with a male cooperating teacher—a veteran teacher of 21 years—who entered the teaching profession later in his professional career. The working relationship between Molly and her cooperating teacher was healthy, constructive and collegial. Throughout Molly’s first placement, the rapport with students developed to the point that they were disappointed to see her move on to her second placement. The physical classroom was set up with traditional lab desks (2 students per desk), situated in rows facing the front of the room where there was one main whiteboard and a teacher’s desk. Slate lab tables lined the sides of the classroom where students congregated for lab demonstrations and experiments. Molly’s cooperating teacher worked diligently to cultivate green plants to bring the biological sciences to fruition along the perimeter of the classroom—most of which seemed to generally go unnoticed by the students. Molly’s cooperating teacher
developed a positive working relationship with his students, creating a positive, dependable learning environment for them to enter.

Over the course of Molly’s first student teaching placement, the researcher observed six lessons and conducted six post-observation interviews. The lessons that were observed are summarized in Table 4.1.

Table 4.1
Molly’s First Student Teaching Placement Observed Lessons

<table>
<thead>
<tr>
<th>#</th>
<th>Lesson</th>
<th>Method</th>
<th>Technology Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bacteria Gram Staining Laboratory</td>
<td>Mini-lecture</td>
<td>PowerPoint Microscopes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laboratory</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Student Presentations on Diseases/Bacteria</td>
<td>Student presentations</td>
<td>PowerPoint Google Docs</td>
</tr>
<tr>
<td>3</td>
<td>Algae &amp; Protist Laboratory</td>
<td>Mini lecture</td>
<td>PowerPoint Microscopes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laboratory</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Jeopardy Review: Plants/Algae</td>
<td>Jeopardy review</td>
<td>PowerPoint</td>
</tr>
<tr>
<td>5</td>
<td>Primitive Plant Laboratory</td>
<td>Mini lecture</td>
<td>Microscopes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laboratory</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Jeopardy Review: Plants</td>
<td>Jeopardy review</td>
<td>PowerPoint</td>
</tr>
</tbody>
</table>

**Lesson one.** Molly’s first observed lesson was a bacteria gram-staining laboratory. On the previous day, the students swabbed common surfaces around the school in preparation to test them in the observed lesson for positive or negative gram
stains. The lesson began with a PowerPoint overview of the laboratory outcomes for the gram stains as well as the protocol for preparing the slides for the lesson. The students rotated through various laboratory assembly-line stations, preparing their slides while Molly assisted in answering students’ questions and checking their slide accuracy. Once the students began testing their slides on the eleven microscopes around the perimeter of the laboratory for negative or positive outcomes, Molly monitored the students’ progress and assessed their slide outcomes. A few times during the class, Molly encouraged the students to check their results against the expected outcomes by redirecting the students to the PowerPoint slide on the board. Molly would continually ask the students—“did it turn purple or pink? The results are up on the screen.” Students would then compare their results to the outcomes on the board and conduct further analysis of which gram stain they had collected. Once the students had finished analyzing their gram stain under the microscope, they returned to their seats to draw and label three other bacteria results from peers.

**Lesson two.** Molly’s second observed lesson showcased students’ oral presentations on pathogens where students presented a “Disease Wanted” poster presentation. Presentation expectations were distributed to the students with a rubric that outlined the student requirements and the project descriptions.

Molly began the class reminding the students of the expected presentation etiquette as well as providing some guardrails for side conversations. “You [students]
should be respectful of each other as your peers are presenting; but you can have small
talk in between presentations.” Each of the students were instructed to save their
PowerPoint presentations on a flash drive, the school’s Google documents site or
emailing their presentation as an attachment to Molly’s cooperating teacher (last
preference). Molly had written the names of the presenters of the class period on the
white board and as she called on the next presenter, she accessed their presentation so
that their presentation was up and ready by the time they reached the front of the
classroom. Each of the students presented for about three minutes with a time for
questions following each presentation. Throughout the course of the presentations, Molly
was quick to troubleshoot the technological glitches that surfaced and worked quickly to
get the student presentations up on the screen.

Lesson three. “Have you ever eaten algae?” was Molly’s opening question to the
students in the third observed lesson. The lesson consisted of an algae & protist
laboratory in which students observed various species of algae using student-prepared
slides. Once students identified their algae and potential protist, they completed their
laboratory packet by drawing their field of view and answering questions. Following
their own analysis of their slide, students were instructed to observe three other
microscopes and analyze what they observed. Many of the students displayed comments
of engagement, interest and curiosity throughout the laboratory. “I just had them on there
and then I lost them. I had a family under there and then they all disappeared.”
student, in particular, was interested in keeping the organism in focus under the
microscope so he could show his laboratory partners what he had discovered. Another
student commented on the organism he observed eating another under the microscope.
Molly then redirected the entire class’s attention to the microscope.

Lesson four. Molly’s fourth lesson was a Jeopardy review game on plants and the
laboratories they had completed during the unit of study. The students were grouped
according to the three columns of desks. Students passed a colored piece of construction
paper that allowed them to answer when they had possession of the “answer card.” The
team that raised the construction paper first was given the first opportunity to answer the
question. If the three pairs of students were unable to answer the question, then they
could pass the construction paper to another member of their team for half of question’s
points. The answer card was passed backwards until it recycled to the front of the room,
thus providing the opportunity for each pair of students to answer at least one question.
Students that did not have the answer card at their laboratory desk were invited to listen
as a review and help their team answer if need be. Throughout the review game, students
were encouraged to review their notes, textbooks and laboratory reports to determine the
correct answer. In an effort to answer the questions correctly, students repeatedly
thumbed through their notes and chapters in pursuit of the answer—providing one more
cursory glance at the material.
Each of the slides that Molly had prepared contained both a content question and an associated image. Once the students had answered the question correctly, Molly advanced the slide and showed the answer on the same slide as the question. This combination of the question and the answer on the same slide provided students the opportunity to copy down the information as an additional study aid. About half of the students were copiously writing down the information, while about half were involved in simply answering the questions. The lesson concluded with the “double Jeopardy” question and students were reminded that their exam would be administered the next time the class met.

**Lesson five.** Molly’s fifth lesson began with a review of a recent exam on plants. Molly read through a few selected questions that the student had issues with and then opened up the floor for additional questions. Following the exam review, Molly provided an overview for their primitive plant laboratory. The laboratory consisted of fifteen stations that showcased both simple and complex plants. The students were groups in pairs and instructed to evaluate each specimen and determine its rank order based on characteristics from a flowchart in their laboratory packets. At the conclusion of the class period, Molly revealed the rank order of the plants as a means of assessment on the students’ progress throughout the laboratory.

**Lesson six.** Molly’s final observed lesson in her first student teaching placement was a Jeopardy review activity on primitive plants. Molly reiterated to the students that
she was her responsibility to determine which final answers were acceptable and that students needed to minimize their arguments, otherwise points would be taken away. The Jeopardy review was similar in format to the fourth observation, which combined questions and images to solicit student answers.

**Molly’s midpoint understanding of PCK and TPCK.** After completing her first ten weeks of student teaching, Molly reevaluated herself using Shulman’s PCK model and Mishra & Koehler’s TPCK model. Her PCK self-evaluation and rationale indicated that she felt she had a blend of both content knowledge and pedagogical knowledge. She mentioned that her content coursework supported her teaching with respect to transferring the information to the students, yet going through the actions of teaching the content opened her eyes to her pedagogical improvements that led to greater understanding. Her evaluation of her PCK and TPCK is shown in Figure 4.3 and Figure 4.4 respectively.

![Figure 4.3 Molly’s Midpoint Self-placement of her PCK](image1.png)

![Figure 4.4 Molly’s Midpoint Self-placement of her TPCK](image2.png)
Molly provided the following bridling response to her self-placement of her PCK understanding (Figure 4.3). She referenced the fact that she perceived an increase in both content and pedagogy during her first student teaching placement.

I have learned a lot more about pedagogy, and my knowledge of the content increase a fair amount. I have been most comfortable with biology of all the sciences, so I had a lot of that background knowledge. I learned more as I prepared for my lessons, so I certainly gained content knowledge, but had so much experience and learned so much about pedagogy that I feel I grew most there.

Molly’s TPCK self-evaluation and rationale (Figure 4.4) indicated her perception of an increase in both her content knowledge and pedagogical knowledge. While her comments regarding technology indicated she thought she “stayed about the same,” she also alluded to the idea that student teaching had exposed her to new technologies, resulting in an impact on her technology knowledge as well as her TCK, TPK, and TPCK. She provided the following explanation of how she perceived her TPCK following her first student teaching experience.

My content and pedagogical knowledge increased, but my technology knowledge stayed about the same. I learned about using Google Docs, and got some experience using microscopes and PowerPoint from a teacher’s perspective rather than a student’s.

**Molly’s second student teaching placement.** Molly’s second student teaching placement occurred at a medium-sized, Midwest, suburban public middle school from the
middle to upper-middle class socio-economic status. This school was one of three middle
schools in the district, serving approximately 700 students in grades 6-8, 15.8% of whom
are eligible for free or reduced priced lunch. The student demographics were as follows:
2.7% Black; 0.1% American Indian/Alaskan Native; 5.0% Asian/Pacific Islander; 6.8%
Hispanic and 85.3% White. Placed in 6th grade, Molly taught four sections of physical
science and observed one section of communication arts each day. The school operated
on a bell schedule of three days a week for 40 minutes and two days a week for 90
minutes.

Molly’s second placement cooperating teacher was a female teacher with eight
years of teaching experience, who worked with Molly to collaborate, brainstorm and
provide feedback to her during her five weeks of student teaching. Molly also had the
opportunity to meet via webcam with all of the district-wide middle school science
teachers for planning, assessment and collaboration purposes. Molly’s cooperating
teacher indicated that this experience was very valuable in sharing ideas and maintaining
consistency around the district. The physical science classroom was clean, organized and
showcased science terminology using a wordwall that was utilized both in the daily
lessons and life. The classroom space was divided into six table groups (indicated with
table numbers in the ceiling) to foster cooperative learning groups for both laboratory and
seat work. The front of the room contained both the laboratory material collection bins as
well as the teacher’s demonstration table.
Over the course of Molly’s second student teaching placement, the researcher observed Molly teaching four lessons, summarized in Table 4.2. An explanation of the lesson material, methods used and Molly’s thoughts on the lesson are also discussed.

Table 4.2

Molly’s Second Student Teaching Placement Observed Lessons

<table>
<thead>
<tr>
<th>#</th>
<th>Lesson</th>
<th>Method</th>
<th>Technology Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Gravity &amp; Motion</td>
<td>Lecture notes</td>
<td>PowerPoint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Demonstration</td>
<td>Video clip</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Directed reading homework</td>
</tr>
<tr>
<td>8</td>
<td>Newton’s Three Laws of Motion</td>
<td>Lecture notes</td>
<td>PowerPoint</td>
</tr>
<tr>
<td></td>
<td>Balloon Force Lab</td>
<td>Demonstrations</td>
<td>Video clips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lab</td>
<td>Directed reading homework</td>
</tr>
<tr>
<td>9</td>
<td>Newton’s Three Laws of Motion</td>
<td>Student responses</td>
<td>PowerPoint</td>
</tr>
<tr>
<td></td>
<td>Potential and Kinetic Energy</td>
<td>Demonstration</td>
<td>Directed reading homework</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lecture notes</td>
<td>Online Images</td>
</tr>
<tr>
<td>10</td>
<td>Types of Energy</td>
<td>Lecture notes</td>
<td>PowerPoint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Student response/share</td>
<td>Directed reading homework</td>
</tr>
</tbody>
</table>

Lesson seven. Molly’s first observed lesson in her second student teaching placement (seventh lesson overall) covered friction, gravity and air resistance. Molly began her lesson with a T-chart on the helpful and harmful purposes of friction. Students offered answers like the wax on the bowling alley, burnt rubber from tires, and adding wheels to the bottom of something to help it move. Following the T-chart brainstorming session, Molly instructed the students to take out their directed reading assignment and
switch papers with a seat partner. These directed readings were assigned almost every day as a follow-up to their textbook reading assignments. Molly projected the answer key that contained yellow highlighted answers following each question. Molly read each question aloud and then explained the answers listed on the screen as well as asked the students if they had any other answers they thought were correct. Molly answered a few student questions and provided clarification on a few problems for students that needed further explanations. After the directed reading was reviewed, the students were dismissed for their 30-minute lunch period. Following their lunch, the students returned for the second half of the lesson.

Once the students returned from lunch, Molly instructed the students to report their directed reading scores to her cooperating teacher who recorded them into her computer. Following the score recording, Molly directed the students’ attention to the learning target on the side board for the lesson: “I can explain the effects of gravity” and the terms pertinent to this lesson that would eventually be posted on the word wall following the lesson—free fall and gravity. Following a review of the learning target, Molly presented notes on motion and gravity using PowerPoint slides using an example of Wily E. Coyote and a falling boulder.

The students were reminded of a classroom poster above the white board that stated “science notes; BLUE you do” indicating that students were expected to write down the notes that appeared in blue font on the slide. Almost all of the students
followed along and wrote down the notes as Molly continued to teach on the elements of air resistance. She continued by demonstrating how air resistance causes a flat sheet of paper to fall more slowly than a crumpled piece of paper.

Molly continued her lesson by presenting notes on terminal velocity and free fall with and without the effects of gravity. Next, she showed a short YouTube video of an astronaut dropping a hammer and a feather on the surface of the moon to demonstrate how two objects dropped in the absence of gravity experience equal free fall. Following the astronaut’s demonstration, the students were instructed to begin their directed reading assignment and ask Molly or her cooperating teacher if they had questions.

Lesson eight. Molly’s eight observed lesson covered a combination of notes, video clips, demonstrations and a student laboratory reinforcing Newton’s three laws of motion. The class, began with a “brain warm-up,” where Molly asked the students to phrase Newton’s second and third law in their own words.

Following the brain warm-up, students were encouraged to take notes on the worksheet that Molly passed out outlining the three laws. Molly continued by showing a short video clip by on Newton’s first law and then demonstrated the effect of pulling a paper towel out from under a cup of water without spilling the water. Newton’s second law was introduced to the students with a video that portrayed two projectiles shot from an air canon at a stationary man, taking note that the lighter projectile contacted him first. Molly demonstrated the different forces necessary to slide an empty chair and a student-
occupied chair across the floor. Molly concluded the notes with a video showcasing Newton’s third law with a man propelling himself on a cart by emptying a fire extinguisher in the opposite direction. Following the video, the students were introduced to their mini-lab (an activity they audibly cheered for when they heard what it was) using balloon rockets. Each of the table groups constructed a balloon rocket by taping a filled balloon onto a straw and letting it travel down the path of a string like a rocket. Students were reminded to observe the relationship between how much air occupied the balloon versus how far the balloon rocket traveled down the string. With the remaining few minutes of the class, the students returned their materials to the laboratory equipment station and began their directed reading assignment for the evening.

**Lesson nine.** Molly started her ninth observed lesson by giving each student a notecard-sized picture as they came in. Each of the students determined whether their picture represented Newton’s first, second or third law and taped it on the wall in one of the three spaces designated for each law around the room. Once all of the students had committed their picture to one of Newton’s laws, Molly invited each table group to come up and defend their rationale to the class. As the students described their pictures and supported their reasoning, Molly instructed the students to fill out a chart in their notebooks that was projected on the screen listing five examples of Newton’s laws from the presentations. As Molly transitioned from the matching activity, she began the momentum and energy section of notes with a demonstration (Figure 4.5).
Molly held a suspended balloon up to a student’s face and let go, demonstrating that “kinetic energy does not equal potential energy.” The student remained still and the balloon oscillated like a pendulum, but did not make contact with the face. The students were attentive to the demonstration and many volunteered to be the next participant. After the demonstration, Molly read the analysis questions aloud and unpacked the answers with the students for the remainder of the class period.

**Lesson ten.** Molly’s final observed lesson began with a review of an energy conversion worksheet the students completed for homework that required them to identify a process that converts one form of energy to another one of the six forms of energy—sound, chemical, electrical, nuclear, thermal and light (SCENTL). Following the worksheet review, Molly began presenting notes on “getting energy into your home.” This lesson addressed the sources and pathways of the energy that could be converted into the electrical energy needed for residential use. The students asked many questions...
of Molly about the pathway and use of electricity—many of which, if not all of them she was able to answer. The lesson ended with an activity that required students to brainstorm and record various ways that the six forms of energy were used in their houses. Students shared their ideas with their seat partners and then worked on their directed reading assignment for the remainder of the class period.

**Molly’s final understanding of PCK and TPCK.** At the conclusion of Molly’s student teaching experience, she reevaluated her understanding of her PCK. While she continued to locate herself at the intersection of content knowledge and pedagogical knowledge, she indicated that both of these areas increased as a result of her middle school experience. She mentioned that in order to teach the physical science content, she needed to review the material from her Introduction to Physical Science class from her sophomore year in college as well as the curricular material used in her second placement. Molly also identified the developmental differences between the high school and middle school students, noting the increased requirements of classroom management techniques necessary to keep middle school students focused on learning. Her self-evaluation and rationale of her PCK and her TPCK can be found in Figure 4.6 and Figure 4.7 respectively.
Molly provided the following explanation as to her perception of what her PCK (Figure 4.6) was at the conclusion of her second student teaching placement.

My content and pedagogy knowledge both increased during my second placement. I had to learn several concepts of physical science over again so I could teach them. I also learned a lot about teaching middle schoolers—it was very different from teaching high school and there were many lessons I had to learn by working with them.

Molly also reflected on her TPCK (Figure 4.7) understanding at the conclusion of her second student teaching placement. Her comments about her self-evaluation indicated that student teaching provided her the opportunity to increase in all of the areas—content knowledge, pedagogical knowledge and technology knowledge. While her evaluation posited her in the center of Mishra & Koehler’s model, her comments indicated that she felt she had more of an increased in her technological pedagogical knowledge than in her technological content knowledge. Her cooperating teacher assisted her in identifying ways to teach the science content in a way that fostered greater interaction and interest, rather than just information transmission she experienced at the
high school. She provided the following bridling explanation as to why she chose the self-evaluative location.

My content and pedagogy knowledge both increased, and so did my technology knowledge. I didn’t really learn much in the way of new technology, but I learned some new ways to use it. In high school, the technology was a bit more about giving the students the information, but in the middle school it’s a bit more about getting their interest and attention. I learned techniques that increased my overall knowledge of technology.

**Molly’s self-selected lessons.** Each student teacher was asked to select and annotate four lessons—two lessons they felt best demonstrated effective teaching and learning and two lessons that they felt needed remediation. The four lessons and reflections Molly selected are described in the following section.

*Molly’s effective lessons.* The first lesson that Molly selected to showcase effective teaching and learning was her first observed lesson in the study—the bacteria gram-staining lab. This lab required students to swab common items and locations around the school and stain their slides to determine what type of bacterial cultures had grown.

Molly began her lesson with a reminder for students to listen carefully to reduce the confusion surrounding the lab procedure and expectations. She described the
laboratory report sheet in which she created space for the bacteria to be drawn in the pseudo-petri dishes on the lab sheet:

If you look at the backside on the bottom, there’s four circles. These are going to be from the four slides that you’re going to be making, okay? So on the first line, that says “shape.” What were those three shapes of bacteria that we talked about in class…”circle”…that was one (agreeing with a student). The spiral and the rod. So the circle is cocci, the um, rod is baccilus…actually let me just pull the slide…there right here.

When reflecting on this lesson, Molly recognized the benefit of showing the image of the shapes (Figure 4.8) immediately. “The picture definitely helped the students remember the shapes and have them make more sense.”

![Figure 4.8 Shapes of Bacteria slide](image)

Molly realized that showing the image on the PowerPoint slide presented the material more clearly than just through the verbal description. She continued to show them a screenshot (Figure 4.9) of what a positive gram (purple) and negative gram stain
(red/pink) should look like through their microscope. These images allowed the students to make a direct transfer of comparison between what they were looking at through their microscope and what the “expected” outcome was on the screen.

Figure 4.9 Gram Stain results slide

As Molly began giving directions to the class about how to set up their slides, she refocused their attention to the procedure slide and then directed them to the assembly line set up in the back of the room. She later reflected on the procedure—“It really helped to actually show the students how to set up their slides. We didn’t do it like this for the first class of the day, and we were working with individual students to set them up, which took a long time.” Her comments portray the collaborative relationship she shared with her cooperating teacher as well their desire to streamline the process for the students. Over the course of the 46-minute lesson, Molly fielded 62 questions about slide preparation and “what do I do next” type of questions and then 24 questions regarding lab procedure and gram stain results. Molly later bridled about the set-up procedures from
the lab, recognizing that the students still came to her for guidance. Her comments can be seen below.

Set-up took a while for a lot of students, but I think once they got going it was better. I still seemed to have to repeat instructions…each station had directions—still many students came to me for each next step.

As the students transitioned from the slide preparation phase to gram stain analysis, Molly tried to stop the class for further instructions. While she provided instruction on proper microscope magnification, there were a number of students that did not pay attention to what Molly was saying. She reflected on this in a bridling entry.

Sometimes I gave direction to the group during the lab or activity. It is hard to get everyone’s attention when I do that, but I think it is beneficial to let them get into the lab and give some directions throughout, rather than frontloading absolutely everything.

Once she determined that most of the students had progressed to the analysis phase of the lab, she monitored student learning by rotating to each of the group’s microscopes, asking them if they had identified a positive or negative gram stain and which shape it resembled. When she requested the help of her cooperating teacher (CP) on focusing a microscope (after many trials), he came over and identified the issue.

Molly: Would you mind taking a look at this microscope? I can’t seem to find the slide in focus.
CP: How’s that? Who’s is this one, Sarah (pseudonym)? Uh…uh…Gram stain negative.

Sarah: Whoa.

CP: Coccus! It’s actually staphylococcus because it’s all clustered together.

Molly: There you go! So you can see there is little tiny, they some of them look like circles, but most of them are actually rods…they are just really, really, really tiny.

This interchange helped to see where Molly has learned this sense of “reporting the answer” to the students when they ask instead of providing the necessary scaffolding around them so that the students can identify the lab results on their own.

Molly provided the following bridling entry in response to her entire lesson on gram staining.

I think this was a really good lesson, although there are a couple minor things I would adjust, which I think most teachers would say about any lesson. My instructions were pretty clear and I felt gave the students a little review (shapes of bacteria, for example), and clearly showed them my expectations for how they were to complete the lab. I could have been a little clearer about some things, like what to do with the slides when they were all done, but it’s hard to remember every little detail. Some things I couldn’t really prevent though, like students who simply tuned out and needed to come to me throughout the lab for
reminders about what to do. Classroom management is probably the thing I struggle most with, and I would work on making sure I have everyone’s attention as I go through things like lab directions.

I would also work a lot with my own students about listening to me the first time because it gets really annoying when I have to repeat what I just said 20 times. But overall I really felt that this was a good lesson – the students completed it, enjoyed it, were seeing their own bacteria grow and seeing their textbooks come alive – the bacteria cells were no longer just pictures. They were real, live, growing things. This was a good class in particular for me, too – I just had a really good connection with this class as a whole and they were a good group to work with. For the most part they listened to me, and participated well in the lessons and labs.

Molly chose her eighth lesson covering Newton’s three laws of motion as her second self-selected lesson that demonstrated effective teaching and learning. This lesson introduced the students to each of Newton’s three laws of motion using video clips, demonstrations and concluded with a student-constructed, balloon rocketry laboratory. The students were asked repeatedly throughout the lesson to share their interpretation of the laws in their own words with each other. The lesson began with a brain warm-up where students wrote Newton’s second and third law of motion in their own words based on the context given to them in their textbook. The students began
working quietly as Molly rotated around the room checking their progress. After a few minutes of seeing that the students were struggling a bit to differentiate from the book’s definition, Molly worked through the first law that was completed for them as an example at the top of the paper and projected it on the screen in the front of the room. Molly then directed their attention to the worksheet to point out that as they continued in the lesson, the students should summarize how each of the videos and demonstrations in the lesson supported Newton’s laws. Molly provided the following bridling response to her pedagogical reasoning behind her lesson.

I am explaining that for this worksheet, they are going to see demonstrations of each of the laws, and they are to use the lines on their sheets to jot notes about the laws based on what they see in the demos and videos. My cooperating teacher uses a lot of demos and labs for the students to get hands-on with the material. It really helps the concepts, especially these laws, make more sense.

Molly began the series of videos with a short clip by a Dr. Carlson who demonstrated how stationary objects only experience motion if a sufficient force is applied to that specific object. He modeled this through several demonstrations and finished by showing how a table’s place setting remains still when a tablecloth is quickly pulled out from underneath it. The students were very engaged in the video as they commented that they wanted to keep watching when Molly stopped the video. Molly clarified the use of the worksheet when students were unclear as to what to write.
Student 1: So, what are we supposed to write on this paper?

Molly: You are just kind of summarizing what you saw or making some kind of note about umm...how the law works.

Using the cart in the front of the room, Molly then conducted a follow-up demonstration to Dr. Carlson’s video.

Molly: So, my demonstration is kind of similar to his with the table cloth. So I have an empty container (showing the students the container) and a container that is half full of water and just a paper towel. So if I use just a little bit of force, it's going to apply to both objects (paper towel and empty container) and I'll be able to slide them both. But if I bring it over here (close to the edge of the demonstration desk), and then I use a lot of force just on the towel (pulled the towel out), it's the only thing that moves (holds up just the towel). So, I'm going to add the cup of water.

Students: Low rumble of excited chatter.

Molly: What do you think is going to happen?

Student 1: The water's gonna fall.

Student 2: It's gonna fall over.

Student 3: The paper towel is gonna rip.

Molly: Okay. Alright. The mass is actually going to help me because if we had the empty container...it doesn't have much weight by itself, but if I didn't
pull it fast enough, this is much more viable to just fall over. So I'm going to try it with the water. Ready.

Student 1: Whoa!
Student 2: Whoa!
Student 3: Whoa!

In response to her demonstration, Molly provided the following bridling entry as she reviewed her lesson, indicating that she was trying to foster a sense of inquiry amidst the students.

My demo uses an empty water container and a half-full one, both of which I pull a paper towel out from under. For the demos, I tried to ask a lot of questions of the students, like their predictions about what will happen - this gets them thinking about the concept.

Molly prefaced the second video by reading Newton’s second law and then showed the students the video depicting two objects with different masses traveling different speeds and distances when shot out of a pneumatic air cannon. Molly concluded Newton’s second law by demonstrating that more force is necessary to move a chair with a student sitting in it than moving an unoccupied chair across the floor.

Finally, she prefaced the third video by reading Newton’s third law from the students’ textbook and then provided the following introduction that captured the students’ excitement for laboratory experiments. Molly recognized their reactions in her post-
lesson bridling by saying, “Notice the students' reaction when I said "lab" - they love doing labs!” The piece of the lesson that Molly was referring to is below.

Molly: So for this one (third law) I have one more video. It's another Dr. Carlson and then we are going to do a lab.

Student 1: Alright.
Student 2: Awesome.
Student 3: Yes.

(Many other students are bouncing in their chairs out of excitement.)

The third and final video captured Dr. Carlson propelling himself down a hallway sitting on a scooter by releasing the pressure inside a fire extinguisher. Molly transitioned from the video to the lab by reminding students that they were going to do a similar activity on a smaller scale. Molly provided an overview of the activity to the students as she directed their attention to the lab projected on the screen.

This lab is not going to take very long. You should be able to go through it once or twice, maybe three times if you're quick. Okay. Your set-up is: you're going to have a string, and you're going to feed your straw through it, just like this (pointing to the projected lab on the screen). This is how it's going to be set up. So you'll have one person at each end of the string, holding it. You kind of have a track. Once that's on there, you're going to blow up your balloon and attach it with two pieces of tape to the straw so that it can move umm...up and down on the
Once Molly had finished providing the overview, she dismissed the “gofer” to retrieve the necessary laboratory materials from their bins and the students began the lab. The four students in each group constructed their balloon rocket and tested its speed by inflating the balloons to various diameters. When the period was over, Molly reminded the students to return all of their laboratory materials to the bin shelves and the students were dismissed.

Molly provided the following bridling entry in response to her entire lesson on Newton’s three laws of motion. Through her bridling she identified with the students’ level of engagement through the use of the videos and demonstrations—something that was common practice in this particular classroom.

This lesson was great – both the students and I enjoyed it. The brain warm-up blended into an activity that actually took up the rest of the class hour. We were just getting into Newton’s three laws of motion. For the brain warm-up, they were given a Spider Map, which had lines for notes on each of the three laws. To begin the class, they were to write the laws in their own words, then as we went through the rest of the class they were to jot down notes on the laws themselves. I had a few videos and demonstrations and a mini lab to help them see and understand the laws. They are difficult to grasp just based on their definitions especially for sixth graders, so the videos and demos were very
helpful. They were fun too – the students really enjoyed the videos and had a lot of fun with the mini lab.

I explained each of the laws a little before getting into the videos and demos for each, but for the most part left the teaching to the videos and demos. I used my cooperating teacher’s plans for the lesson, and we both felt that it would be easier for me and the students to see rather than hear the laws. Again, we discussed and used each law, and at the end of each the students had time to think about what they saw and write down some notes about each one. Their last activity was one they could do with their lab groups, and the students really enjoyed it. My cooperating teacher uses a lot of demonstrations and labs so the students can get out of their seats and hands-on with the concepts. This was a great lesson, and every class really enjoyed it. It gave them a reprieve from lecture and was both fun and educational. I felt they got much more out of this lesson than if it had been purely notes.

_Molly’s lessons for remediation._ The first lesson that Molly selected for remediation was her laboratory lesson on plant algae where students investigated various strains of algae using microscopes. Molly began her lesson by asking the students “have you ever eaten algae?” While the students thought about their responses, Molly provided a few common items that contained algae like plastics, deodorant, paint, and lubricants and bridled about the fact that these opening remarks were something that her
cooperating teacher decided he wanted to add right before the class entered the room. Since Molly had not prepared a PowerPoint slide as she had done in the past, she wrote the items down on the board to refresh her memory. Molly’s bridling entry depicted how she felt about the opening hook. “I did not have this prepared well before the lesson - it was an addition my cooperating teacher brought up that morning. I would have liked to prepare for this a little more.”

Following the introduction of various forms of algae, Molly presented the instructions for the laboratory activity.

What we are going to do for today is a lab. It is more exploratory than the previous labs we done. You're going to pick your own slide, and you're going to look at protists. Hopefully they'll be really active for you guys and you can see them swimming around and you'll see different kinds of protists. So you have your worksheet for the lab on your desks. On the back, there's the different kinds of protists that you might be able to see, so you'll use that when you're identifying the protist that you have on your slide. What you're going to do is...I'm going to give you a couple drops of pond water that has the protists in them on a slide. Just as a barrier, I'm gonna have this little chunk of cotton in the back...just literally take a couple strands...two or three...just acts as a barrier to keep the protist in the area that you wanted....that you're going to be looking at. So you'll
need a slide, a cover slip—those are on the paper towels back there and a little bit of cotton. And then we're going to have two people to every microscope.

Alright? So...you'll pretty much just follow all of the instructions and all of the questions on here (laboratory worksheet), but we are going to take out part 2, numbers 1, 2, and 3. If you just want to cross those out and then at the bottom of the second page 9. We're not going to use the yeast today. Umm...we discovered that when you add the yeast, it really clouds up the water and you can't really see the protists. But what ideally what we'd see when we add the yeast, is the protist eating the yeast under the slide. It would be really nice to see that but he (her cooperating teacher) said it really clouds the water and you wouldn't see anything anyway. So, we're gonna skip that. So part 1, part 2, numbers 1, 2, and 3 and 9. Alright! Go ahead and find a partner, please try and stick to two.

Molly indicated in her post-lesson bridling that she felt as though she rushed through the directions for the laboratory and would have taken more time to explain the steps of the laboratory.

Looking back, I should have taking a little more time with the instructions - this was first hour and I was nervous (I wasn't with them as long as I was with the other classes), but I should still have spent sufficient time on the instructions.

Molly then transitioned with the students to the laboratory section of the classroom and helped them prepare their slides. As the students prepared their slides, one
male student referred to Molly’s cooperating teacher by his first initial and last name and said, “we need help.” Molly referenced this in her post-lesson review and indicated that she had requested her cooperating teacher to assist in the activity since this was her first time with this particular class. “This might have been my first lesson with this class, and I wanted him to stick around to help me as the students were going to be all over.” The students prepared their slides in under a minute and moved on their own to view them under the microscopes at the perimeter of the room. While the students continued to try different levels of magnification with their microscopes, there was a constant hum of both on-topic and off-topic conversation in the room. Molly also referenced this in her post-lesson bridling—“preventing chatting and giggling and goofing off entirely is probably impossible, but they still for the most part complete the tasks and refocus.”

Throughout the laboratory, Molly rotated around the room checking that everyone was able to see the algae in the microscope. After visiting with each of the students, Molly continued to monitor the students’ progress while a few students were gaining enthusiasm about what they were experiencing on their slides.

Student 1: Dude...he just ate something! This is so sweet. Dude...he just ate one of those things. Oh my gosh!

Student 2: Look at that. No, look at it.

Student 3: You liking this lab, Tom (pseudonym)?

Student 2: Dude, there's like this little thing in there and there's a bunch of little
guys swimming around. He opens his mouth and they all just like
go in. It's so cool!

Student 1: Oh my gosh.

Student 3: That sounds pretty cool.

Molly noticed their excitement and gathered everyone’s attention when she was arrived at
their microscope. She agreed with the students about the “cannibal” behavior on the slide
and wanted to make sure that every student had the opportunity to observe.

Molly: Does anybody have one that you can see where the...some of the cells are
eating other cells? If you want to see that, come over to John's
(pseudonym). Some of his cells are eating other ones. Very cool!

Student 4: Tom...can I see it again.

Student 5: Look at all these little guys...they're all like running around!

Student 6: It's actually pretty awesome.

Student 5: Definitely...you want to check it out, man?

Students finished viewing their slides, cleaned up their materials and completed
the remaining questions on the laboratory worksheet. Molly commented in her bridling
that she would have planned the lesson differently if she knew the students would have
finished with twelve minutes remaining in the period.

Most students by now were just about done with the microscopes and finished or
finishing the last questions on the lab packet. I should have had something to
bring them back together with at the end, or have used more time earlier on clarifying directions, but this was also a good time to help the stragglers, and to get to know some of the students who were done…Too much time left at the end. Molly provided the following bridling entry in response to her third observed lesson, indicating that this was a lesson that she would have liked to have re-taught for greater effectiveness.

This lesson was challenging for me because it was first hour (my first time going through it) and because, I believe, it was my first time teaching this class. For the following classes, it went smoother as a whole. At the beginning of the class I talked a little bit about where we find algae in various foods and products we use every day. I would have liked to prepare for this more – my cooperating teacher had me add it that morning, so it wasn’t very smooth and might have been confusing. Overall I was kind of nervous so I would like to do it again feeling more comfortable. I should have gone over the instructions for the lab in more detail – again, this went better with the other classes. It was just really short and ended up with me needing to repeat them to many students as they went through the lab. Since it was my first time with this class, and a lab at that, my cooperating teacher helped me work with the students on the lab. They were going to be all over the place, and he helped me by answering questions, working with students, and just being there to work with them.
Classroom management is another big thing I would change. There was quite a bit of chatting and off-task behavior, and I was missing a lot of it because I would be working with a student or a pair of students and my focus would be off the rest of the class. At that point I had had some experience trying to stay tuned into what was going on with the rest of the students, but I was distracted, busy, and a little flustered with this particular class. I did with the other classes, but I also would have talked about some of the things they would be able to see at the beginning of class as well. Finally, I would have had something for them to work on at the end of the hour so there wasn’t so much wasted time.

Molly’s selected her tenth lesson as the second lesson for remediation that presented the forms of energy and the transmission of that energy into the students’ homes. The lesson began with a review of a homework worksheet on types of energy. While reviewing the homework, Molly solicited answers from numerous students and when the students were finished providing their answers, she continued to brainstorm new ideas that could have been acceptable answers. Molly transitioned to a PowerPoint presentation for notes that had a blue background and blue font. Molly apologized to the students, knowing that it would be hard to determine which notes followed the “blue you do” science notes in comparison to the other text on the page. She also mentioned this in her post-lesson bridling—“something to consider - color in PowerPoints.” As the
students began notes, Molly reminded the students of the brain pop video they had previously watched that discussed mechanical energy.

Molly: So we have three sources of energy that we use to generate electrical energy. Yup. Go ahead and write this down. So one is steam. Sorry another is wind. And a third is water. If you remember from one of the brain pops we watched, he talked about how wind and water have mechanical energy. We are able to take that mechanical energy they have and convert that into electrical energy for us to use.

A student asked Molly a question that had an accompanying tangential story that created a class wide off-topic conversation. Molly recognized this in her post-lesson bridling—“comments definitely need to be kept in check, especially in middle school - they lead to bunny trails too easily.” During the notes, Molly was continually trying to get the students quiet with “sshhh” and made small redirecting comments or proximity to the students to get them to refocus. The frequency of the needed redirections as well as the numerous questions students asked out of curiosity, yet not completely pertinent to the lesson affected the flow of her lesson. Molly mentioned this in her post-observation bridling entry.

Lots of redirection in one class gets to be irritating. I try to still be patient and kind, but since classroom management is still new to me and something I struggle with, I miss a lot (which makes it seem like I allow it), and then problems happen
- kids talk too much, goof off, pass notes, etc.

Following the notes, Molly projected a worksheet on the screen (Figure 4.10) that required the students to brainstorm six forms of energy (SCENTL) that had been transformed into their homes. Molly recognized that after her brief explanation, the students were still somewhat confused. She provided the following bridling response after reviewing the lesson.

This activity was quite confusing for each class, and by this class I actually cut out a part of it. Here they were to come up with examples of each form of energy using things in their homes. Two of them - nuclear and chemical - were challenging. The idea, though, really was to get them thinking more about SCENTL, the six forms of energy, and making connections.

![Figure 4.10 Screenshot of Energy Transmission](image)

The students were then instructed to roam around the classroom and share their SCENTL list in an effort to double their list. Molly provided the following response, indicating her intentions to the brainstorming share time.
Sharing was good for two reasons - to let them talk a little bit, and to share ideas with each other. If someone struggled to come up with ideas for one form of energy, they can hear what other students came up with.

The students were then dismissed to pick up their directed reading assignments and work quietly at their desk for the remaining five minutes of the period.

Finally, Molly provided the following bridling entry on her tenth and final observed lesson as a lesson that she selected that she would reteach if given the opportunity.

A major thing I would adjust for this lesson (would need to be changed earlier as well) would be classroom management. This class is really chatty and difficult to manage, though I should have been more aggressive with controlling the talking right away when I took over their class. I would also change the notes a bit, or do more research myself so that I can be more clear with things like voltage so that I can explain these concepts better and not leave so much dead air as they write down notes. It would also be good to change some of the ways I explain things, like using the example of a fire hydrant to describe transformers (thank you Prof. Benson!). Another big part of the class I would adjust is the activity they do with SCENTL (six forms of energy) at the end of the hour. I had already made an adjustment before this class hour from the previous ones, but what we used was still confusing. The change might just need to be give any
example of the forms of energy, not limited to things in your home, although we had already done very similar things with SCENTL. I might actually try to come up with something different since their homework was pretty much the same task.

The lesson wasn’t terrible – they got the information, it made sense for the most part, and they were able to get up and move around a little. Part of the problem was I was already tired and grumpy, and the constant talking and goofing off was really getting to me. But again, this would probably have been different if I had been harder on that stuff earlier, and would definitely be different if they were my own students from the beginning of the year. These kids were a lot of fun, and much of the time they were good thinkers and participated well; they just also really liked to talk.

**Lily’s Case**

Lily was a dependable, hard-working, thoughtful woman who hailed from a rural, farming community in the northwestern United States. Born and raised on her family’s farm, Lily’s life exudes the daily applications of how science is lived out on the family farm. Her firm, yet respectful approach in the classroom is augmented by her natural instinct to relate scientific concepts to her life’s experiences through stories and anecdotes. Lily’s demeanor is polite, yet assertive in the sense that she was raised to speak up for the injustices that surface in life’s daily routines. Lily also has a sense of continually asking the “why” questions of life that foster her lifelong learning and
inquisitive nature towards the natural world. Lily’s student teaching experience was the first major exposure to the public school classroom since she was homeschooled through her entire K-12 experience.

**Lily’s initial understanding of PCK and TPCK.** Prior to her start in student teaching, Lily completed a self-assessment in which she located herself in both Shulman’s PCK model as well as Mishra & Koehler’s TPCK model. Using Shulman’s PCK model (Figure 4.11), Lily perceived her understanding of PCK to be balanced between pedagogy and content knowledge, slightly below a self-imposed equilibrium line that she pictured horizontally in the diagram. She viewed her initial position as being lower (below the equilibrium line) in content knowledge and pedagogical knowledge than she hoped to achieve as a result of completing teaching. She perceived herself having a slightly greater understanding of content knowledge compared to pedagogical knowledge based on her lack of teaching experience in an actual classroom. Her self-evaluation also indicated her desire to continue to improve on the growth she experienced through her courses and associated practicum teaching experience. She anticipated that through student teaching, she would gain the necessary pedagogical information such that her awareness of pedagogy becomes equally as strong as content knowledge—or “overrides content knowledge.” Her perception of her PCK and TPCK may be seen below in Figures 4.11 and 4.12 respectively.
Lily provided further explanations as to her perceived placement with the following bridling response to her PCK.

I think I am slightly more competent in content than pedagogy at this point in my pre-service teaching education for several reasons. First, I have taken more classes that are not pedagogical content (methods) over my college career than classes that are pedagogical. Not all are content related, but they also touch on other information I will need in the classroom; for example, history, art, and composition can be incorporated into the science classroom.

Pedagogically, I am confident I will be able to move the mark closer to the pedagogy side of the diagram after student teaching, and have already moved it much closer through my practicum experience and methods classes the past semester. Although I have had many good pedagogy classes the past three semesters, and several positive observations and practicum experiences, I still understand content better at this point. I don’t think it will take much student teaching experience, though, to gain pedagogical knowledge to the point that it overrides content knowledge.
Using Mishra & Koehler’s TPCK framework (Figure 4.12), Lily positioned herself in a similar position with regards to the PCK and indicated that she perceived to be “mostly out of the technology sphere” because of her lack of experience with technology from the classroom teacher’s perspective. While she challenged the benefits of technology integration (video of a flower blooming) when physical, hands-on science could be made available to students, she indicated an interest in developing her capacities from a teacher’s perspective during student teaching. She provided the following rationale to support her perceived location on the TPCK framework in a bridling response.

I placed this ‘x’ on the place I did because I feel that I don’t implement technology well in the classrooms in which I teach. I know how to use the PowerPoint on the overhead, and use it often, and I have used webquests before. I don’t, however, feel comfortable on a SMART Board, with clickers, or using digital technology in the classroom. Part of this is because I don’t think it’s beneficial to watch a flower open via video when the class could watch a real flower, for example. Primarily, however, I did not experience digital technology in my secondary education so have little foundation from which to build my skills in this area. I look forward to expanding both my knowledge and my experience in this area through student teaching this coming spring semester.
**Lily’s first student teaching placement.** Lily’s first placement transpired at a small, Midwest rural public high school serving grades 9-12 in a low to moderate socioeconomic status farming community. This high school is comprised of approximately 350 students, 14.3% of whom are eligible for free or reduced price lunch and characterizes a 16.77 student to teacher ratio. The student demographics are as follows: 1.5% Black; 1.5 Asian/Pacific Islander; 2.9% Hispanic and 94.2% White. Her ten-week placement provided her with three sections of biology and two sections of human anatomy and physiology, operating on a 50 minute bell schedule under the auspices of a male cooperating teacher who has been teaching nine years. While Lily’s cooperating teacher was helpful and readily available if she needed him, it became clear early on in her student teaching experience that she would be given the reigns to the classroom from the start and that her cooperating teacher intended for her to teach full time teacher for eight of the ten weeks (six weeks more than her TED program expectation). While this teaching schedule reflects the daily workings of the classroom teacher, this would eventually lead to an exhausted, tired-out student teacher who had not yet developed the necessary, maintainable stamina necessary for this type of teaching.

The physical environment of Lily’s first placement was very unique in that there were very few spaces that were not occupied with either living reptiles, snakes and fish (15 aquariums), or bovine, avian and reptilian skeletons around the room. Her cooperating teacher also littered the empty spaces with his outdoor adventures and
pictures of previous students—indicating that students had taken an engaged-enough interest in him as a teacher in order to give him a picture of themselves to post in his classroom even after their departure. Lily’s cooperating teacher utilized the need to care for the live animals as a means to periodically stop in and see how her instruction was progressing. While this placement had the potential to intimidate perspective teachers, it was familiar ground for Lily and her childhood on the farm and its inculcation to living organisms—something that she indicated “made her feel at home.”

During Lily’s first student teaching placement, the researcher observed her teaching six times. The lesson topic, method and technology integrated can be found below in Table 4.3. Further explanation and lesson details are located following the table.
Lesson one. Lily’s first observed lesson in her first student teaching placement was with her anatomy and physiology which began with an oral quiz on the nervous and endocrine systems. The students switched papers with a seat partner to grade them and as Lily collected them, her cooperating teacher responded to a challenge on the quiz by redirecting the students to the exact page number in their textbook where the answer could be found. Lily then commented that “these quizzes are not meant to be mean, but to help you” as both Lily and her cooperating teacher reminded the students that the questions focused on the bold terms in their textbook.

Table 4.3
Lily’s First Student Teaching Placement Observed Lessons

<table>
<thead>
<tr>
<th>#</th>
<th>Lesson</th>
<th>Method</th>
<th>Technology Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hormones</td>
<td>Oral quiz Lecture notes</td>
<td>Video clip PowerPoint</td>
</tr>
<tr>
<td>2</td>
<td>Properties of Blood</td>
<td>Lecture notes</td>
<td>PowerPoint</td>
</tr>
<tr>
<td>3</td>
<td>Evolution &amp; Natural Selection</td>
<td>Jeopardy review</td>
<td>PowerPoint</td>
</tr>
<tr>
<td>4</td>
<td>Platelets &amp; Clotting Mechanisms</td>
<td>Lecture notes</td>
<td>PowerPoint w/images</td>
</tr>
<tr>
<td>5</td>
<td>Heart Anatomy</td>
<td>Lecture notes Valve replacement video</td>
<td>Video clips PowerPoint</td>
</tr>
<tr>
<td>6</td>
<td>Cardiovascular System Cow heart dissection</td>
<td>Lecture notes Dissection Lab</td>
<td>PowerPoint</td>
</tr>
</tbody>
</table>
Lily continued her lesson with an introductory YouTube video clip on the pituitary gland and the hormones released and then continued using PowerPoint slides to present notes on hormones and their effects on the body systems. Following the notes, Lily provided students with the remaining nine minutes of class to begin their reading comprehension questions. While Lily was occupied with showing students their missing or late assignments at the computer, five of the nineteen students utilized the time in class to work on their homework, while the other fourteen students socialized.

Lesson two. Lily’s second observed lesson was a continuation from a previous class on the properties and functions of blood in anatomy and physiology. Through the use of directed instruction and PowerPoint slides, Lily encouraged the students to fill out the chapter outline as they worked through the image-driven PowerPoint slides on blood. Throughout the lesson, she offered many reminders for the students to write down the information on the slides, paying close attention to those terms that were highlighted, underlined or displayed in a different colored font. Lily had created this slide presentation as a conglomeration of content from multiple sources and reminded the students that they would be held accountable to the information on the slides on their upcoming exam.

Lesson three. To begin the third lesson, Lily invited the students to share their highs and lows of from the holiday weekend with the class. She finished the activity by sharing her own high and low and then invited them to participate in a review activity.
Lily hosted a Jeopardy review activity in preparation for the biology class’s exam on Darwinism and natural selection scheduled for their next class session. The students were divided into two teams and each nominated a spokesperson to provide the official answers. Prior to the start of the game, Lily reviewed the rules for Jeopardy:

Okay, do we remember the rules here guys? Do we remember the rules? Only the spokesperson can give me the answer. 30 seconds to come up with your answer. If you run out of time, and have not answered, the other team gets a chance. So it's in your best interest for both teams to be thinking about every question. If you answer, but it's incorrect, then we're going to review the answer...but the other team does not get a chance. And the team with the highest points wins. If you do not answer, you do not get points deducted, but you lose a chance to get points. And the other team gets a chance to get points. Part of it is…strategy, part of it is…try something.

Lily revealed each question on the screen and then gave one team the opportunity to answer the question. Students were not allowed to use their textbooks or class notes during the review activity, yet were allowed to take notes on the review activity questions and answers. When students were unable to correctly answer a question like the six types of speciation, Lily directed their attention to the textbooks in search of the answer and requested selected students to explain each of the six types. Students were unable to answer more than half of the questions, thus causing Lily to either review the information
or direct students back to their textbooks for answer investigation. She reiterated that requesting to take the exam after the holiday break was their choice and thus expected more from them.

Lily: Do we really need to put this test off a day so that we can continue review, or do we need to pay attention a little better in class?

Student: It’s Monday and we just had a long weekend.

Lily: I understand. So you had more time to study. Okay, that's why I'm giving you a review day instead of just saying, "okay...we're having the test today." You guys...listen up...you chose this last week. Remember...I gave you the opportunity to have the test last week or to put it off about three days and do it this week. You chose this week. So, I expect a little more paying attention and doing better than this cause you had the choice. I would hope you would chose to do something in your best interest. Okay? You might have to crack the books harder than you thought tonight.

Following the review activity, Lily reminded the students about their exam the following day and the correlated review sheets that would be turned in for a grade at the start of the exam.

*Lesson four.* Lily’s fourth observed lesson was delivered through direct instruction to the students in her anatomy and physiology class. At the start of this class,
Lily returned short answer response papers on stem cell research to the students and reviewed the previous session’s information at the white board. She solicited responses from the students, allowing them to recall from memory as well as search their notes. She provided the following rationale for her pedagogical decision in her post-lesson bridling:

Reviewing by asking the class to tell me what we covered, from notes if necessary, helps students review and remember material better. If a student hears content he or she is not as likely to remember it as if they read it for themselves. They are more likely to remember if they discuss or interact with material than by just reading, as well. Here, I am asking students to discuss briefly and engage, both in the paper and in review. People also remember material longer if they review it shortly after learning it, so I ask students to review now, especially because this is a bigger point that I want them to remember.

Following the short review, she began a two-day presentation on platelets and the clotting mechanism inherent in blood. Lily alternated between the image-driven PowerPoint slides and the figures available in the textbook that supported the content. After thirty-six minutes of direct instruction, Lily passed out a three-page handout of true and false questions on platelets and clotting for the students to complete as a review. The students had the remaining 16 minutes to work on this review assessment as well as their routine chapter assessments that were due at the end of this lesson.
Lesson five. Lily presented a lesson on the cardiovascular system to the students in her seventh-hour anatomy and physiology class. The lesson began with a two and a half minute video tracing the pathway of blood as well introduced the effects of diastole and systole throughout the cardio vasculature. Following the video, Lily presented notes on the anatomical placement and anatomical structures of the heart as she walked the students through the atria, ventricles, and blood vessels pointing out nuances like muscle wall thickness. Her comments can be found below.

Lily: You’ll also notice as we…if we look here [projected rendering of the heart] at the muscle, the muscle wall of the left ventricle is about three or four times thicker than the right ventricle. Why would that be?

Student: It’s going to the whole body.

Lily: It’s going to the whole body. So from here [left ventricle], it’s going out to the whole body. From the right ventricle, it’s going just a few inches to the lungs. So it doesn’t need to have near as much pressure and force.

Lily continued her lesson by showing a four-minute video of an aortic valve replacement surgery. Due to the lack of sound, Lily narrated as the video began, providing some context and background information on the patient for the students. In her post-lesson bridling, Lily commented on the idea that she should have prepared the students with what they were going to see and caution them to the graphic nature of the video.

I should have prepared students more in depth for what they would see rather than
asking them to read the information. I should have also mentioned that if anyone is opposed to watching it, they are excused to sit in the hall. This student (one that requests permission to leave) asked permission to leave, but it would have relieved her from having to draw attention to herself by asking to leave if I had given permission before the video started.

Students are very talkative at the conclusion of the valve replacement video and asked multiple follow-up questions of Lily in response to what they watched. The students were given the remaining sixteen minutes to work on their unit paperwork to help review for their upcoming exam.

Lesson six. Lily’s final observed lesson in her first student teaching placement took place in her anatomy and physiology class. She started her lesson by making a few comments from the feedback that she had received from surveys the students completed on her teaching. After the opening comments about the evaluations, Lily began the notes section of her lesson with an introduction of the valves of the heart. She continued to reference the need for the students to take notes so that they had the necessary information for the bovine heart dissection in this observation as well as the student dissection of the sheep’s heart in the following class session. Once Lily had completed the class notes on heart valves and provided a review of the path of blood, she invited the students to the front of the room to observe the dissected bovine heart. Since she was only able to bring one bovine heart from her family’s farm, Lily reviewed all of the
incisions that she made in the previous class period and walked the students through the
order in which she made them so that they could understand the anatomy. For the
remaining twenty minutes of class, Lily circulated around the room helping students with
their worksheet and their pre-laboratory handout on the heart’s anatomy. Students
continued to work on their pre-laboratory handouts until the end of the class.

Lily’s midpoint understanding of PCK and TPCK. At the conclusion of her
first student teaching experience in the high school science classroom, Lily reevaluated
her perception of both her PCK and TPCK locations. She indicated that as a result of her
student teaching experiences, her understanding of PCK (Figure 4.13) had increased in
both content knowledge and pedagogical knowledge. She indicated that student teaching
had also illuminated areas within the content areas of anatomy and physiology and
biology that were lacking in understanding necessary to teach the material to students.
Through her bridling entry on her PCK understanding, Lily indicated that she saw
improvements on particular pedagogical techniques like questioning and student
monitoring from the beginning to the end of her ten-week placement. As a result, she has
chosen a location that favors pedagogical knowledge. Her self-evaluation of her PCK
and TPCK respectively in Figures 4.13 and 4.14 are below.
Lily provided the following bridling response to her perceived understanding of her PCK.

Compared to my self evaluation before placement #1, at the end of the placement I would consider myself more knowledgeable in both content and pedagogy (hence, the mark is higher on the diagram) but have recognized many deficiencies in content knowledge and have grown a lot in pedagogical knowledge. After teaching in the first placement, I discovered some holes in my content knowledge that I was not as aware of before. By reviewing some of the early videos from the placement, I can see several striking differences in pedagogical knowledge, namely questioning techniques, monitoring methods, and voice inflection during delivery. While these areas can still use improvement, I can honestly place myself further to the ‘P’ side of the overlap than before starting the first placement.

Shortly after starting her second placement, Lily reflected on her perceived understanding of Mishra & Koehler’s TPCK framework. Her evaluation was slightly different than what she expected because she completed the evaluation after starting in her second placement and realized that she had only “touched the tip of the iceberg in
understanding ways to integrate technology.” Her perceived level of understanding was altered once she was exposed to greater technology integration in her second placement. Lily’s bridling entry about her midpoint TPCK evaluation (Figure 4.14) is below.

The mark on this diagram reflects the above content-pedagogy beliefs, and is at the edge of the technology overlap for several reasons. Leaving the classroom, before starting placement #2, I felt that I had a decent handle on technology in the classroom, compared to other pre-service teachers. I felt that I had sufficient but not exemplary experience for running a class of my own.

After reflection, though, I place the mark near the edge of the technology overlap because I realize that I have only touched the tip of the iceberg in understanding ways to implement technology and have not used some of those ways in my classes. Based on belief immediately out of the placement, before starting in placement #2, I would have marked the diagram much further into the ‘T’ circle, but now realize the need for improvement.

Lily’s second student teaching placement. Lily’s second placement was considerably different from her first—situated in a large, Midwest, urban public junior high school setting with a low to moderate socio-economic status student population. This junior high serves approximately 720 students, 69.7% of whom are eligible for free or reduced price lunch, and characterizes a 13.03 student to teacher ratio. The cultural fabric of the students in Lily’s five-week placement was very diverse—comprising 44.2%
Black; 0.8% American Indian/Alaskan Native; 23.8% Asian/Pacific Islander; 13.1% Hispanic and 18.2% White. The diversity of the students was something that challenged Lily’s pedagogical beliefs, yet also became an element in her placement that she came to appreciate and pay particular attention to in her planning and instruction. Her teaching schedule was comprised of four sections of 9th grade physical science and one section of high performance physical science. The school’s bell schedule operated on 40 minute periods three times per week and 80 minute periods twice per week. Lily’s cooperating teacher was a confident, knowledgeable, industrial chemist who entered the teaching profession after twenty years in the field to better equip future generations of scientists with his applicable science. The physical classroom space was sterile in comparison to her first placement, as it constituted just the shell of a meeting space. The students sat in pairs at lab desks that faced the front of the room in rows. Her cooperating teachers desk was positioned towards the students in such a way that he could operate his computer from the front of the room.
Table 4.4
Lily’s Second Student Teaching Placement Observed Lessons

<table>
<thead>
<tr>
<th>#</th>
<th>Lesson</th>
<th>Method</th>
<th>Technology Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Nuclear Energy &amp; Disasters</td>
<td>Video</td>
<td>Video clips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lecture notes</td>
<td>PowerPoint</td>
</tr>
<tr>
<td>8</td>
<td>Motion</td>
<td>Lecture notes</td>
<td>Images</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PowerPoint</td>
</tr>
<tr>
<td>9</td>
<td>Velocity Lab</td>
<td>Lab</td>
<td>Document camera</td>
</tr>
<tr>
<td>10</td>
<td>Momentum Lab</td>
<td>Lab</td>
<td>PowerPoint</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Document camera</td>
</tr>
<tr>
<td>11</td>
<td>Momentum Lab</td>
<td>Workshop</td>
<td>Mobile computer lab</td>
</tr>
</tbody>
</table>

*Lesson seven.* Lily’s first observed lesson in her second student teaching placement (seventh overall) began with the daily “I can” statement outlining the “student friendly learning objective based on the state standards. The “I can” statement that her cooperating teacher chose for her lesson on energy was “I can explain what happened in Japan.” This “I can” statement referred to the students’ ability to explain the effects of the 2011 tsunami in Japan and the devastation that took place. Lily began this lesson with a five-minute opening video on the tsunami and the destruction it created for the Japanese landscape. Lily commented that the class had to watch all of the lesson’s videos at one time because the battery in the audio-assistive technology device were dying and so they needed to play the videos and project the sound before the batteries died. Lily
paused the video periodically to provide commentary and feedback to the students on the course of the tsunami. As Lily prepared the next fifty-second video, she requested that they pay particular attention to the effects of the earthquake on the nuclear reactor off the coast of Japan. Lily then continued her lesson by explaining how activity in the Earth’s subduction zones led to the earthquake in Japan.

Following a three-minute discussion on earthquakes and the process of subduction, Lily transitioned to a PowerPoint presentation that provided students with some background information on nuclear energy and nuclear power plants. She used a ninety-second video clip to illustrate the splitting of the radioactive uranium nucleus and how uranium breaks down. Lily referenced this video in her post-observation bridling: “Students should be able to understand this because it is more visual, rather than looking at diagrams. It is also incorporating technology relevant to their culture because most students have probably seen this commercial on TV.” Lily’s lesson continued with a few short video clips that continued to reiterate how the uranium atom splits and creates a chain reaction that can be devastating. Her lesson concluded with addressing some of the effects of radioactivity and what measures had been taken to prevent future crises like Chernobyl.

**Lesson eight.** Lily’s eighth observed lesson introduced the topic of motion using a PowerPoint presentation of still, sequential photographs. At the start of the lesson, the students were given a pre-test on motion to determine what aspects of the curriculum
would be taught in the coming weeks. Following the pre-test, Lily began her lesson with photographs that showcased a ballerina and her movement across the stage as well as an equestrian jumping hurdles. Lily’s lesson consisted of a string of questions that engaged students in the content. Lily continued her lesson on motion by exploring how people can tell that objects are in motion. She and the students discussed how they could tell whether the Earth is moving, and how the students were moving relevant to particular reference points. The students remained attentive until the bell rang, which is something that Lily referenced in her bridling entry.

Students have done remarkably well to stay focused for this long and are not putting away notebooks as they usually do 3 minutes before this point. I attribute this primarily to using questioning strategies that help students feel that their conclusions are theirs rather than mine that I have imposed on them. They also seemed more interested partly because we were going deeper in a concept that is directly related to daily living, rather than a brief survey of several directly related topics or an in depth look at information that has little immediate impact.

**Lesson nine.** The ninth observed lesson for Lily presented the students with a laboratory activity that investigated the velocity of three different marbles from various heights of an inclined plane and three different track lengths. Lily provided the opening instructions for the laboratory using the document camera, which allowed her to project both the laboratory worksheet as well as the necessary set-up and laboratory equipment
for the students. Lily and the students then relocated to a nearby room where the laboratory supplies were ready for each group. As the lesson progressed, she rotated around the laboratory to check whether students had their station set up properly. She commented on the importance of a proper set up in her post-observation bridling.

As students begin set up, I walk around helping groups follow instructions and remind them to take variables into account. The coop teacher does the same. The biggest challenge for this lab was setting up correctly, since most students understood that a larger mass or height would increase speed of the object. If I did the lesson over, I would combine this lab, abbreviated, with an abbreviated lab on momentum. If it was available, I might use an interactive computer program to avoid set up complications and go straight to the point of what the lab goals were, understanding the relationships between mass, velocity, and speed.

As the lesson continued, she continued to reiterate the importance of identifying the known variables that effected the laboratory results. She also bridled on the interactions she had with the students as she rotated from group to group.

As students are getting farther along in their experiments and starting to see patterns, I start asking students about the variables they see in their experiments. Some students have opposite explanations for the phenomena; for example, they believe going over a hill in the floor will speed up a marble because the marble goes down the hill. They don't take into consideration that the marble will need to
go up the hill first. I try to clarify this misperception by questioning and suggesting reasons that they may not be accurate.

After all of the students conducted the necessary three trials with each of the marbles at their set track lengths, Lily retuned with the students to their regular classroom and inquired about what type of variables each group encountered. Students finished their laboratory write-ups and shared ideas on the variables that needed to be accounted for in the final five minutes of the lesson.

**Lesson ten.** Lily’s tenth observed lesson presented the students with the opportunity to conduct a laboratory on momentum. The lesson began with an overview on how the laboratory experience correlated to one of the “I can” statements for the unit.

Here's the basic instruction sheet. The purpose says to determine the effect of mass and speed on momentum. That kind of goes along with the third "I Can" statement. We're basically going to be completing the lab safely, collecting the data, and understanding mass, velocity, momentum--kind of the way all of those go together. Then we are going to be using this data at the end of the week and next week to create the tables, the data tables like we did yesterday and that will go into a graph and that will actually be a summative assessment. So try and collect the data appropriately and effectively.

Lily continued to demonstrate how the laboratory materials were to be used to complete the trials using marbles of different masses released from prescribed heights using the
document camera (Figure 4.15). The students were instructed to release the marbles down the center groove of a rule from prescribed heights and record the distance the plastic cup moved along the desktop ruler as a result of the collision between the cup and the various marbles.

![Figure 4.15 Document Camera Demonstrating Momentum Laboratory Set Up](image)

Following the instructions, Lily brought the students to a nearby room where the laboratory materials were set up. She rotated around the classroom monitoring student progress and provided suggestions and feedback to groups when necessary. Lily provided the following bridling entry regarding the students’ progress and their results.

Students are engaging in the lab more, partly evidenced by groups in front of the camera working together, and partly because group members are asking for me to check their set up or data to make sure they’re doing it right. With encouragement on the things they have set up correctly, students accept correction better and
invite my interaction with them. This builds a better working relationship and helps them gain confidence in me as a teacher and in themselves and their skill set. For example, when a group takes an educated guess on how to set up the ramp in their lab, and then asks me to look at it and make sure it's right, I can confirm it, encouraging students to have confidence in understanding and executing instructions.

The students completed their trials and entered their data on the tables on their laboratory handout. Lily collected these sheets as students left in preparation for their next class period where she planned to have them analyze their data using Excel on the computer. She provided the following bridling entry as a reflection on the conclusion of the lesson.

I collected data sheets and kept them in the classroom so they didn't forget them or lose them and create future problems when we needed data in the next step of this project.

**Lesson eleven.** Lily’s final lesson in her second student teaching placement consisted of a student workshop in the school’s computer laboratory where lab partners entered their data from the momentum laboratory (tenth observed lesson) into Microsoft Excel and produced graphs that supported the third “I can” statement. Lily recorded the lesson on her own volition because she was interested in bridling through a lesson where technology was utilized to produce data tables that supported the laboratory activity. The
researcher was not present at the time of the lesson, yet bridled about Lily’s lesson while watching the recorded video.

Lily began her final lesson on the momentum laboratory by reminding the students that they would be going to the computer lab for this lesson. The following dialogue captured the students’ reactions to Lily’s announcement that they would be working in the school’s computer laboratory.

Lily: We are going to go to the computer lab.

Student 1: Woo!

Student 2: Woo!

Student 3: Woo!

Student 4: Yes!

Student 5: Yeah, yeah!

Student 6: Yeah baby!

Lily continued by introducing the third “I can” statement with the class.

Lily: Alright, everybody ready? We're going to go over the number three I can statement. Calculate the speed and acceleration of a moving object.

We're going to figure out how to make a computer to do the work for us.

Student 1: Woo!

Lily: That's the good thing.

Student 2: Yeah.
Following the “I can” statement, Lily and the students relocated to the computer room that afforded a lap top computer for every two students. The students were instructed to log in, open Excel and begin typing in their data as suggested by the instructions on the screen in the front of the room.

As the students began their data entry, there was a continually stream of both on-topic and off-topic conversations. While Lily rotated around the classroom checking on student progress, her cooperating teacher also provided some guidance to two students that were off-task. “So, that's Excel and you're doing what you are supposed to be doing, right? No you're not. She told you to type that in (referencing the data on the screen). Type it in.” Lily also commented on the support in her post-lesson bridling. “The two girls that moved have been off topic and the coop has caught them not working. He is reiterating my instructions since they weren't following them before, probably because they weren't listening.” Lily continued to rotate around the classroom, troubleshooting with students as they needed assistance. Periodically, she made suggestions to the entire class as well as walked them through how to add border and shading effects on their data tables. The students continued to work at their computer stations and then saved their laboratory data on the network drive.

**Lily’s final understanding of PCK and TPCK.** At the conclusion of her second student teaching placement, Lily completed her final PCK and TPCK evaluations (Figures 4.16 and 4.17). In reference to her PCK evaluation, Lily perceived more of a
balance between content knowledge and pedagogical knowledge, yet felt that she did not get the pedagogical coaching she would have liked in her second placement—thus giving her the impression that she “may have even lost some of that knowledge because I wasn't practicing it.” She indicated that navigating the school climate and classroom environment provided opportunities to “improve her pedagogical knowledge,” despite the lack of exposure to new teaching methods and theory. Lily also indicated that she strengthened her understanding in the physical science content—an area of science that she had not had much academic exposure to and thus one that enhanced her level of content knowledge. Her PCK and TPCK evaluations can be found below.
Lily provided the following bridling response to her self-placement of her PCK (Figure 4.16).

At the end of placement #2, I feel more balanced between content and pedagogy for several reasons. First, unfortunately I had a harder time continuing in growth in the pedagogical aspect of the placement so feel like I may have even lost some of that knowledge because I wasn’t practicing it. The school was a completely different environment so I had the opportunity to improve my pedagogical knowledge, but the coop teacher did not push me to learn as much about teaching method and theory as the previous placement did. Second, while in this placement I expanded in to a field of content in which I had not spent much time. This allowed me to balance the diagram by increasing my content knowledge in several areas.

Lily also completed the self-evaluation of her perceived understanding of her TPCK (Figure 4.17). Her evaluation and bridling indicated that she had greater
exposure and accessibility to technological affordances in her second placement that impacted her teaching. She positioned herself more centrally in the framework and indicated that teaching with and through the technology enable to troubleshoot pedagogical decisions as well as develop her TPK, TCK and TPCK. The bridling rationale that accompanied her TPCK evaluation can be found below.

The mark is significantly farther inside the technology area of knowledge after the second placement for several reasons. The school had funding and provided high quality technology to all classrooms, including voice assist, SMART Board, computers, student computer labs, and other devices. I had the opportunity to teach a unit of the class in which I led students through collecting data in the lab, creating tables in Excel, and using those tables and equations to create graphs representing lab data. I learned a lot about the programs I used so that I could efficiently lead students through the process as well about potential problems I may encounter while using technology, such as using computers to be off topic, limited amounts of partners working together since only one person can work on the keyboard at a time, students taking computers apart in boredom or disinterest, batteries dying in voice assist microphones, etc. I also was able to improve my content and pedagogical skills when the network was down for 4 out of 6 class periods in which I had planned to use computers for the whole lesson. Part of the
technology knowledge I have gained is how and when to use the technology and part of it is how to adjust when technology doesn’t work. Simply from having access to more technologically advanced equipment I have gained knowledge in this area.

**Lily’s self-selected lessons.** Lily provided the following four lessons as selections for effective teaching and learning and lessons for remediation.

**Lily’s effective lessons.** Lily selected her sixth and final lesson from her first student teaching placement as a sample of effective teaching and learning. The lesson began with a discussion about surveys that students had completed on Lily’s teaching. She commented that she appreciated the students’ honest feedback on the surveys and that she planned on implementing changes in her teaching. Lily’s classroom dialogue regarding the evaluations is below.

Lily: I thank you for your evaluations you filled out on me Friday.

Student 1: Oh yeah.

Student 2: You're welcome, Ms. Johnson.

Student 3: Oh wait, do you get to read those?

Lily: Yes...absolutely--that's why I asked you to not put your names on it, so I don't know...oh well, this student really doesn't like me, so I'll just give him a bad grade.

Student 4: You wouldn't do that.
Lily: No. Um. It was actually very eye opening for me and I appreciate it.

And, I'm going to be managing the classroom better for next three or four days cause that was a big complaint I saw. And try and make it interesting was another one...well even before that, um...I was kind of bringing this heart in. So, hopefully that can be a little bit interesting. And then we are doing a dissection tomorrow, so I really hope that it's interesting...because that is anatomy.

Lily had the following to say in her post-lesson bridling about her surveys.

“Students filled out evaluations to help me know what I needed to improve and what I was doing well. I should have done it several weeks earlier in the semester so I could improve more.”

These evaluations were a task required of her student teaching experience through her teacher preparation program. Lily indicated that the timing of when the evaluations were to be completed was up to the discretion of the student teacher, yet recognized in her bridling that if she would have administered the surveys earlier in her student teaching, she would have had more time to implement the necessary changes.

Following the class discussion about the evaluations, Lily presented notes on the heart valves and the path of blood checking that the students understood the anatomy before they began the cow heart dissection. She provided the following rationale in her bridling entry.
I don't provide much information about the valves because we have covered some of the material previously. However, this was done on the day I was gone, so I'm also checking for understanding and attempting to determine where they left off.

While the students were taking notes, Lily disseminated a worksheet that the students were instructed to complete after the dissection. The interchange created a scenario where Lily had to encourage them to continue to keep working hard.

Lily: I'll hand those [worksheet] out while you're taking notes on it so that we can best use our time here because of course everything goes slower in this class.

Student 1: What do you mean?

Lily: We're already behind.

Student 2: How are we behind? We just had a two day advantage.

Lily: I know. That's the way this class seems to work and you still get behind.

Student 4: Oh...Oh, okay. I see how it is. You just give up on us here...

Lily: I'm not giving up. I'm pushing you.

Lily then invited the students up to the front laboratory desk where she presented the dissected bovine heart. She walked the students through each of the slices she had made in the previous class and pointed out specific anatomical features like the heart
chambers, valves and the interventricular septum. Molly provided instruction by
pointing certain structures out as well as asking directed questions to the students.

Lily: We're working on the heart. Look at this. Which part are we looking at
here?

Student 1: Top.

Student 2: Apex.

Lily: The apex is down here.

Student 3: That's the base.

Lily: The base is on top.

Student 4: That's a frontal peel.

Lily: Yes. This is the right...uh, hold on. No, this is the right because the left
is pushing it into the body. Therefore, this is thicker than this.

Student 5: Yeah, cause it has to push it into the body.

Lily: Yup. So, if you open it up like this...this is the left one. You eat it all.

You...this is...look at how much thicker guys, this is than this.

Student 6: That's a good size steak.

Lily: This is...

Student 7: That's a nice cut right there.

Lily: This is going to the lungs. How far does it have to push it to the lungs?

Student 8: Not very far...maybe a foot.
Lily: Six inches. Yeah...not even a foot.

Student 8: I meant round trip.

Lily: He said, "not even a foot." Okay.

Lily continued with the cow heart dissection, pointing out structures and commenting on the fact that the heart had been previously cut open for FDA inspection. She bridled as to why she chose to comment on the inspection.

I explain briefly the reason the heart has been opened for inspection and when, and explain the food value of the heart because students often don't associate organ meat with dinner. I wanted them to recognize this as more than just a heart, but also as food and an organ that circulates blood.

Following the dissection, Lily directed the students to their seats to work on their worksheets for homework. While the students were working and Lily was circulating, she identified that students were having difficulty identifying with the heart’s orientation on the page compared to its orientation in their body. Lily suggested that the students pick the paper up and hold it up to their chest to help determine the right and left sides of the heart on the paper. Students seemed to gain further understanding as a result of her class wide announcement. Students continued to work on their worksheets for the remainder of the class session.
Lily provided the following bridling reflection in response to her sixth observed lesson, making reference to adapting her instruction to accommodate for different types of learners.

I chose video #6 because I believe it is an example of hands on learning more than average in my anatomy class. Students were more engaged than normal, largely because they are a tactile and kinesthetic group so moving around to look at the heart and touching it were highly anticipated activities. If I had the chance to teach this lesson again, I would watch for students hanging back during the dissection/ viewing and call them out specifically, asking if they weren’t going to watch with us. This would give them a better chance of participating well in the dissection with a group the following day. I would also unwrap the packages before bringing them to class to ensure that the contents inside was the same as how they were marked. Students in this class would have benefitted from an intact heart to cut open rather than using the same heart as the previous section had.

I would also maybe get students up and moving as we discussed after the lesson to help kinesthetic learners understand the blood flow through the heart. We could use hand signals to show flow direction, for example. I should have done this after the dissection, but I need to get over my inhibitions on that.
Lily also selected her second lesson from her second student teaching placement (eighth overall) as an example of effective teaching and learning. Her lesson covered an introduction to motion using a PowerPoint presentation with still images that were projected on the screen in the front of the room. Lily began the lesson by giving the students a pre-test to determine the depth of instruction necessary for introductory physics. She and her cooperating teacher had forgotten to give the pre-test the week before, so they both recognized the fact that giving the students the pre-test on the first day of the unit was not the most effective. Lily elaborated on her opinion of the pre-test in her post-observation bridling entry.

The students tend not to try on the pretest, believing that it is only paper work required by administration, so I lecture them briefly on doing their best but not stressing over the test. I am hoping students will be able to do some parts so I don’t need to reteach them, which I try to put across. The school’s department data team will meet when scores have been collected and determine what topics students already understand and what needs to be taught. The idea is that we can move more efficiently through material and teach to individuals better. In practice, however, instruction does not change based on the pretests in this classroom. The other teacher(s) in the team attempt to change instruction based on information as much as possible, but because teachers create curriculum together, this can be tricky as well.
Lily taught almost the entire lesson using the Socratic method as she continually asked students questions and challenged their answers in order for them to think about their responses. Her lesson began with freeze frame pictures of a ballerina (Figure 4.18) and explained her pedagogical rationale below.

![Screenshot of Lily’s opening slide](image)

**Figure 4.18 Screenshot of Lily’s opening slide**

Lily provided the following bridling comments in regards to her teaching pedagogy.

I redirect attention to the dancer in the picture to introduce motion. I do this by asking questions about the picture rather than making statements, in an effort to draw students in to the material and create interest as well as help them draw conclusions about the topic. Students at this level believed they understood most of what there was to know about motion so it was more of a challenge to keep their interest. That is the primary reason for using a questioning, inductive reasoning approach to this lesson.

She continued in her bridling to provide background information as to why she chose the instructional decisions she used.
During questioning I also restate what students say to let them know that A) I’m listening and processing what they are saying, not just trying to make the lesson harder for them and B) to help other students who didn’t hear the statement or question and clarify for those who are confused. This is a better lesson primarily because students were working together as a class to figure out the motion involved, which rarely happens.

Lily started the discussion about the ballerina by asking the students to make observations. Once they provided their initial thoughts, she continued to delve deeper to get at their misconceptions about motion.

   Lily: This is a dancer...I want you to make an observation about what you see here...Does it look like she is moving?

   Student 1: No!

   Student 2: Kind of.

   Student 3: Yes...she's getting down and then up.

   Student 4: Wait...how did she get from there (pointing to the far left) to there (pointing to the far right)?

   Student 3: She danced.

   Lily: What part or parts of her are moving?

   Student 1: Her arms.

   Student 2: Her legs.
Student 3: Her whole body.

Student 4: Her face doesn’t look like it, but it has to be because her body is moving.

Lily: Okay. What evidence do you have to support your response?

Student 5: Motion. Ha ha.

Student 6: She is…your mind already knows. Your mind just knows.

Lily: We need to look closer at maybe a more scientific way.

Lily continued the dialogue, asking the students to analyze each part of the ballerina’s body to determine what was in motion as well as how the students thought that the actual picture was taken. Students varied in their interpretations as some thought she had posed for the camera while others thought that the photographer had captured her lateral movement across the stage. Lily then transitioned to a series of pictures of an equestrian jumping over a hurdle with his horse. She asked a similar set of questions to the students trying to get them to provide visual evidence that motion was occurring in the picture. Lily provided the following bridling response to the series of pictures involving the equestrian.

Students are questioning if the camera or horse are moving at this point, trying to use information from the previous slide to inform their learning. They use indicators such as what parts of the background are showing, and they realize that the horse in the background, for example, could move so motion has to be
relative.

She continued to try and provide other examples like riding in a car or on a bike to help students associate with the actions themselves. She indicated her rationale in her post-lesson bridling prompt.

Here I am contextualizing the concept to a more every day occurrence that a much higher percentage of students may be able to understand. Most students have ridden in a vehicle but have not ridden a horse in this class.

In her final example of motion, Lily initiated a dialogue with the students about Earth’s motion and whether or not that resulted in movement of the students, the classroom or the school. She commented about this final section in her post-lesson bridling entry.

I take a poll of students for "yes" and "no" to the question "Is the desk moving?" I then get reasons from both and attempt to incorporate every student in the discussion. It is hard to do because I don't know many of their names, but I call on every student with their hand up, and know many students who are disengaged because I have interacted more with them due to their lack of motivation.

Lily provided the following bridling reflection in response to her eighth observed lesson—one that she selected as a lesson that demonstrated effective teaching and learning.
I chose the video #8 at placement 2 for my second good lesson for several reasons. The feedback I got when we had our post lesson conference helped me see the merits in teaching by the Socratic Method. I also saw that more students in this lesson were engaged longer than in 90% of lessons, including lab where motivation is usually higher. I didn’t have to continually remind students to be on task because many were trying to figure out the answers that were both logical and what I wanted, and I had opportunity to call on more students when I was asking more questions.

I need to learn how to use questioning more effectively in more lessons, but have several hindrances to doing so. Primarily, I have learned how to teach by modeling. The teachers and professors have been exceptional, but we all teach in a direct style naturally, based on habit and modeling from previous teachers as well as human nature, but I won’t go in to that (unless you want me to, then please let me know). If I taught this lesson again, I would probably break students up successfully in small groups and use a cooperative learning method for about 3 minutes at the beginning of class to get students thinking about motion and movement based on the picture of the dancer and perhaps 1-3 questions on the board for students to answer. This would warm them up to the topic and get the brain gears turning more efficiently while being short enough to keep social time limited. Over all, I
think this was probably one of my most effective lessons at this placement.

*Lily’s lessons for remediation.* Lily selected her second observed lesson as one of the two lessons she would have wanted to reteach if given the opportunity. Lesson two continued her lesson from previous classes in dealing with the functions of blood. Lily began her class with “sarcastic comments” about the importance of the students taking notes to prepare for their upcoming exam as they began the PowerPoint slides. She referenced this in the following post-lesson bridling entry as well as commented that she would like to start the class in a more effective way if given the opportunity to reteach the lesson.

My sarcastic remarks got the class in another off topic direction for a short period. I should not continue to address every question from students if they are not directly on topic. Looking back, I was trying to make opportunity for any teachable moments that students were interested in. This follows in the theory that if the subject is somewhat student driven, students will participate better and be more interested. That was my goal, but it was not working in this class. If I could reteach this class, I would have asked students to get ready to take notes and cut out much of the small talk before starting on the lecture. She continued by referencing what information on the slide should appear on their required outline worksheets that the students turn in. Lily provided some background
information in her bridling to help understand the purpose of the handouts that accompany each unit.

Here I reference an outline that I handed out to students at the beginning of the unit, a few days previously. Students are expected to take notes from class either on their own note paper or on the outline to prepare for the test. They get 10 points for a complete, accurate, well done outline when it is finished by the time of the chapter test and turned in with the completed test. I am attempting to help students prepare for the test and learn good study skills.

As the class continued on the properties of blood, Lily recognized that students were not taking notes and thus, gave the students the following reminder and guidance as to what is pertinent versus peripheral for note taking.

I shouldn't have to tell you exactly every slide to write this down: A) Because you are advanced enough in school to know that some of what's talked about in class is going to be on a test and B) I'm not just talking about nothingness up here. I have a slide, I'm talking because I want to give you information so you can add it to your outline. So if I put it up here, it means that it is important. If I'm just talking about it, and it's not on the PowerPoint, it's not as important, but I would still like your attention. Does that make sense and help a little bit when I lay it out in those terms?
This struggle to get the students to take notes continued to be pervasive throughout the entirety of lesson two, despite further reminders. Lily recognized this as an issue in lesson two and bridling about how she tried to regain the learning environment.

Here I am trying to encourage students to practice good note taking by explicitly stating what they should write down and what they can listen to but don't need to copy in their outlines. I try to use a bit of humor to lighten the atmosphere so that more timid students don't feel like they're in trouble, since they are usually the ones doing the expected work already.

Lily also inserted anecdotal stories to the material on clotting and circulation to try and gain the students’ interest and build connections between the content and real life application. She supported her decision for anecdotal stories in her post-lesson bridling.

I am trying to tell stories to make the material more interesting and keep it on topic. This class is the last period of the day so students are tired as well as the class in general being students less studious. Without stories, the class's attention in general will be lost, so I try to tell stories on topic.

While Lily presented on blood’s circulation and bruising, students became interested in how circulation affects the bruising process. As she frequently did, Lily told a story about driving a team of steer on their family farm and how the fatter steer were
less likely to feel pain and bruise as a result of the associated actions necessary to
drive the team. What began as a story about a bruise on her knee finished as a story
of driving the steer on the farm. She indicated that the students were interested in this
topic and commented that if she could have predicted this conversation, it would have
been a good place to utilize technology in her lesson.

The conversation on fat is a teaching moment that I could have expanded on if
I had the background knowledge and foresight to be prepared for these
questions. If I had seen the potential questions about fat, I could have had a
YouTube video loaded on the subject and how blood flows through fat
compared to other tissues. Switching to this video would have answered
questions, used technology well, and interested students while covering
needed material.

As Lily bridled about her lesson, she made the following entry in regards to altering
the teaching strategy with blood clots.

Here I could have drawn a diagram or somehow made the concept more visual
and concrete for students. This is an overview day at the beginning of the unit,
but in the future with this class I asked them to form a blood clot with their
bodies, assigning different roles and functions to different students and putting
students in the passage between the door and the teacher's desk in the front of
the class. This was a rare opportunity to reach the kinesthetic learners. I
should have created more kinesthetic environments and would do so if I retaught the class as a whole, especially because many athletes are kinesthetic learners and at least 80% of the class were in sports or cheerleading.

As Lily began talking about blood transfusions and the potential complications inherent in certain medical procedures, she told a story about a family friend and his kidney transplant. She recognized that allowing students to speak into the classroom narrative would have built connections to the material.

Instead of launching into my story about the man with a kidney transplant, I could have asked if anyone wanted to tell about the transplants they had heard about. This would have connected the subject much closer to home for all students. I could have added my pieces of information after the story. I would have to limit the time to one or two stories.

As Lily finished her lesson on the properties of blood, she made two other bridling entries in regards to student engagement and trying to keep the material interesting to the students.

I should have been more swift in either shutting down off topic conversations or taking the opportunity to chase this rabbit trail of a topic and helping students learn more about what they're interested in. It was hard for me to tell if students had a genuine interest in some of these topics of they were just trying to keep slowing progress down so they didn't have to take notes and do
Lily also made the following comment with regards to classroom management and how students continued to divert her attention towards off-task conversations.

I check for understanding when I asked "do you understand the difference...." but students try to get off topic again. This whole problem started toward the beginning of the placement when I was too lax in classroom management.

Lily finished her lesson by dispelling the myth that deoxygenated blood is blue as they discussed the slight color variation in blood found in veins and arteries.

Lily provided the following bridling response in regards to the entirety of lesson two.

I chose this video because I feel that it addresses content but students don’t understand the concepts I am trying to teach. This is primarily because my management of the class time needs to improve greatly. For example, students are capable of learning about all of the information without as many stories, but I am enabling their lack of motivation by telling so many stories. Some are beneficial and increase interest, too many bore motivated students and keep unmotivated learners from accomplishing what they could, namely more in-depth understanding of each of the concepts on the slide. Part of the reason I tell so many stories, in reflection, is because I don’t have the background knowledge to dig deep in to the topics. Instead, I fill the time with personalized stories and rationalize my method by saying I’m trying to keep
Reviewing this video helped me recognize the need for better management in the future, since I can’t go back and change it with this class. This video was taken near the ½ way point of my placement in the school, and already I see how much should have been improved. At the time, I thought it wasn’t great but was tolerable. Now, I don’t think it is close to tolerable. This helps me see my weak points (an ongoing theme in places to work on is taking more control of the class) but also points out where I have grown through the rest of the placement and in the second placement.

Finally, Lily selected her eleventh lesson of the study as a lesson that she felt needed remediation in order to be considered effective teaching and learning. Lesson eleven provided the students with the opportunity to work in the computer laboratory where they created graphs that represented their data from their momentum laboratory from the previous day. The lesson began in the classroom where Lily informed the students that they would be working in the computer laboratory for the classroom after she had finished taking attendance. Prior to leaving the classroom, Lily reviewed the third “I Can” statement regarding speed and acceleration of a moving object. She provided the following explanation of the “I Can” statements in her bridling response.

'I Can' statements are school mandated student-friendly objectives listed on
the board in front, to the left of the SMART Board. I refer to them here to help students focus. These statements are put on the board for the whole 'loop' or teaching segment, so the first one or two statements have to do with completing the lab. The 3rd statement, to which I refer, is focusing on data tables and computer work, done in this section and one before it in the computer lab.

As the students walked down the hall, Lily reflected on her overall presence in the classroom in her second student teaching placement. She had the following to say through her bridling entry—

This is the first class of the day, so students are slightly slow. I am abrupt with them because I don't have the relationship groundwork laid to motivate students to stay on task and follow instructions. If the placement had been longer and/or the coop teacher had been neutral rather than discouraging of relational interaction with students, it would have helped.

As students found their workspaces and laboratory partners, Lily’s cooperating teacher also made a few “executive decisions” about lab partners that were contrary to Lily’s previous arrangement in the classroom. Lily referenced this as well in her bridling entry.

In the background you can hear the coop teacher saying no, to the combination of the boy and girl sitting next to each other. I have intentionally
allowed the grouping because I think it will give the students a chance to prove their capabilities in staying on task with some guidance, if they choose to do so. It had worked before in a previous class with the same students.

After about a minute of conversation, the coop told the girl to 'move or get out' referring to a school wide behavioral policy in which the student goes to the Reflection Room to fill out paperwork in why he or she misbehaved. The student chooses to move and stay in class.

The students are instructed to follow the direction that Lily has projected up on the front screen as she rotates around the workspace to help struggling students. After a few minutes, Lily reiterated her instructions to the entire class: “Please go ahead and enter the information you see on the front screen. As soon as you have it, um...raise your hand and I'm going to tell you exactly what to do next.” She also provided the following bridling response to support her pedagogical decision.

I tell students to enter the information because as I am walking around the class I see students not working or working too slowly to complete the project. I am not willing to restate my instructions to every group individually, so try to announce to the class what they are supposed to be doing. This is supposed to keep them on task and moving at the appropriate speed. By raising their hands when they have finished the current set of data, I will know that I can check for understanding on the tables and equations they are entering. It also
gives me time to monitor other groups.

Throughout the lesson, the students maintained a moderate level of conversation that Lily chose to try and speak over in order to provide step-by-step instructions. She alluded to this in her post-lesson bridling entry.

I am intentionally speaking loud even though one group asked, because I believe so many students are wondering the same thing…I then go on to show students step by step how to format the cells. They can see it on the overhead behind me and follow along.

While the students continued to enter their data and Lily monitored their progress, the frustration levels continued to rise on behalf of both parties. The following excerpt captures the struggle that Lily had in convincing the students that working with Excel would be beneficial to them.

Lily: You're double clicking on that line between the category headings.

Student 1: Can't we just draw a graph?

Lily: You might rather draw a graph, but if you every need to know this, um...you're going to be appreciative of the work that the computer will do for you. Once you get it set up, it's a whole lot easier.

Lily perceived this interaction as the turning point in the lesson (fourteen minutes in) as she indicated in her post-lesson bridling. Her bridling indicated that she viewed this more as a lesson in technology than in science.
This is the key point on which I don't think the lesson is effective. Students are constantly asking if they can do the equations manually and draw the graph on paper because it would be easier. This tells me that they know how to do this, and the confusion comes primarily from using the computers. While the intention is good, the lesson has now turned into a technology lesson rather than a science content lesson, taking time away from content and creating frustration in the classroom on all parts.

While the majority of the students remained in their seats, there were a few that left to meander around the classroom visiting with friends. Lily referenced one such event in her bridling and mentioned that if she were to teach the lesson again she would have utilized the roaming student to help others through peer tutoring.

In the background you can see the shadow puppet show, but I did not discipline the student because she is consistently the first one done with her work and the majority of the were not distracted. If I could reteach the lesson, I would ask the student giving the puppet show to help others by peer tutoring. This would occupy her if not stretch her, and would help others as well.

After about seventeen minutes, many of the students appeared to be confused on what to do or how to execute the proper formula commands. Lily redirected their attention to the screen where she provided the following instructions.

Lily: The next thing you are going to do--you want it to look like this
(projected on the screen behind Lily). The way you do it...you click on the top left. You drag it over and down to highlight it. So go ahead and do that now please.

Student 1: I prefer to actually have it written down.

Lily: Click on the distance...go over and down while you hold it. There you go. Now you make sure you're under your home tab at the top. Go to the font box, which is on the left side. Click on that little square arrow thing in the corner.

Student 2: Where's the font box?

Lily: In your home tab. It's right up here (shows the students on the screen). Font one is right here. Click on this little thing. Guys...if you are confused, I'm showing you up on the big screen up in the front so try and watch that. You're gonna click on this little arrow thing right here.

Student 3: Oh, this little arrow thing.

Lily: Ok. Once you have that highlighted, you're gonna click on it. I'm gonna do it now. It comes up with this dialogue box. Hit the border tab on the top. Now you're gonna hit the under the lines/styles, you're gonna pick the big thick line. Click on it. And click on outline. Then go over to the line styles and the thinner line styles and click on the inside lines. Okay.
Once you have done both of those steps, click okay.

Student 4: Wait, what are we doing?

Lily: Who has not understood how to do this? Okay...I'll go over it once more here.

As a result of watching this small step-by-step teaching segment, Lily provided the following bridling entry.

I'm trying to bring students back in topic by telling them to watch my example if they are confused. One student complains that I'm going too fast, but I don't slow down because I've already shown them how to do this step by step in a previous class. I expect students to pay attention enough that step by step instructions should not be necessary. At the time, I was trying to not allow too much slacking off by not giving endless amounts of time for students to follow instructions. Now, I see that I was plenty lenient and should have stopped when students asked for another explanation. I should have explained that I was not going to endlessly repeat myself so they needed to figure it out from peers, pay attention in class, or stay after school for help. This would keep the class at the same level in general better and force students to take some responsibility for their own education.
After a couple of minutes, Lily checked for student understanding on whether or not they were tracking with her on what she expected. Her bridling entry depicted the struggle she felt she was having as she tried to keep the students engaged.

When I ask "do you understand what we're doing?" I am speaking to a specific group or student. I should have asked the question to a specific student by name, or gone over to take care of the problem. I say "listen up" to try to get students back on topic. At this point, I have lost a large percent of students' attention and am having trouble regaining it.

Lily continued to express the struggle of keeping their attention concurrent with achieving the objective of the lesson. A few of her bridling prompts indicated that she changed her teaching method by providing a handout to the students that walked them through the difficult steps.

I am repeating myself a lot in this class, a sign that students are not understanding. They are not trying to stay on topic, some because they are finished and bored, others because they don't care or are lost.

I lay the line down by saying "I'm not talking over you any more" and threatening to give them a piece of paper and remove myself from the position of having the answers. Students temporarily pay attention better, but many would prefer the paper so they can follow it and blame the instructions if they aren't right. I end up giving other sections of the class the paper instructions.
for the most difficult parts and it helps students do as much as they can without getting bored.

The students finished the lesson by saving their documents, shutting down the computers and returning to the regular classroom. Lily provided the following bridling entry reflecting on the entirety of lesson eleven.

Again, I can see that classroom management is the key improvement needed. Anticipation of problems would be helpful, as well as handing out the instruction paper when students got farther ahead of the class than I could help them with.

By watching this video, it is painfully obvious that I was not as alert as I should have been and not nearly as in control of the classroom as would have been good. I don’t know what I could have done differently to improve many of the problems. Some of it would come from more experience in a similar highly diverse school, and some from knowing students better. The continually off topic student would not have responded well to more discipline, which is the only thing I could think of at the time to try. Other students may have benefitted from it though, and would have sent the right message to the remaining classmates to be more careful about their behavior.

Over all, I think, as I bridled about one time, that technology was detracting from learning content in this instance. If students would have had
training in their previously required technology class in how to use the Excel program it may have been successful, or if I had allowed time to teach strictly on using the program and then started combining content with it. Either way, more support was needed for the lesson to be successful. If I retaught the content, I would probably do so with a calculator, graph paper, and pencils this year and speak with the technology teacher to see if we could incorporate a stronger emphasis on Excel in the classes next year, laying the foundation for doing a similar project a year in the future.
Chapter V

This chapter presents the findings of the study and how each of the participants came to understand and exhibit their pedagogical awareness of technology integration in their student teaching experience. The analysis of this study will first present single case analyses (functioning as the whole analysis) of the participants investigating how each of the candidates perceived their level of TPCK throughout their student teaching experiences as well as what the researcher perceived throughout his observations, interviews and bridling. Following each of the single case analyses, a cross-case analysis (functioning as the part analysis) will be presented to identify similarities and differences between the participants in an effort to provide further evidence for implications for teacher preparation. The final whole analysis will be presented in chapter 6 as a means of suggested implications for science teacher preparation.

Analysis of Molly’s Case

The case analysis is structured to illustrate the what, how, and why of technology integration into the science classrooms, following McCrory’s suggestions. Following a discussion of the what, how, and why, the development of Molly’s TPCK across the student teaching experience is discussed.

Molly’s implementation of technology—the what. Table 5.1 captures a snapshot of the instructional technology that Molly implemented during her student
teaching—the *what* of her pedagogical awareness related to technology integration.

After debriefing with her about the entire student teaching experience, she indicated that the technology observed in the study was a representative sample of the technology she used throughout her entire student teaching experience.
Table 5.1 Molly’s Uses of Instructional Technology

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<thead>
<tr>
<th>Technology Used</th>
<th>Observed Lessons</th>
<th>First Placement</th>
<th>Second Placement</th>
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<td>7   8   9   10</td>
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<tr>
<td>PowerPoint</td>
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<td>Projected content</td>
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<tr>
<td>Images</td>
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<td>Google Documents</td>
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<td>Jeopardy Review</td>
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<td>Video Clips</td>
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<tr>
<td>Demonstrations*</td>
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<td>1   2   1   1</td>
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<tr>
<td>Laboratory*</td>
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*With technology integration.
Table 5.1 also indicates a persistent, repetitive use of technology throughout each of her ten lessons. In each of the post-observation interviews, Molly responded in a straightforward and positive way with regards to the question—do you think technology was utilized in an effective way? She felt that technology—PowerPoint slides, microscopes and video clips were used well and brought students into authentic contexts with the subject matter.

**Molly’s implementation of technology— the how.** Molly’s use of technology in the classroom was directed at increasing students’ level of engagement as well as making routine classroom practices more efficient. Throughout the study, many of her comments indicated that these uses led to the *how* of her pedagogical awareness and how recognizing these uses were creating these responses in her teaching. Her perception that technology integration enhances student engagement was also identified in lesson eight which utilized multiple videos to present Newton’s laws. In her post-lesson bridling, Molly provided the following response regarding her technology use and how the use of video fostered engagement.

This was a great lesson, and every class really enjoyed it. It gave them a reprieve from lecture and was both fun and educational. I felt they got much more out of this lesson than if it had been purely notes.

Molly’s use of technology with the Jeopardy review activities also created cooperative environments for the students. As an alternative means of instruction,
Jeopardy facilitated complete student engagement in a friendly, yet competitive atmosphere. Molly’s Jeopardy review game featured slides containing questions and related images that prompted student responses. Her questions probed the students understanding of both the terminology and processes from their plant unit. Once the students had properly answered the question, Molly advanced the slide to reveal the answer directly below the question and image.

Her reflection on her first student teaching placement, illustrates recognition of her use of technology for pedagogical efficiency.

It was easy for me to see how much more comfortable I became over the time I've been here....with using different methods like Jeopardy, when I was doing the different presentations, I was able to see how quickly I could get through or move them along so that there wasn't this huge pause in between each presentation.

..and then I think we talked a little bit about how I've been able to step away from my notes and that's been be able to be something that I refine and remember throughout the day and so by the time I get to this class, this one is pretty much a breeze for me.

Through a retrospective lens, Molly recognized that her presence in the classroom became more comfortable and her ability to navigate through PowerPoint presentations without being dependent on her teaching notes created a more fluid
presentation. She was able to more effectively use the PowerPoint slides to guide her didactic instruction in ways that compensated for a lack of content knowledge in the physical sciences. She indicated this in her TPCK self-placement: “I had to learn several concepts of physical science over again so I could teach them.” While Molly’s use of PowerPoint was a low-level technology use, her recognition of comfort level and ability developed throughout the study.

Finally, a theme of technology integration as visualization emerged from Molly’s practices and bridling. For example, in the post-lesson interview, Molly indicated that she used technology as both the content as well as the vehicle to deliver the content. She indicated that having the students see Newton’s laws demonstrated via video was more effective and interesting than what she might otherwise provide.

I did very little talking about the laws and the two or the three videos, but the two guys were able to explain them very well and had several different ways to show them. And then I just added a little bit so.

Molly also drew students’ attention to key terms and ideas on her slides using different fonts and text colors and directed students to recognize these nuances on the screen and consequently to reflect these hints in their notes.

**Molly’s implementation of technology—the why.** Despite the fact that Molly did not have an abundance of scientifically-oriented technological affordances in either of her student teaching placements, it was evident that she attempted to
utilize what she had at her disposal to enhance her classroom instruction. Molly’s technology integration was one of intentionality—an element of her teaching that led to the why of her pedagogical awareness. All but one of her observed lessons included the use of PowerPoint presentations, images or videos—highlighting her frequent technology integration. Molly also demonstrated a willingness to develop her TPK as she commented that continual collaboration with her cooperating teachers enabled her to see how various classroom practices could be enhanced with technology. Her frequency and level of technology integration was significantly dependent on her cooperating teachers’ beliefs on technology and what, how and why it should be integrated into the curriculum. Molly referenced this perspective in a post-observation bridling—“My cooperating teacher uses a lot of demos and labs for the students to get hands-on with the material.” Molly’s comfort level seemed to increase as a result of the positive perspective her second cooperating teacher had towards technology integration into science teaching. Her teacher approached each lesson with the sense that technology use was necessary for student engagement and an integral part of her teaching. Much of Molly’s increased comfort towards technology can be attributed to the technological advocacy of her second cooperating teacher.

**Molly’s development of TPCK.** As Molly began her student teaching experience, she indicated in her self-placements on the PCK and TPCK frameworks
that she felt comfortable with her content knowledge, yet mentioned that she would need to do some content research prior to teaching each lesson. She had indicated that some of the lessons she taught involved science content that she had not studied for two or three years. Her limited content knowledge in particular areas created the need to refresh and placed greater stress on her overall pedagogical knowledge in an effort to compensate for her content knowledge.

Molly indicated that while she knew basic skills necessary for the classroom, she would not classify herself as being “tech-savvy.” She did, however, express an openness to “learn new things” when it came to technology. The following quote in response to the bridling prompt, “What are your thoughts when you think about technology integration into science education?” revealed Molly’s preliminary beliefs about technology as enhancing traditional classroom instructional delivery:

Today, it is difficult to not use technology in education. PowerPoint has become a major presentation tool, and overheads have largely given way to LCD projectors. As society is moving toward being paperless, assignments are done online, classroom directions and worksheets are electronic or just projected on the classroom screen and discussed, etc. I think it is important for teachers to embrace these changes and additions, and integrate them into the classroom, especially since students are so exposed to technology on a daily basis.
In deed, many of the technology tools Molly referred to in her bridling entries were observed in her science teaching—PowerPoint and the use of a projector to minimize excess paper—and constituted the \textit{what} of her pedagogical awareness. The way in which she implemented technology into her teaching was effective in helping the students engage with the material and facilitated a natural flow to her lessons, yet was characteristic of lower-level uses of technology. Her increased comfort level and fluidity with the technology led to her self-identified development in TPCK within the TPK base as she implemented technology in ways that were pedagogical advantageous. While Molly did not exhibit high-level uses of technology, the integration of her low-level technology integration was efficient and effective. She interpreted this as a sufficient level of understanding that centered herself on the TPCK diagram—a placement that might have been a little too over confident.

Molly also indicated that she had “learned a lot more about pedagogy” through her experience in student teaching. She perceived that her understanding of her TPCK had “stayed about the same,” yet had learned how new tools like Google Docs created efficiency and how these tools streamlined the process to access student presentations during the class. This use of Google Docs provided her the affordance of efficiency eliminating downtime between student presentations as opposed to using individual student USB drives. Similarly, Google Docs allowed Molly to efficiently review draft iterations of student presentations prior to their presentations. She
indicated that she learned how to integrate technology from a teacher’s perspective instead of from a student’s perspective—“technology...maybe a little bit.

Molly’s second placement provided more opportunities for technology integration as a result of her cooperating teacher’s bent towards technology in the classroom. Following that experience, Molly completed the PCK and TPCK framework evaluation and provided insight into her development of TPCK throughout her student teaching experience.

I didn’t really learn much in the way of new technology, but I learned some new ways to use it. In high school (first placement), the technology was a bit more about giving the students the information, but in the middle school it’s a bit more about getting their interest and attention. I learned techniques that increased my overall knowledge of technology.

Molly also indicated that through teaching with and through the technology that she perceived more of a development in her TPK than with her TCK. Molly’s use of images in lesson nine captured this notion of teaching with and through the technology as well as indicated part of the how of her pedagogical awareness as she distributed images to the students and requested that they attribute those images to one of Newton’s laws and provide a rationale for their choice. The combination of video demonstrations that led to a student laboratory also demonstrated her ability to utilize a “with and through” approach. Molly perceived her technology integration to
be supported by her TPK more than her TCK as she did not find herself integrating scientifically-oriented technology tools like probes and sensors, but rather technology tools that facilitated the lesson activities (projection of the opening hook or activity, homework assignment review, lab expectations). She indicated this in her final TPCK bridling—“I didn’t really learn much in the way of new technology, but I learned some new ways to use it…I learned techniques that increased my overall knowledge of technology.” Similar to her first placement, inherent in her second placement was the sense that technology could really be used to streamline the content, aid in the instruction and engage the students—something she alluded to in her pre-student teaching bridling entry on science and technology.

Molly’s comfort level seemed to increase as a result of the positive perspective her second cooperating teacher had towards technology integration into science teaching. Her second cooperating teacher approached each lesson with the sense that technology use was necessary for student engagement and an integral part of her teaching. Much of Molly’s increased comfort towards technology can be attributed to the technological advocacy of her second cooperating teacher. Molly’s cooperating teacher shared with her how technology could be used to review homework, draw attention to key ideas and terms and consequently streamline the note taking process, yet also modeled how short video clips could be used as anticipatory hooks, the content itself or a means to reiterate the lesson from another
perspective. Molly also learned that through integrating technology, her students could execute their brain warm-ups and class activities more efficiently. As a result of her experience in her second placement, Molly was able to better experience how preparing lessons with technology use in mind affects the student learning—thus deepening her ability to enact her TPCK in her own teaching.

**Analysis of Lily’s Case**

This case analysis is also structured to illustrate the what, how and why of technology integration into the science classrooms, following McCrory’s suggestions. Following a discussion of the what, how and why, the development of Lily’s TPCK across her student teaching is discussed.

**Lily’s implementation of technology—the what.** Table 5.2 summarized the various instructional technology that Lily implemented during her student teaching—the *what* of her pedagogical awareness of technology integration.
Table 5.2  Lily’s Uses of Instructional Technology

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<th>Technology Used</th>
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<td>First Placement</td>
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<td>Jeopardy Review</td>
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<td>Video Clips</td>
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<td>Demonstrations&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>Laboratory&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Document Camera</td>
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<td>Computer Laboratory</td>
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<sup>a</sup>With technology integration.
Table 5.2 gives a clear picture of the frequency and modality of Lily’s technology integration throughout her student teaching as well as an indication of the what of her pedagogical awareness. Lily’s effectiveness of technology integration was lesson dependent and the way in which the students received her instruction. Her experience with the various technologies helped develop a greater sense of pedagogical awareness throughout the study. She intended for the technology to provide students with learning opportunities that would be more engaging and represented science content in authentic ways.

Lily’s implementation of technology—the how. At the outset of the study, Lily suggested that her technology knowledge and subsequent TPK and TCK were limited, thus influencing the how of her technology integration. She referenced the influence that limited technology knowledge had on her teaching in her initial self-placement—“I don’t implement technology well in the classrooms.” Yet, on the other hand, Lily indicated that she perceived technology to increase student engagement and interest levels in the science content as long as the technology is used properly. Her perception that technology integration enhanced student engagement was identified in lesson three which utilized a Jeopardy review game. When asked about how technology affected her lesson, Lily responded—“it was based on technology today…definitely a positive. The game promotes good relationships with the students rather than just giving them a worksheet.”
perceived that the videos in her fifth lesson on a heart valve replacement “created some intrigue.” In preparing her lessons, she indicated that she purposefully searched for videos that would create interest and engagement, a practice that informed the how of her pedagogical awareness.

Her post-observation comments from lesson eight also indicated her intentions of increasing student engagement with technology in ways that supported her didactic instruction. When asked how technology affected her lesson on motion with freeze-frame photography, Lily indicated “it helped with the lecture part of it, assisting me in that…definitely helped with notes, especially because we are not based on the book in this class.” While she did not reference it directly, her eighth lesson really captured her ability to think on her feet and engage with the students in a way that created a natural flow to her lesson as she was not tethered to her teaching notes. The intentions of her questioning were determined by the direction and feedback that she received from the students and their understanding the images on the screen. Her integration of technology through the still images fostered a more comfortable, student-centered teaching disposition.

Lily’s initial bridling illustrated her intentions of pedagogical efficiency as well as a caution for effective, proper use—“with sufficient practice, the teacher may also be able to save time; technology assists in overcoming the demands of the classroom teacher, it also has its drawbacks when not used properly.” While Lily’s
initial bridling on technology’s role in the science classroom alluded to pedagogical efficiency and effectiveness, some of her observed lessons and bridlings indicated that her technology integration was not as effective as she might have thought. Lily recognized the benefits of potential student engagement in the Jeopardy activity, yet neglected to notice the pedagogical ineffectiveness of her lesson structure. The students were split into two teams and a team spokesperson was nominated to report the team’s final answer. More than half of the questions on the PowerPoint slides went unanswered due to their specificity, lack of sufficient answer time or incorrect word choice. As a result, the students appeared frustrated in the process and disengaged in the lesson.

Lily was convinced that the students were not able to recall as much information in the Jeopardy review game from her third lesson because they had just returned from a long weekend. It appeared that the lack of success in the Jeopardy game was more likely a result of multiple instructional limitations. The procedure limited the students from using their notes, review packets and textbooks—hence making the review a game of mental recall of very specific, minute details from Lily’s PowerPoint presentations. The social influences also contributed as particular students did not appear to have a way of channeling their voice to their team spokesperson—something that was expressed throughout the lesson and never addressed by Lily. While this lesson had a few logistical concerns, it did provide the
students with greater exposure to test-like questions that they could use to prepare for their test the following day. While an activity like Jeopardy holds tremendous instructional potential, restructuring of the parameters and learning environment would have facilitated a more effective use of instructional technology.

While Lily did not perceive her Jeopardy lesson to be ineffective, she did indicate a development in the how of pedagogical awareness in her final TPCK perception and her eleventh lesson in the computer laboratory. “Part of the technology knowledge I have gained is how and when to use the technology and part of it is how to adjust when technology doesn’t work.” She perceived that learning “how and when” to use technology had further developed her TPK as well as the idea that sometimes the most effective means of instruction occurs in the absence of technology.

Lily’s response really provided insight into how she derived meaning from scientific material as well as how, at least in this particular lesson, that she felt technology would “fluff” up the content. This interaction in lesson five was really perplexing for me as I grappled with whether this was Lily’s true perception of what technology affords her instruction. While I’m not completely convinced she intends to provide such a negative impression of technology in the classroom, it did provide a salient reminder to the fleeting and changing nature of the phenomena that resides in pedagogical awareness.
Lily’s implementation of technology—the why. While Lily experienced two cooperating teachers with different levels of technology integration, she attempted to utilize what she could to augment her classroom instruction. Her final bridling indicated that she felt that the technology she implemented “can be very helpful in showing videos of demonstrations, dissections, and other concepts.” Although the integration of the valve replacement video in lesson five did not capture a holistic picture of the why behind Lily’s pedagogical awareness, it did depict an aspect of her thought process. As Lily began the lesson, she informed the class that the other anatomy and physiology section had earned a “fun movie” and so this particular class was going to watch a few extra videos as well. While she suggested that videos were engaging and worthwhile, she also implicitly implied that technology integration lightened the rigor of the lesson’s content.

Lily: So what we're going to do...we're gonna kind of um...fluff it up a little bit for you guys with videos.

Student 1: Fluff it up!

Student 2: Yeah, yeah.

Lily: They're really good though. I'm excited about the one today. There's two of them.

Lily also referenced her comment in her post-observation bridling (without any prompting). “We're 'fluffing' the lesson because the other class is watching their fun
movie. I try to get students interested in the topic with the videos and my enthusiasm.” While her intentions to engage the students in the lesson were acknowledged, her comments suggested that the intellectual rigor of the day was diminished through the use of the heart valve replacement video. On the other hand, the same bridling indicated an intentionality towards engagement and real-life simulations.

Especially when dealing with the heart and I thought it was more meaningful if they saw it in the actual chest cavity pumping to see how it works than an animation of the atria and the ventricles squeezing. To me that just seems so bland and white lab coat like that it doesn't really make an impact.

Lily also suggested that the integration of technology enhanced her lesson with photographs on motion as it supports the why behind her pedagogical awareness. She perceived the direct connection between the science content and the images shown to the students—“because those pictures were necessary because it was so based on the images.”

**Lily’s development of TPCK.** As Lily began her student teaching experience, she indicated in her self-placements on the PCK and TPCK frameworks that she had a slightly stronger understanding of content than pedagogy and felt that she did not integrate technology well. Lily also recognized “deficiencies” in her content knowledge necessary to teach high school anatomy and physiology. At the
conclusion of her first placement, Lily stated she “had a decent handle of technology in the classroom, yet after a few weeks in her second placement indicated that she had “only touched the tip of the iceberg in understanding ways to implement technology”—vividly capturing the tentativeness inherent in post-intentional phenomenological research through the use of bridling. This change in Lily’s perception stemmed from the fact that her first cooperating teacher had less access to technology than her second cooperating teacher. Lily proposed that the funding available in her second student teaching placement allowed for greater integration. She also mentioned that her TPCK increased as a result of adapting four out of six lessons when the technology failed to connect to the network.

Lily alluded to her perceived technological and pedagogical development in the following response as part of her final self-placement of her TPCK perception.

Part of the technology knowledge I have gained is how and when to use the technology and part of it is how to adjust when technology doesn’t work. Simply from having access to more technologically advanced equipment I have gained knowledge in this area.

Lily’s TPCK development was also evident as a result of her pedagogical awareness with her use of the document camera. In the post-lesson interview following her momentum lab, Lily commented on the affordance the document camera provided.
It allowed me to put the images up on the screen so that students who weren't in a front row seat could see what I was demonstrating and could see for example the slot in the cup or how the ruler and the triangle were supposed to work together to measure things. Instead of trying to take it apart off the desk and hold it up or something like that….Because they wouldn't have been able to follow instructions as efficiently here if they hadn't seen me display it there on the document camera above so that they could actually see it.

Lily also indicated development in her TPCK in reflecting how her eleventh lesson would have been better without the presence of technology. This supported her notion that technology is effective if it is used properly and works correctly. When asked how she thought her lesson went overall, Lily provided the following response.

I think this lesson was one of the worst I did in student teaching. I attempted a step by step approach which didn't allow for students at varying paces and competencies and didn't explain the big picture outcome before diving in to the details.

The students had reached a level of frustration with Excel and were unable to see the benefits inherent in the computer program. Lily also commented on how technology affected her lesson effectiveness and consequently created an awareness of her TCK and TPK in her post-lesson bridling prompt.
In this lesson, I think it [technology] was a major distraction. A much higher percentage of the class would have understood, with better explanation from me, how to create the end product of tables and graphs if computers were not incorporated into the plan. It was just too much new content for students to understand both the technology and the content of the lesson.

This lesson represented an experience where Lily’s understanding and enactment of TCK and TPK affected the outcome of the lesson and created the impression that “technology was a hindrance.” If either Lily or the students had greater familiarity with the Excel program the outcomes of the lesson would have been met more efficiently. While Lily recognized that not all of the students could synchronously process her instructions, she did not create a mechanism for peer assistance or peer checking—thus creating the impression for her that she was teaching a “technology lesson rather than a science content lesson.” Lily’s bridling entry alluded to this sense that she felt like more of a technology teacher than a science teacher when students asked if they could complete the graph with paper and pencil.

This is the key point on which I don't think the lesson is effective. Students are constantly asking if they can do the equations manually and draw the graph on paper because it would be easier. This tells me that they know how to do this, and the confusion comes primarily from using the computers.

While the intention is good, the lesson has now turned into a technology
lesson rather than a science content lesson, taking time away from content and creating frustration in the classroom on all parts.

Lily also referenced the struggle of developing TPK and TCK as she felt she was teaching content in the area of computer applications rather than in physics content during her eleventh lesson in the computer lab. The question that prompted her response was: “How do you know when technology is not helping you teach your lesson?”

When there is more emphasis on learning to use the technology than on using the technology in the lesson, it is not helpful. For example, my class collected data in a lab recently and were supposed to create a data table and graphs from the data. Students spent 4 days trying to figure out how to use the technology, and could predict the outcomes of the graph accurately before creating the tables and graphs via Excel. While this information can be helpful, I question if the exercise was helpful to students in a science class, since it slowed the class down 3 days compared to if students had plotted the information by hand.

Finally, while Lily indicated that technology had detracted from this particular lesson, she was encouraged by the fact that this was only one of the few lessons she reported this perspective of ineffective technology integration.

I think technology definitely detracted from this lesson, even though the
lesson was based on technology. Thankfully, this is one of the few lessons I need to say that it detracted from, and with better planning and classroom management skills I think it would improve.

**Cross-Case Analysis**

Following the analysis of each of the two participants in the study and their perception of pedagogical awareness of technology integration into science teaching, a cross-case analysis was conducted to determine which commonalities and differences resided in the student teachers’ perception of their pedagogical awareness. The cross-case analysis of this study, facilitating the part analysis in phenomenological research, presented overarching themes (tentative manifestations of the phenomena) across the forty-one lessons that surfaced through observations, bridling entries, direct and indirect references from the participants and through student comments from within the lessons themselves. The categories that most commonly emerged were: *uses of technology, perceptions of engagement with technology, benefits of reflexivity in teaching, cooperating teachers’ influences, and content knowledge*. For the purposes of this cross-case analysis, the uses of technology in conjunction with the pedagogical awareness were analyzed as the focal point of the study.
**Tentative manifestations of pedagogical awareness.** The following section presents the ways in which the phenomena of pedagogical awareness manifested itself through the course of the study.

**Uses of technology.** After the final lesson observations were completed, the researcher evaluated the types of technology (the *what*) used in the classroom by the participants during the study. Each of the participants utilized similar technologies (Table 5.3) during their student teaching experiences. In an attempt to find pedagogical awareness amidst McCrory’s (2008) suggestions for effective teaching, the analysis of the data focused slightly more on the how and why of the technology integration rather than what they used in their teaching. While the willingness to learn and implement new technologies was evident in the pre-placement bridlings of these non-technology savvy participants, their actual level of integration was less than expected by both the student teachers and the researcher.
Table 5.3

Participant’s Comparative Uses of Technology

<table>
<thead>
<tr>
<th>Technology</th>
<th>Molly</th>
<th>Lily</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerPoint</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Projector</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Images</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Jeopardy Review</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Videos</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Demonstrations</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Laboratory</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>SMART Board</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Document Camera</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Audio Assistant</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

(Molly: 10 lessons; Lily: 11 lessons)

Each of the participants was exposed to parallel technologies in their student teaching placements. Table 5.3 indicates the technology tools each participant had at their disposal and the frequency with which they implemented the tools. Lily had access to a few additional technology tools (a document camera, SMART board and the audio assistive technology device) in her second placement.

Although each of the participants utilized PowerPoint presentations for direct instruction throughout their teaching, there were significant observed differences in their implementation (the *how*). Molly’s use focused on providing a notes structure that resembled a study guide identifying key terms, concepts and processes. Lily’s use of PowerPoint focused on detailed, line-by-line notes that she created from a myriad of extracurricular sources. While both Molly and Lily gave attention to highlighted and bold-faced key terms and subheadings—indicating the importance of
key elements from the text to their students, Molly was able to foster more collaborative discussions and inquiry into the material by engaging students in discussions and questions and thus demonstrate a deeper level of pedagogical knowledge.

Both participants utilized a Jeopardy activity in their student teaching placements, yet had different results due to the level of student participation and engagement. Molly created a cooperative learning environment with the Jeopardy activity, encouraging students to 1) collaborate with their seat partners and surrounding team members, 2) review their notes, handouts and textbooks, and 3) provide their answer. While Lily’s Jeopardy review activity had a similar physical configuration to Molly’s, the learning environment was not as collaborative as she prohibited the use of any class materials in answering the questions. The students were instructed to 1) read the question on the board, 2) determine and channel the correct answer to their spokesperson and 3) report their correct answer to Lily via their teams’ spokesperson. These instructional parameters limited the responses to the two students in the room—individuals who did not always consider proposing the answers from each of their team members due to some of the social relationships among the team members. As a result, students who were not in close proximity to their team’s spokesperson or socially amiable to the spokesperson gradually became less interested in the game and were not redirected by Lily to actively participate.
This Jeopardy review was an indication of Lily’s need to further develop her pedagogical awareness in a way that prompts immediate changes to instruction during a class period. The questions Molly used in her Jeopardy review were image-based, broad questions that probed the students’ ability to remember, understand and apply the material, whereas Lily’s questions were very specific, and required precise recall of the material. Molly’s Jeopardy review fostered student inquiry as students investigated answers that they could not determine, whereas Lily’s Jeopardy review inherently became a test of what the students could recall in a test-like fashion prior to taking the actual test. Consequently, the students in Molly’s Jeopardy review activity experienced a much more thorough review as they actively engaged in the lesson and interacted at higher levels of Bloom’s taxonomy as opposed to the students in Lily’s review that experienced one more semi-structured, direct-instruction lesson.

Use of video integration. While both Molly and Lily integrated informative, supplemental videos in their instruction, a slight philosophical difference (the why) surfaced through their bridling and in-class comments. Molly perceived the videos to be an instructional tool that functioned as both the content for the lesson (lesson 8) as well as supplemental components to her instruction (lesson 9 and 10) that provided “real life examples”. Her use of images of Newton’s laws (lesson 9) also demonstrated how the use of visuals can provide a framework for the lesson’s interactions as students presented their justifications as to why their image
represented one of the laws. The students were very engaged in this lesson as they listened and presented their individual pictures. She bridled, saying “a teacher can know that technology is helping a lesson by observing the engagement level of the students.” This indicated that if the students portrayed limited engagement with her lesson activity that she might look for alternative methods to integrate technology, thus implying a pedagogical awareness. She also referenced an approach she adopted and practiced frequently in her middle school placement.

I often asked if the students enjoyed the activity or lab. It doesn’t hurt to get the students’ opinions on what is used in the classroom. They’re the ones using the technology or activity to learn! They might learn the lesson, but if they don’t enjoy it, how much is its effectiveness compromised?

Lily provided mixed perceptions on the use of videos as she commented that they were supplemental and “more meaningful” than just animations, yet she mentioned in one of her bridling entries that “technology enhances student learning by giving more students the opportunity to learn the same material.” Her use of videos depended on her intentions associated with the videos she chose. She indicated that her video on valve replacements acted as a simulation to bring the content to life in the classroom, whereas her use of videos on nuclear fission introduced the students to a new geographic region and highlighted the devastation of the tsunami in Japan.
**Intentional use of technology.** The notion of intentionality (the *why*) surfaced throughout the study in bridling entries like the following quote from Lily:

When using technology in my classes, I try to think through potential problem spots and clarify them for myself before presenting it to the class. I then look at the positives and negatives of the first lesson and make minor changes for the next lesson.

These comments indicated a level of reflexivity to Lily’s teaching that created positive changes in her instruction. Molly was also intentional about her approach with technology integration. Her bridling indicated that she was cognizant of the feedback from students about the various technologies she chose to integrate and whether she would continue using it or looking for alternatives to enhance the learning experience. When asked how she processes through using technology in the classroom, Molly responded by saying

What should be considered is how exactly it will be used in the lesson: when and how it will be used, how to explain the use and purpose in the lesson to the students, and how to connect the technology to the lesson, material, and to science.

Her response indicated that she believed that technology integration did not stand alone, but rather was integrated into the fabric of her instructional design.
Perceiving the role of technology in engagement and interest. The participants also recognized the notion of engagement throughout the study. Lily commented on the assistive nature that technology provides “amateur” teachers (referring to herself) at the conclusion of her second placement.

It is also more interesting to watch a professional do a demonstration on a video than to watch an amateur teacher recreate the same lab in front of the students, but not allow them to take part. Yet in an effort to hook the students at the beginning of the same lesson, Lily referred to the use of videos as technology fillers that “fluff up” a lesson (lesson 5). On the other hand, she also referenced the videos as “helpful” in presenting the content and showing students real-life images and situations (lesson 7).

Molly also indicated the need to be responsive to how engaged the students are with the class material and how technology can facilitate more instructional engagement. “They’re the ones using the technology or activity to learn! They might learn the lesson, but if they don’t enjoy it, how much is its effectiveness compromised?” Molly’s use of technology fostered continual engagement for the students that was reflected in the students’ comments during her lesson (captured in chapter IV).

The participants also indicated that certain videos and demonstrations “can draw students into a topic” and brought real-life examples to the curriculum.
They also commented on the significance of video footage that captured professional demonstrations as opposed to teachers’ replication in the classroom.

It is also more interesting to watch a professional do a demonstration on a video than to watch an amateur teacher recreate the same lab in front of the students.

**Benefits in reflexivity in teaching.** Each of the participants indicated that participating in the act of reflexivity impacted their classroom practice and thus informed their pedagogical awareness. Lily provided one such reference in how reviewing the videos of her lessons and bridling through what she saw illuminated nuances to the changes in her teaching over the course of her placement.

By reviewing some of the early videos from the placement, I can see several striking differences in pedagogical knowledge, namely questioning techniques, monitoring methods, and voice inflection during delivery.

Lily was referencing a change in her classroom disposition as a result of a post-lesson conversation that she and I had following one of her early lessons. Although I tried to instill an “empathetic neutrality” (Patton, 2002), I felt that if Lily saw and heard how she came across to the students, she might desire a change in her approach to the students in the classroom. After watching thirty seconds of her teaching, she commented saying, “Ugh, that’s what I sound like?” Consequently, she intentionally shifted her tone of voice from an authoritative-sounding, scolding type of monotone
to more of an assertive approach with more expression in her classroom conversation. Additionally, the act of bridling provided the participants with the opportunity to question their pedagogical decisions and propose alternative methods for future lessons. This can be seen in the following bridling entry.

It might have been beneficial to present this material in an additional way. In watching this video after having not studied the material recently, I can follow along but don't understand it like I would like to. I could include a brief 30-60 second video between slides to review and make the point clearer for both intrinsic and extrinsic pathways. I could also ask students to tell me about pathways, or give them a scenario per small group and ask them to identify if it is intrinsic or extrinsic and tell the steps of what would happen, using notes and books if necessary.

**Personal perspective on participants’ TPCK.** Situated as a participant observer, it is also necessary to analyze the pedagogical awareness of technology integration from the researcher’s lens and provide my own personal perspective on what I saw. The participants commented that they perceived developments in their perception of their TPCK through the study as a result of evaluating their technology integration. While I appreciate and support their TPCK self-evaluations, I also see the need to comment on how their technology integration was largely used for didactic, direct instruction when it was not intended to create cooperative learning
environments with the Jeopardy reviews. Much of the technological uses in their science classrooms featured presentation tools or video usage that resembled McCrory’s (2008) first classification—usage that is unrelated to the science content itself, but used “in the service of science” (p. 197). Both of them recognized the benefits of simulations and videos that portrayed science content (Newton’s three laws, motion, heart valve replacement), yet did not identify a difference in their intentionality of integration with regards to McCrory’s (2008) uses of technology in science teaching. Each of the participants also had frequent opportunities to integrate McCrory’s (2008) third category of technology integration designed and used to do science with their experience with microscopes and document cameras.

Another aspect of analysis to highlight was the issue surrounding content knowledge and how the participants’ depth of understanding was utilized or compensated for with regards to technology integration. While student teaching provides one of the first real-life opportunities for application of the pre-service teachers’ content knowledge, it also provides the first transparent evaluation of the depth of their content knowledge as they enter the student teaching experience. Not only did each of the participants indicate areas of their content knowledge that needed refreshing prior to teaching their lessons, but each of the participants also indicated that their content knowledge affected their integration of technology and vice versa. Molly mentioned that her lack of content knowledge in physical science was
connected to her more saturated use of videos with Newton’s laws, electricity and magnetism in her second placement. Lily mentioned that utilizing her PowerPoint slides while she taught anatomy and physiology decreased her study time in preparation for her lessons. While each of the participants recognized the pedagogical affordances surrounding technology integration in the study, it was necessary to highlight how their awareness and TPCK was influenced by their content knowledge. This further supports the importance of developing ones’ content knowledge in order to further strengthen ones’ ability to integrate technology effectively using a TPCK framework.
Chapter VI

This chapter summarizes the findings of the study and the connections made to the research literature from chapter II. Secondly, this chapter provides implications for science teacher education programs, cooperating teachers, and student teaching supervisors. Finally, areas of interest for future research in science education and technology integration are introduced.

Conclusions

This study sought to explore the teaching practices of two secondary science student teachers and their integration of technology in their lessons. The study attempted to capture the tentative manifestations of pedagogical awareness surrounding technology integration in science teaching and how this phenomenon presented itself to the student teachers and the researcher. For the purpose of this study, I have intended for the phrase pedagogical awareness to represent the what, how and why behind the participants’ integration of technology in student teaching. This term pedagogical awareness is supported by McCrory’s (2008) work on science teachers’ development of TPCK, in which she identified four essential knowledge bases vital for effective implementation—knowledge of the content, students, technology and pedagogy. It is with a deeper understanding of how the conglomerate of these knowledge bases of “in knowing where [in the curriculum] to use technology, what technology to use, and how to teach with it” (McCrory, 2008, p. 188).
195) positively impacts instruction. Using the term pedagogical awareness positioned both the participants and myself to explore how the participants recognized their decisions on the what, how and why of technology integration in their science teaching. It is within this structure of pedagogical awareness that the following research questions were explored.

1) In what ways do pre-service teachers come to identify the tentative manifestations of their own pedagogical awareness of good teaching and learning through the implementation of technology in the secondary science classroom?

2) What challenges exist in identifying how and why the tentative manifestation of or intentional relationship with pedagogical awareness changes throughout teaching?

In an effort to support the research questions, it is critical to return to the phenomenon and analyze how it manifested itself through the subjective, lived-experience of the participants. In the context in which I studied it, salient tentative manifestations surfaced that support the notion that pre-service teachers were able to recognize the what, how and why behind their technology integration. Throughout the course of the study, each of the participants and the researcher reviewed and annotated videos of the lessons. This created the time and space for the pre-service teachers to analyze their decision-making processes in the classroom. By situating
themselves in their lessons again, the participants were able to provide explanations, clarifications and suggestions for their teaching. Molly and Lily’s pedagogical awareness towards what, how and why they chose to integrate into their science teaching indicated a developing understanding of TPCK. Conclusions from each of these areas are presented below.

**Identifying tentative manifestations of pedagogical awareness—what.**

Molly and Lily’s decisions in what technology they chose to integrate into science education indicated a portion of their pedagogical awareness throughout the study. Implementing videos, demonstrations, PowerPoint presentations, images, document cameras and audio assistive technology provided them with the ability to identify to what extent the various technologies were effective in their instruction. As a result of this study, both participants were asked to reflect on their pedagogical awareness surrounding technology integration, thus gaining a clearer indication of effective technology integration—a concept that Dias (1999) claims is not seen enough in teacher’s practice. Creating time and space for the participants to investigate the what of their technology integration led to the development of their TPCK during their student teaching (as indicated in their bridling and lesson reflections). While the amount of Molly’s technology integration remained relatively constant in her placements, however, her level of insight and pedagogical justification as to why she chose what technology to use and how it affected her lesson became more articulate.
in her bridling. Lily’s pedagogical awareness also came out through the study as she bridled that specific technology (the what) both enhanced as well as detracted from her lessons—dependent on how it was received by the students and their level of technological understanding with the implemented tools. Her comments regarding technology provided various perceptions of technology as she indicated that what she implemented really enhanced the lesson, was the lesson itself, and that technology was used to “fluff up” her lesson. In her eleventh lesson, she highlighted that she thought her lesson would be more effective with the absence of technology. All of these examples indicated that Lily’s ability to integrate technology fluctuated (as a means of practice), yet she indicated that her perception of her pedagogical awareness and TPCK deepened as a result of reflecting on the what in technology during her student teaching. Her acknowledgement that experience and exposure to various technologies led to further development in her pedagogical awareness supports the findings of van Driel, Verloop & de Vos’s (1997) study in which they concluded that “familiarity with a specific topic in combination with teaching experience positively contributes to PCK” (p. 681). Lily’s comments supported the idea that while her understanding of TPCK developed throughout the study, additional experience and exposure would deepen her level of PCK and TPCK respectively.

Unfortunately, the level of technology integration observed in the study was not as constructivist and student-centered as hoped for, yet stands to support
Lanahan’s (2002) findings that teachers and students are still integrating technology with low-level productivity tasks. While each participant created opportunities for the students to learn with and through the technology, work still must be done to promote “generative” learning experiences (Doering et al., 2003). The various technological affordances that comprised the what of their pedagogical awareness also contributed to the how of their integration—which is discussed in the following section.

**Identifying tentative manifestations of pedagogical awareness—how.**

Molly and Lily’s decisions in how they chose to integrate technology into science education also indicated a pedagogical awareness in their teaching. For example, they both indicated that their use of PowerPoint afforded their students with a structural framework to take notes as they highlighted key terminology and processes. Molly provided the students with a frequent reminder of “blue you do,” indicating that the students needed to write down the text in blue. The use of PowerPoint also gave the participants an outline from which to teach as they became more familiar with their content knowledge (as indicated by their self-placement TPCK frameworks and their bridling entries). Lily provided the following bridling response capturing her pedagogical awareness of how the PowerPoint presentation assisted students in taking notes. “After scanning the class, I make an observation aloud to encourage students to continue taking notes. With a few exceptions, those who are taking notes
will have a basis to study from that will increase test scores.” Her comment indicated that she was aware of the necessary wait time for the students to copy down the essential notes from the PowerPoint slides she had prepared. On the other hand, she also commented that she depended on the PowerPoint to help remind her of instructional components as well as provide the necessary terminology she presented to the students. This pedagogical awareness highlighted the notion that Lily was using context-related teaching skills to inform or support her lack of content knowledge in particular topic-specific domains—something that developed through her student teaching experience. Similarly, van Driel, Verloop & de Vos’s (1997) found that science teachers lean on their general PK when teaching out of their area of expertise or content area as well as rely on didactic approaches to teaching when they are uncomfortable with the science content they are expected to teach.

Both of the participants also indicated that the use of videos and demonstrations functioned both as the science content as well as supplemental components to their lessons. They acknowledged that the content in the videos helped determine how video would be implemented into the classroom—either as the content itself or as a support to the curriculum. Each of them utilized the videos as a means of simulation of actual science content (heart valve replacement) or a demonstration of science principles (Newton’s laws). Molly referenced the series of
videos she showed her students in lesson eight as being more substantive as content rather than supplemental.

It's [the videos] probably leaning towards being the content because I did very little talking about the laws and the two or the three videos, but the two guys were able to explain them very well and had several different ways to show them. And then I just added a little bit so.

Supporting this notion, Molly indicated inherent benefits that videos provided. “We [Molly and her cooperating teacher] both felt that it would be easier for me and the students to see rather than hear the laws.” Both participants also indicated a pedagogical awareness with the indication that some videos and demonstrations needed to be contextualized and prefaced with background information to properly situate the video in the learning context. Molly provided one such insight—“I explained each of the laws a little before getting into the videos and demos for each, but for the most part left the teaching to the videos and demos.” Lily also provided some commentary for the how factor of her pedagogical awareness, alluding to a pedagogical decision to become more familiar with the video due to limited knowledge of the content—“Because there is no commentary on the video, I have watched it several times so I can explain it as students watch.” Both participants were perceptive to when they felt the videos were able to stand on their own and when they needed to situate them in their lesson—something that McCrory (2008) says happens
when teachers “anticipate and prepare for what will likely happen when the technology is used (p. 198).

The participants also felt that their use of technology through the Jeopardy review activities promoted engagement and fostered cooperating learning environments encouraging students to work together to identify correct answers. Based on how the learning environment was established, these Jeopardy reviews shifted the instruction from the teacher-centered approach characteristic of didactic instruction more to a student-centered approach inherent in cooperative learning groups. The PowerPoint presentations used in Jeopardy presented the visual and text-based information in ways that relieved the participants from their regular didactic instructional methods as well as created enthusiasm in the students. During these activities, the participants became facilitators in the lessons rather than lecturers of the science content. The integration of technology created an environment where students collaborated, competed and became directly involved in their learning. Both participants recognized the students’ excitement and energy that surrounded their three lessons with cooperative learning—something that might foster greater implementation in their future teaching if used more often.

On the other hand, participants also indicated the how of pedagogical awareness in the fact that they detected circumstances when technology integration was not the right pedagogical tool for the students—thus supporting Mishra &
Koehler’s (2005a) finding that some technologies are “more applicable in some situations than others (p. 132). When Lily integrated technology in her eleventh lesson in the computer lab, she indicated that the technology integration was detracting from learning content in this instance. “If students would have had training in their previously required technology class in how to use the Excel program it may have been successful, or if I had allowed time to teach strictly on using the program and then started combining content with it.”

Afterwards, she commented that she felt her teaching effectiveness might have increased with the use of paper and pencils instead of computers. Her comments indicated dissatisfaction with the how of her technology integration—“when there is more emphasis on learning to use the technology than on using the technology in the lesson, it is not helpful.” This highlighted her perception that some teaching objectives were more easily met without the use of technology if the students did not have sufficient technology tools to begin with. This concern of sufficient student knowledge and the necessary time to compensate for this lack of understanding supports the findings of Donna & Miller (2011) in which they found concerns surrounding the effectiveness of implementing in non-ideal circumstances.

Consequently, as the participants became more familiar with how to integrate technology in their teaching practice, they developed their level of TPCK at the intersection of technology and pedagogy. As they continued to understand and
experience more of the *what* and *how* of technology integration, their level of TPCK developed with time. Additionally, as pre-service teachers came to recognize these perceptions of deeper levels of TPCK, they indicated that they were able to identify the what, how and why of their pedagogical awareness as well as suggest potential changes for future practice. The participants were beginning to see how reflexive practice leant itself to further development of TPCK in the act of teaching and reflecting on their practice. This development of the participants’ TPCK agrees with previous studies conducted by Becker (2001), Flick and Bell (2000), and Niess (2005) who found that students’ learning the subject matter concurrent with the use of technology is informed by the instructor’s pedagogical decisions and informs their teaching. Supported by the aforementioned studies, these participants developed their TPCK as they contemplated their pedagogical awareness surrounding the interaction of technology integration and science content. The *how* of the participants’ technology integration is deeply connected to the pedagogical awareness surrounding the *why* of their integration discussed in the following section.

**Identifying tentative manifestations of pedagogical awareness—why.** This study also investigated the *why* behind the participants’ decisions of technology integration. Both participants indicated that technology presented the content in more interesting ways than if they had not implemented it—as indicated by one of Molly’s bridling responses in which she said “technology can enhance engagement by
presenting information in new and interesting ways.” Repeatedly, the participants reported that they were attuned to student feedback on technology integration and that the students’ responses informed their decisions to use particular videos in future lessons.

Additionally, the participants indicated that the why of their pedagogical awareness was also dependent on the existing technological practices of their cooperating teachers as they collaborated and implemented strategies that were already part of the existing curriculum. While each of the participants were given periodic license to solicit their own videos or PowerPoint slides, each of them also collaborated with their cooperating teachers to use the existing technology they had used in previous lessons. This created a tremendous influence on the why of their pedagogical awareness as they were frequently implementing their technological choices of their cooperating teachers. Both Molly and Lily perceived the differences in the level of integration from their cooperating teachers and how it led to the development of their pedagogical awareness.

Both participants utilized various technologies in their instruction because they saw the inherent benefits provided by the technology in the curriculum. They referenced the use of many technology tools that aided in their instruction. Through the study, the participants commented that document cameras allowed students around the room to see the laboratory set-up at the front of the room, PowerPoint
slides presented the laboratory’s expected outcomes and procedures, videos brought real-life examples into the classroom and enacted the content in particular lessons when the video presented the material more effectively than the participants felt they could, and projector screens displayed correct answers to the daily homework and helped to streamline the review process. As reflected in their decision making processes, the why of their pedagogical awareness had direct implications for the types of technology they used as well as what their projected outcomes were as a result of using the technology.

The why of their pedagogical awareness also appeared to be influenced by their overall approach to teaching and their beliefs inherent in their practice. Both of the participants were developing their awareness of how utilizing technology in their instruction facilitated greater engagement and interest, fostered pedagogical efficiency, and provided visualization for the students. Their desire to create engaging and interesting lessons was driven by their dispositions as educators and their desire to build connections between their students and the science content. The participants’ decisions in the classroom and the reasons behind those decisions were fueled by their developing beliefs and limited experiences as teachers. While the pre-service teachers practice relied heavily on the pedagogical guidance of their cooperating teachers, they were also given time and space to investigate Ertmer’s (2005) claim that “current classroom practices are rooted in, and mediated by,
existing pedagogical beliefs” (p. 36) and how their pedagogical awareness and views on technology integration emerged from this dynamic relationship in their placements.

**Challenges existent in identifying pedagogical awareness.** The study also identified a few challenges that existed in identifying how and why the tentative manifestation of pedagogical awareness changed throughout teaching. While the participants perceived growth in both their self-placed TPCK and their ability to integrate effective technology throughout the study, there was also an undulation of their lesson effectiveness with the technology. This was indicated by the fact that when asked to select four teaching lessons for further analysis—two effective lessons and two for remediation—not all of the selected effective lessons came at the end of the study in the participants’ second placements.

Another challenge that surfaced in identifying the changes in pedagogical awareness of the participants was determining the extent their pedagogical awareness was affected or influenced by their cooperating teachers’ ideas of technology integration. The uses of technology were dependent on the affordances that the cooperating teacher provided for the participants in their placements as well as the what, how and why of their cooperating teacher’s perspective on technology. Both participants commented that their cooperating teachers helped them see how and where technology was implemented into the curriculum based on their expectations.
of how they would organize their lessons—key factors in what McCrory (2008) found
in identifying effective practice with TPCK.

I would also argue that the participants’ pedagogical awareness was also
affected by the curriculum they were required to teach and consequently how they
integrated technology into the curriculum. As a result, this presented another
challenge in how the curriculum influenced their ability to determine their
pedagogical awareness of technology integration. As these participants were placed
in classrooms with ongoing curriculum, they were challenged to situate their teaching
in the domain-specific and topic-specific PCK that Veal & MaKinster (1999)
identified in their general taxonomy of PCK in science teaching. A challenge exists
in identifying how their depth of understanding in the particular domain-specific and
topic-specific affected their technology integration and vice versa.

Finally, this study has hinged on the notion that pre-service teachers were able
to accurately identify their own pedagogical awareness regarding technology
integration in light of Mishra & Koehler’s (2006) TPCK framework and McCrory’s
While I posit that pre-service teachers do not have profound, veteran definitions of
the construct of TPCK and its nuanced components, I do think that they, just as
practicing in-service teachers, have the ability to evaluate and receive constructive
criticism on their practice and make necessary changes towards greater student
engagement and motivation in the science classroom. While the perceptivity towards pedagogical awareness might be limited in its overall scope, the most effective way to keep developing an awareness of pedagogy is to continue the act of reflexive teaching with technology.

Implications

Post-intentional phenomenological work positions itself in the highly reflective family of qualitative methodology and thus requires the participant researcher to take a scholarly step back from the study to identify implications for the larger audience (Vagle, 2012). Given the whole-part-whole and single-cross case analysis shared in chapters four and five, this study informs the work of science teacher education and the roles that cooperating teachers and supervising teachers play in the professional development of pre-service teachers.

Science teacher education. While much work and writing has been done in the field of science education and technology, this study contributes from the perspective of the subjective, lived-experience of pre-service teachers from a post-intentional phenomenological approach. As a participant-observing researcher, student teaching supervisor, and pre-service science educator, this study deeply informed my way of knowing, understandings and functionality with respect to technology integration into science teaching as well as my position within student teaching supervision. Significant implications for my own practice resulted from
being situated in the “researcher chair” as opposed to the “supervisor chair.”

Continual work must be done to meld these two locales together in order to more effectively mentor and develop the work of pre-service science teachers.

Much of the impact this study originated from the opportunity that reflexive bridling offered the participants and the researcher. Bridling created the time and space to reflect on the phenomenon itself and committed the researcher and participants “to continually interrogate his or her understandings through the study” (Vagle, 2010b, p. 396) as a means of “reflecting on reflection-in-action” (Schon, 1987, p. 308). The act of bridling concurrent with teaching, positioned the pre-service teachers in a way that necessitated them to provide rationales for what they did in the classroom and how they perceived its influence on their instruction—something that McCrory (2008) found to be true in his study as science teachers identify their pedagogical justifications in their practice.

Asking pre-service teachers to participate in this type of reflexive work encourages them to interrogate their pedagogical underpinnings of their teaching practices. Through this iterative and reflective process, pre-service teachers can identify their perceptions and more clearly identify how TPCK can be enacted in the classroom. By asking pre-service teachers to bridle about what they notice and perceive is happening in their classroom with regards to technology integration, they become more attuned to their pedagogical awareness affecting their instruction.
As pre-service teachers develop their TPCK understandings, they may be more adept at inculcating technology in their instruction like the pre-service evidenced in this study. As pre-service teachers uses and integration frequencies increase, so might their creative capacities for technology use as well. They may begin to see technology as a fluid, fully integrated approach that becomes second nature in their instruction. Research supports that this process of technology integration may be one of intentionality and persistence as it necessitates a reflective, iterative, constructive process (Doering et al., 2003; Guzey & Roehrig, 2009; Hughes, Kerr, & Ooms, 2005; Sandholtz, Ringstaff, & Dwyer, 1997).

Cooperating teachers. While this study investigated pre-service teachers’ pedagogical awareness in the science classrooms, it was also heavily dependent on the teaching philosophy and instructional strategies of their cooperating teachers. With that said, teacher preparation programs must work hard to collaborate and align their pre-service student teachers with cooperating teachers they feel align with their philosophical approaches and instructional strategies. Cooperating teachers have tremendous impacts on either fostering or discouraging the instructional strategies with technology embedded in the daily routines of the K-12 classroom. Teacher preparation programs should be aware of and foster further development of the level of understanding and integration of TPCK in their cooperating teachers. Consequently, cooperating teachers would service the teaching profession as well as
local teacher preparation programs to inquire about professional development opportunities related to content-related technology integration. While it might be fair to assume that cooperating teachers and student teachers collaborate on instructional practices, it is also expected that the pre-service teacher adopts the instructional strategies, classroom management and learning environment that the cooperating teacher has worked to establish—thus limiting the potential for creative license for student teachers with regards to technology integration. Cooperating teachers have incredible potential to collaborate with pre-service teachers if they are willing to instill a positive, nurturing learning environment.

**Supervising teachers.** Student teaching supervisors bridge the gap between the theory taught in the teacher preparation program and the practice in the K-12 classroom. While pre-service teachers are exposed to various placements, none is more influential than the total immersion experience of full-time student teaching. As supervising teachers scaffold and mentor student teachers in the field, they should be deliberate about embedding reflexive practice in their evaluations and feedback to the candidates. This study speaks to the benefits of both the student teachers and supervising teachers bridling through the process—paying particular attention to how various aspects of effective teaching manifest through the process. This bridling process for both constituents must move beyond the standard short reflection papers
that summarize the order of teaching events and instead position the individuals to think deeply and openly about their subjective lived-experience in student teaching.

**Further research**

The findings and implications of this study have resulted in a newfound interest on the impacts of reflexive practice through bridling inherent in post-intentional phenomenology. While Lily made the following comment regarding bridling and how reviewing the videos and bridling through the process, she noticed nuances to her teaching.

By reviewing some of the early videos from the placement, I can see several striking differences in pedagogical knowledge, namely questioning techniques, monitoring methods, and voice inflection during delivery. Excerpts like these foster an interest to investigate further implications of how early bridling in teacher preparation programs informs the transition from theory to practice. Secondly, this study illuminated the pedagogical awareness surrounding “low-tech” practices in science student teaching. Further research could be conducted to determine how pre-service teachers progress from “low-tech” to “high-tech” constructivist uses of student-centered technologies in science education. As a result, participant research may be conducted on teaching with and through technology in secondary science methods coursework as a means of drawing the conceptions of
TPCK closer together for pre-service teachers and situating them in the center of the framework.

Finally, this study illuminated the ways in which researchers can find threads of intentionality within the phenomenological act of bridling around a phenomenon. Further interest centers on the influence and meaning that resides in the potential of cooperating teachers bridling through their collaborative experience with student teachers. In an effort to identify areas of teaching practice that tentative manifest themselves while hosting a student teacher, significant threads of intentional hold promise for teacher preparation programs and their work with pre-service teachers.
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Appendices
Appendix A

Technological Pedagogical Content Knowledge Framework Identification

Directions: Please place an “X” on the TPCK framework diagram that identifies where you believe your current location resides with respect to your understanding of technology, pedagogy and content knowledge for your teaching.
(retrieved from http://tpack.org/)

In the space below, please explain why you chose the location on the diagram.
Appendix B

Bridling Prompts

1. What are your thoughts when you think about technology integration into science education?

2. Why do you think that technology enhances student learning, motivation and engagement?

3. How do you explain the nature of science to secondary life science students?

4. How do you think students come to understand scientific principles?

5. What do you think lies at the heart of good teaching and learning?

6. How do you know when technology is helping you teach your lesson?

7. How do you know when technology is not helping you teach your lesson?

8. How do you process through using technology in the classroom?

9. How do you process a situation where you believe that technology might not be aiding in student understanding?

10. Why do you think that there are such strong connections between science and technology?