DEVELOPING TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE: PRESERVICE TEACHERS' PERCEPTIONS OF HOW THEY LEARN TO USE EDUCATIONAL TECHNOLOGY IN THEIR TEACHING

By

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ABSTRACT

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This study uses activity theory and current conceptions of knowledge for teaching content with technology to analyze the working knowledge and experience of a group of seven preservice teachers in order to yield insights into how preservice teachers learn to teach with technology. Seven preservice teachers, two secondary and five elementary, who participated in a technology integration mini grant program shared their internship technology implementations and their perspectives on how they learned to teach with technology. The preservice teachers' data on technology implementations were analyzed for evidence of Technological Pedagogical Content Knowledge (TPACK) and its components. Using activity theory, the preservice teachers' perspectives on learning to teach with technology were examined for settings and mediating tools that enabled the interns to learn to teach with technology.

Findings showed that the preservice teachers exhibited more Technology Knowledge than Technological Pedagogical Knowledge and Technological Pedagogical Content Knowledge. In addition, preservice teachers exhibited more Technological Pedagogical Knowledge than Technological Pedagogical Content Knowledge. Breadth of knowledge in terms of technology affordances exploitation and content area implementation was also examined. A developmental trajectory of learning to teach with technology is suggested that takes into account knowledge exhibition and breadth.

Several contributing activity settings were probed, including daily life, K-12 experiences, other workplaces, teacher education program, technology conference, mini grant program, internship placement setting, and online communities. Although the preservice teachers used digital technology in their daily lives and in some classes of their teacher education program, they did not notice or connect the Technology Knowledge and learning experiences to their own teaching. The preservice teachers reported that they learned to teach with technology, in part, from interacting with fellow mini grant recipients and the coordinator, from designing lessons integrating technology, and from the conceptualizing technology as a tool to teach content. Through the mini grant program their identities as teachers who use technology also developed. In their internship placement settings, the preservice teachers recalled little assistance from their collaborating teachers or technology assistants in using technology to teach their students content.

The study suggests a framework of TPACKtivity that employs activity theory to track TPACK development. The findings suggest that teacher educators need to call explicit attention to educational technology modeling and aid their preservice teachers in making connections to possible K-12 implementations. Teacher educators can also aid preservice teachers in conceptualizing technology as a tool and employ lesson designing from pedagogical, content, or technology entry points. Both teacher educators and collaborating teachers need to recognize their own Pedagogical Content Knowledge and how, even if they lack Technology Knowledge, they can assist their preservice teachers learn to teach with technology.

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Undertaking a study with a sociocultural framework made me even more aware of how much I owe to the wonderful people in my life and the creative settings of which I have been a part.

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In all of this, Soli Deo Gloria.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

CONNECTING WITH THE LITERATURE

Introduction

> Technology alone does not teach. . . . Teachers teach, and they are an essential part of the sense-making process that must go on for students to learn disciplinary content in meaningful ways. (McCrory, 2006, p. 153)

Although computer technology has been integrated into the business world for over 30 years, and children and young adults use computers in their daily lives outside of school, school implementation of technology for educational purposes has lagged behind (Rosaen & Wolf, 2007). For some time lack of access to technology prohibited school computer use, and a digital divide separated those who had computers in their classroom or school from those who did not. Now, however, the term "digital divide" pertains to whether and how digital technology is *used* in classrooms, just as much as describing whether there is access (Attewell, 2001; Kelly, 2008; MacGillis, 2004; Warschauer, Knobel & Stone, 2004). The use of school and classroom technology, such as computers, projectors, interactive white boards, the Internet, and educational and productivity software depends largely on teacher implementation. Teacher implementation depends on a number of factors: software and hardware availability, time, technical support, teacher confidence, and classroom teacher knowledge of how to use technology to teach content in pedagogically sound ways (Floden & Bell, 2006; McCrory, 2006; Koehler & Mishra, 2008; Zhao, Pugh, & Byers, 2002).

This dissertation focuses on the developing knowledge for teaching content with technology. What does knowledge for teaching with technology look like? How does knowledge for teaching content with technology develop in preservice teachers? What

enables one preservice teacher to use technology in effective ways to promote student learning and what prohibits another preservice teacher from using educational technology? How do contexts and communities of practice impact their learning? This study uses Activity Theory and current conceptions of knowledge for teaching content with technology to analyze the working knowledge and experience of a group of seven preservice teachers in order to yield insights into how preservice teachers learn to teach with technology. Four case studies of two elementary interns and two secondary preservice teachers illustrate the complexities of Technological Pedagogical Content Knowledge (TPACK) and its development within specific contexts.

For the purposes of this study, I chose to use a rather narrow definition of technology. While technology can be defined as "the tools created by human knowledge of how to combine resources to produce desired products, to solve problems, fulfill needs, or satisfy wants" (Koehler & Mishra, 2008, p. 5), I narrowed my definition to individual digital tools. Individual digital tools are those that depend upon binary code to process, store, and transmit information. In today's digital tools the code is not evident to the user, making the implementation of the digital tool much simpler. Computers, software, digital cameras, camcorders, probes, document projectors and SMARTBoards are all examples of digital technology. This narrow definition enables a better focus on learning to teach with digital technologies, the focus of the technology and teacher preparation standards, and the skill needed at this point in history. Some digital technologies, such as the Oregon Trail software, were created specifically for educational use, but others, like PowerPoint, were designed for business use. In this dissertation when reference is made to educational technology, I am including both types of digital

technology, those that were intended for educational use, and those that have been repurposed or could be repurposed for educational use.

Review of Literature

In this chapter I review the literature that forms the basis for this study. Changing technology requirements for teachers are reviewed first, illustrating the necessity of training teachers to teach with technology. Next, studies and theories about knowledge for teaching with technology are examined in order to determine what is currently known about the sort of knowledge needed to teach effectively with technology. A discussion then follows concerning how teacher knowledge develops, including sociocultural perspectives on teacher knowledge development.

Technology Requirements

While schools have purchased new technology, studies and observational data have shown that many classrooms remain much the same as a decade or more ago (Cuban, 2001), or, if changes have been made, only cosmetic modifications have been made to the enacted curriculum, such as typing reports rather than handwriting them. Professional development seminars that train teachers in new technology skills do not produce the necessary deep understanding (Mishra & Koehler, 2006) for incorporating the technology into classroom use. Instead they equip teachers with skills for using the technology, but not for aiding their students' learning or their students' learning to use technology while learning subject matter. New, younger teachers who have grown up with technology know how to use technology, but they use it for professional tasks rather than as an aid to student learning (Russell, Bebell, O'Dwyer, & O'Connor, 2003).

Some of this disjuncture between teacher technology skills and student learning may be due to changing views on technology's role in education and what students need to learn. When the International Society for Technology in Education (ISTE) published its first set of National Education Technology Standards (NETS) (ISTE, 2008) in 1998, the standards focused on the technology tools students need to learn to use. ISTE's recently published new set of standards connects technology skills to learning and thinking processes more than to specific tools. The new standards focus on: "creativity and innovation; communication and collaboration; research and information fluency; critical thinking, problem solving, and decision making; digital citizenship; [and] technology operations and concepts" (ISTE, 2008, p. 1). The chief executive officer of ISTE, Don Knezek, noted,

> In 1998, it was enough to define what students needed to know about and be able to do with technology. Now, we're defining what students need to know and be able to do with technology to learn effectively and live productively in a rapidly changing digital world. (ISTE, 2008, p. 1)

Much of what the ISTE standards describe also requires student-centered instruction. Student-centered instruction focuses on the student's active engagement in learning, for example, through collaborative learning groups, simulations, inquiry, researching, problem-based learning, and synthesizing information through creation of new products. In student-centered instruction the teacher acts as a guide aiding student exploration and discovery instead of the expert dispensing information.

As expectations for student learning of technology become more complex, the pressure for teachers to respond with sound pedagogical practices increases. Technology in education will not be disappearing. For instance, in Michigan, the state in which this study took place, both the Michigan Educational Technology Standards and Expectations

(METS)(Michigan Department of Education, 2005) for student learning and the Professional Standards for Teachers (Michigan Department of Education, 2008) commit state teachers and students to learning to use technology. The METS (Michigan Department of Education, 2005) quote the Federal No Child Left Behind law's goal for schools to, "Assist every student in crossing the digital divide by ensuring that every student is technologically literate by the time the student finishes the eighth grade, regardless of the student's race, ethnicity, gender, family income, geographic location, or disability" (p. 2). The document continues, defining technological literacy as "the ability to responsibly use appropriate technology to communicate, solve problems, and access, manage, integrate, evaluate, and create information to improve learning in all subject areas and to acquire lifelong knowledge and skills in the 21st century" (p. 2). While the emphasis is on technological literacy, the goal of improving learning in all subject areas points toward teachers needing to use technology to teach content, not use technology for technology's sake (Harrington, 2008).

Turning to the revised Professional Standards for Michigan Teachers (Michigan Department of Education, 2008), one whole standard is dedicated solely to addressing technology, while each of the other six standards, with the exception of one, also includes a reference to technology. This emphasis on technology conveys the Department of Education's valuing of teacher use of technology for productivity and their own learning, and also for students' learning. The seventh standard, Technology Operations and Concepts specifies the following:

> Use of technological tools, operations, and concepts to enhance learning, personal/professional productivity, and communication, including the ability to:
> d. Plan, design, and evaluate effective technology-enhanced learning environments and experiences aligned with Michigan's Content Standards

and Grade Level Content Expectations and Michigan Educational Technology Standards for each student;

e. Implement curriculum plans that include effective technology-enhanced methods and strategies to maximize student learning. (Michigan Department of Education, p. 3)

It is obvious, therefore, that preservice teachers need to learn to teach content with technology in effective ways. But what characterizes the knowledge that enables them to "plan, design, and evaluate effective technology-enhanced learning environments and experiences" that teach content and use "effective technology enhanced methods and strategies" (Michigan Department of Education, p. 3)?

Knowledge for Teaching with Technology

Several theorists have outlined the knowledge that teachers use when teaching with technology. In order for teachers to be able to find and use technology for meaningful learning, they need to know what affordances or enabling conditions the technology offers for learning and teaching (Koehler & Mishra, 2008; McCrory, 2006; Wiske, 2006; Zhao, Pugh, & Byers, 2002; Zhao, et al., 2006). Zhao, Pugh, & Byers studied a group of K-12 teachers and found that knowledge of the technology and its enabling conditions were important to integrating technology effectively. McCrory laid out four possibilities that technologies can offer inservice teachers for their students' learning: representation, information, transformation, and collaboration. *Representation* offers new ways of representing ideas and processes that are difficult to understand. Angeli and Valanides (2008) list representation as one criterion for evaluating whether a technology implementation is appropriate. Representation allows for the transformation of content, and can make it more accessible to students. For instance, simulations or virtual dissections allow students to speed up processes or manipulate materials not

readily available to them. *Information* affordances point to the possibilities for students to access data and content not available in textbooks. As an example, students in a social studies classroom can download the latest immigration data and track immigration trends over the history of the United States. *Transformation* describes the ability of technology to change how students work with content. Transformation enables more inquiry-based learning (Angeli & Valanides, 2008; McCrory, 2006) and student-centered instruction. Students in a science class, for instance, might use probes to record data about the stream behind their school and track the changes they observe. The fourth affordance, *collaboration*, refers to how technology enables students to connect with peers and experts to enhance their learning. For example, in Galaxy Zoo 2[1] (Galaxy Zoo, 2009) students examine photos of galaxies and classify them according to shape. Students actually join in the work of the astronomers and collaborate with them by contributing to the data analysis. Another example, communicating and collaborating with peers on projects via wikis, allows extension of the school day and the classroom to any time and anywhere there is Internet access.

In addition to understanding technology's affordances, it has been proposed that inservice and preservice teachers must also know what effective teaching with technology looks like (Angeli, & Valanides, 2008; McCrory, 2006). Criteria have been developed to aid in recognizing effective implementations. Effective teaching with technology transforms instruction in ways that allow students to better access the content (McCrory, 2006), promotes student inquiry (Angeli & Valanides, 2008), fits the goal of

[1] All software and hardware references are compiled in Appendix E.

the instruction, includes all students (it's not just a reward) and takes time and effort (McCrory, 2006).

McCrory (2006) also emphasized that in order for teachers to build a portfolio of effective technology use, they need knowledge of the technologies they can use as well as knowledge of technologies that are based in the content of the curriculum. Curriculum content knowledge and deep and flexible subject matter knowledge (Ashburn, 2006; Floden & Bell, 2006; Wiske, 2006) are requirements for effective educational technology use because with students' expanded access to information and representations, teachers need to be able to help their students recognize how their inquiries fit the discipline and aid them in determining the validity of the collected facts and theories.

Mishra and Koehler (2006) set forth the theory that teachers draw upon a unique knowledge for teaching with technology, which they called Technological Pedagogical Content Knowledge (TPACK). Mishra and Koehler built on the concept of Pedagogical Content Knowledge (PCK), a term coined by Shulman (1986) to describe the type of knowledge required for teaching. PCK "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, p. 8). Shulman based his theory on a set of studies focused on how secondary teachers develop knowledge for teaching. The PCK construct emphasizes the importance of particular kinds of pedagogies for particular content areas. It describes content knowledge (CK) and pedagogical knowledge (PK) and then their intertwining in PCK.

Content Knowledge (CK) represents the knowledge of the disciplines. Not only are the facts or concepts of the subject matter included, but also an understanding of how the discipline is structured (Shulman, 1986). The structure of the discipline describes how principles, concepts and facts are organized, and how the discipline accepts or rejects claims. In understanding how the discipline is structured, teachers are equipped to help their students learn not just concepts, but why those concepts are important to the discipline, and how to help their students build disciplinary knowledge. For instance, recognizing that scientific inquiry forms the basis for scientific knowledge, teachers engage in scientific inquiry with their students in developing scientific content. Similarly, understanding that the goal of literature discussions is different from science discussions, literature teachers aid their students' sharing of their varied literary interpretations in order to construct new understandings (Rosaen, Lundeberg, Cooper, Fritzen, & Terpstra, 2008).

Pedagogical Knowledge (PK) deals with the knowledge of teaching, the knowledge of classroom management and organization (Shulman, 1987), how students learn, and what sorts of activities encourage learning and also the knowledge of assessing learning. Pedagogical knowledge is generic in the sense that it cuts across content areas to include knowledge of learning theories and how they apply to the classroom (Koehler & Mishra, 2008). For example, using authentic tasks that connect to students' lives is a basic motivational principle (Brophy, 2004) that teachers apply in all curricular areas.

As mentioned above, the way in which a teacher represents and makes subject matter accessible to learners describes Pedagogical Content Knowledge (PCK) (Shulman, 1986; Koehler & Mishra, 2008). PCK involves an understanding of multiple ways of

teaching content, the representations for particular content, an understanding of what students might find difficult, as well as an understanding of the topic knowledge (or misconceptions) which students at various grade levels bring. For example, understanding students' difficulty with conceptualizing the multiplication of fractions, teachers use pizza diagrams and fractional manipulatives to help students figure out how much one-half of three-quarters of a pizza is. PCK also includes knowledge of curriculum and curricular materials, and knowledge of instructional strategies for particular content (Grossman, 1990). Knowledge of content intersects with knowledge of pedagogy to teach particular content in particular ways.

Mishra and Koehler (2006) advocated including Technology Knowledge (TK) as a third component of teacher knowledge. While PCK researchers (Ball, Thames & Phelps, 2008; Fernandez-Balboa & Stiehl, 1995; Howey & Grossman, 1989) include Technology Knowledge in PCK, Koehler and Mishra (2008) contend that Technology Knowledge is not a part of Pedagogical Content Knowledge. Unlike PK and CK, which are relatively stable domain bodies of knowledge, the domain of Technology Knowledge (TK) continues to change and develop as technologies change and new technologies emerge. If a technology's classroom implementation becomes transparent, like that of a pencil, then its implementation would be considered pedagogical (Cox, 2008). Due to the changing and novel nature of digital technologies, however, Technology Knowledge distinct from Pedagogical Content Knowledge needs to be developed. For that reason, teachers' Pedagogical Knowledge of how to use traditional educational technologies like chalk, paper, and pencil to teach content is included in PCK, while teachers' Pedagogical

Knowledge of new technologies such as software, camcorders, Web 2.0 technologies, and twitter is categorized within TPACK (Cox, 2008).

Koehler and Mishra (2008) link TK with fluency of information technology (FITness), a description coined by the Committee of Information Technology Literacy of the National Research Council (NRC, 1999). FITness includes using information technology productively at work and in every day lives, the recognition of when a particular technology can aid or impede goal achievement, and continual adaptation to informational technology changes. It allows the person to use technology flexibly for their own purposes and design, not just those for which the particular technology was constructed and allows the user to receive new technologies and envision their possible uses.

Koehler and Mishra (2008) point out that knowledge of technologies' possibilities can be limited by the users' "functional fixedness", a term that expresses how a user's ideas about a tool's use can hamper the user's ability to envision other uses for that tool. For educational technology use teachers need to know how a tool is used, but also look for other possible applications of that tool, especially because many digital technologies have been created for purposes other than specific classroom applications. Although earlier technologies required and enabled revised teaching practices (imagine receiving a chalkboard which all students could see at the same time), digital technologies' characteristics complicate their integration into classroom use. Because they are protean, or can be used in more than one way (Papert, 1980), a variety of occupations use computers in diverse applications and therefore they are not easily integrated into one fixed application in classrooms. A literacy teacher might use concept mapping software

like Webspiration to help his students brainstorm necessary components to be addressed in a research report and then switch to the outline view to build the outline from the brainstorming. A science teacher, however, might assign her students to use Webspiration to map atoms and electrons. Digital technologies change quickly and require continuous learning and envisioning of new ways of use. Another characteristic of digital technologies is that they are not always tested completely prior to release so they can be described as unstable (Koehler & Mishra, 2008). The unstable feature of new technologies discourages teachers who want something to work consistently all the time. Digital technologies are also described as functionally opaque (Turkle, 1995; Koehler & Mishra, 2008). Users cannot see the inner workings or programming of computers or software so they also do not easily understand the complexities. On the other hand, such opacity allows novice users to take advantage of highly complex programs without needing to understand how everything works. Taken together, these characteristics make it difficult for teachers to acquire knowledge of digital technologies for use in their classrooms.

Adding that one component of TK to CK and PK led to three more interconnections of knowledge in addition to PCK (Figure 1). The integrations of knowledge become Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK).

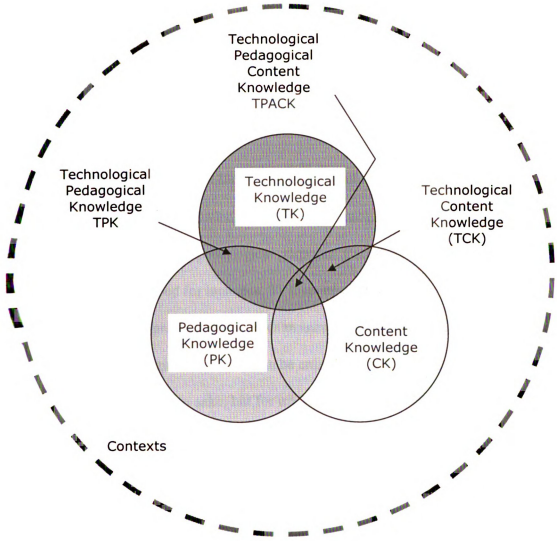

Figure 1. The TPACK framework and its knowledge components (http://tpack.org, 2009)

How subject matter can be changed by technology use is the focus of Technological Content Knowledge (TCK) (Koehler & Mishra, 2008). TCK refers to the combination of Technology Knowledge with Content Knowledge and how the two support and constrain each other. Modeling and simulation are two examples of how Technology and mathematical Content Knowledge have been pushed forward by each other. Using software to model mathematical relationships has allowed mathematical

understandings that were previously unreachable, such as the concept of "fractals" (Grandgenett, 2008), and have therefore allowed more complex programming and software. Because Pedagogical Knowledge is almost always a part of classroom concerns, TCK, separate from Pedagogical Knowledge, is difficult to distinguish in K-12 classrooms.

Understanding how technology can change teaching and learning defines Technological Pedagogical Knowledge (TPK). TPK recognizes the affordances and constraints of technologies for pedagogical purposes. Because so many of the available digital tools were developed for business, TPK requires flexibility in order to re-purpose technologies for pedagogical purposes. It examines technology's capabilities and determines what pedagogical functions can be enhanced by technology's implementation. It is not used for technology's sake, but for improving students' learning (Koehler & Mishra, 2008). It is distinguished from TPACK in its focus on general pedagogical use (Cox, 2008), not on teaching particular content. Webquests, for example, challenge students to answer a significant overarching question using provided links to web pages that shed light on the issue. Employing webquests for researching questions can be used across content areas as a general pedagogical tool and therefore TPK labels the knowledge for implementation. Developing TPK requires specific pedagogical training according to Orlando's (2005) study of inservice elementary teachers, but the study did not specify what that involved.

Adding in Content Knowledge to interact with Technology Knowledge and Pedagogical Knowledge contributes to the complexity of working knowledge. That interaction, TPACK, entails

> an emergent form of knowledge that goes beyond all three components (content, pedagogy, and technology).... [TPACK] is the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (Koehler & Mishra, 2008, p. 17, 18).

Although each knowledge component is described separately, in reality they all interact and all need to be considered in understanding teaching (Koehler & Mishra, 2008). When any component changes, for example when a new technology such as podcasting debuts, the other components, in this case, content and pedagogy, need to be addressed as well. For instance, with podcasting, a French teacher could recognize the new possibilities to extend student listening opportunities and audio memories, which are subject-specific activities (Cox, 2008), and would understand the scaffolding necessary in learning a new language. He might then record his voice reading French vocabulary words and post them on the Internet, thereby making them available to students wherever they have Internet access. Or, for those without access to the Internet but using mp3 players, he would download the files directly to the students' personal devices for anytime use and review. In contrast to the TPK webquest example given earlier, a social studies teacher who creates a webquest for her students to investigate an event and provides links to primary sources on web pages such as diaries, eyewitness reports, videos, music, and audio recordings would be exhibiting her TPACK. Her use of technology to aid her students' access to primary sources, thereby doing the work of the social studies discipline, develops their understanding of the social studies and their understanding of the event.

The TPACK framework emphasizes the complexity of teaching, describing the problems teachers face in helping their students learn as ill-structured problems (Koehler & Mishra, 2008). As teachers face planning for particular students in particular classrooms with particular resources on a particular day, they find that one size does not fit all. To solve such ill-structured problems, teachers adapt plans and resources to fit their particular setting. TPACK views teachers, therefore, as curriculum designers who draw on their knowledge and experiences to solve problems for particular situations. Teachers as designers revise in response to their users (students), their resources, the content to be taught, and the context, bringing together all elements to ensure student learning. Viewing teachers as curriculum designers situates teachers as "active participants... with a certain degree of autonomy and power in making pedagogical decisions" (Koehler & Mishra, 2008).

Teacher beliefs about the relationship between technology, pedagogy and content can also be included in TPACK because the line between knowledge and belief, especially in teachers' professional knowledge, is so indistinct (Kagen, 1992). Ertmer (2005) related studies that showed how inservice teacher beliefs impact practice, but also noted that other studies supply conflicting data of how the setting influenced inservice teachers not to act on their beliefs. Cavin's (2007) study revealed that preservice teachers' beliefs related to learning and teaching with technology influenced the choices they made about peer instruction within their lesson study group.

Perhaps most critical to knowledge of how to teach using technology is McCrory's (2006) assertion that teachers recognize that technology does not teach; technology requires the "mediation of a knowledgeable teacher" (p. 152). How does that

knowledgeable teacher develop? Specifically, how do preservice teachers develop knowledge of how to teach with technology?

Teacher Knowledge Development

How do preservice teachers learn to take their Technological Knowledge and their Pedagogical Knowledge and their Content Knowledge and use them effectively together? McCrory (2006) proposes that it is not automatic, that knowledge of each area does not imply that the use of the three knowledges in combination will result.

Kafai (1995) claimed that learning by design, using technology to produce new knowledge, changed pedagogy, because participants become the producers rather than the using what the leaders produced for them. Mishra and Koehler (2006) used the structure of learning by design to explore how TPACK developed in inservice teachers and teacher education faculty as they worked to build web sites or online resources for online classes. Mishra & Koehler's study found that group discussions moved from questions about technology and content and pedagogy as separate domains "toward a more transactional and codependent construction" (p. 1043) when using a design construct. The design process involves an iterative process (Schön, 1983) of planning and revising and fitting the plan to the context, a process teachers need to use when planning for their particular students, subject matter, and resources. Learning by doing in the design process requires active engagement in the project and enables the participants to construct meaningful artifacts and learning (Mishra & Koehler, 2006).

While Mishra and Koehler (2006) claimed that design based learning aided in college faculty and inservice teachers' development of TPACK, there have been few similar studies of preservice teachers. Harrington (2008) explored the complexities of the

development of preservice teachers' TPACK within a mathematics pedagogy class combined with a short-term placement component. Teams of preservice teachers taught the math lessons they developed together. Cavin (2007) employed a micro teaching lesson study structure in which preservice teachers developed math lessons, taught them to students in an undergraduate mathematics class, reflected on the lessons, and then revised the lessons. More work is needed in exploring individual preservice teachers in their long-term placements as they learn to teach with technology in many subject areas. It remains to be discovered how TPACK develops in preservice teachers and how its development can be encouraged in preservice teacher education classes and experiences (Niess, 2005).

Shulman (1986) called for research on the concept of Pedagogical Content Knowledge, that "special amalgam of pedagogy and knowledge" (Shulman, 1987, p. 8) in order to learn more about how teachers help their students learn. Research on how PCK develops could give insights into how TPACK develops, but few results have been published in the PCK line of study. While work has focused on what PCK entails (Ball & McDiarmid, 1990; Ball, Thames, Phelps, 2008; Grossman, 1990; Shulman, 1986; Wilson, Shulman, & Richert, 1987), the results have not described how PCK develops or how teacher education programs can aid such knowledge development in preservice teachers.

Recent studies (Ertmer, 2005) have shown that inservice teachers feel confident with their computer use, but not with how to use computers in their teaching. How much more important it is then, that we discover how to help preservice teachers learn to teach with technology (Cox, 2008; Orlando, 2005).

Ertmer (2005) suggested that teacher beliefs about technology for educational use develop through three strategies: personal experiences, vicarious experiences, and social-cultural influences. She proposed, based on Guskey's (1986) argument, that belief follows practice, that engaging in a practice may actually slowly change a belief rather than the belief needed in order to act. Beginning with a more basic implementation of technology may eventually build the belief of technology's use in education (Ertmer, 2005). Vicarious experiences include the modeling of others' teaching with technology. Observing how others incorporate technology into their practice enables preservice teachers to envision how they might use the same technology in their own classroom (Cavin, 2007). Although social-cultural influences will be discussed more fully below, Ertmer advocated a professional community with high expectations for computer use that shares and discusses new technologies and supports its members in implementing new ideas and technologies. To substantiate these ideas, research that examines preservice teachers' beliefs and practices within their contexts is needed.

It must be recognized that development of TPACK, like all teaching, is a developmental process (Feiman-Nemser, 2001, Mishra & Koehler, 2006) and that preservice teachers, as well as inservice teachers, will exhibit varying degrees of such knowledge. Inservice teachers' stages of learning to teach with technology (Zhao, et al., 2006; Sandholtz, 1997 as referenced in Wiske, 2006) begin with the *mechanical*, or entry, level during which teachers follow instructions explicitly and use the technology as the manufacturer or programmer intended. Next teachers progress to the *meaningful* level during which they think of or accept alternate ways of using the technology. Sandholtz broke this stage into two parts: adoption of technology and adaptation, recognizing other

applications of technology. In the final stage of learning to teach with technology, teachers' practice reflects the *generative* level in which they move away from traditional uses of technology, take into account their context, and are aware of appropriate and inappropriate uses of technology. According to Sandholtz's descriptors, these teachers are in the appropriation and invention stages, first working collaboratively on curriculum design and then serving as mentors for colleagues and researching innovative uses of technology. Whether these same levels apply to preservice teachers has not been researched and whether the same stages are still applicable is also questionable. Web 2.0 technologies are so open-ended that teachers do not necessarily need to move away from traditional uses in order to be generative. Educational software can be used the way it was intended; teachers only need to adapt it for their students' needs. These stages, therefore, might no longer fit. Perhaps because of the changes in technology, the developmental process may be different than previous results showed.

Learning to teach with technology is fraught with challenges and difficulty. Lack of models for teaching with technology poses one obstacle for preservice teachers (Rosaen & Wolf, 2007). With so many of their K-12 teachers not using technology in their teaching, either because it was not yet available or because the teachers did not know how (Ertmer, 2005), preservice teachers lack the "apprenticeship of observation" that Lortie (1975) described. Lortie claimed that through their years of participation in classrooms, preservice teachers develop ideas of what teaching is like and how to do it. Without such an apprenticeship in the use of technology in teaching, preservice teachers may not even conceive of technology implementation as part of teaching. On the other hand, because they do not have fixed views of what technology use in schools entails,

they may be more open to learning how to teach with technology (Feiman-Nemser, 2001).

The nature of technology presents another difficulty. Because the available technology is always changing (Koehler & Mishra, 2008), the practice of using technology to support content learning keeps changing. As discussed above, Technological Knowledge needs to keep growing and changing as new applications and tools emerge (Mishra & Koehler, 2006), while Content Knowledge evolves more slowly as knowledge develops in the discipline. In spite of the many promises of educational technology, like other curricular reforms, if it is not used well, educational technology is not effective (Cuban, 2001). As technology changes, teachers to need to adapt and revise implementations in order to impact students' learning. It requires a mind-set of continuous reflection and growth, one that serves teachers well in all areas (Feiman-Nemser, 2001; Rosaen & Wolf, 2007). Clearly, the challenge to teacher educators has increased: "Therefore, teacher educators need to prepare teachers not as followers, drawn along, but as leaders, as professionals who are thoughtful, reflective, inquiring, self-directed, and active participants in goal setting and decision making" (Schultz, 2005, p. 149). Just what this type of preparation would entail in preservice teacher preparation programs is not well understood.

Sociocultural Perspectives on Teacher Knowledge Development

Teacher knowledge development always takes place within a context, a social setting. Activity theory examines individual and group development within the individual or group social settings and seeks to learn how those social settings, whose structures were developed through historical, cultural activity (Grossman, Smagorinsky, &

Valencia, 1999), impact development towards an ideal (Smagorinsky, Cook, Moore, Jackson, & Fry, 2004). Instead of describing learning as solitary, activity theory emphasizes the influence of contexts on teacher knowledge development (Grossman et al., 1999; Smagorinsky et al., 2004; Ogawa, Crain, Loomis, & Ball, 2008). Studies have engaged activity theory to aid in understanding how the practices of preservice secondary English teachers (Grossman et al., 1999) as well as a preservice elementary third grade teacher (Smagorinsky et al., 2004) were impacted by their settings, but these studies did not focus specifically on how teachers' knowledge of technology for teaching was impacted by teachers' settings.

Rooted in Vygotsky's (Wertsch, 1998) work on the role of society in learning, activity theory seeks to explain why humans develop the way they do. Vygotsky claimed that people interact within a culture or context and then internalize or appropriate that context's way of thinking. Activity theory proposes that when individuals interact within a social context, conceptual learning occurs in the taking on of public and shared meanings (Grossman et al., 1999; Ogawa et al., 2008). Because an individual is involved in multiple contexts, activity theory allows us to take multiple contexts into account as we seek to understand how individual preservice teachers develop (Grossman et al., 1999) teaching, technology, and content concepts. Contexts include ever-widening influences on preservice teachers: supervising teachers, students, teacher education faculty, colleagues, school administrators, teacher education administrators, curriculum, school mission, teacher education mission, community vision, state and federal educational policies (Smagorinsky et al., 2004). At times the social settings of individuals

conflict with each other in terms of motives, constituents, and ideals, therefore emphasizing different values and practices (Smagorinsky et al., 2004).

Various elements in activity theory can be described individually, yet in reality, all interact together and impact each other. Vygotsky (1978) first conceived of activity theory as mediated action with *object* (goal), *subject*, and *artifact*. In order for an activity setting to exist, its actions must be goal-oriented and involve a set of practices and artifacts that mediate action toward the goal or goals (Grossman et al., 1999).

The object is defined as the purpose of the activity, what the subject is seeking (Ogawa et al., 2008). As an objective, it guides the actions of the subject, connects them to group activity and delivers results that might be intended or unintended (Ogawa et al., 2008). Some writers use words such as goals, ideals, or purposes to describe the object (Grossman et al., 1999). For example, in a preservice teacher internship placement, the preservice teacher (subject) seeks to develop the knowledge and skills for helping students learn (objective).

Closely connected to the object is the expected outcome of the object, sometimes named the motive, future ideal, or result. Identity, a part of the activity theory framework, reflects the pursuit of an ideal, the developing of the teaching identity one views as ideal (Grossman et al., 1999). Across social contexts, or within a social context, multiple, sometimes competing, conceptions of an ideal teaching identity exist; in addition, multiple, sometimes competing means for reaching the ideal also exist, making it difficult for preservice teachers to navigate towards the ideal (Grossman et al., 1999). Preservice teachers face problems such as developing both Content Knowledge and Pedagogical Content Knowledge, conceptualizing teaching and learning and their role as a teacher,

developing classroom management, and developing ways to work with colleagues (Grossman et al., 1999). While the teacher education program might advocate constructivist teaching in which students work together using technology to solve problems and construct knowledge, the collaborating teacher and the textbooks might advocate teacher-centered, textbook-mediated information-giving teaching in which the teacher expertly delivers content to the students. Vygotsky (1978) also was clear that people are not constrained by their cultural settings; they are not simply pushed to and fro by the alternating influences (Holland & Lachicotte, 2007). With a developed identity persons can evaluate the options and choose those actions that best fit with their chosen identity. Research sheds light on preservice teachers' process of defining subject-specific problems, designing and implementing solutions using the resources available to them and how that process helps mold their teacher identity and changes the individual in the process (Grossman et al., 1999). Further study is needed regarding this process when technology is one of the resources.

The subject is the individual (or smaller group) who is acting in the environment toward an object. Subjects can influence the object, the social network, and artifacts either by themselves or with the group, although the influence may be limited by social position, culture, and history (Ogawa et al., 2008). Activity theory posits, therefore, that individuals cannot escape their social systems (unless they are time-limited settings), but they are also not completely controlled by them. In this light, Wertsch (1998) chose to use "agent" to communicate that active role of the subject. Subjects' roles depend upon their context; they take their cues from the situations' schematic structures to choose their actions (Ogawa et al., 2008). For example, although student teaching internships are

time-limited settings, effects of the social systems appear in the ways student teachers become like their supervising teachers in their use or non-use of technology, even though the student teachers claim they will be different when they are on their own in their own classroom the following year.

Activity theory suggests differing responses by a subject to an activity setting: *resistance*, *acquiescence*, and *accommodation* (Smagorinsky, Lakly, & Johnson, 2002). *Resistance* occurs when the subject refuses to be directed by the mediating artifacts and practices towards the activity setting's goal. Some activity from the individual's history works to resist the goals of the setting and, in spite of the setting's pressure, the participant does not take on the same goals and object (Grossman et al., 1999). *Accommodation* is described as a "grudging effort to reconcile personal beliefs" (Smagorinsky et al., 2002, p. 201) with the goals of the setting, but is not comfortable for the individual. Preservice teachers who grudgingly adopt their supervising teachers' management style illustrate accommodation. *Acquiescence* implies submitting to the goals of the setting and complying with them (Smagorinsky et al., 2002).

Mediating artifacts of the activity setting allow subjects to pursue objects and connect subjects to others. Both symbolic and concrete, artifacts are tools that subjects construct (Wertsch, 1998), learn, and use and are produced from activity (Ogawa et al., 2008). Examples of symbolic artifacts include language, facial expressions, principles and visual representations while concrete artifact examples employed by subjects include computers, markers, and desks. Grossman et al. (1999) labeled these tools as conceptual and practical tools. Conceptual tools are tools such as principles, frameworks, and ideas about teaching and learning that guide decisions about instructional practices, while

practical tools are of much more immediate use, such as instructional practices like guided reading and the concrete tool resources like textbooks or computer software. A practical mediating tool that pre-service teachers draw on is the language of their collaborating teachers (Grossman et al., 1999); the mediating tool helps them develop their teaching skills. Vygotsky theorized that without mediating tools, people would respond to each and every stimulus rather than being able to "control, organize, and resignify their own behavior" (Holland & Lachicotte, 2007). Although identity is a goal, it can also become a mediating tool. Studies on identity (Holland & Lachicotte, 2007) illustrate how "identities are not byproducts of social change; identities are the means by which change acquires agents and becomes effective" (Holland & Lachicotte, p. 128). Cultures seek to bring about change through producing new mediating tools. The No Child Left Behind Act of 2001 (NCLB)(2002) emphasized the idea that schools and teachers are responsible for the achievement of their students, seeking to overcome the student deficit mentality that placed the achievement problems with students and their families rather than schools and teachers. It should be noted that new mediating tools do not necessarily bring about the change desired (Church & Sedlak, 1976; Tyack & Cuban, 1995). While NCLB (2002) ushered in new accountability for student achievement for schools, some schools have focused on achievement as success on standardized tests rather than success in learning and higher order thinking skills.

Vygotsky (1978) and his colleagues argued that all human actions on objects are mediated by the socio-cultural context, the community with its rules and division of labor (University of Helsinki, 2003-2004), also called the "activity setting" (Grossman et al., 1999). Communities are defined by their members, by their shared activities, their shared

resources, and shared beliefs. As the community continues to act, it reinforces its beliefs and history (Ogawa et al., 2008). Through their cultural history, community members have set up specific outcomes, or ideals and artifacts that sustain their relationships and influence their actions within the setting (Grossman et al., 1999). Sometimes, however, competing goals toward the same outcome can be seen in a setting, making it difficult for participants to satisfy both. Grossman et al. (1999) give the example of a student teaching setting with competing goals of encouraging the trying out of new practices in a safe environment, but also of assessing competence of teaching. With several overlapping community settings, it is likely that competing goals exist and that choices will have to be made as to which to pursue. If, however, the goals are the same, it is much more likely that congruence of foci will be stronger (Grossman et al., 1999). It seems likely that when both the teacher education program and the classroom setting press toward using the best technology, whether new or old, for student learning, the choice to use classroom and school technology will not be difficult, but more research is needed.

TPACK and Activity Theory

I am hypothesizing that the TPACK conceptual framework and activity theory complement each other to give a fuller picture of the development of knowledge for teaching with technology than either framework by itself. For this study I used these two frameworks as theoretical perspectives together to more clearly identify the knowledge needed for teaching effectively with technology and the contributors to that knowledge development. The TPACK framework offers a picture of what the knowledge might look like in action and activity theory provides a view of possible contextual factors and mediators across activity settings that might impact the knowledge development in other

settings. In addition, the two theoretical frameworks overlap with each other in some areas. The TPACK framework theorizes component knowledge integrating into a unique amalgam of knowledge, thereby also describing a developmental process. Activity Theory, like the TPACK framework, illuminates knowledge. It identifies knowledge that might be stored and accessed through conceptual and practical tools, as well as shared meanings and beliefs of activity settings that might be taken on by preservice teachers. Both theories also address the use of tools. TPACK specifies knowledge of how to use tools for teaching, and activity theory views tools as a way to learn and reach a goal. Using the two theories together as lenses should aid in learning more about how preservice teachers learn to teach with technology.

Summary

Technology in education will continue to increase, given the current emphasis on teacher standards (ISTE, 2008; Michigan Department of Education, 2008) and the prevalence of technology use in today's society. Preservice teachers, therefore, must be equipped with the knowledge required to teach with technology. Much has been theorized (Angeli & Valanides, 2008; Cox, 2009; Mishra & Koehler, 2008; Niess, 2005) about the TPACK framework of teacher knowledge but little work has focused on identifying it in preservice teachers' practice. Activity theory has been used to explain preservice teacher behavior and choices, but not to analyze the development of preservice teachers' knowledge of teaching with technology, TPACK.

The following chapters describe how I studied a group of seven preservice teachers to determine whether and the extent to which they exhibited TPACK and its components and their perspectives on how that knowledge developed. Chapter Two

describes the study, its research questions, setting and participants, and methods of data collection and analysis. Chapter Three describes the evidences of TPACK in the interns' practices and outlines a trajectory of TPACK development. Chapter Four discusses the factors that interns named as contributors to their learning to teach with technology. The contributors are examined within the context of the activity settings of the interns, illustrating the multifaceted nature of TPACK development. In Chapters Five and Six four case studies of interns are presented in order to illustrate the complexities of TPACK and its development within differing activity settings. Chapter Five provides studies of two elementary interns and Chapter Six presents two secondary interns. Chapter Seven, the final chapter, outlines implications from this study for teacher education and further research opportunities.

CHAPTER 2

CONNECTING WITH THE INTERNS

The purpose of this qualitative study (Miles & Huberman, 1994) was to learn how preservice teaching interns develop Technological Pedagogical Content Knowledge (TPACK), in other words, how they learn to teach content effectively with technology. This study examined seven interns' experiences with learning to teach with technology during their year-long internships and a grant-supported project aimed at learning to use technology for teaching content. A qualitative approach was chosen in order to take a close look at how their TPACK developed in the context of their settings and whether and how the TPACK development in one setting might contribute to TPACK development in another. In this chapter I review the research questions that guided the study, describe the seven intern participants, their cultural historical setting, and their activity settings and lay out the data collection and analysis methods employed in the study.

Research Questions

Questions that guided the study include:

How do preservice teachers develop and use technological pedagogical content knowledge? Subsidiary questions include:

a) What do their lesson plans, questions, and the ways they use technology tell about their knowledge base?

- What kinds of technology affordances do they implement: representation, information, transformation, or collaboration (McCrory, 2006)?

- How do they draw upon their knowledge base in their use of educational technology?

b) To what do preservice teachers attribute their learning to use educational technology?

- What are the roles of their daily life, their K-12 experiences, the technology conference, the mini grant program, the teacher education program, their placement setting and online communities?
- What conceptual and practical tools do they describe as contributing to their learning how to teach with technology?
- How do they respond to settings with whose goals they do not agree?

Feiman-Nemser (2001) described a continuum that articulated what preservice and inservice teachers learn at different stages in their career, pointing out that at different stages teachers need to attend to different aspects of teaching and exhibit varying levels of knowledge. Hughes (2005) studied four classroom teachers who had taught for varying lengths of time and concluded that the most experienced classroom teachers more easily integrated technology into their curriculum in a more pedagogically sound manner than less experienced because they drew upon their pedagogical experience and knowledge as well as their subject area knowledge and experience. In this study it was important to keep those guidelines in mind while looking at preservice teachers at an early point in their career. Although I looked for evidence of all the aspects of TPACK, I recognized that only some might be evident at this point in the preservice teachers' careers.

Better understanding of how preservice teachers develop TPACK will aid in

improving future interns' preparation for using technologies in their teaching and hopefully give insights into other areas of teacher knowledge development. My hypothesis was that examining the perceptions and experiences of these seven interns would yield insights into how TPACK develops and how activity settings aid or detract from knowledge development.

Research Methodology

Setting

Cultural- Historical Context

In order to understand the preservice teachers' perspectives on learning to teach with technology, we must first look at their cultural historical context in addition to their activity settings. Each intern had their own context, yet they are all part of a broader context as well, the complex public educational system in the United States of America. Public education in the United States claims its inception with Horace Mann. Mann (1848) reasoned that common schools would be economically beneficial for all as poor and rich were educated together, as all students would be fit for work in the country's economy, and as immigrants were assimilated into the general society. While Mann's goal focused on moral training and citizenship, in order to gain support, he allowed the utilitarian goals of fit for work in the economy to be broadcast. Mann's push for common schools ushered in a system of education that connected schooling and society with schools as a way to solve social problems, making the schools system an indispensable component of society.

As the school systems developed, they took on the structure of the place where most students would take their place in the economy: the factory. Rows and order and

discipline were the important components of school life in order to ensure the enculturation of good factory workers (Tozer, Violas, & Senese, 2005; Ogawa et al., 2008). In the early 1900s progressives called for reform, urging more child-centered education, with some responding by educating students for their role in the economy (Bobbit, 1918) and others focusing on children's interests, educating for democracy, and problem-solving (Dewey, 1938). Those debates continue in education regarding constructivist or traditional methods of instruction and intertwine with debates about culture and race and socio-economic status. Although the common school was meant for all students, it has been a long road to gain effective education for all students. U.S. educational history has shown that policies intended for the good of all students are changed for a variety of reasons in the enactment (Church & Sedlak, 1976; Tyack & Cuban, 1995). Separate but equal schools for African-Americans were found to not be equal, yet desegregating schools, ensuring access for all students to the white public schools, deprived African-American students of their strong African-American teachers and models, forcing them to work with teachers who did not understand their culture.

As noted before, the public schools became the place to right the social problems. In an effort to eliminate poverty, funds were allocated for preschoolers and low-income schools in hopes of boosting education and success. Funds were provided for new technologies in low-income schools, banking on the promise that computers and software could educate each student in an individualized manner and in hopes of enabling students to learn and to build the skills the country would need to remain a world leader.

All the money, however, did not seem to make a difference (Church & Sedlak, 1976). Studies of technology implementation brought to light a new problem. In higher

income schools the technologies were used for problem solving and higher order thinking skills while in lower income schools, skill and drill was the order of the day (Attewell, 2001; Warschauer, Knobel & Stone, 2004), pointing out the different preparations for differing socioeconomic statuses. Computers were relegated to computer labs, and were not integrated into the classroom teachers' instruction. Experts in technology taught students how to program and use word processors and some educational games made their way into school use. Many classrooms retained their factory model base with some child-centered experiences.

When the money didn't seem to make a difference, policy makers took a new tack: the No Child Left Behind Act of 2001 (NCLB)(2002). Prior to NCLB it was assumed that if teachers taught, students should learn. Because of the failure of so many students in the U.S. educational system, however, it seemed the fault lay with the teachers and not the students. NCLB therefore requires schools and teachers to help their students achieve no matter what their capital. NCLB mandates strict goals for student achievement on standardized tests, with schools that fail to make adequate yearly progress losing funding and gaining more restrictions on the funding they do receive. In Michigan, the state in which these interns were learning to teach, the Michigan Educational Assessment Program (MEAP) is given to students in grades 3-9 in mid-October. In order to ensure students' achievement on the test, schools have implemented test review programs for the first six to eight weeks of school. Many schools concentrate on the structures recommended by the MEAP all year long and train their students in standardized test-taking and essay writing. Some teachers have noted that the first of November is really the first week of school, when they really dig into the grade level curriculum.

With the emphasis on achievement, standards-based instruction has become the norm. Teachers plan their lessons to align with the Grade Level Content Expectations (GLCEs) because the GLCEs are derivations of the Michigan Curriculum Framework standards upon which the MEAP is based.

In addition to standards for K-12 instruction, NCLB (2002) set standards for teacher quality by requiring teachers to be highly qualified, only being allowed to teach in areas in which they are certified and have training. Michigan has also adopted standards for beginning teachers, markers of what a highly qualified teacher knows and can do. As noted in Chapter 1, the standards emphasize teacher knowledge of technology for "enhancing learning, personal/professional productivity and communication" (Michigan Department of Education, p. 3).

Teacher Education Program

All of the seven interns who took part in this study learned to teach as part of a large mid-western university's teacher education program. Examining that context yields more data to facilitate our understanding of the interns' learning to teach with technology. With a 100-year history, the teacher education program at the university adapted and changed with the movements in educational philosophy. Its first certification program required one year to complete while its present program demands five.

Preservice teachers begin their program in the liberal arts, taking an introductory education class each of their first and second years of their university experience. After preservice teachers are admitted into the teacher education program in their junior year, they begin taking education classes populated solely with education majors along with classes in their majors and minors. Their senior year includes content methods classes in

math, literacy, social studies and science with a field component for each class. Completion of the four-year program results in a baccalaureate degree in a subject matter major for secondary preservice teachers and a baccalaureate degree in elementary education with a subject matter major for elementary preservice teachers. In the fifth year of the program preservice teachers complete the requirements for certification through their internship and begin work on a Master's program.

The internship for the teacher certification program includes a classroom placement in an elementary or secondary school and weekly Masters level classes at the university. The interns typically spend four days per week in their placement classrooms and one day per week in their classes. Elementary interns participate in two classes each semester, one each in math, literacy, social studies, and science. Secondary interns focus on their subject area and courses on their professional roles. Three weeks in the fall semester and eight weeks in the spring semester are dedicated to full time teaching with no class meetings. Elementary interns also meet in weekly seminar groups with their field instructor and both elementary and secondary interns work with their field instructor to improve the intern's practice.

Responding to the standards climate, the teacher education program established eight standards and rubrics were developed for intern conferencing based on those standards. The eight standards in basic form include: 1) Acts as an educated person; 2) teaches elementary subject matters; 3) works with students as individuals; 4) organizes and manages a class; 5) uses an equipped classroom; 6) joins a faculty and school; 7) engages families and community; 8) teaches deliberately and learns from experience. Three of the six subpoints for Standard Five deal with technology in teaching: uses

multiple literacies, materials, and media to promote inquiry, interaction, and learning; uses information technology to enhance standards-based instruction and assessment; teaches students to use information technology wisely and ethically. Field instructors used the standards to guide their discussions with collaborating teachers and interns and to assess interns' progress. The adopted standards illustrate the teacher education department's commitment to equipping their preservice teachers with the technology and design skills for teaching today's students.

The same commitment can also be seen in the program strands of the elementary program. The program made a decision to not offer separate, required classes for each of the program strands, which include technology, classroom management, English Language Learners, global education, and special education. Instead, the elementary program incorporated all six strands in all classes across the program. Integration of technology into all content methods courses fit better than portraying it as separate content to be learned. The elementary subject area leaders planned together when and where certain technologies would be integrated into course work. The difficulty, however, in a large university teacher education program is the turnover in the teaching staff. As graduate students complete their work and move on, untrained graduate students take their place, leading to great variance in experiences for preservice teachers. The secondary program offers a module for special education as part of its regular course work, but does not specify how the other topics are integrated into each course.

In support of the technology integration, the teacher education program received a grant from the federal government, Preparing Tomorrow's Teachers to Use Technology (PT3). The PT3 project brought together teachers, preservice teachers, educational

technology and content area experts to explore the affordances and constraints of technology in order to better use them in powerful teaching. Products of the design teams included the integration of a web site and online document submission in the secondary science program, video cases of literacy teaching, portfolio creation assignments, video case creation assignments, and social studies software applications. The PT3 project also provided four technology-proficient graduate students as technology aides to the teacher education department. They worked with instructors one-on-one, led workshops, and assisted in classrooms where needed. One final project was the Getting Ready for Implementing Technology in Schools (GRITS)[2] mini grant program in which the interns of this study participated.

The seven interns included in this study participated in the GRITS mini grant program during summer, 2007, the summer prior to their internship. I served as coordinator for the GRITS program, and was responsible for recruiting grant participants, reviewing grant applications, working with the interns on developing their projects, and approving payment of grant funds as they met their goals. The College of Education's PT3 committee provided oversight and assistance to me in my work.

Working with the GRITS participants provided a useful approach to understanding TPACK development as it was situated within the GRITS program. My work with them and my observations of their development triggered my desire to explore more of how their TPACK was developing and what would happen later in their placement settings.

The GRITS participants first voluntarily attended an introductory session in which

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[2] As with all names of participants, a pseudonym has been used for the mini-grant program.

a variety of technology rich lessons, student products, software and hardware were described. Following the presentation, the interns applied for a mini grant. The application process required several steps: researching what kind and how much technology was available in their already-assigned future internship setting; talking with their future collaborating teacher about the curriculum, possible integration of ideas and whether the teacher would also like to participate in the grant; determining a possible technology integration idea; and writing a plan of the resources (time, software, hardware, technology assistance) required to implement the plan. Seventeen interns applied for and received the GRITS mini grants and eight of their collaborating teachers participated with them. One of the interns did not know her placement until August but her project fit into her grade level so she was approved for the program even without having an assigned collaborating teacher at that point in time.

Following their acceptance into the mini-grant program, the interns met with me, the GRITS coordinator, at three strategic times, first to review the expectations and requirements of the program (see Appendix A for an outline of the requirements), and then the second and third times for assistance and accountability along the way. I served as a mentor, guiding their practice (Feiman-Nemser & Rosaen, 1997; Schwille, 1997) as they formulated plans for their internship year. I brainstormed with individual interns, questioned to help them make their purposes explicit, and discussed content, technological and pedagogical concerns. I reviewed their lesson plans and provided feedback as challenges to their thinking and encouragement of their practice.

The interns received software and the use of hardware for their classrooms and were paid for the time they spent on their projects. They determined the time lines for

completing their plans, with the requirement that all plans be completed before their internship began. They were encouraged to explore and learn the software or hardware on their own in order to develop their technology exploration skills, but the GRITS coordinator could be consulted if needed. For their projects they developed detailed lesson plans for use in their internship classroom. In keeping with Michigan's standards context, the GRITS requirements stipulated that lesson plans include the Grade Level Content Expectations (GLCEs) addressed by the instruction. The lesson plans also needed to include the rationale/big picture, the objective(s), procedures (lesson activities plus addressing Internet safety, media awareness, copyright and acceptable use issues), and assessment of student learning. They planned their technology-infused lessons with guidance from the GRITS coordinator, submitting them via email and discussing them via email or in face-to-face meetings. All planning took place during the summer to ensure time was not taken from their internships in the fall.

After the completion of their project, the interns wrote a reflection on their mini grant work, outlining what they did and what they learned through the process. The final requirement specified that the GRITS interns participate in a session at the College of Education's fall technology conference. Each intern prepared and delivered a five-to-fifteen minute presentation on his/her work. At the technology conference, four interns presented in the opening session, each allotted about 15 minutes. The other thirteen interns were divided into two groups, one group of seven made up of those whose projects focused on language arts and social studies, and the other comprised of the six who created science and math projects. These two groups presented their work in hour-long simultaneous sessions that they both repeated the following hour, each taking about

five minutes. After each session the conference attendees asked questions of each of the participants regarding their work. Following the conference there were no further requirements or accountability for implementing the plans. At the end of the internship year, all interns returned hardware to the College of Education, but retained their software.

Participants

For this study I recruited the interns by emailing the seventeen interns who had participated in the GRITS program. Seven interns responded. In this group of seven interns for this study, five were pursuing elementary certification, and two were pursuing secondary certification, one in French, and the other in social studies. The group consisted of six females and one male. Two of the interns were placed in schools with 65-95% of students qualifying for free and reduced lunch, three in schools with 50-60%, and two in 0-20%. All of the interns were White, like most of the interns in the university's teacher preparation program, although five of the seven intern participants were placed in schools where a majority of the students did not share the interns' race. Each participant (pseudonyms are used) with his or her setting is briefly presented with summaries in Table 1 and Table 2.

Ambrosia. Ambrosia's placement school was a visual and performing arts magnet public school in a midsize city with 560 students, 58% of whom qualified for free or reduced lunch. Many of the students, 57%, were African American, some, 28%, were White, ten percent were Hispanic, four percent were Asian, and less than one percent were American Indian (Great Schools, 2009). For her GRITS mini grant, Ambrosia applied for and received the use of a SMARTBoard and projector as well as payment for

time to explore the hardware and develop lessons integrating it into all subject areas. With minors in math and social studies and a strong interest in science, she wanted to work on all content areas. She consulted with her collaborating teacher (CT) regarding lessons and trained her teacher in use of the SMARTBoard. Ambrosia's fourth grade classroom had a digital camera and one computer in the back of the room that the teachers used for grading or students used to finish their Internet researching. Ambrosia's laptop, and the GRITS-provided SMARTBoard and projector rounded out the remaining classroom technology resources. The computer lab next door and a laptop cart could be reserved in advance for classroom use. The data do not show whether students attended a computer class in fourth grade, but Ambrosia related that very few students had computer or Internet access at home.

Brian. Brian and his CT worked in a social studies placement in a midsize city public high school, with Brian teaching the tenth grade History classes. Of the 1675 students in the school, 51% qualified for free and reduced lunch. Nearly half of the students were African American, one-third were White, 14% Hispanic, six percent Asian, and less than one percent American Indian (Great Schools, 2009). Brian expressed interest in the GRITS mini grant program early on, but found his summer of taking classes and working cancelled any opportunities for mini grant work. Near the end of the summer, however, with his other commitments diminishing, he applied for and received a GRITS mini grant for time to develop lessons and a teacher web site for use with his classes. His lessons included Google Earth and YouTube-infused PowerPoints and a lesson for creation of a YouTube-posted podcast question for the U.S. presidential candidates. Brian talked with his CT about the projects, but his CT did not work closely

with him on their development. In his classroom, the computers in the back of the classroom did not work, but a receiver, DVD, projector, and TV along with Brian's laptop made the room feel well-equipped from Brian's perspective. The school's library housed the computer lab that Brian used with his students. That lab was not available after 2:30 p.m. At the time of the interview Brian had just recently found out about another computer lab in the building that could be reserved during school as well as after school. The music room also contained a group of Apple computers with audio and video recording and editing software. Brian explained that his students varied greatly in their technology skills. While some listened to music they had downloaded to their iPods, others did not know how to deal with files and folders and saving on the computers.

Kelly. Kelly interned in a third grade public elementary classroom in a midsize city. Her preschool to grade 5 school had 327 students, with 51% of them qualifying for free or reduced lunch. 42% of the school's students were White, 37% African American, nine percent Asian and nine percent Hispanic, three percent multiracial, and less than one percent American Indian (Great Schools, 2009). A language arts major, Kelly received her mini grant to develop a wiki for her students' current events postings, including text and audio. The program gave her use of a digital audio recorder and camera for her summer teaching trip to South Africa and for the school year as well. She also received payment for time to develop lesson plans on writing about current events and lessons on Internet use and safety. She produced a sample podcast, wrote postings on the wiki, and developed lesson plans for using the wiki in her class. Kelly consulted initially with her CT on the project, but then with differing travel schedules, they did not connect further until Kelly began her internship in the fall. Kelly's classroom had a teacher's computer in

the back of the room and a VCR in the front of the room that both connected to the television in the front of the room for projection purposes. Kelly brought her own laptop to the classroom, but there were no other digital technology resources. Each week Kelly and her CT worked with their class in the computer lab on lessons connected to the technology curriculum of the school. Kelly found that other computer lab times were difficult to schedule because of all the other specials in their schedule. She noted that a lot of students did not have access to computers or Internet at home.

Lucy. Late in the summer Lucy's placement was finalized as a fourth grade classroom in an urban public preschool through sixth grade building, 89% of whose students qualified for free or reduced lunch. Two-thirds of the 815 students identified themselves as African American and nearly one-third Asian. The remaining American Indian, Hispanic, and White students made up less than one percent of the student population (Great Schools, 2009). At the end of her elective Teaching with Technology class in the teacher education program, Lucy's professor urged her to apply for the GRITS mini grant. Although she had worked as an assistant in the College of Education's technology center, Lucy apprehensively applied because she did not know her exact placement. She had been assigned to the school in a large urban public school district, but she had not been told the grade level or who her CT would be. In spite of her situation, Lucy was granted a mini grant because her project seemed adaptable to various grades and placements. Lucy planned lessons around and produced a sample Google Maps mashup of her school community. Her students would walk the neighborhood and take pictures of historic and important buildings in their community and then research their assigned building and write a short report about it. With Lucy's help they would add their

information and picture of the building to Google Maps. In the classroom the students had access to a computer center, an option for learning offered with other centers, and a digital camera. Lucy had also heard a fifth grade teacher mention that he had a document camera sitting unused in the back of his closet, so she asked him whether she could use it in her classroom. He readily handed it over to her, so combined with a projector she borrowed from the College of Education and her laptop, she and her class shared Internet experiences together. The class spent one hour per week in the computer lab, but a technology teacher planned those lessons, so Lucy did not know much of the learning there. She and her CT could reserve the computer lab on Fridays for their class use. She did not talk about her students' technological proficiency or home access.

Malia. Malia interned in a suburban K-5 public school that had 333 students, with only 11% qualifying for free or reduced lunch. The student body was predominantly white, with only six percent of the students African American, 14% Asian, and two percent Hispanic (Great Schools, 2009). Malia began her first undergraduate degree as a computer science major but quickly switched out of that career. She worked in an insurance business for many years, with part of her responsibilities including administration of their database. During her teacher certification internship she continued to work part-time long distance for the same company. As a second career preservice teacher, therefore, Malia was a bit older than her fellow interns. For her GRITS project Malia, a social studies major, designed lessons and created a sample for her students' production of podcasts that would serve as review after each unit of Michigan history studied. She included lessons on Internet safety and copyright issues to prepare her fourth grade students for online work. Malia's CT worked with her on the project, but not

extensively. Her classroom was equipped with a document camera and projector as well as two computers for student use and one for teacher use. The teachers led their classes during their assigned weekly times in the computer lab, and Malia and her CT worked with her CT's fourth grade teammate to plan lessons that connected to the rest of the curriculum. Like Lucy, Malia did not mention her students' technology proficiency.

Margaret. Margaret's CT was not available for collaboration during the summer but Margaret worked with him teaching the French language for the fall semester in a suburban 10-12th grade high school setting. The school's 1411 students were primarily White, with nine percent African American, five percent Hispanic, three percent multiracial, two percent Asian, and less than one percent American Indian. Only 19% of the students qualified for free or reduced lunch (Great Schools, 2009). For the second semester, Margaret moved to a rural 9-12 high school where she also taught French. There were considerably fewer students in Margaret's rural school, 1093, with 15% qualifying for free or reduced lunches. The student body was much more racially homogeneous, with 94% of the students White, three percent multiracial, two percent Hispanic, and less than one percent African American, American Indian, or Asian (Great Schools, 2009). For her GRITS mini grant, Margaret, a French major and secondary preservice teacher, received payment for time to develop lessons in which students used Comic Life, iMovie, and Google Earth and in which Margaret's audio recordings of French words and phrases were used by students for their pronunciation learning. She created samples of all the lesson products and recorded the podcasts of her pronunciation tools. To enable implementation of these lessons, the GRITS program provided ten MacBook laptops for Margaret to borrow whenever needed. Her classroom had one

computer, a document camera and projector, her own laptop computer, plus any borrowed from the GRITS program. The French textbooks included software that could be used in classes. Margaret noted no computer lab in the building. She related that her students in her first placement all had computer and Internet access at home, whereas in her rural placement that was not necessarily true. She also noted that she could use movies from sites like YouTube in her first placement, but they were blocked in her new placement. Her second placement included a computer lab, but she told of an incident when the Internet failed and she and her students waited 20 minutes for the server restart. In her new classroom she had her own digital camera and laptop and any laptops borrowed from the GRITS program.

Terese. Terese's placement K-5 public school in a midsize city drew 275 students, 65% of them qualifying for free or reduced lunch. 65% of the school's students were African American, 15% White, 12% Hispanic, seven percent Asian, and one percent multiracial (Great Schools, 2009). In preparation for her GRITS application, Terese searched for software to be used in teaching her third grade science lessons. For her GRITS mini grant she was given twenty-five copies of Science Simulations and payment for time to develop lessons and materials for her particular placement situation. Several simulation topics were included in the software and Terese chose to focus on the plant growth simulation for her lessons. Her CT had a difficult time getting the curriculum information from the school during the summer, but eventually Terese and her CT collaborated on the lessons. In Terese's classroom, students could use the two computers in the back of the classroom when they met individual reading goals; they also went to the computer lab once per week. The technologist in the computer lab sometimes led the

lesson there and other times told the teachers as they accompanied the students that the teachers could lead. Because YouTube and other sites were blocked at school, Terese always chose computer sites for student use at school. She noted that many of her students did not have computer or Internet access at home although some parents would type documents for their children at work.

Table 1
Interns' Settings

Intern	Grade Level	School District	Total Students	% Free and Reduced Lunch	% AA[3]	% AI[4]	% A[5]	% H[6]	% M[7]	% W[8]
Ambrosia	4	Midsize	560	58	57	<1	4	10	0	28
Brian	9	Midsize	1675	51	47	<1	6	14	0	33
Kelly	3	Middle-sizer	327	51	37	<1	9	9	3	42
Lucy	4	Urban-dale	815	89	67	<1	32	<1	0	<1
Malia	4	Suburbia	333	11	6	0	14	2	<1	78
Margaret	9-12	Suburb-anado/ Ruralton	1411/ 1093	19/15	9/<1	<1/<1	2/<1	5/2	3/3	81/ 94
Terese	3	Midsize	275	65	65	0	7	12	1	15

[3] African American
[4] American Indian
[5] Asian
[6] Hispanic
[7] Multiracial
[8] White

Table 2

Interns' GRITS projects, Resources, and Students

Intern	GRITS Project	Resources Received	Intern Major	Technology in Classroom	Computer Lab	Students and computers
Ambrosia	Integrate SMART Board into all subjects using PPT, Google earth, SMART technologies	Use of SMARTBoard, projector, Time	math, social studies (science)	computer in back of room, digital camera (SMARTBoard & projector)(laptop)	sign up for lab use; weekly use unknown, tech teacher	very few have access to computers or Internet at home
Brian	Integrate Google Earth & YouTube videos into PPT; video record and post to YouTube; Web page creation	Use of MacBook laptop, Time	Social Studies	receiver, TV, DVD, VCR, projector (Laptop)	library lab, computer lab, music lab with Macs/ sign up in advance	skills vary greatly
Kelly	wiki, podcasting, digital photography	Use of digital camera, audio recorder, Time	Language Arts	teacher computer, TV as projector, VCR (laptop)	once/week classroom teacher; tech curriculum	a lot of students do not have access to computers at home
Lucy	interactive online community map	Use of digital camera, Time	Geography, TESOL	student computer(s?) for centers, digital camera, document camera (projector)(laptop)	once/week tech teacher; can reserve on Fridays	not mentioned
Malia	Podcasts of MI history posted on web page	Time	Social Studies	document camera, projector	once/week; classroom teacher	not mentioned
Margaret	Use digital pictures to learn French language and communicate with French native speakers	Use of digital cameras, MacBook laptops, Time	French	document camera, projector in Suburbando (MacBook laptops) (laptop, digital camera)	sign up; no YouTube access and less consistent Internet access in Ruralton	Suburbanado- more proficient, all home Internet access; Ruralton- not all home Internet
Terese	*Science Simulations*- Software for Plant unit plus other topics	Software, Time	Language Arts	two computers for student use	once/week, tech teacher; can reserve; YouTube and other sites blocked	many do not have computer or Internet at home

Data Collection

The data for this study consisted of interview video and audio recordings and their transcripts, interview field notes, and existing artifacts from the GRITS mini grant program.

I conducted interviews with the interns between March and May of their internship year. I sat down with six of the intern in their placements in a variety of mid-Michigan elementary and secondary schools. I interviewed one intern via telephone because she was concerned about the safety issues with staying after school for an interview.

Active interviewing (Holstein & Gubrium, 2002) acknowledges that both the interviewer and interviewee construct the interview event (Richardson, 1997) and the focus should be on "how meaning is constructed, the circumstances of construction, and the meaningful linkages that are made for the occasion" (Holstein & Gubrium, p. 116). For this reason the interview protocol (Appendix B) included open-ended questions on the interns' use of technology in and outside of their school setting, their preparation for teaching with educational technology, and their perception of the importance of technology in classroom instruction. They were also asked for suggestions for improving teacher preparation for teaching with technology. The protocol was used a guide for the interview, but varied depending on the responses and attitudes of the interviewees and their questions for me. Consent Forms for the interns and building principals were distributed and discussed before beginning interviews.

In order to allow me to focus more on the conversation with the intern and their ideas, and less on the note taking (Hatch, 2002) required for recording their ideas, the interviews were video recorded if the participants agreed. I audio recorded three

interviews, one when the intern did not agree to videotape, one in which the video equipment did not work, and the one interview that was conducted via telephone, using GarageBand on my computer. The video and audio records served as additional memory for me to check back on what interviewees actually said rather than my reliance on my notes. I took field notes, with notes fleshed out as soon as possible following the interview. Transcripts were made of all the interview recordings.

Existing artifacts from the GRITS mini grant program included applications for the mini grant, emails to and from the researcher, meeting notes, lesson plans at various stages, final reflection essays, and technology conference presentations.

Data Analysis

TPACK

Data analysis drew initially on the TPACK framework to learn more about preservice teachers' knowledge. As discussed previously in Chapter One, while there are many influences that impact preservice teacher learning, the learning of teaching with technology is unique in that very few preservice teachers experienced an apprenticeship of observation (Lortie, 1975), and technology has continued to develop so that within a preservice teacher's teacher education experience, new technologies have already emerged and morphed. Because of these changes, and because of the wide variability of available technologies, Mishra and Koehler (2008) emphasized the uniqueness and flexibility of the knowledge required for teaching with such technologies. In identifying TPACK, Cox (2009) proposed that pedagogical use of ubiquitous or transparent technologies, such as the white board, overhead projector, books, pencils and pens, for particular content learning is categorized as PCK, Pedagogical Content Knowledge. Cox

viewed the use of common technologies as part of PCK, knowledge of the instructional strategies and curricular materials for teaching particular content (Grossman, 1990; Cox, 2008). The pedagogical use of new technologies for teaching content would therefore be labeled TPACK because of the complexities in decision-making and using the new technologies. I've chosen to use Cox's distinctions in order to aim the spotlight on the learning to teach with new technologies and possibly shed light on teacher learning in general.

Data Analyzed. In order to identify the TPACK knowledge components in the interns, I chose to analyze their reported personal uses of technology, the lesson plans they had made for GRITS and the technology implementations that they reported in the interviews about their classroom use. I chose the reported personal uses of technology because those uses revealed their comfort with and knowledge of using technology outside of the classroom, the basic knowledge of technology and its affordances and constraints.

I chose the planned lessons because I had data about the interns' planning process from the GRITS grant application, email correspondence, lesson plans, and reflection, thereby revealing their active thinking that went into the plans. They had planned in advance as best they could for the settings in which they would intern and many had revised and reworked the plans following my feedback, so they were more than just ideas for implementation. They had thought through as much as possible how they would use the technology to help their students learn. I considered each lesson plan as one use because separating the lesson into parts diminished the complexity of the lesson and the knowledge at work in designing the complete lesson.

I chose to analyze the reported classroom uses because they illustrated the interns' knowledge in action beyond the requirements of participating in GRITS. I did not include any ideas the interns had for future implementation or their discussion of other options because it is in the actual enacting that knowledge as design presses forward in taking into account the resource limitations and learner needs. In the interviews the interns brainstormed possible teaching with technology ideas, which aided my understanding of their thinking. If their actual implementations were limited, their reasons for not using technology more provided evidence that implementation required more knowledge than brainstorming did. I also analyzed the reported classroom uses within the context of the whole reported lesson, and coded one lesson as one use.

Unit of analysis. Each of the interns' reported personal uses was coded as an example of TK by its type of use, not by the number of times used. For example, when an intern reported taking digital pictures in their personal life, that use was recorded as one example of TK.

Each of the interns' lesson plans and their reported classroom uses was coded as a single example of a particular TPACK component, PK, CK, PCK, TK, TPK, TCK, or TPACK (See Appendix C for examples). If, however, the intern talked in general about a use and did not give a number of times it was implemented, it was coded as only one use. For example, Ambrosia talked about using the SMARTBoard for science lessons. "So if I'm gonna do diagrams for science, I'll do that, and we'll fill in the diagrams as we go. . . . I'll have a blank; one of the kids can go up and write in the parts of whatever" (Ambrosia Interview, p. 1). When she specified plant diagrams, that use, too, was coded

as another example. I chose to count another use because she relayed it as an example and not the only time she had used the SMARTBoard for science diagrams.

For the purposes of the study I was concerned only with the Technology Knowledge components of TK, TPK, TCK, and TPACK; the interview questions aided in compiling Technology Knowledge data rather than all of the knowledge components. I did, however, note any aspects of lessons or conversations (unlike full lessons and implementations) that revealed PK, CK, or PCK for my own notation and understanding of intern development, especially for those interns who exhibited little of the Technology Knowledge components. I have not included the PK, CK, or PCK examples in the findings. Often the only difference between TPACK and PCK coding involved whether the technology was digital or not, with digital uses being assigned TPACK coding and the traditional technology PCK. When Brian related how he turned on the television to watch and discuss coverage of Kosovo's declared independence from Serbia, I coded it as and example of PCK in action. Because Brian used the traditional technology of television to help his students experience and discuss a social science situation, the use was considered PCK. If, however, he had showed Internet coverage of the event, a digital format, I would have considered it an example of TPACK in action.

Process of analysis. Initially I used a separate spreadsheet for each participant, categorizing the implementations their class had experienced with the CT or other staff, their GRITS lesson plans, their actual implementations and their ideas. As noted above, I later decided to only include the interns' actual implementations and their fleshed-out plans from their GRITS projects because they served as a better reflection of knowledge enactment. Once I had coded all of the individual uses, I compared them to each other

and adjusted some codings to be consistent across all the interns. For instance, several of the interns described webquests they had used for instruction. I reviewed all of them to ensure the webquest implementations using a webquest in a general way to research a question on the Internet received the TPK coding. Those webquests that dealt with content in the discipline-specific manner, for example, accessing primary documents in social studies for exploring life as an immigrant, received the TPACK coding.

Coding uses by TPACK knowledge components. I categorized how each intern described technology implementations according to the evident TPACK knowledge components. The TPACK framework definitions (Cox, 2008) assisted in delineating the knowledge components. For example, in the instance of Terese's web page of links, the Technology Knowledge of how to create a web page, how to find appropriate web sites and how to create hyperlinks was evident as well as the knowledge as design in her taking the idea from another intern and applying it to her situation. Her Pedagogical Knowledge evidenced itself in the desire to give her students access to information that would aid in their learning, yet protect them from inappropriate web sites on the Internet. Although she probably formed this web page around particular subject matter, I categorized this instance as evidence of her TPK rather than TPACK. I considered it TPK because Terese did not talk about the content or how this web page enhanced her students' ability to interact with the particular content. Additionally, the idea could be used with many different content areas. For the Light and Shadows simulation software, on the other hand, because it illustrated her first introducing the software and then encouraging with her students' learning about a particular content topic through use of a software, I categorized the use as showing her TPACK, that amalgam of Technology,

Pedagogy, and Technology Knowledge. The differentiation between TPK, the more general Technological Pedagogical Knowledge, and the more highly specific TPACK assisted in exposing depth of knowledge.

Coding uses by TPACK breadth. In order to highlight another dimension, the breadth and flexibility of knowledge, I coded all lessons exhibiting TPACK components according to two additional scales: subject areas and technology affordances exploited. Subject areas I coded as social studies, science, literacy, math and French. Employing labels delineated by McCrory (2006), representation, information, transformation, or collaboration, I coded the lessons and classroom uses according to the technology affordances exploited. For example, Terese related her creation of a web page with links for students to use in their research that pointed them toward good informational sites and enabled them to avoid inappropriate sites. That use was categorized as information because it took advantage of the information affordance of the Internet. When Terese talked about using the Light and Shadows portion of the Science Simulations software, I categorized that use as transformation and representation. The transformation category fit because it allowed students to explore light and shadows in new ways they could not have previously and it allowed student inquiry. Representation described the use because the software offered simulations of light and shadows that made them more accessible to students.

As I worked through interns' uses, I found it difficult to fit the document camera uses into McCrory's (2006) categories. Lucy described displaying the textbook on the document camera while the students read aloud. While this use allowed students to glance up and note the place in the text in order to find the place or to follow along on the

screen instead of their own books, it did not provide new representations for students to better access the content. It provided a way to keep the class together, and that was a valid use, but it did not fit the rich implementations that McCrory described. Lucy also related modeling note taking on the document camera screen. The process was like using a traditional overhead projector but with more visual clarity. I noted, therefore a need for an amplification affordance category for general pedagogical tools that enable amplification of learning materials. I decided to add another category, amplification, because amplification aids learning, but it does not necessarily encourage student-centered learning. Amplification describes the affordance of technology that amplifies the size and projects the amplified image of a computer screen, object, video or other multimedia, and thus enables a group or an individual to view and/or interact with the learning materials. The amplification affordance needs to be highlighted to call attention to its difference from the other affordances listed by McCrory. Many teachers and hardware vendors give the impression that implementing a document camera or a SMARTBoard exemplifies rich technology integration. While SMARTBoards and document cameras offer helpful amplification, they do not necessarily encourage the learning to be more student-centered as McCrory argued could be the case.

Trajectory of TPACK development. Based on the TPACK pedagogical components, the depth of TPACK as seen in TPACK as opposed to TPK, and the breadth of TPACK evidenced in affordances and subject areas exploited, I constructed a trajectory of TPACK development in order to give some sense of developmental progressions or indications of development. This trajectory served as a heuristic device to aid my thinking about development, but, given the complexity of learning to teach with

technology across contexts, was not precise enough to enable me to determine an exact position for each intern. While I did not place the interns on the continuum, Kelly might be seen as a preservice teacher as near the beginning of the trajectory. She related how she found images to accompany the class's fact of the day in order to help her students better understand the context of the facts. Her implementation dealt with general content rather than curriculum content although she focused on students' making connections to their own experiences. Ambrosia, who might be seen as further along on the trajectory, when told by her collaborating teacher that her fourth grade students in past years had trouble with plagiarism and understanding how to do research, decided to develop a project that scaffolded students' Internet research on lighthouses for Michigan history, culminating with a paper brochure product because of students' lack of typing skills. She drew upon her TPACK to develop a project based in her curriculum specifically for her context.

Beliefs about technology in education. While the coding of the TPACK components was based upon lesson plans and classroom implementations, the coding of the interns' beliefs about the purpose of technology in education was based in the expression of their ideas and beliefs. I wanted to spotlight the purposes for any indications of how that knowledge might be working in their TPACK development. I, therefore, coded the interns' interview and GRITS data regarding their views of technology as separate from the TPACK evidence. Through an iterative process, including consultation with another graduate student, four broad categories suggested by the interns' responses regarding technology's purposes in education emerged: economic

efficiency and utility, cultural exposure, general pedagogy, and teaching and learning content.

TPACK Development Using Activity Theory

In order to learn more about how the interns' TPACK developed, the interview protocol began with an open ended question, but then also probed six possible influences: own experimentation; K-12 influence, the teacher education program, GRITS, the collaborating teacher, or colleagues. The factors they listed, whether related as positive or negative, were coded in an iterative process of analyzing and regrouping into categories and subcategories of activity settings. For instance, Lucy talked about her senior science methods class and how they used Lesson Labs for their learning. This influence I first coded as Teacher Education. Once all the contributors were coded, I then looked for subcategories within the large categories. Lucy's example dealt with her own learning with technology so the final code became Teacher Education- learning with technology. In addition to those that the interns explicitly listed, I also noted their purposes for educational technology implementation and the influence of online communities. Eleven broad categories, four with subcategories, emerged, which will be discussed in greater depth in Chapter 4.

1. Daily life
2. Other workplaces
3. K-12 classrooms
4. Technology Conference
5. Teacher Education
    a. Technology integration discussions
    b. Modeling technology use
    c. New ideas of technology
    d. Learning with technology
6. Placement Setting
    a. Collaborating Teacher
    b. Other teachers

7. Classmates/Colleagues
8. GRITS Experience
    a. Colleagues
    b. Coordinator
    c. Planning for lessons
    d. Learning technological possibilities
    e. New ways of thinking about teaching
9. Online Resources
10. Teacher Identity
    a. Pedagogy
    b. Interest
11. Experience
12. Design Process
13. Purposes of educational technology

Activity settings. From those categories of influences emerged activity settings, places in which the interns had gained knowledge and skill for teaching with technology:

1. Daily Living/Home environment
2. Other workplaces
3. K-12 experience
4. Technology Conference
5. Teacher Education
6. GRITS Experience
7. Placement Setting
8. Online Communities

The categories of teacher identity, experience, purposes of educational technology, and design process seemed to fit within activity settings but also across settings. I therefore included them in both the GRITS and placement settings as mediators for learning. Interest and passion also fit across all settings but seemed separate so I chose to discuss interest and passion as another category. Transcriptions and document artifacts were examined for activity setting factors (mediating tools, identity, setting object, and community rules and roles) that interns perceived as contributing or detracting to TPACK growth or lack of growth. For instance, Terese spoke strongly of how her teacher education instructors fumbled with the technology so much that she received the message

that technology is a lot of trouble and requires more preparation time than is available. For her, the instructors' modeling of technology did not serve to mediate TPACK development. Margaret, on the other hand, related enthusiastically that her teacher education instructor encouraged her and her classmates to use technology by speaking about it, sharing examples, and providing an online forum for the class. Margaret's instructor's modeling mediated Margaret's learning to teach as well as her TPACK development.

Conceptual and practical tools. Conceptual and practical tools that interns reported as contributing to their learning how to teach with technology were analyzed for patterns and similarities to each other. The lesson design process as a practical tool described Ambrosia's process for learning to teach with a particular technology.

> I learned how to use the SmartBoard, then thought . . . , "Is there any point in my teaching that I could fit this in? Well, I might be able to use it here, because I want to show them maps with the SmartBoard. . . . and then you decide what maps you want to use, how you want to use them and all that stuff. (Ambrosia Interview, p. 10)

Brian related a similar design process of learning the technology himself, using it with students for a particular content, evaluating for himself the technology's effectiveness and its implementation, asking for input from students, and then trying it again with modifications for another content. The process of designing lessons includes learning the affordances and constraints of a tool, using it to engage students with particular content within a particular setting, reflecting, then adapting and trying again.

The conceptualization of technology as a tool for learning proved to be powerful for Ambrosia as she prepared lessons drawing upon the strengths of the SMARTBoard.

The conceptual tool enabled her to focus on designing learning opportunities around the content rather than the technology.

Personal uses of technology were contrasted with classroom uses of technology. Overlaps and conflicting experiences were analyzed for how the interns responded to their activity settings, whether with resistance, acquiescence, or accommodation or other responses that emerged from their experience (Smagorinsky, Lakly, & Johnson, 2002).

Cases were initially constructed of two interns, Ambrosia and Terese, in order to gain a better understanding of how the activity settings impacted individuals' TPACK development. Looking closely at the two allowed me to think more deeply about their agency within their settings and the mediating tools that they shared but with different effects. As data on other interns were analyzed, especially the coding of the content portion of TPACK, it became evident that there were differences between elementary and secondary interns in terms of connecting content and technology. I then constructed cases of the two secondary interns, Brian and Margaret, to enlighten another side of TPACK and its development.

TPACK and activity theory as lenses. Using the two lenses of the TPACK framework and activity theory for coding the interns' TPACK evidence and their reported contributors to their TPACK development enabled me to see the knowledge and the knowledge development within contexts. TPACK is best identified in implementations within settings rather than in brainstorming possible implementations and TPACK development is best viewed within and across the multiple settings of a preservice teacher. The two frameworks also illuminated the variability of TPACK expression and TPACK developmental processes across individuals and also within individuals.

Potential Significance of the Study

This study is limited, first of all, by its small number of participants. Seven interns' experiences cannot generalize to the larger population. The study is also limited in that the data is largely dependent upon interns' recall and sharing on one particular day. In taking a retrospective approach, there is not much access to the participants' thinking process and iterative design process. Nor is there confirmation from the collaborating teachers of the success of the interns' projects.

Another limitation of this study is its concentration on the Technology Knowledge of the TPACK framework, TK, TPK, and TPACK, and not the Pedagogical Knowledge, Content Knowledge, and Pedagogical Content Knowledge, which would have the potential to show how all components come together.

As noted in the literature review, while studies have explicated PCK and TPACK, very few have actually identified TPACK development in action or addressed how such integrated knowledge develops. Mishra and Koehler (2006) found that learning by design processes aided inservice teacher TPACK development, but it is not known whether similar processes aid preservice teacher TPACK development. This study of preservice teachers who planned and used technology for curricular purposes was designed to help flesh out the knowledge construction process and add more examples of how to code and identify the TPACK components. The study investigated the learning by design process as a mediating tool and therefore could yield additional mediating tools for helping preservice teachers develop and draw on TK, CK, and PK and the three in combination (TPACK). Because the study investigated interns' reported technology uses in an actual teaching setting, results may also indicate how preservice teachers respond to interactions

between various activity settings and how those interactions relate to their knowledge development and implementation. While this study examined the interns' perspectives and not pre-and post-intervention situations, learning more about the knowledge construction process, identifying TPACK mediating tools, and learning how preservice teachers perceive and act in various settings can aid teacher preparation programs in developing the TPACK of their preservice teachers. Learning about TPACK development may also lead to further discoveries and theories about other teacher knowledge development, particularly in relation to how TPACK and activity theory may be integrated to provide a more robust understanding of developing knowledge for teaching content with technology.

CHAPTER 3

EXAMINING THE INTERNS' EVIDENCE OF TPACK

In this chapter I report the results of examining the data for evidence of TPACK enacted in the interns' practice. Interns' Technology Knowledge as exhibited in their reported personal technology use is compared to the Technology Knowledge they employ in their pedagogical settings. The examples for TPK and TPACK are compared for the group of interns and also for individual interns. From the TK, TPK, and TPACK data a TPACK developmental process is suggested. The breadth of TPK and TPACK is discussed in terms of content areas and in terms of technology affordances and from those findings a process of TPACK breadth development is suggested. I then suggest a trajectory of TPACK development in terms of TPACK component knowledge and TPK and TPACK breadth.

TPACK Components

All of the interns' descriptions of their personal technology use revealed evidence of Technology Knowledge. Table 3 lists their reported uses and reveals that the interns displayed knowledge of technology for a variety of implementations. All of the interns used email and cell phones while most also used digital cameras, mp3 music players, and a social networking web service. Instant messaging, paying bills online, editing photos and videos, creating Google documents, using GPS, and facilitating collaboration through wikis, forums and blogs were less universally reported. It should be noted that interns were only asked about their personal uses in an open-ended format so some may have under-reported their uses and might have said more if they had seen a list. In any case, these interns knew how to use technology in their daily life. The most common uses

centered on communication, photos and music, but many interns also addressed organizational, collaborative, and financial concerns through technology.

Table 3
Interns' Personal Technology Use

Personal Technology Use	Ambrosia	Brian	Kelly	Lucy	Malia	Margaret	Terese
Communication							
email	x	x	x	x	x	x	x
Instant Messaging	x					x	
cell phone	x	x	x	x	x	x	x
FaceBook/MySpace personal	x		x	x		x	x
blog		x					
Photos & music							
iPod music		x	x	x	x	x	x
Photoshop photos			x	x		x	
digital camera- upload photos			x	x	x	x	x
Video and videogames							
digital camcorder, video editing				x	x		
YouTube							x
Video games		x				x	
Information- web surfing/Internet							
news and research			x		x	x	x
Organization & productivity							
database					x		
web maze- keeping track of documents				x			
planner	x						
GPS				x			
create class materials in Microsoft Office	x					x	x
Finances							
paying bills						x	
purchasing online					x	x	
Collaboration							
wiki for collaboration						x	
forum						x	
FaceBook/LinkedIn professional		x				x	
Google documents, etc.				x			

While this study focused on technology use in the classroom, most of the conversations and lesson plans fore grounded some component of Technology Knowledge, whether alone or in combination with Pedagogy or Content Knowledge.

Because the interviews included questions about the interns' personal technology use, those examples are included in the number of TK occurrences in Figure 2. In order to illustrate the difference between their Technology Knowledge for personal life and Technology Knowledge in the classroom not connected to content or pedagogy, two categories are given in the graph for TK: TK (total) and TK class. The TPACK knowledge components most evidenced, therefore, are, not surprisingly, TK, TPK and TPACK.

As described in Chapter Two, the TK numbers in Figure 2 represent the number of personal uses and classroom uses reported by the interns. The TK classroom uses, TPK, and TPACK numbers represent the number of GRITS lesson plans and intern reported enacted classroom lessons that exhibit that particular knowledge.

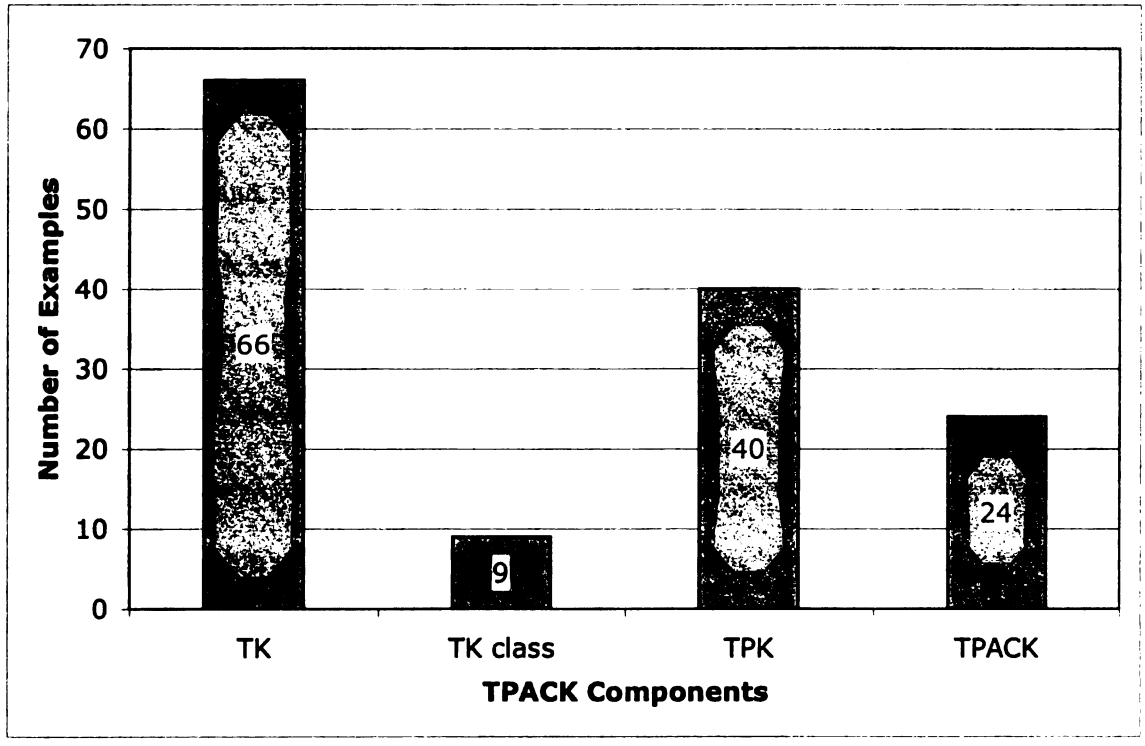

Figure 2. Total number of intern lessons and uses exhibiting TPACK components

As Cox (2008) and Mishra and Koehler (2008) noted, TCK is not evidenced easily in an educational setting because pedagogy always has a place due to the nature of the context. Discussions of content in schools are rarely divorced from how to teach the content. Not surprisingly, no examples of TCK emerged from the interns' data.

Technology seems to always be connected with pedagogy in the classroom, but it is not always tied in particular ways to content. Although interns talked about content in many of their examples, many of their technology uses were not subject-specific. In other words, they could have been used with any content. Ambrosia's example of using the SMARTBoard to label diagrams for science could be extended for any diagrams, whether diagramming sentences or geometric figures. Other examples of interns' TPK evidences are document camera projections for reading books, completing worksheets, and modeling note-taking; digital photography for adding students' pictures to graphs; webquests; adding text to comics; showing video clips from YouTube.

Some TPACK examples qualified as such because they illustrated the preservice teacher enabling and encouraging their students in the discipline's way of knowing. Brian's use of podcasted interviews with the presidential candidates enabled his students' access to these primary documents and discussing them together opened social studies learning to his students. Another group of examples depicted the representational aspect of TPACK for unique content. Terese used the Science Simulations software for her students' exploration of light and shadows and also planned to aid her students' observational skills through their interaction with the plant growth portion of the software. Others used Google Maps and Google Earth for social studies lessons, video clips of simulated processes for science and social studies lessons, and animations of land

formation processes and waterways. Many of Margaret's implementations qualified as TPACK-inspired because they involved foreign language development using media to support multiple modes of language development. The magazine articles, movies produced in French by students, taking pictures to illustrate adjectives, phonetics podcasts, checking the French grocery store site, and Babelfish incorporated audio, video, images, and text to help students learn French. It could be argued that videos could be made in other content areas, meaning that the use should be coded TPK rather than TPACK. Margaret's explanation of filming video because it offers multiple times to practice vocabulary and fluency rather than just performing in the front of the class justified the TPACK designation because of how she connected the particular skills to the technology and pedagogy and how it helps "redress some of the problems students face" (Koehler & Mishra, 2007, p. 18).

With the group tallies (Figure 2) there seemed to be a pattern in occurrences. TK examples appeared the most frequently, then TPK examples about a third less often, and finally TPACK instances only about one-third as often as TK examples. Knowing how to use technology in personal life seemed quite widespread. Teaching with technology in general ways, however, is a bit more complex and fewer instances were recorded. Even more complex is the teaching particular content with technology that opens that content for student learning. This evidence points toward a developmental progression of learning to teach with technology (Figure 3). I suggest that preservice teachers first develop Technology Knowledge, knowledge of technology and its affordances and constraints. As their Technology Knowledge and Pedagogy Knowledge expand they begin to develop ways to teach using technology in general ways that can be used across the curriculum,

Technological Pedagogical Knowledge. When they begin taking advantage of technology's affordances for particular content, TK, PK, and CK have merged and interacted to form TPACK.

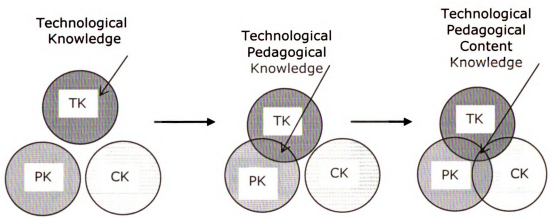

Figure 3. Progression of TPACK Development

Similar patterns of TK, TPK, and TPACK can be seen for individual interns (see Appendix D for a summary of each intern's TPACK), with more TK, less, TPK, and even less TPACK. Two interns, however, Ambrosia and Margaret (Figure 4 and Figure 5), do not fit the pattern. Ambrosia's examples of TPK outnumber her TK and TPACK, while Margaret's TPACK examples outnumber her TPK but not her TK. I suggest that Ambrosia's SMARTBoard impacted her development in that her Technology Knowledge was not expanding because she worked so extensively with one resource. Her TPK grew because she kept finding general pedagogical ways to use the SMARTBoard in order to make the most of the resource. Her commitment to working with content helped her develop specific content uses for it as well, displaying her TPACK.

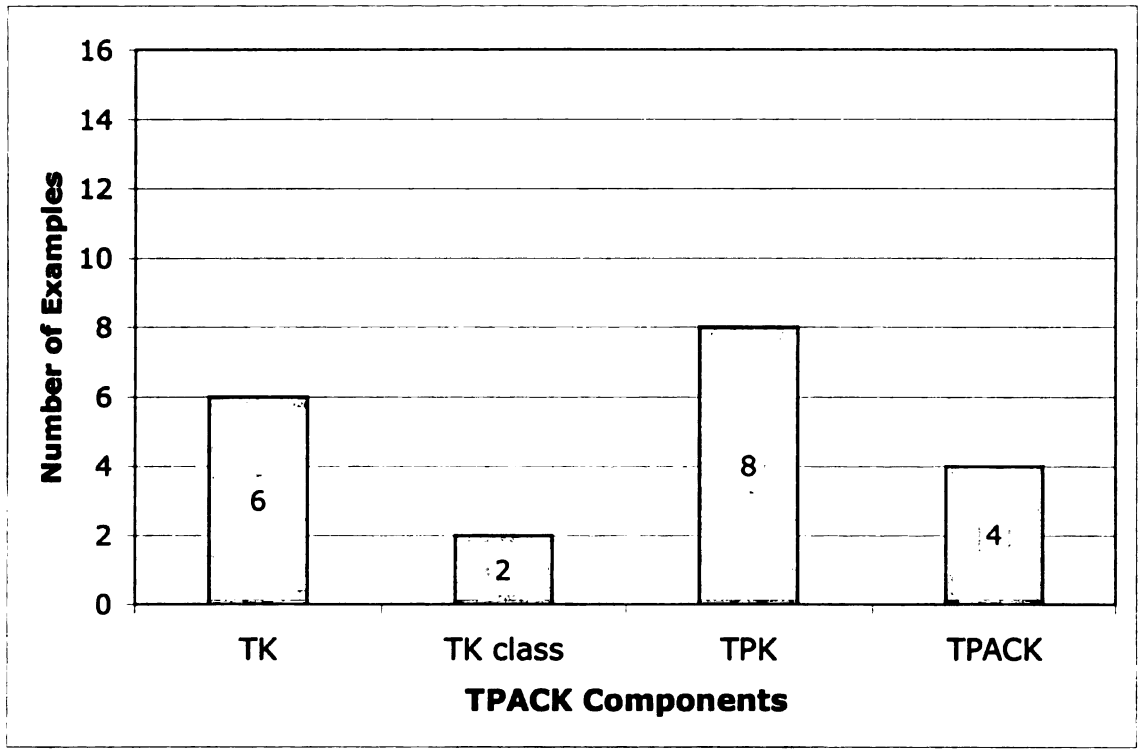

Figure 4. Ambrosia's lessons and personal uses exhibiting TPACK Components

Margaret, on the other hand, a secondary preservice teacher, dealt primarily with content, the French language and culture. In a literacy field she found many ways to tap into the new literacy development tools of video, audio, and the Internet to help her students learn French, so her TPACK was already developing beyond her TPK. I would expect that as teachers develop TPACK, that knowledge becomes stronger and more prevalent than the more general PK, CK, TK, TPK and TCK. One component knowledge, PCK, however, would continue to emerge along with TPACK. As Cox (2008) theorized, as a new technology takes on familiarity, it becomes part of the teacher's repertoire and is then classified as PCK instead of TPACK. PCK and TPACK, therefore, would continue to develop together as content-specific implementations of technology for educational purposes emerge.

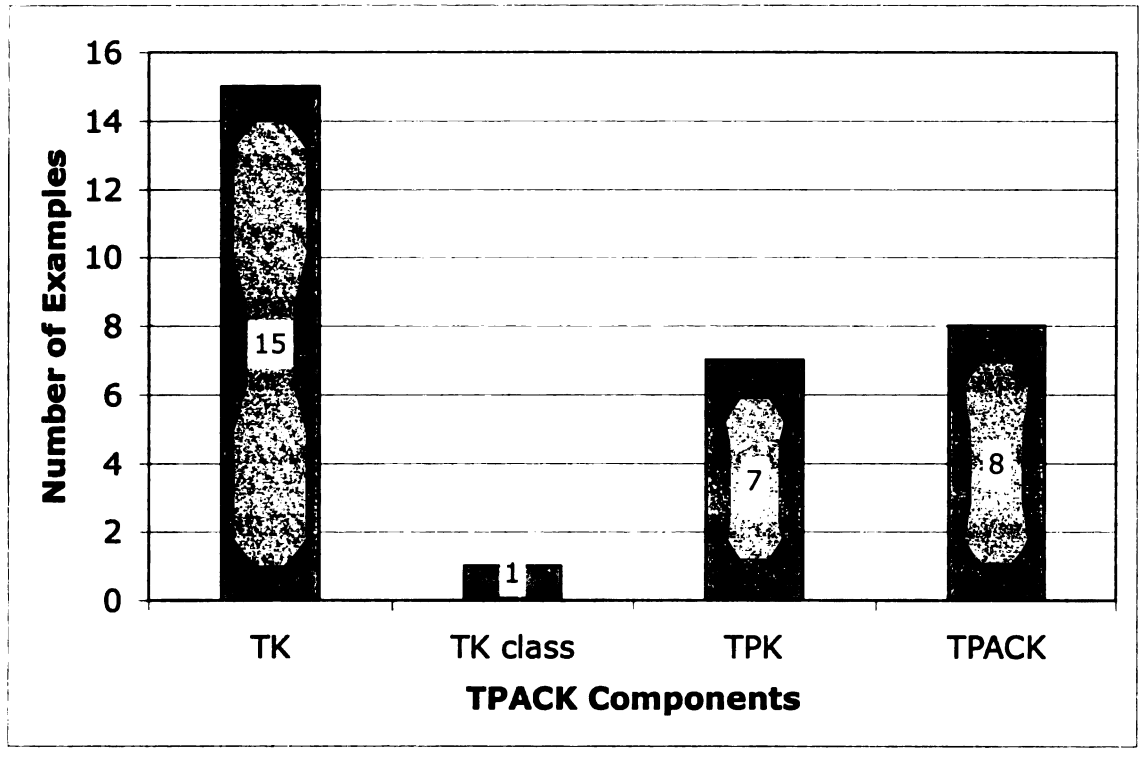

Figure 5. Margaret's lessons and personal uses exhibiting TPACK Components

This study focused only on the development of the Technology Knowledge integrations with Content Knowledge and Pedagogical Knowledge. Additional research focused on PK, CK, and PCK along with TK, TPK, TCK, and TPACK could illuminate this development more fully.

I suggest this developmental process as a descriptor of what seemed to be happening with the interns in this study. It is possible, however, that given other mediating artifacts within and across activity settings, as suggested by Ambrosia's and Margaret's data, the knowledge components and knowledge integrations might develop differently.

Breadth of TPACK

Technology Affordances

Are the interns "full spectrum frequency" (Ching, Basham, & Jang, 2005) users of technology? McCrory's (2006) categories and my one added category of amplification provided a window into the interns' thinking about technology and how they were employing it, whether for amplification, representation, information, transformation, or collaboration. In this data analysis I used only the TPK and the TPACK lesson examples from the interns' GRITS lessons and classroom uses because I was interested in pedagogical uses, not their personal uses. As shown in Figure 6, across all the interns, representation stood out as the most common use, with 33 examples given. Online videos, simulations of processes, animations of processes and satellite imagery gained the most implementation by the interns with their students.

Examples of taking advantage of amplification affordances numbered nearly as many as the representation examples. The amplification affordance is based in hardware's ability to enlarge and project the image of an object, computer screen, video, or other multimedia to enable the viewing and/or interacting with the materials by a person or group of people. It is not surprising, therefore, that when interns shared representations with students, if they had the hardware, they took advantage of the amplification affordance. The bulk of the amplification examples described document camera implementations: sharing a reading book, modeling note taking, filling out a worksheet together. Similar uses involved the SMARTBoard: filling in diagrams, playing a Jeopardy game, and viewing pictures. It should be noted that a large portion of reported

uses took advantage of the amplification affordance of technologies, an affordance that can be used for particular content, but often is not.

Given the informational affordances of the Internet, it comes as no surprise that information was the next most common technology affordance exploited by the interns. The interns working with their students gained information through webquests, online research, maps, and informational videos and podcasts, listing 24 examples across the group.

Transformative uses were rare because so many lessons were teacher led and not student-centered and so few put students in the role of a disciplinary learner. The seven transformative examples given included Lucy's plan for her students to research buildings in their community and share their findings on Google Maps and Terese's plan for students to record data on their plant growth simulation. Margaret's content area lent itself a bit more to transformative lessons through technology. Her students' practicing invitations using video, creating a French weather forecast, and planning a trip through Paris transformed their learning experience, changing the nature of learning to speak a foreign language from rote memory to authentic meaning making in another language.

Collaborative uses did not appear often in the interns' repertoire. Even though McCrory's collaboration affordance category (2006) showcased collaboration with peers and experts regarding data, I also included technologies that encouraged creative collaboration in production of a result, such as a video that required more than one person to produce, and podcasts that were posted for others' information or response. With the advent of Web 2.0 tools that encourage collaboration and communication, it was surprising that only five examples of the collaborative affordances of technology were

highlighted. It should be noted, however, that some of the interns' examples did demand collaboration on the part of their students. That collaboration was not technology enhanced, but created by the teacher and therefore not included in this collaboration category.

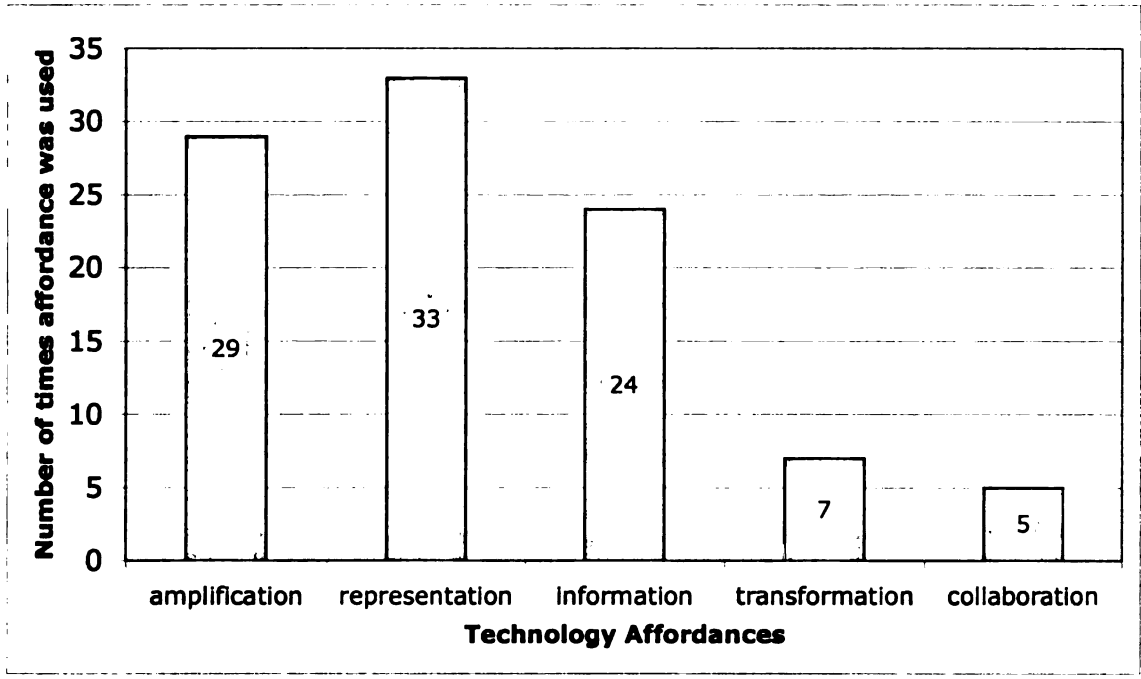

Figure 6. Technology Affordances that Interns Exploited in their Lessons

An argument can be made, however, that the content determines the technology affordance, so some content may demand more of one affordance than another. Such is not the case, however. McCrory's (2006) examples in all the categories draw from the science content area and Margaret, the intern in the French classroom, gave examples that drew upon all affordances within the foreign language content area.

I argue that the abundance of representation, information, and amplification affordances examples as contrasted with fewer transformation and collaboration examples is more of a resource issue and a pedagogical issue than a content area issue. Ambrosia's SMARTBoard resource enabled her to share representations and information

with her students, but it did not encourage collaboration any more than a white board. Ambrosia's uncertainty with the SMARTBoard as a learning tool surfaced as she expressed, "And I kind of wonder... how helpful it is for younger kids. I think they really get into it, but because with younger kids, what I've found is, they really need something where they can do it themselves too" (Ambrosia Interview, p. 8). Even though she shared manipulation of the SMARTBoard with her students, they could not all take part at the same time. Margaret's access to the multimedia MacBooks, on the other hand, gave her resources with all types of affordances. She and her students worked with video, audio, Internet, cameras, and a document camera and she took advantage of the affordances to aid her students' learning of the French language and French culture.

A related explanation for narrow affordance examples among the interns concerned pedagogical issues. Except for Margaret's, most of the interns' examples of technology use were teacher-directed and not student-centered. Typically the teacher presented in the front of the room and interacted with the students and the technology. Each intern did offer at least one example of students working with the technology, usually as a webquest accessing information on the Internet, so there was some understanding that technology is not just for the teachers' use. It could be that this teacher-directed instruction stemmed from the resource issue. Interns did not know how to compensate for lack of one-to-one classroom computer access or how to navigate the use of the computer lab. Or it could be a pedagogical issue dealing with instructional styles.

The lack of collaboration is also a pedagogical issue in that student work is regarded as individual and takes place within the classroom, not in authentic work on the

Internet or across school networks or via handheld devices. Some of the interns planned for minimal student collaboration. Kelly planned a small amount of collaboration into her wiki space, Lucy planned for collaboration in that each individual would contribute a part to the whole of the Google Map mashup of the community. Terese planned for partners to work with the plant simulation. Others assigned student collaboration in the creation of a product: Malia's groups built their podcasts together, Ambrosia's pairs researched, planned and produced brochures on their lighthouse; Margaret's students recorded movies and created comics. None of the interns, however, took advantage of the collaborative opportunities afforded by Internet sites where students could interact with experts and peers around the world. Chapter Four's focus on the interns' activity settings will shed more light on this issue concerning intern's TPACK development.

Figure 7 represents the individual interns' exploitation of affordances and reveals that some interns did not take advantage of all the affordances. There seemed to be a developmental component to the breadth of affordances as well. Looking across the individual utilizations of affordances (Figure 7), there appeared to be a progression of use (Figure 8). I suggest that taking advantage of the amplification affordance comes first for preservice teachers because it is easy to incorporate if the hardware is available. It simply amplifies pedagogical processes previously practiced. Such use, however, is hardware-dependent so it does not appear for all the interns. Representation affordance exploitation appears to be a use that most understand, and information is the next affordance most commonly tapped. It may be that teaching that takes advantage of representations and information, whether based in digital technology or not, is most familiar to these interns, possibly from their apprenticeship of observation. Taking advantage of collaboration

affordances and transformational affordances appears less often, meaning those affordances are a bit more difficult to implement or discover.

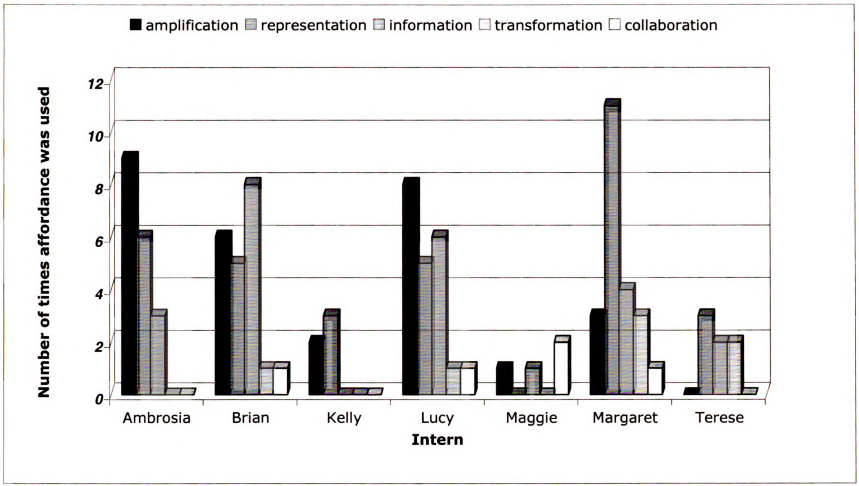

Figure 7. Interns' Individual Technology Affordances Exploited

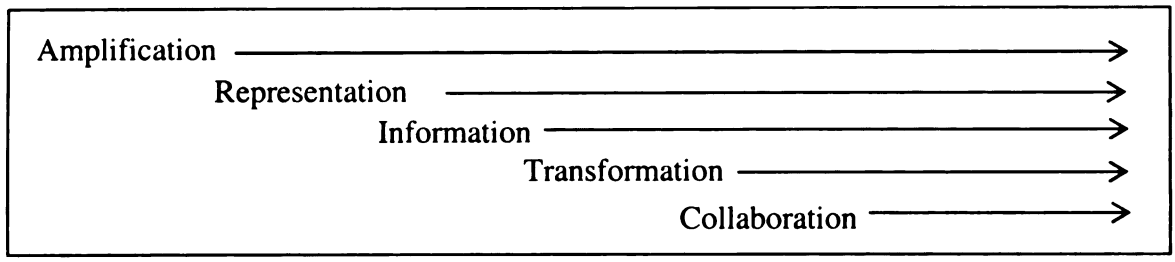

Figure 8. Developmental Continuum of Breadth of Teaching with Technology Affordances

Taking advantage of these affordances requires a more student-centered approach to instruction, employing inquiry learning, looking beyond the classroom walls, and planning authentic learning tasks. Perhaps developing the instructional mode is as much a difficulty as developing the TPACK. While I suggest that this developmental process describes this group of interns, I also suggest that developing knowledge of all five affordances and rich examples of exploiting each may change the order in which the affordances breadth is developed.

Content Areas

Another consideration in discussing the depth of TPACK is the breadth across content areas. As with the affordance breadth examples, only the TPK and TPACK lesson examples were included. Both Brian and Margaret, the two secondary interns, exhibited quite a few examples of TPK and TPACK, but Brian's examples dealt exclusively with social studies and Margaret's with French. Secondary interns spent many of their classes studying and discussing their discipline while elementary preservice teachers concentrated on a major or minors and focused on learning to teach all content areas. It makes sense that the secondary interns would exhibit more TPACK in their content area because they have spent so much more time learning the subject matter and

learning how to teach the discipline. Lucy, an elementary intern, on the other hand, used technology in math, social studies, and literacy lessons, but her uses were few in number. Ambrosia employed technology in both science and social studies in numerous ways, but did not branch out into literacy or math.

Representing the data in a few more formats brought up questions regarding content areas and technology use. With the secondary interns' examples exclusively in their content areas, their data was excluded in order to focus on the elementary interns and their content areas. Viewing the examples of TPK and TPACK lessons by content areas (Figure 9) showed many more intern social studies and science examples than literacy or math. Figure 10 illustrates that four out of the five elementary interns used technology in a science lesson. Three of the interns used technology in social studies lessons, two employed technology for literacy, and only one used technology with math. Combining their examples, in Figure 9 it can be seen that social studies examples are nearly double those of literacy and far more numerous than the one math example. It is important to keep in mind the small number of interns and their few examples, but with today's emphasis on math and reading instruction, and complaints of limited social studies and science instruction, it would seem that literacy and math examples would be more prevalent. The next chapter, which examines the activity settings in which these interns developed TPACK, may shed light on the reasons for the content differences.

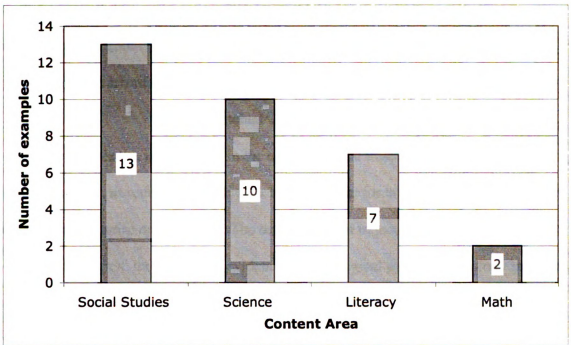

Figure 9. Elementary Interns' Combined Content Area TPK and TPACK examples

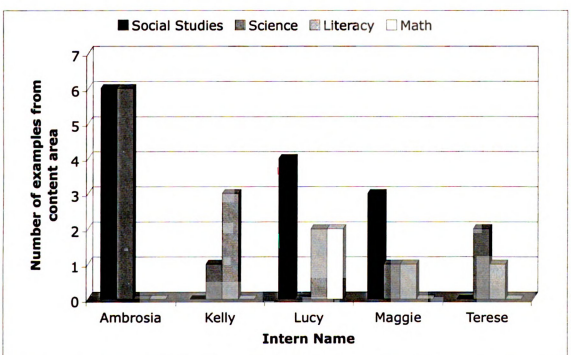

Figure 10. Elementary Interns' Content Area TPK and TPACK Examples

This discussion of TPACK highlights the complexity of the emergent knowledge. With so many factors to take into account, it is complex work for preservice teachers to

set the stage with technology that will best enable students to interact with content. They must take into account the grade level, the teaching most appropriate for the particular learners, and the affordances of the technology available in that particular place.

Developmental Trajectory of TPACK

This complexity is illustrated in the developmental trajectory of learning to teach with technology, as represented in Figure 11, a heuristic for thinking about the different aspects that comprise development. The developmental trajectory takes into account several factors: first, the amount of evidence of pedagogical uses of technology in action, which means the total of TPK and TPACK examples; second, TPACK breadth in terms of content areas and affordances exploited in the TPK and TPACK examples; and third, the depth of pedagogical uses of technology to teach particular content as evidenced in the number of TPACK examples. Because this developmental trajectory aims to identify and track flexible knowledge for teaching content with new technologies, the other TPACK components evidenced in teacher practice (P, C, PCK) are not included. The three aspects of the developmental trajectory make it multidimensional, yet do not capture all the complexity of TPACK development within contexts.

The developmental trajectory begins with no technology in teaching and builds toward teaching content with technology in ways that make content more accessible to students. The developmental trajectory actually has no end because new technologies continue to evolve so teacher knowledge for teaching content with them also continues to emerge.

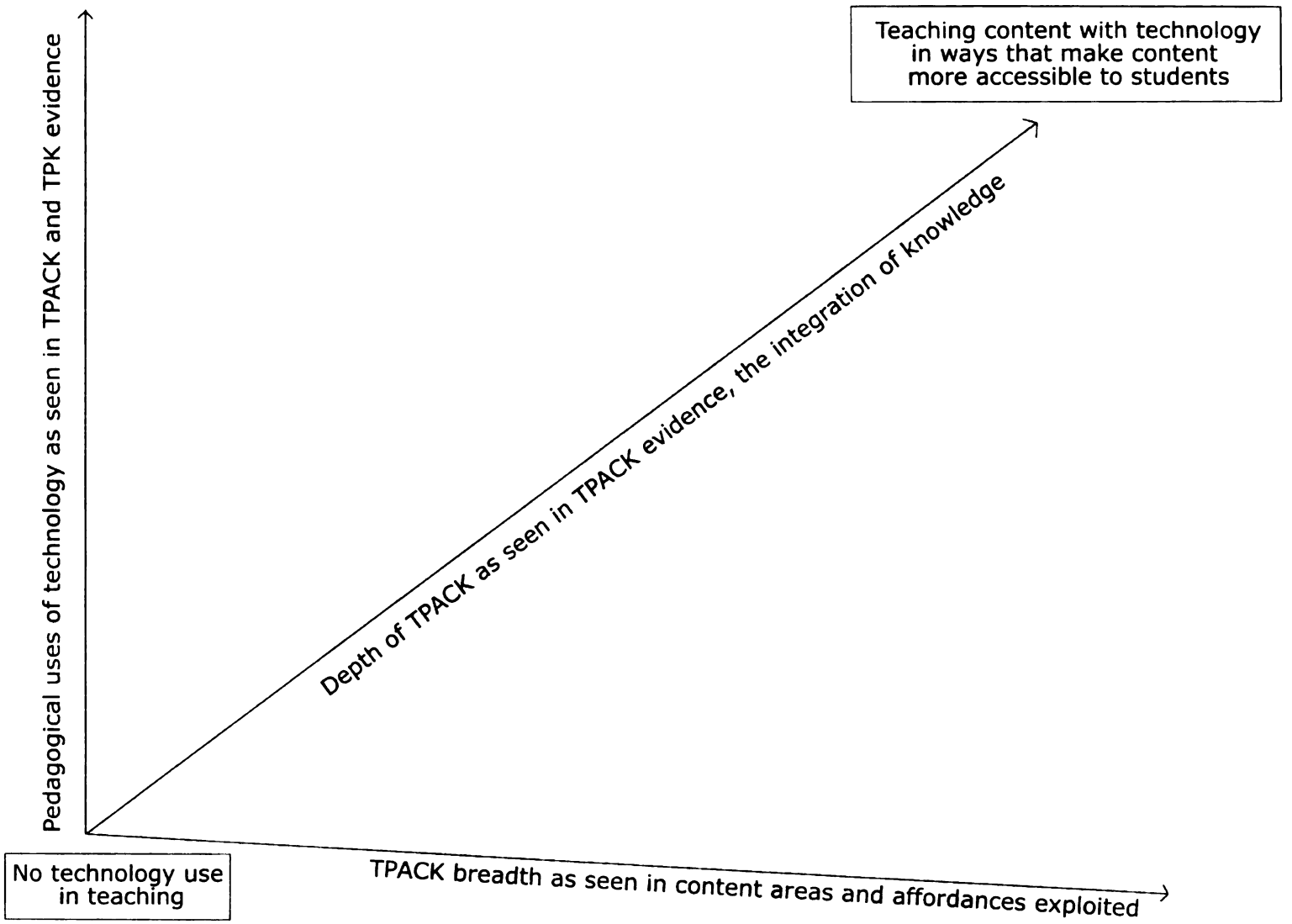

Figure 11. Trajectory of TPACK Development

All the interns in this study belong somewhere on the developmental trajectory because they have all evidenced TPACK components in their teaching. Taking into account instances of TPACK component evidence, it is difficult to place interns at just one spot on the trajectory because of the myriad of factors involved. Ambrosia seemed to be further along on the trajectory because of her many uses and design knowledge, yet Terese's choice and evaluation of software highlighted her critical knowledge and desire to fit with her content even though she did not report many classroom implementations. Lucy and Kelly both dealt with the problem of little access to technology and therefore their TPACK might not be as evident as others' due to lack of opportunity. Those who gave more project evidence, Ambrosia, Brian, and Margaret, were further along the TPACK evidence developmental trajectory than those who provided less evidence. But Lucy and Terese surpassed Brian and came close to Margaret with the number of TPK examples. They, too, were on their way towards using technology in general ways in the classroom.

The GRITS program aimed at technology integration and while it did specify that activities be tied to the curriculum, it did not require the technology to be content-specific. The seven interns, therefore, varied in the focus of their knowledge. Ambrosia sought to plan lessons that capitalized on the strengths of the SMARTBoard with her social studies content. Because of that, many evidences of her TPK can be seen in her finding new ways to use the SMARTBoard pedagogically. Her TPACK also came together as she thought about the difficulties of the content and how the affordances of the SMARTBoard, i.e., animations, highlighting, moving objects, saving activities for later use, could aid her student learning. Terese's technology choice, Science

Simulations, connected closely to specific content so she needed to deal with the interaction between the specific content and the software, forcing TPACK development. Brian and Lucy's work with Google Maps and Google Earth naturally connected with representations for geography and the social studies, and Margaret's French content intertwined easily with the communication tools she chose. Kelly's wiki, Malia's podcast, and Brian's podcast and PowerPoint presentations, however, proved to be more general pedagogical tools that could be used across content. Each use has its place, but the more specific an instructor can make the application, the better its fit for the particular content. Herein lies the rub with technology in teacher education. Should content-specific technologies be explored, or those that work across a broad range of content? Or is there an optimal mix of content-specific technologies and those that work across a broad range of content?

Because "each 'wicked problem' or situation presented to teachers is a unique combination or weaving together" (Koehler & Mishra, 2008, p. 18) of Technological, Pedagogical, and Content knowledge, Koehler and Mishra (2008) advocated that "teachers need to develop fluency and cognitive flexibility not just in each of these key domains, T, P, and C, but also in the manner in which these domains interrelate, so that they can effect solutions that are sensitive to specific contexts" (p. 18). As with most cases in development, growth of TPACK is often uneven. Because each "wicked problem" is unique, what was learned from previous situations did not always apply to new situations, so interns' TPACK growth pattern may not be consistently forward. Malia, for instance, used her TPK in developing podcasting lessons for her GRITS mini grant, working with the complexities of recording for an online audience and maintaining

copyright. While she implemented a revised version in her internship, she did not expand to other implementations on her own beyond what she planned with the 4th grade team teacher for science and social studies online activities.

Knowledge of Educational Technology's Purposes

In their GRITS applications and reflections, the interns noted their conceptions of the purposes for using technology in the classroom. In the interviews I asked what they thought the place of technology in education might be and how their use of technology with their students positioned their students to know and experience the world. From all of those data, several categories of purposes emerged (Table 4). Many of the interns talked about the economic efficiency and utility aspects of learning technology, reflecting the early emphasis of technology experts on learning the tools. Emphasizing the utility aspects, they noted their students' need of technology skills in future jobs and in order to be able to compete in the economy. Brian related the importance of "teaching them how to find these different websites because if you don't know how to do that you're just so far behind everyone else, especially kids coming out of schools like, you know, [the suburban school a few miles away]" (Brian Interview, p. 10).

The interns also discussed the cultural exposure benefits of using technology with their students, especially the Internet. As the French teacher, Margaret appreciated how she could share French movies and web sites with her students. Lucy noted how her use of Google Maps aided her urban students' understanding of the world.

> A lot of these kids have never left, you know, they walk from home to school and that's it. So considering they haven't seen anything besides those borders is to me an important concept. . . . technology can bring in, I mean, at least by an example. I mean when I showed them pictures of the Appalachian Trail and we did a zoom in, zoom out of like the earth. I mean, these kids might never leave [this city]. . . . But now you know twenty kids from [this city] have seen the end of the

> Appalachian Trail and they've seen, you know, a desert out in Nevada. And they've seen the Mississippi River. (Lucy Interview, p. 22)

An important general pedagogical purpose given by the interns was student motivation. The interns surmised that students enjoyed using computers so computer integration could motivate them to get involved in their schoolwork. In fact, according to Terese, her students like the computers so much they "fight over the computers" (Terese Interview, p. 2) and who gets to use them. Malia talked about her students' immediate engagement with computers and other technology. Another general pedagogical purpose of technology that interns noted dealt with teaching in different ways. Ambrosia elaborated

> I think technology provides, um, different ways of teaching. Different ways to present material. I mean, you can't just stand up and talk the whole time. You can't just take notes the whole time. You can't just read the whole time. You know, so, even using the overhead, and then using the front board. Two different forms of technology. (Ambrosia, p. 11)

A few interns also connected teaching to multiple intelligences with the multiple ways to teach afforded by technology.

All of the interns identified teaching and learning content as a purpose of educational technology. Ambrosia believed that students learned content through activity and technology offered opportunities for activity. Brian, Kelly, and Lucy talked about technology aiding in comprehension. Several mentioned the assistive benefits of technology. For example, Malia related how one of her students had such a difficult time with handwriting. It was slow, tedious work. But when he typed, his ideas flowed much more quickly. Brian worked to capitalize on the audio and visual components to aid his students' learning. Most of the interns named technology as a learning tool, although only two of the interns, Margaret and Ambrosia, named technology as an aid to student active

learning. Students involved in active learning reflect the new ISTE standards' focus on "creativity and innovation; communication and collaboration; . . . critical thinking, problem solving, and decision making" (ISTE, 2008, p. 1). It may be that the new standards' emphasis on effective learning is slowly being adopted.

Table 4
Interns' Conceptions of the Purposes of Educational Technology

Purpose	Ambrosia	Brian	Kelly	Lucy	Malia	Margaret	Terese
Economic Efficiency and Utility							
Needed for future jobs	x				x		
Compete in the economy	x	x					
Learn capabilities of technology		x			x	x	x
Speed up production	x						x
Communication					x	x	
Information					x		
Cultural Exposure		x		x		x	
General Pedagogy							
Motivation		x		x	x	x	x
Different Ways to Teach	x	x		x			
Teaching and Learning Content							
Active Learning	x					x	
Aid Comprehension		x	x	x			
Learning tool	x		x	x		x	x
Practice skills	x						
Assistive tool		x		x	x	x	

These interns displayed a breadth of knowledge about technology's purposes in education. Only one intern reported purposes in only one of the broad categories. While all of the interns demonstrated static knowledge of the purposes by talking or writing about them, for some of them, the knowledge became a mediator of action, that is, became a tool to encourage TPACK growth. In the next chapter, interns' perceptions of how their TPACK developed and the tools that encouraged TPACK growth will be outlined and discussed.

CHAPTER 4

LISTENING TO THE INTERNS: CONTRIBUTORS TO LEARNING TO TEACH WITH TECHNOLOGY

Using the TPACK framework to interpret the data in this study affirmed that participant's knowledge for teaching with technology was developing. But how does that knowledge develop? What factors in activity settings enable this flexible knowledge for teaching with new technologies? This chapter reviews the interns' perspectives on learning to teach with technology. It examines the activity settings of daily life, workplaces outside of teaching, their K-12 education, the teacher education program, the annual technology conference, the GRITS mini grant program, and their internship placements. Important mediating tools, setting rules, and responses to settings are highlighted.

Gaining preservice teachers' input on their TPACK development was difficult because they did not always differentiate between knowledge for *using* technology and knowledge for *teaching* with technology. When first asked about their readiness for teaching with technology, participants responded that they were prepared. In response to where they received that preparation, many of them talked about how they learned to *use* technology than how they learned to *teach* with technology. When pressed about how they learned to *teach* with technology, not just *use* technology, however, they responded differently. The difference is important for teacher preparation faculty and collaborating teachers as they work with preservice teachers who know how to *use* technology but still need guidance in learning how to *teach* with it. Brian explained,

> As far as using it myself, I feel very prepared. I- I can sit down and use Power Point, Excel, this other stuff that you have to do. But as far as, I realized this when

> I did the project, I hadn't quite thought everything through as far as, umm, getting the kids prepared because I assumed I took it for granted. (Brian Interview, p. 5)

Ambrosia differentiated between her comfort with applications like webquests and blogs and comfort with digital cameras. She explained her hesitancy with webquests and blogs, "I'm not sure I feel like I'm that prepared in the sense of I'm not sure about ideas to be able to use it. I think the majority of it is ideas of *how* to use it" (Ambrosia Interview, p. 4, emphasis added).

As the interns' perspectives on contributors to their learning to teach with technology are examined in this chapter, it should also be noted that there was not any one consistent influence, across all the interns, except for the GRITS program.

Contributors

As shown in Table 5, interns related a variety of sources for their learning to teach with technology that ranged from using technology in daily life and growing up in the digital age to their internship placement and helping students learn. As noted before, the influences will be examined in terms of their activity settings, with the activity settings and influences elaborated in the sections that follow.

Table 5
Activity Settings and their Reported Contributors to Interns' Learning to Teach with Technology

Influences	Ambrosia	Brian	Kelly	Lucy	Malia	Margaret	Terese
Daily Life							
using technology daily	x	x		x	x	x	
growing up in the digital age/feels natural				x			
parents supported		x		x		x	
Other workplaces				x	x		
High school model		x		x		x	
MSU Tech Conference	x						
Teacher Education							
classes			varied	x		x	
learning from colleagues	x	x		x		x	x
GRITS							
working with another and getting feedback	x	x	x		x		x
learning new ways of thinking about teaching	x	x	x		x		
learning tech possibilities				x		x	x
learning from colleagues		x	x		x		x
Internship Placement							
CT or other teacher	ideas	x		x	x		
thinking about ways to help students		x	x				
Across all settings							
passion/interest	x			x		x	
own research/trial and error	x	x		x	x	x	x

Daily Living/Home Environment

Four of the seven interns, Ambrosia, Brian, Lucy, and Malia, attributed their learning to teach with technology to daily living, or living in the digital age. Daily living involves surviving and thriving within contemporary society. In describing their personal technology use, all the interns, not just the aforementioned, revealed how technology mediated their living in the world. They used it for communicating with friends and family, for keeping in touch with the world, for enriching their lives with the arts, and for entertainment. Although the goal of daily life is not to learn to teach with technology,

with technology use a seamless part of all the interns' lives, their technology knowledge developed in an ongoing way in their daily lives. The important component of knowledge as design was also being mediated in their daily use because several of the interns talked about how they "play around with" the technology to learn it. They didn't necessarily take special classes to learn how to use their phones and iPods, but they "played" with them to learn how they worked, they asked friends for help and ideas, and they read instructions if needed. They tweaked the settings on their technologies to fit their particular needs, building their design skills along with assisting their daily living.

It is important to note, however, that the interns were not implementing many of these personal uses in their classrooms for their student learning. Table 6 highlights personal uses that were not transferred by any interns to the classroom for student learning. While interns used many different communication technologies and social networking applications like email, instant messaging, cell phones, FaceBook, MySpace, and blogs, they did not connect the communication affordances of these technologies to student learning. They also did not transfer any of the organizational tools, like databases, web mazes, planners, paying bills and purchasing online, or GPS, to the classroom to enhance their students' learning. The collaboration tools of Google documents, wikis, forum and FaceBook remained part of their own space and not their students'. As shown in Table 7, some did, however, talk about implementing iPods, digital cameras and digital pictures, digital camcorders and video editing, YouTube videos, video games, Internet research and news, and the Microsoft Office applications in their classrooms.

The cultural-historical influence may be partially responsible for the interns' lack of transferring their personal technology use to the classroom. The remnants of the

factory model of education remain and can be found in teacher-dominated instruction and the emphasis on students working on their own. Another cultural-historical impact might be in the technology standards. Even the first technology standards focused on learning the tools, not how the tools could be used for learning. Student collaboration and communication with experts and peers do not have a long history of broad implementation in U.S. public education so it is not surprising that preservice teachers do not connect collaboration and communication tools to their students' learning.

Table 6
Interns' Personal Technology Uses that did not Transfer to the Classroom

Personal Technology Use	Ambrosia	Brian	Kelly	Lucy	Malia	Margaret	Terese
Communication							
email	x	x	x	x	x	x	x
Instant Messaging	x					x	
cell phone	x	x	x	x	x	x	x
FaceBook/MySpace personal	x		x	x		x	x
blog		x					
Photos & music							
Photoshop photos			x	x		x	
Organization & productivity							
database					x		
web maze- keeping track of documents				x			
planner	x						
GPS				x			
Finances							
paying bills						x	
purchasing online					x	x	
Collaboration							
wiki for collaboration						x	
forum						x	
FaceBook/Linkedin professional		x				x	
Google documents, etc.				x			

Table 7 illustrates another way of looking at the overlap or gap between interns' daily life technology use and their technology use with their students. A plain x marks intern-reported classroom uses, with a bold **x** marking those personal uses that transferred

to the classroom. A plain o marks interns' reported personal uses that did not transfer into their classroom use. Some uses are uniquely classroom situated, like webquests, websites for student assignments, Science Simulation software, student typing, document camera projectors, grade reporting software, and the SMARTBoard, so overlap with personal uses would be quite unlikely. While Kelly, Malia, and Margaret researched on the Internet, they did not do so with their students. Ambrosia, Lucy, Malia, Margaret, and Terese did not talk about student uses of Microsoft Office, except that Ambrosia's students made a PowerPoint presentation slide. Terese enjoyed viewing YouTube videos, but did not use them with her students. While Lucy and Malia both recorded and edited personal videos, they had not done so with their students. Kelly, Lucy, Malia, Margaret, and Terese related using digital cameras and images in their daily life, but only Kelly and Lucy had used them with their students. Kelly accessed the news online but did not work with it with her students. On the flip side, some classroom uses that might have been also used in daily life were not reported by any of the interns. The interns who integrated interactive web sites for science concepts, animations, podcasts, Google Earth and Google Maps, and comic creations into their lesson plans did not mention personal uses of the same technologies.

Table 7

Interns' Personal Technology Overlapping with or Missing from the Classroom

Key: x= reported use in the classroom
x= reported use in personal life and in the classroom
o= reported use in personal life but not in the classroom

Technology Use in the Classroom	**Ambrosia**	**Brian**	**Kelly**	**Lucy**	**Malia**	**Margaret**	**Terese**
Internet							
webquest(s)	x	x		x			
created website for student assignment	x						x
student Internet research w/ provided links	x	x	o		o	o	x
web sites connected to curriculum		x			x	x	
interactive web sites for science concepts					x		
animations	x		x				
Science Simulations software							x
Microsoft Office tools							
student production of PowerPoint slide(s)	x	x	o	o	o	o	o
PowerPoint presentations	o	x	x	o	o	o	o
student use of Word, Publisher	o	o	x	o	o	o	o
allow student to type rather than handwrite					x		
Podcasts							
podcasts from iTunes		x					
teacher podcast of language examples						x	
student- produced podcast					x		
Google Earth/Google maps	x	x		x			
Video							
video clips from YouTube and United Streaming	x	x				x	o
student-produced videos				o	o	x	
Digital Imagery							
comic creation						x	
digital images	x	x	**x**	**x**	o	o	o
students' digital camera pictures			o	**x**	o	**x**	o
Edline		x					
News		x	o				
Amplifications							
Document camera/projector				x		x	
SMARTBoard map markups	x						
SMARTBoard diagrams	x						
SMARTBd sci & ss lessons	x						
SMARTBoard games	x						
SMARTBoard highlighter	x						

It is important to realize that not all uses may be appropriate for student use because of content or age considerations, but the discrepancy between the Technology Knowledge for personal use and the Technology Knowledge used in the classroom points out the need for knowledge beyond technological. TPACK, the flexible knowledge that integrates Technology, Pedagogy, and Content Knowledge domains did not seem to develop through these preservice teachers' experiences in daily life. It seems that something more is needed to make the transfer from life implementation to pedagogical content implementation. Ideas of what has the potential to aid the transfer should become clearer in the discussion of the following activity settings.

Although interns did not attribute their learning to teach with technology to home life with their parents, Brian related that his mother was "always been big on having a computer and Internet and stuff like that" (Brian Interview, p. 3). Lucy and Margaret remembered computer programs like Mario Typing, video games and movie-making software in their adolescent years at home. As will be discussed later, their home experience contrasted with many of their students' lack of home computer access.

The two secondary interns talked about connections between their students and technology. Margaret connected her students' world to the classroom as she thought about reasons to use technology. "You know, the kids that we work with are very technologically based . . . they use it everyday. We need to be able to, you know, hold their attention, so we do that with technology" (Margaret Interview, p. 2). Hoping to help his students, Brian mused, "Opening the door is just getting them to think about using it [technology] not just for email and MySpace because I think a lot of them, that's where the worldwide line kind of starts and ends" (Brian Interview, p. 10).

Other workplaces

Two of the interns drew upon other work places for their technological knowledge. In Lucy's previous work setting, she had served as a technology assistant to instructors in the College of Education and loved playing around with the technology. The goal of the setting was to equip instructors with technology and technology knowledge, so Lucy was expected to learn the technology and be able to assist instructors when needed. Lucy's technology learning was mediated by group training, talking with fellow technology assistants, or by her own individual exploration. "We were always working with technology.... I just had an interest in all that stuff. I just wanted to play with every toy possible" (Lucy Interview, p. 7). This setting built Lucy's identity as a technology savvy individual because she used technology so often and was considered an expert by instructors.

Malia's previous business career setting had profit as its goal and technology facilitated organization and record keeping towards that end. As database administrator, Malia was required to install software upgrades and continue learning the changes as they presented themselves.

> Well, I'd have to say a lot of that was just, um, carry over from my job, because when I worked full time, and I had that responsibility of ... administering that software program, I was kind of on my own just to figure out. . . . If they released a new version of the software, I had to go out and figure out . . . what's gonna work and what's not gonna work and do we want to update to this new version.... [It was] having to do it....[It was] a job that needed to get done, and you figure out how to do it, trial and error. (Malia Interview, p. 4)

Although Lucy's setting provided training if needed, Malia was on her own. The difference between the business setting expectations and the educational setting expectations regarding technology implementation is striking. Although teachers could

get along without learning the newer software, Malia needed to maintain her skills with shifting and changing software and hardware in order for her employment to continue. The school paradigm may be shifting slightly as schools require teachers to learn how to use grading software and communicate via email. In the daily instructional tasks, however, at this point a teacher can survive without technology skills.

It should be noted that while Malia and Lucy talked about their learning to teach with technology developing from previous work experience, neither setting focused on educational uses of technology, just the implementation of technology. Lucy may have picked up some educational ideas from some of the instructors with whom she worked, but she did not explicitly note that aspect of her work. So in these settings again, while the interns' technology knowledge grew, their Technological Pedagogical Content Knowledge as design did not.

K-12 Experience

> The goal of K-12 schooling centers on enabling
>
> students to construct and use knowledge in ways that (1) transform their thinking, (2) promote their intellectual development, and, over time, (3) prepare them to participate in and benefit from their society as knowledgeable citizens, capable workforce participants, and contributing members of families and communities. (Oakes & Lipton, 2007, p. xix)

The goal of K-12 schooling is not to teach preservice teachers how to teach, with or without technology, although such learning inevitably occurs. Lortie (1975) described how the apprenticeship of observation impacts preservice teachers' identity, perceptions of teaching, and their teaching. Preservice teachers learn from hours of sitting in classrooms watching their teachers and adopt them as positive or negative teaching models. They learn the mediating tools of worksheets and simulations, of movies and

lectures and learning tools. In the case of technology tools, however, the evidence suggested there is little of an apprenticeship of observation. Only two interns, Lucy and Kelly, remembered using any computers in elementary school, and used them for interacting with the Oregon Trail simulation software. In middle school both Kelly and Lucy recalled learning to type as their technology learning. Kelly also remembered working with a tessellation software program and Lucy worked on the yearbook staff using computers for layout, and learned science content through The Voyage of the Mimi. The other interns did not remember any computer applications from elementary or middle school. Kelly and Lucy observed their high school teachers using PowerPoint and online movies in their instruction and employing a document projector for mathematics instruction. Margaret described working with a partner to program their graphing calculators and also videotaping their group's presentation for a high school class. While very few of the group did not observe computer use in their high school teachers' instruction, most of the interns took a required word processing class in their high school career. As a second career preservice teacher and therefore older than the others, Malia professed to not having any computers in her high school until her junior or senior year.

These interns' apprenticeships of observation may have played a role in creating a vision of classrooms where collaboration is not encouraged and the paradigm that school exists within four walls. In such a paradigm, communication and collaboration beyond those walls is not necessary, except to consult experts via Internet research. As noted earlier, interns' personal uses of technology did not connect to their classroom uses. A closer look reveals a large discrepancy between the amount of daily life collaboration and communication implementations and similar implementations in school. Many personal

technologies enabled communication and collaboration while such school implementations were absent.

If interns are drawing from their apprenticeship of observation, teacher education programs face work in overcoming the null curriculum of not using technology and of non-collaboration and communication. In another light, this offers an opportunity to start fresh with some powerful ways of using technology for learning.

Technology Conference

One intern, Ambrosia, attributed her learning to teach with technology to the College of Education's annual fall technology conference. The daylong setting aimed at exposing educators, both preservice and inservice, to educational technology implementations. The Saturday conference offered presentations and workshops in a variety of educational technologies to mediate attendees' learning to teach with technology. Ambrosia clarified that she did not use any of the specific ideas from the conference, but gained confidence with the idea of teaching with technology when others demonstrated and talked about their ideas. It was at her first technology conference that she encountered the SMARTBoard and how a teacher used it in her classroom.

Although some of the sessions showcased particular implementations of technology to teach particular content, most of the sessions focused on the technology and its affordances and constraints. Thus, while the conference may have mediated some TPACK development, for preservice teachers without the Pedagogical Knowledge or content to which to apply the technology, TK probably resulted more than TPACK.

Brian felt it was great to be part of the technology conference and to attend the other sessions, but thought it would be helpful to have different workshop sessions spread

over the year for interns to attend. Although all of the GRITS participants presented at the technology conference as part of their grant requirement, none of the others named the technology conference as a learning tool except within the context of their GRITS experience.

Teacher Education

Just two of the seven interns related learning to teach with technology in their teacher education courses. The goal of the teacher education setting is to

> provide teacher candidates with opportunities to gain the critical knowledge and skills needed to teach all children.... [and to prepare candidates] in both subject matter knowledge, gained through strong undergraduate academic coursework, and in classroom instruction and management, gained through combined bachelor's and post-baccalaureate education courses and field-based experiences" (Department of Teacher Education, 2009).

In the teacher education setting the preservice teachers' identities were shaped even more as they focused on gaining the knowledge, skills, and dispositions for teaching all children. As previously discussed in Chapter 2, the teacher education program had chosen to integrate the technology strand into all the content methods courses in order to aid preservice teachers' connections of technology to instruction. Reflecting on that setting, some interviewees talked about technology integration discussions that mediated their learning to teach with technology. Brian appreciated it when fellow students shared their ideas of technology integration, although the sharing was not instructor-prompted. "Technology was only seriously discussed in my [senior level methods] classes when we, the students, brought it up" (Brian Reflection, p. 4). Terese talked about her moment of learning when she heard others talking about using web pages they had created for their students' learning. "I had made web pages before and I just never thought of making a web page for them and having it accessible in the computer lab" (Terese Interview, p. 3).

Once she connected web pages with student learning, Terese implemented the idea. Ambrosia had used other colleagues' general ideas and then revamped them to fit her situation. Terese wished technology and learning would have been discussed in her content methods classes. She wished for more guidance in using technology in effective ways to teach content, thereby mediating her TPACK development.

Margaret related how one of her professors had mediated her TPACK growth, "My methods professor at MSU is very into technology. So she's kind of given us some ideas, she pushes us to use technology a lot" (Margaret Interview, p. 2). Margaret's instructor took advantage of using technology to bring her students together.

> We have [online] discussion forums every week, so anything that's going on in our placement, if we want to ask for specific ideas for lesson plans or if we're having a hard time with classroom management, kind of throw ideas out there or ask for ideas or stuff like that. So it's really helpful. (Margaret Interview, p. 1)

Margaret also shared how her classes had taught her to scaffold students' use of technology, not assuming technology knowledge students might not have. She found that important as her students' technology skills differed greatly in her two placements. Lucy took the elective Teaching and Learning with Technology course and summarized what she learned from it.

> I love that class. I love everything about it. I love the whole aspect of just finding out new technology.... I took that class and then the class kind of said, "Yup, you can use so many tools but you really have to go out there and find your own" (Lucy Interview, p. 7).

Kelly hedged a bit on teacher education's influence, "Although we were exposed to teaching with technology my senior year at [the university], I have not been entirely confident in my ability to do this" (Kelly Reflection, p. 2). It seems that exposure to technology as mediation was not enough for Kelly. Malia related that her science class

had "talked a little about technology with science" (Malia Interview, p. 3), but they were not new ideas for her so she felt they had not impacted her learning to teach with technology.

Modeling educational technology use was another way the teacher education program impacted the interns' learning to teach with technology, but it became a negative influence for Terese. As she watched her instructors fumble with the LCD projectors or not be able to find files they had saved, she felt discouraged. The mixed messages she received bothered her. "'Time is crucial.' They keep pushing 'time is crucial' but they're wasting our time to find a file that they could've just placed . . . on their desktop" (Terese Interview, p. 10).

Terese focused on negative modeling of hardware use, but other interns' instructors modeled using technology for teaching content. The preservice teachers, however, did not recognize it as modeling and viewed it as part of their learning the content. Lucy talked about Lesson Labs specifically and other technologies in general in the science methods course. Her class used technologies designed specifically for the science content area and some more general software. Kelly, on the other hand, in spite of saying that she did not learn how to teach with technology from her teacher education classes, later recalled using Kidspiration in her science class and thought about using it when asked about helping students use organizers in their learning.

Kelly felt that she had learned new ideas about technology through her literacy class and the assignment to explore new technologies. Several interns talked about learning to see literacy as more than reading and writing with paper and ink but also including visual, cultural, emotional, and other ways of reading the world and

communicating with the world. Conceptualizing new literacies and the importance of aiding in students' new literacies development served as a mediator for some interns' learning to teach with technology.

When asked what message they received from their teacher education program regarding teaching with technology, half of the interns responded that they heard the explicit message that technology was good and that they should use it in their teaching. That message fit with the commitment shown by the teacher education department in incorporating the technology strand and in making teaching with technology part of the program's standards. Implicitly, however, some other messages came through in how technology was not used, in how instructors did not know how to use the equipment themselves, and in how students were not held accountable for using technology. Malia noted, "I almost felt like with some of the instructors that it was an afterthought. 'Oh, and the department says we need to do this, too'" (Malia Interview, p. 9). Some instructors excused themselves from the very tool they explicitly told their students to implement, while some even exempted their students from technological components of assignments. What is important to note with the interns' recollections is that they heard the intended message from the teacher education department, but they also heard the conflicting negative message.

It is also important to note that while some messages came through loud and clear, others did not. The interns who talked about using technology in their teacher education classrooms did not easily connect those same applications to their placement classrooms. It may be that they did not apply to the interns' grade level or content, yet they were not making connections of how they might use similar applications or

hardware for particular content. Modeling technology integration is important (Pope, Hare & Howard, 2005), but for modeling to serve as an effective mediation, explicit calling attention to instructor decisions (Boling, 2008; Fairbanks, Freedman & Kahn, 2000; Keating & Evans, 2001) and possible K-12 integrations seems to be required.

Teacher education programs will do well to provide time to discuss how specific applications might be adapted for differing circumstances in order to enable preservice teachers to begin the designing processing. Many interns referenced the ideas they learned from other colleagues. While the expected role is that the instructor provides the guidance for instruction, the preservice teachers were taking the lead and requesting discussions with their peers regarding teaching with technology. This role reversal does not need to happen because teacher education instructors can still maintain their pedagogical leadership role while asking for student input. They play a key role in developing critical analysis in their students. Even without in-depth knowledge of the particular technology, instructors can facilitate discussions about technology integration by asking students to identify the affordances and constraints of suggested technologies.

In addition, Kelly's observation about exposure also points up the need for practice with planning for implementations. Instructors can push their students to the next step by asking them to brainstorm specific contexts and content in which the technology would be particularly effective. Beyond discussing particular implementations, Malia suggested that preservice teachers go the next steps of planning for instruction with technology and implementing the plan. "I would suggest requiring the use of technology in one of the [senior]-level lesson plans. We were required to create a website but we weren't required to use any technology in the lessons we took to the classroom" (Malia

Application, p. 5). In the designing and implementation of instructional plans, preservice teachers continue to develop their TPACK.

Note should also be taken of the inconsistencies across the interns' experience, both across the group and across the individuals. The teacher education department had chosen to integrate technology across courses rather than offering a separate technology course. This made each instructor in each course responsible for some technology integration. When interns spoke of learning to teach with technology it was usually within the context of a single course, not across all their courses. Across the group of interns, there also was not one consistent course that stood out as aiding in teaching with technology, so each preservice teacher's experience was truly unique. A broader implementation across teacher education classes and instructors should encourage greater TPACK development, especially when it connects to the disciplinary content.

GRITS Experience

The seven interns participated in the GRITS summer mini grant experience. Because this setting focused on technology integration, the interns who applied were probably more confident in their teaching with technology and their expectations of how such teaching might look. The setting aimed to develop TPACK in participants through their learning new hardware or software and designing lessons for implementation in their particular internship placement. Three of the interns' collaborating teachers (CTs) chose to participate with their interns on the mini grant project. They received payment for their time as well.

All of the interns reported positive learning outcomes from the GRITS experience. They may have wanted to show kindness to me, the researcher and former

GRITS coordinator, but the individual responses mirrored the others' and fit with their classroom uses. Their reported learning mediators from the GRITS mini grant program encompassed five areas: colleagues, coordinator, lesson planning, technology as a tool, and technology possibilities.

Colleagues

The social aspects of interacting with other interns and the coordinator topped the interviewees' comments. Kelly learned ideas for teaching with technology from the presentations of the other GRITS interns at the technology conference. Because of lack of resources in her placement situation she felt she could not implement them, but she would use them in the future. Listening to the others made her realize the valuable tool that technology is and that she should use it whenever possible. Malia, Brian and Terese all noted that they learned from talking with the other GRITS interns and seeing their presentations of what they were doing. During their interviews, this remembering of others' projects stood out immediately. It gave the impression that they had spent a lot of time sharing their projects, but in reality they only had chance meetings with each other as they waited for individual consultations with me plus their time spent together at the technology conference. At the conference they had rehearsed their presentations in their small groups and then presented them twice, spending only a few hours with each other. Again, it was not much time, but sharing their projects made an impact.

Coordinator

All the GRITS participants worked with me, the coordinator, although some spent more time than others in face-to-face and email discussions. Brian, for example, joined the program late in the summer and had only about two weeks to complete his project.

Kelly traveled to South Africa for a month where she worked on her project but did not communicate with the coordinator for that time. Most of the others worked two to three months on their projects. Some sent plans early and often, like Terese, Malia, Lucy, and Ambrosia, but others, like Margaret, did not spend much time finessing the plans, sending the bulk of them at the end of the project time.

In spite of her absence for some of the summer, Kelly talked about how the coordinator opened her eyes to the complexities of teaching with technology. "Actually, like when I did the Internet lesson and you said, 'First teach them how to use the Internet, you need to teach them', and that had never even really come to mind" (Kelly Interview, p. 9). Brian, too, expressed his learning facilitated by the coordinator, "You also managed to explain in the most simple terms the difference between a goal and an objective. That was something I had trouble with all senior year but you just made it crystal clear. Thank you!" (Brian Email, p. 6). He along with Malia and Lucy also expressed appreciation for the feedback on lesson plans. Malia described, "Starting to plan for that, and then, . . . the feedback. 'Did you think about this?' 'Oh, I really hadn't!'" (Malia Interview, p. 11).

In both his GRITS reflection and his interview, Brian talked about how GRITS had challenged his approach to teaching and how it helped him think more critically about using technology. In reviewing his lesson plans I first suggested that he think about making his immigration lesson more group work than just a PowerPoint lecture, or even to make the PowerPoint more interactive. He responded that he did not feel group work would be constructive and that he preferred to stay away from animations in PowerPoint.

By his final version, however, he included more interactivity and discussion starters in the PowerPoint, but the lesson still depended heavily on lecture. In his

interview he spoke more about how his experience with his students taught him that PowerPoint lectures every day are not the most engaging form of instruction.

Ambrosia wrote extensively about the importance of the GRITS coordinator in her work, emphasizing the mediating effects of collaboration.

> I have learned many important things from writing these lessons, but I have learned a great deal more from the GRITS advisor.... She has taught me the importance of keeping the focus of the lesson on the content and not on the technology, as well as giving me many different ideas in how to use the SMART Board in my lessons. Throughout the entire experience, she has demonstrated the importance of keeping an open mind about new ideas and always considers new things. I have realized more than anything else, the importance of sharing ideas and working with others to enhance lessons in many different ways. I have learned that as a teacher, there is not just one person responsible for the education of a classroom of students, but many people that work as a team to teach the upcoming generations. (Ambrosia Reflection p. 1, 2)

I appreciate Ambrosia's emphasis on the sharing ideas and working with others. I did not know much about the SMARTBoard when I began working with her, but I learned from her as well as the others as they explored their technologies. We brainstormed together and talked about the limitations and possibilities of the hardware and software as they became evident and how implementation would be impacted. Terese, especially, faced a difficult challenge when she realized that her Science Simulations really wasn't that powerful of a simulation for learning about plant growth. After looking at it together and discussing what she had learned and what her students needed to learn, according to the GLCEs, we found another powerful use, that of building observation and data collection skills.

I feel it is important to emphasize that my Pedagogical and Content Knowledge enabled me to assist these preservice teachers even more than my Technological Knowledge. I argue that the same is true for teacher educators and collaborating teachers.

Technology as a Tool and other Purposes

"So the technology is just the tool! I'm supposed to think about how to teach the content using the tool!" (Ambrosia Meeting, June 18, 2007). Ambrosia's expression of enlightenment came with the "light-bulb on" look after she had been peppering me with questions to clarify my comments or questions. Ambrosia highlighted one of the meditating tools used in the GRITS mini grant. "Technology is the tool" became an important conceptual tool as she planned her lessons with the SMARTBoard. It freed her to plan for mud and water[9] when those tools were more effective and helped her look closely at the SMARTBoard tools for their best application. Terese echoed Ambrosia's perception of technology as a tool. "I believe that technology is an important tool to be used in the classroom but it is important to remember that it is simply a tool; it should not be the complete basis of a lesson" (Terese Reflection, p. 1).

"Technology is the tool" illustrates knowledge as design at work. Once Ambrosia and Terese connected with the concept and purpose of technology, they could use that knowledge as a design tool in their work with classroom technology.

Earlier I presented the findings from the interns' perceptions of technology in education and most showed a broad knowledge of reasons to use technology in the classroom. While Ambrosia continued to wield her knowledge of technology as a tool for learning, the findings show the others did not seem to act to the same extent on their knowledge of the purposes of technology.

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[9] Ambrosia's rivers and watersheds lesson planned for her to pour water over a large mound of clay to help her students visualize how watersheds functioned.

Mediating Tool- Lesson Designing

As Ambrosia's above quote references, the lesson planning exercise pushed the interns to use technology to teach particular content in a particular setting- a wicked problem (Koehler & Mishra, 2008). Kelly, Lucy, and Malia listed the planning process as an important component of the GRITS learning experience. This concrete tool helped them realize all the steps required to help students use technology as well as their own necessary preparation they themselves would need to do. Brian and Margaret felt the lesson planning helped them think about how to actually use the technology in a classroom.

The lesson plan design required interns to include the Rationale/Big picture of the lesson, the GLCEs, the objective of the lesson, procedures of the instructional activity, and assessment. This concrete tool aided my mentoring in that it required the interns to account for content and pedagogy, using the tool of technology and I could continue to call them back to the important components. An email exchange between Malia and me illustrates my trying to move her from technology thinking to TPACK thinking.

> Marj,
> Quick question regarding your comment about the Michigan History content . . . I wasn't sure about any history-curriculum specific content in the lesson plans because I'm not technically teaching the curriculum. The podcasting was going to be a culmination of a unit and would be used as an informal assessment. Should it still be included?
> Malia
>
> Hi Malia,
> Because it's being used as assessment, I would include it. . . .
> The technology is the tool to learn the content, not an end in itself (even though there are tech GLCEs), so think of how this podcasting is helping your students review the history content, or improve their writing and speaking skills, and what you expect to see from that. Does that make sense? Let me know what you think.
> So, am I reading your email right in that your CT is teaching the content and then you are helping with this final project? Because I don't want you to lose your

> focus on the curriculum, could you ask your CT for their (sic) objectives for the unit? . . .
> Marj (Malia Emails, p. 6-7)

In their final form, Malia's podcasting lessons included technology GLCEs, language arts GLCEs, and social studies GLCEs. The GLCEs reflected the complexity of podcasting and how it would aid in students' writing for a purpose, proofreading and editing, adjusting for an audience, placing events in chronological order, summarizing the sequence of key events, and identifying and analyzing problems from the past.

Ambrosia reflected on the importance of the lesson designing, and how it maintained focus on content.

> While writing these lesson plans, I have also learned about using other tools for teaching, but keeping the focus on the lesson content. ... I have gained an avid amount of experience in how to write lessons that focus on the content and not stray into other ideas or activities" (Ambrosia Reflection, p. 1).

In the GRITS setting, the interns varied in their approaches to designing lessons that capitalized on technology. Some interns, Ambrosia, Kelly, Lucy, and Malia, began with the technology, Terese began with content, and still others, Brian and Margaret, with pedagogical considerations. As examples, the three figures below, Figure 12, Figure 13, and Figure 14, trace Ambrosia's, Brian's, and Terese's processes of lesson design, each with a different knowledge component starting point, melding in another knowledge component and then adding in the third.

Ambrosia began with technology (Figure 12). She had seen a SMARTBoard at the Technology Conference, had demonstrated one for her senior level class, and desired to gain knowledge and experience with integrating one into a classroom. She knew objects on the SMARTBoard screen could be moved and that the user could write on the board and mark up images, but wanted to learn more of the affordances of the

SMARTBoard. Because users could move objects and mark up images, she felt that the SMARTBoard fit with her pedagogy of engaging students in active learning.

Ambrosia consulted with her collaborating teacher and received the major topics her students would need to learn in the first nine weeks of the school year. To gain more knowledge of how the SMARTBoard could be used with these topics, she accessed the SMARTBoard web site and perused the sample lesson plans in all four core subject areas: literacy, math, social studies, and science. For her GRITS work, after consulting her district standards guide, she narrowed her content focus to social studies, more precisely, the study of landforms, beginning with a lesson on United States landforms. At the same time she explored the SMARTBoard and its tools, learning more affordances such as the ability to highlight text and areas of the screen with the highlighting tool and the ability to record what happened on the screen with the recording tool. She also discovered the ability to cover parts of the screen with gray windows as well as the ability to create a slide show for instruction in the SMARTBoard Tools application.

Using her knowledge of the SMARTBoard's affordances, her knowledge of active learning, and her knowledge of United States landforms, Ambrosia planned a lesson introducing her students to the various landforms. She planned a pre-assessment in which her students would take turns drawing a particular landform on the SMARTBoard. A classroom discussion on the landform would follow with Ambrosia adding any necessary missing information and labeling necessary portions of the drawings. She prepared a slide show for the lesson and typed in the definition for each landform on its page. She made use of the moving objects affordance by covering the definition with a colored box that she or students could move later. After each successive landform

Ambrosia planned to project photo images of all the landforms thus far and all students would identify the name of each landform by holding up a paper with their answer.

Ambrosia connected the landforms to the affordances of Google Earth: the ability to view satellite images of land and the ability to zoom in and out and pan across images. She decided to add another component to her lesson, therefore, that of identifying the landforms in satellite view of the United States. She realized that students might not be able to connect aerial views with the side views she had used, so she planned to address that in her lesson as well.

While Ambrosia began with technology, she quickly integrated her Pedagogical and Content Knowledge as she planned instruction for her students with the SMARTBoard.

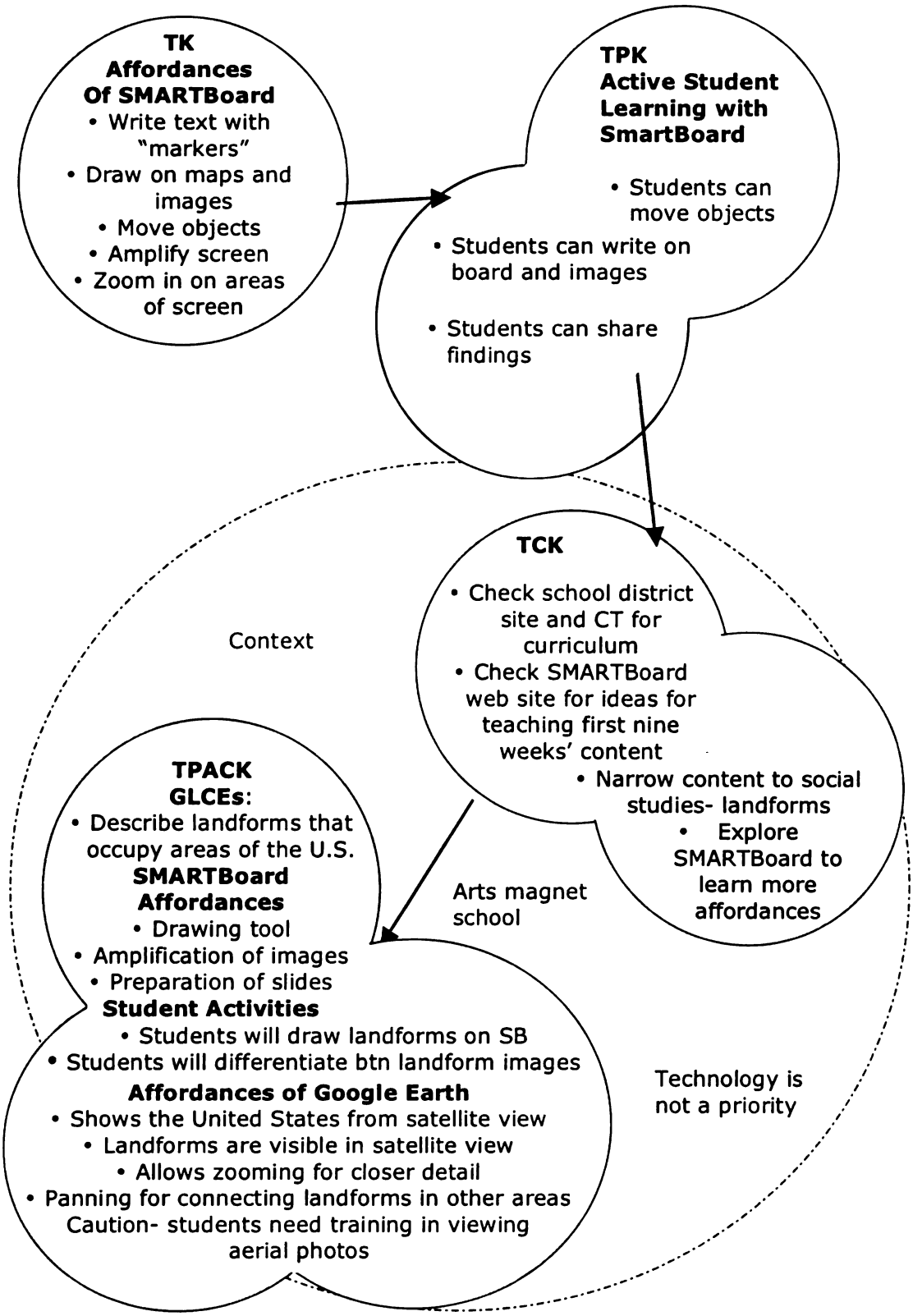

Figure 12. Ambrosia's Map of Integrating Knowledge

Other interns like Terese (Figure 13) began their work with content. She asked her CT for suggestions, but her CT left the door wide open for Terese's exploration. Looking for guidance, Terese emailed me with a description of the computer situation and then wrote about content. "The sorts of things that will be covered in science is- Earth materials, Lights and Shadows, Force and Motion, Plants. In Social Studies - economics, core democratics, regions. In Math - regrouping, multiplication and division and problem solving" (Terese Emails, p. 1). I emailed back with online learning possibilities and suggestions for overcoming resource issues such as borrowing from the university and recognizing that small groups on computers sometimes work better than one-to-one computing. I shared my key word search using her content terms and what I had found. Terese investigated the suggestions and decided to pursue the software for science simulations. She built her technology knowledge as she worked with the software, discovering its affordances and constraints in regard to the content she had considered. She noted that the Science Simulations afforded changing of the variables in plant growth and allowed speeding up the plant growth process. She expressed disappointment in the software's limitations in that it did not offer a variety of plants and the opportunity to discover the varying needs. She noted that the software did not enable saving of trials or recording of data. Terese expressed dismay that the software did not really enable students to discover how plants grow except that they require water, soil, and sunlight. As she and I talked, it became evident that even if the software only taught a little about plants, it could be used to teach about requirements for living things, observation, and generating questions based on those observations. She checked the Grade Level Content Expectations (GLCEs) for her grade level and found she could use the program to meet

different GLCEs than originally planned. In order to do so, however, she would need to supplement the software's shortfalls. Terese created a poster of measurements to aid students' understanding of metric measure and developed a science journal for recording of hypotheses, data, and questions based in the data. She then planned her instruction with the Technology and Content Knowledge and built her lessons on the pedagogical principles of scaffolding new material, inquiry, and working in pairs to increase learning.

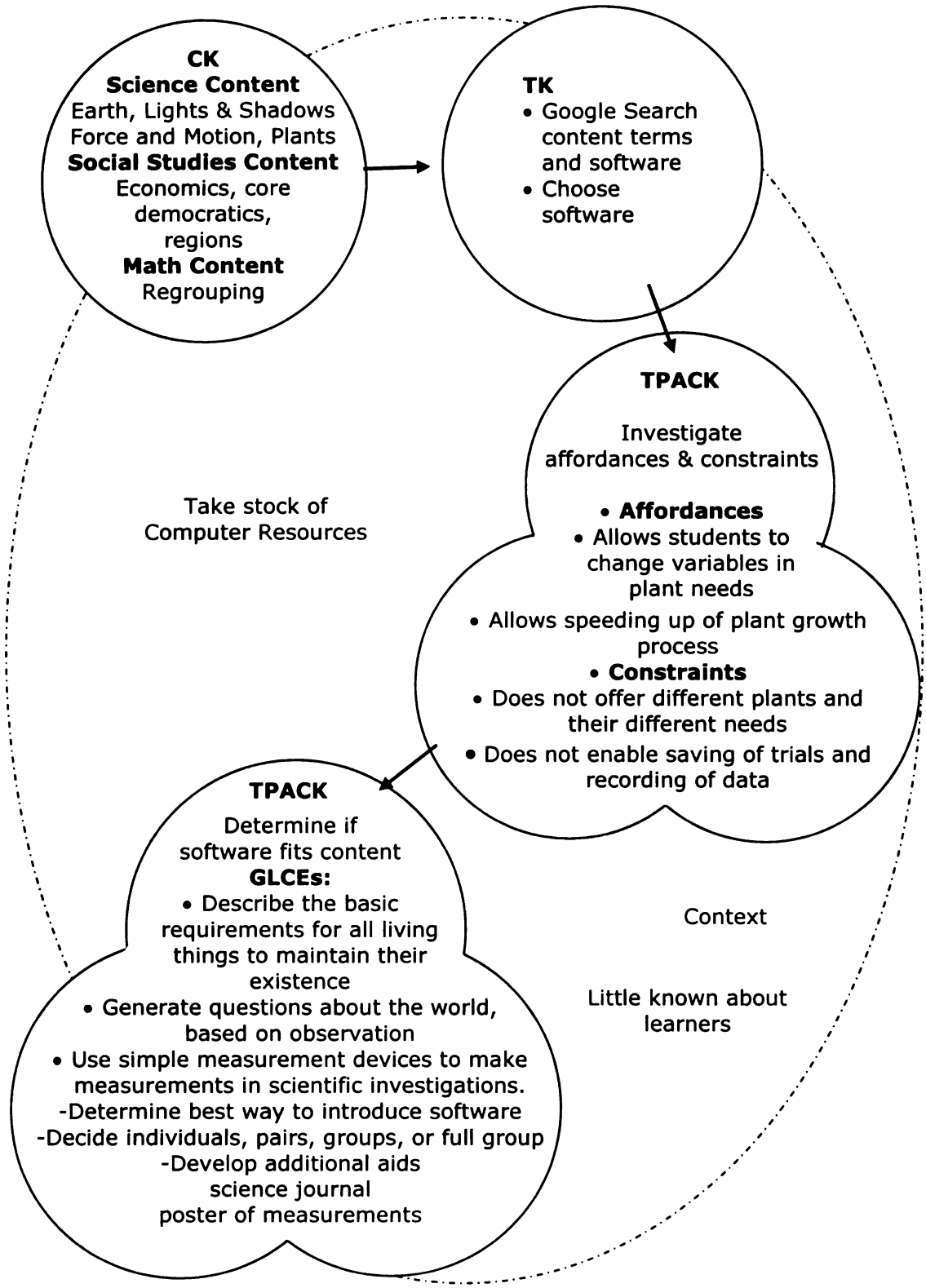

Figure 13. Terese's Map of Integrating Knowledge

Brian approached his grant from the pedagogical perspective (Figure 14). In his GRITS application he wrote:

> 1.) Technology will enable me to reach more students in a classroom full of diverse learners. Furthermore, it will allow me to strengthen students in areas they may be weak and don't have the resources needed to grow otherwise.
> 2.) Using technology would allow me to integrate the teaching of history into other subject matters and real world situations.
> 3.) Many of the ways I would use this technology would better prepare students for college and life in general after high school. They would work in groups in different ways then (sic) usual, improve their presentation skills, enhance their ability to organize, among numerous other advantages.
> 4.) A very unique way to use a microphone in a history class comes with digital story telling. I would be able to read an excerpt of a letter in a historical context in a way more engaging then just words on a screen. (Brian Application, p. 1)

In his application Brian's ideas for technology integration were not well fleshed out. "Unless indicated otherwise, none of this equipment I am applying for is subject specific" (Brian Application, p. 1). He requested podcasting software, photo and web site editing software, a web camera, microphone, and video iPod and planned to use Blogspot, Google Maps, and iMovie. In our first meeting we talked about software and hardware built into the MacBook laptops and other open source software such as Audacity and Movie Maker. We then discussed the affordances and constraints and advantages of one over the other. He realized that PowerPoint served as an organizational tool for his presentations and allowed him to display text as well as pictures. PowerPoint would allow him to smoothly link to other applications and media like Google Earth and YouTube, both of which Brian wanted to include in his teaching. Although PowerPoint encouraged the lecture format, Brian felt, pedagogically, that was the most appropriate instructional mode for his students, so he chose to base his lessons there.

In looking at Google Earth, Brian appreciated how it enabled various magnifications, and allowed movement around the globe without changing web pages. He wanted his students to be able to connect places to one another and Google Earth met that need. He thought of places such as Sutters Mill, CA, and Ellis Island, N.Y., and how beneficial it would be for his student to discuss them within their geographical as well as historical contexts. Given that only one computer in the classroom was capable of handling Google Earth, Brian felt confirmed in that it would be better for the class to view the Google Earth images together rather than working with Google Earth in small groups. Brian then surveyed his curriculum options and determined that the immigration and settling patterns of Europeans moving to the United States best fit his pedagogy and the Google Earth technology. Employing his TPACK, he developed a lesson on immigration in the late nineteenth century using PowerPoint as the basis for his lecture and classroom discussion points. He included links to Google Earth for viewing Sutters Mill, Pakistan, and Ellis Island in order to help his students better contextualize their learning about immigration.

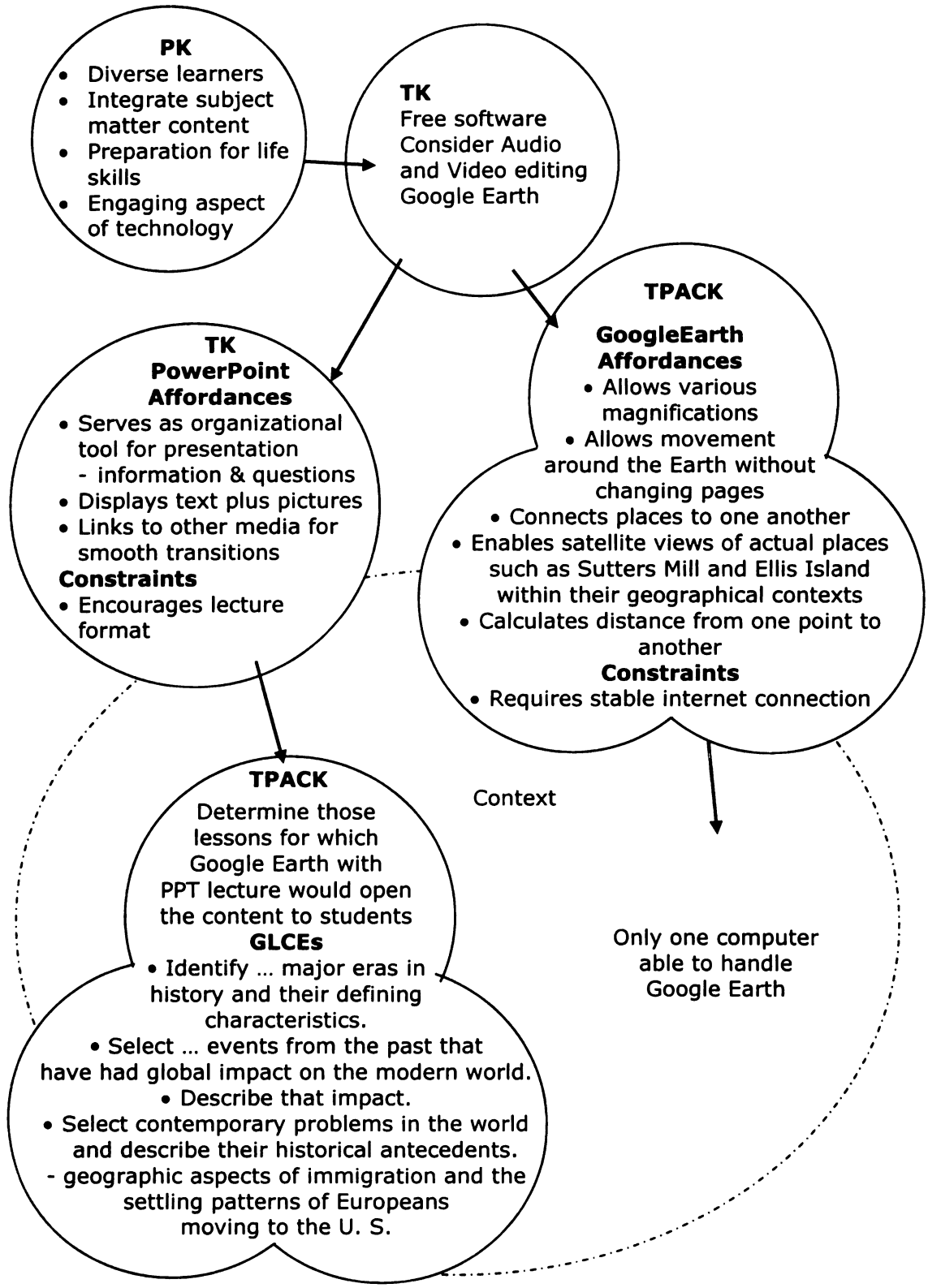

Figure 14. Brian's Map of Integrating Knowledge

While I have used step-by-step diagrams to highlight the process components, in reality the interns engaged in a process more like brioclage (Turkle, 1995) than linear step-by-step actions divided into categories. Bricolage involves "arranging and rearranging a well-known set of materials" (Turkle, p. 51), which is what the interns did as they worked back and forth between technological, content, and pedagogical concerns.

Lesson designing draws upon knowledge of the context and the students for whom the lessons are tailored. The interns' knowledge of their contexts, however, was not as rich as the interns hoped. In her reflection Lucy related that she wished she knew more about where her students lived so she could have better tailored her lesson plans to fit their particular community. She came to appreciate the amount of preparation and background information that good instruction required. Terese, too, expressed dissatisfaction with not having information on her students, but explained her learning along the way.

> I think that it was frustrating trying to write the lesson plans for this program because I did not know my particular group of students. I believe there are certain considerations that need to be taken when writing lesson plans concerning your classroom. I was not able to take these considerations into thought, and was unable to include any particular accommodations that would be needed in my lesson plan. I soon realized after beginning my exploration of this program that I was not only learning how to use the program itself, but I needed to learn how to use it as a tool in my classroom which was somewhat difficult. Again, due to not knowing my class and their previous experiences it was difficult to know how they would personally approach the program. (Terese Reflection, p. 1)

Even though designing lesson plans serves to mediate teaching with technology, Terese's comments touched on the importance of responding to students' ideas and their ways of thinking about content (Feiman-Nemser, Carver, Schwille, & Yusko, 1999). The comments serve as a reminder of what a wicked problem (Koehler & Mishra, 2008) it is

to bring together content and technology for pedagogical purposes within a particular context.

Design- Technology Possibilities

The GRITS experience opened the interns' thinking to the possibilities afforded and constrained by technology. In their exploration of their technologies in relation to their teaching, they developed varied nuances to the "Technology offers possibilities" conceptual tool, including one additional conceptual tool, "Technology is not so difficult to learn".

Brian emphasized the importance of the possibilities technology offered to reaching all students. His goal of meeting the needs of his special needs students encouraged him to try new technologies that assisted their learning. Malia related that GRITS made her more aware of the importance of using technology with her students. "Kids love the technology. And so I think any time that you can use it to enhance what it is you're trying to teach, you almost have an immediate buy-in." (Malia Interview, p. 7). Margaret went one step farther in declaring. "Technology is not only fun, but necessary to use in a classroom to reach all learners" (Margaret Reflection, p. 2).

Kelly reflected that she learned she "should not limit options with a lesson when there are so many possible ways to integrate technology" (Kelly Reflection1, p. 1). She expressed her surprise at how quickly and easily she learned to create a wiki, taught herself how to use a digital recorder, upload videos, and explore the various components of this new technology. In her GRITS application she had planned to use a blog but then began asking questions about the best tool to use. After examining blogs and wikis and their affordances and constraints, she decided to use a wiki because she wanted her

students to be able to post and edit each other's work. "Wikis allow more information to be added at any time-each student can have their own page. Wiki is [*sic*] more classroom friendly for this project" (Kelly Presentation, slide 5). Brian, too, remarked how easy it was to learn the new software. He also appreciated the possibilities of the free open source options. Terese recognized how her experience set her apart from her non-GRITS intern colleagues.

> It's harder for them to think of ways to use it versus because I'm exposed all of the different things. I might have a rough idea and then if I can run it by someone like Ambrosia . . . or . . . emailing to you, I have a lot, a greater idea of the possibilities . . . versus somebody that doesn't know the capabilities of their computer and what their computer is able to do for them." (Terese Interview, p. 10)

Lucy, too, talked about possibilities. "[GRITS] helped me see where my limitations are and, like, what is possible (Lucy Interview, p. 18). She went on beyond her planned Google Map mashup of the school's community and listed several possible extensions such as recording interviews with local residents and employees; calculating perimeter, distance, and area; learning geographical terminology; studying why businesses chose their locations; and the history of the community. "I feel that it was easy for me to brainstorm possible extensions for this project because the use of technology had allowed me to unite so many subjects into one massive unit of study" (Lucy Reflection, p. 2). Kelly also wrote about the new ways of thinking about teaching that she gained from her GRITS project.

> I had originally only thought of the wiki as a way for students to explore social studies and literacy through technology. However, after experimenting with this technology, I realized that a wiki can be used as a place for students to communicate and express their own opinions. The wiki can also serve as an on-line newsletter for parents or a place to post assignments and upcoming events. If there was enough time in the school year, my lesson could also have been expanded to require students to report on a local, state, and national event. There

> are endless possibilities to consider when using a wiki, so I hope that I will be able to explore more ideas for my future classroom. (Kelly Reflection, p. 3)

Once Ambrosia worked with her GRITS project, "It kind of kept getting my mind thinking on technology and how to fit it in" (Ambrosia Interview, p. 9). Combined with her other activity settings, the GRITS experience reinforced Lucy's passion. "But I think if, at least for me, understanding how much technology can bring to the classroom, and to the students, and to an educator, is I think one of the things that drives me and my interest in it" (Lucy Interview, p. 22). Margaret summed it up for all of the interns, "I feel like it's more important. Like, yeah, I can really do this. Like it's possible" (Margaret Interview, p. 4).

Identity

Margaret's confidence echoed that of the others. The interns' presentations at the technology conference set them apart as experts in teaching with technology, those whom others consulted with their technology questions. They were beginning to identify that a well-trained teacher uses technology to help their students' literacy and learning. The experience also built up their identity as teachers, having written and modified their lesson plans based on feedback from the coordinator. All of them had also spent some time with their CT determining content, so they had also built their identity as a co-teacher in the placement classroom. Their lesson plans were set, they had access to all the resources required, and they felt ready to teach with technology.

Summary

To sum up the GRITS experience, several mediating factors contributed to building TPACK of interns: the sharing ideas with fellow GRITS interns, the collaboration with the GRITS coordinator, the concrete design tool of lesson planning for

technology and content, the concrete tool of learning technological possibilities, and the conceptual tools of technology not being difficult to learn, technology assisting the differing learning needs of students, and technology is a tool, not the content to be learned.

It should be noted again that the interns' learning tools were not the same across all the interns. Some grew more from colleagues' interaction, others through working with the coordinator. Not all employed the concept of "Technology is a tool" to mediate lesson designing, but those who did found it very effective. All but one identified the lesson planning design work as a powerful mediator, so that is one mediator that especially seemed to connect with many different teacher learners.

The effectiveness of the GRITS setting depended also upon the rules of the mini grant maintaining accountability and the defined roles aiding access to necessary resources. Although the mini grant community was confined to the summer of 2007, the interns continued to ask each other and the coordinator questions on integrating technology. Their identity, developed within this activity setting as teachers who use technology, carried into new activity settings to serve as a mediating tool there.

Placement Setting

Collaborating Teachers

Collaborating teachers (CTs) play a large mediating role in placement settings. While the goal of field placements is universal, that of preparing preservice teachers in classroom instruction and management (Department of Teacher Education, 2009), CTs vary in their strengths and weaknesses and thus their influence on their interns. Working with interns each day, it is expected that they exert quite a great amount of influence and

share knowledge of learning to teach. In terms of teaching with technology, however, another story emerged of teachers who knew less than their interns both in terms of how to teach with technology and in how to use technology itself. One collaborating teacher asked her intern how to compose an email message, a simple, every-day task by interns' standards. Ambrosia's collaborating teacher tried the SMARTBoard only once and when it did not work as she wished, she did not ever try it again. Ambrosia perceived that she needed to convince her CT and other teachers that technology was a valid learning tool.

Two interns, Brian and Malia, related learning some teaching with technology from their CTs or their CT's team partners. Brian's CT shared his photography and graphics skills with Brian so that Brian felt more confident about his ability to enhance student learning through placement of photos on PowerPoint presentations. Malia worked with her CT's fourth grade team member to find web site activities for working with curriculum content. Her team CT planned lessons employing online climate data as well as the manipulation of virtual simple machines. Malia did not feel, however, that she had learned anything about teaching with technology from her own CT. "She uses technology, but I think I knew more coming in than what she did" (Malia Interview, p. 12).

> At one point I, I wrote a letter to, to the parents about a project we had going on, and I created a Mail Merge so that it would insert their names and the project title because they each were doing something different, and what day they were gonna present on, and she's like, "How did you do that, didn't it take you a long time?" and I'm like, "No, I just did a Mail Merge," and she's like, "Well, I wouldn't even know how to do that!" (Malia Interview, p. 12)

Malia attributed the difference between her and her CT's Technology Knowledge to her previous full time work in the insurance business. It is important to note that Malia's example did not concern teaching with technology, but employing technology in the

professional work of teaching. She probably did not differentiate the two and did not recognize or understand her teacher's PCK or TPACK. Kelly's teacher showed her the difference a technology can make, whether it is a new or old technology.

> My CT suggested the . . . cassette tape for *Sarah Plain and Tall* because . . . when we were reading the book I didn't anticipate . . . the dialogue. There's a lot of dialogue so they were having a hard time understanding who was who. So, with the voices it really helped them understand who was talking. (Kelly Interview, p. 4)

Even though Kelly did not note it, her example showed that CTs were exhibiting PCK, using the tools available to make content more accessible to their students. Collaborating teachers do well to engage in explicit calling attention to decisions about technology use so their interns can understand the processes and principles involved.

For several interns, the refrain sounded the same: "My CT encourages me, but doesn't know how to help". Their CT backed their interns' technology implementations, but did not discuss them or feel they knew enough to aid the planning. Terese expressed her frustration,

> My teacher gives me complete freedom, but there's times if I'm not really sure I don't have somebody that I can ask...because I can't ask her, so if I think, "Well, I wonder if I could make this work?" I'll ask her and she'll go, "I don't know" (Terese Interview, p. 8).

Lucy's experience sounded similar to Terese's:

> I could've implemented- my mentors, they're really easygoing about, you know, "If you have a good idea throw it in." But that would've just taken, I would've, I think to do it successfully I would need kind of a partner that I could trust and rely on. If that's maybe a parent helping me out, or somebody to bounce ideas off because they [the CTs] were both so clueless about the idea that it kind of just got tossed out of the window. (Lucy Interview, p. 18)

While their CTs could help them with classroom management and instruction, most were ill-equipped to help with learning to teach with technology because of their own lack of Technology Knowledge.

> No, my CT really is technologically illiterate really... She didn't even know how to send out an email. She knew how to reply to an email. But she was on her computer one day and asked me how to send an email... I had to show her how to do that.... She can do it on her own now but she... knows how to do the basic check her email. And she can do some web browsing but the minute something goes wrong or something comes up she just freezes and she's not really sure what to do with it. (Terese Interview, p. 4)

Role reversal happened in the settings where the interns knew more about teaching with technology than their CTs. Instead of the CTs teaching the interns, the interns taught the CTs. While the interns benefited from teaching their CTs, greater benefit to both the CTs and the interns could result if the CTs could realize what they have to offer with the PCK they draw upon in their teaching and the interns recognize how they can benefit from their CT's PCK. Margaret understood, "They can kind-of give you that perspective that we don't have as far as time constraints and how to structure an activity like that" (Margaret Interview, p. 6). Salomon (1993) claims in distributed cognition

> there is much *guided stimulation-* or better, *qualitative scaffolding,* whereby one partner activates, provides meaning to, and possibly directs the cognitive activity of the other and thereby qualitatively changes the activity.... [They] do not so much off-load their cognitive activity on one another as reciprocally scaffold it" (p. 133).

In scaffolding each other's learning, the CTs helping the interns' PCK, and the interns aiding the CT's TK, both could build upon each other's strengths and both develop stronger TPACK (Margerum-Leys & Marx, 2004).

Technology Staff

Technologists were in charge of the elementary computer labs in three of the

placement schools. Their presence made technology not the responsibility of the classroom teacher, but "Somebody Else's Problem" (Koehler, Mishra, Hershey & Peruski, 2004), and the classroom teachers did not get involved. The presence of the technologists reflected the earlier paradigm of learning technology to learn the tool's capabilities. Interestingly, all three interns in these schools spoke negatively about what happened in the computer lab. Lucy did not know a lot about her students' weekly one-hour class but she had heard from others.

> Right now they're doing Accelerated Reader. I don't know what they did first semester to be honest... They never really talked about it... From the . . . opinions and statements from the other staff members it kind of is a general understanding that not a lot happens in computers. (Lucy Interview, p. 8)

Ambrosia observed a middle school class practicing their typing in her building's computer lab and corrected several students' hand placements on the keyboard multiple times. "It's really not... from what I've found of technology, in a sense, in this school, is really not a big priority" (Ambrosia Interview, p. 3). In Terese's situation, the classroom teacher needed to be involved. Terese probably expressed the most frustration with their building's technology person.

> A lot of the teachers that are in this building, they don't know how to use their computers. They know the basics. Like the computer teacher down there, she's not a certified teacher. She's just technically an aide so she can't be left alone with the students. (Terese Interview, p. 4)

Terese elaborated on what happened in the computer lab and how having an aide rather than a certified teacher impacted student learning.

> When we go down there she, the computer teacher, is never sure when she'll have something planned or not. So we don't know until the day of whether or not I'll be able to do something with the students or she'll be doing something with the students. . . . Especially because a lot of what she does down there, . . . they're not learning very much in that room. And my teacher has said that herself. She works really quickly. It's a once over and then once the kids ask questions she leaves it

> to my CT to try and to answer them, 'cause I'm at class on Thursday so I'm not here for the computer lab. (Terese Interview, p. 6)

Unfortunately, a majority of Ambrosia's, Lucy's, and Terese's students came from low-income families who probably did not have computers or Internet access at home for learning technology skills outside of the classroom. With technologists who have not developed TPACK, it's clear that their students do not experience rich learning with technology nor do classroom teachers have ready access to assistance with developing technology rich lessons and their own TPACK. These interns' experience confirmed the findings of studies (Attewell, 2001; Kelly, 2008; MacGillis, 2004; Warschauer, Knobel & Stone, 2004) that have addressed the digital divide that exists between classroom technology uses of low- and high-income students. Even though the equipment was present in low-income setting, the teaching needed to connect students with technology and content in higher order thinking was missing.

The other two elementary interns, Kelly and Malia, reported their teachers did plan for the assigned computer lab time. Kelly's class followed a technology curriculum but tied it at times to their classroom work, while Malia's team teacher planned activities that fit with social studies and science content. Their settings' understandings of technology's purposes in education seemed to be shifting more towards learning content.

Colleagues

Without assistance from their CTs, most interns looked to colleagues, fellow classmates, for mediating their teaching with technology. Brian's fiancée who worked in deaf education shared her technology ideas such as webquests with Brian and he was putting them into practice in his placement. Margaret collaborated with another friend who taught French, so they used each other's ideas and created projects together.

Malia did not really have any fellow intern support for her grade level, but she felt confident on her own. A few of the interns, however, lamented their lack of collegial support. Lucy felt far removed from other interns and missed the opportunities to try out ideas on them before presenting them to her CT.

> As a new teacher I'm just hesitant, I'm really hesitant with a lot of stuff that I want to try because... I'm used to bouncing my ideas off, you know, my peers.... As a student, you're always asking, "Well, what did you do? What did you do?"

Terese, too, as noted above, needed someone to ask about educational technology implementations yet her intern colleagues did not know much about technology and the school staff could help even less. She relied, therefore, on Ambrosia who was at another school, but also in her weekly seminar group.

> Our technology guru is gone, the other teachers, like I said, are completely unsure, so I don't have somebody....And the other interns are ok with technology but I don't think they're to the point where if I tried to ask them, they're still really unsure.... So I don't have somebody unless I use email. I do email some of the other interns sometimes... like Ambrosia because she's a really good resource for me when I'm unsure. (Terese Interview, p.8)

Because of their more advanced Technology Knowledge compared to that of those in their placements, the interns' identity as prepared to teach with technology grew, yet they felt uncertainty in how to use technology in pedagogically sound ways. They were looking for help but not finding it.

Rules

Each activity setting operates under its own rules, whether consciously or not. Some rules of the school settings became apparent during the interviews. Working with the collaborating teachers on curriculum-based lessons was a requirement of the GRITS program, whether just to discuss curriculum or to plan and learn together. In spite of that agreement, not all of the interns were able to teach their GRITS-planned lessons. Two out

of the seven GRITS interns did not implement their lessons, and a third still planned to implement her lessons in the month after the interview. When asked about the barriers they faced to teaching their lessons and other lessons with technology, time appeared as the number one barrier.

A few rules about time in school emerged. The interns talked about the time needed to prepare students for the Michigan Educational Assessment Program (MEAP) and the content required for their grade levels, which pressed teachers into not spending time on projects. Interns talked about how they really started regular work in November, after the MEAP.

> I don't wanna say the year started off badly, it didn't start off badly, but . . . we had MEAP, well, even before MEAP we took a field trip to Mackinac Island at the end of September, so September was all-encompassing, . . . getting the kids ready to take that field trip and getting prepared for MEAP because then in October, we had MEAP and it seemed like it wasn't really until November that we got through all of that. (Malia Interview, p. 6)

Rule One, therefore: "Preparation for the MEAP is of utmost importance." The standards based cultural context impacted the interns' ability to express and develop their TPACK more fully.

A corollary of Rule One, "Technology is used for special projects, not for teaching content", also hampered the interns' implementations. Although the interns wrote their lesson plans to teach and review curricular material, some of their projects were seen as "extra" and therefore time was not allotted for their enactment. "During the day there is just so many things that you have to hit and meet by certain- certain times," Kelly explained (Kelly interview, p. 8). Margaret elaborated, "In the end it ended up that they wanted more rigor so the things that I was doing with the technology may have been something that he didn't want" (Margaret Interview, p. 4). As noted earlier, in Malia's

GRITS planning, I attempted to emphasize to Malia how her podcasts related to content. It turned out that her placement setting also viewed the podcasts as extra so implementing the lessons took much lower priority. "Tuesday was really our only day that we had our kids all to ourself and could get started on doing 'projecty' type stuff " (Malia Interview, p. 6). Lucy had not worked with her CT on her GRITS lessons because she did not find out until August who her CT would be. She, too, viewed her GRITS lessons as a project separate from daily instruction. "I don't think that me putting it all separate into this one subject in one, you know, project is really going to be beneficial. Because . . . I have to scramble so much to pick up all my other slack" (Lucy, Interview, p. 17).

Rule Two, "Technology only happens in the computer lab during computer time", emerged from discussions with interns about the barriers to using technology. With each class in the school building assigned a time in the computer lab, not much time remained for reserving the computer lab for other class work. If time was available, it often conflicted with other times that students needed to be elsewhere for art or music. Computers in the back of the room, except in one case, were only used by teachers or in the extreme case when a student needed to finish some work or as a reward with computer game time. Only four of the interns' classrooms had an LCD projector, one of which was borrowed from the university for use with the SMARTBoard, and one of which Lucy borrowed from the university to use with the unused document projector that she found in a hall closet.

Several interns were frustrated by the infrastructural dynamics (DeVoss, Cushman, & Grabill, 2005) embodied within Rule Three, "The district determines which sites can be accessed by students and faculty". Even though the interns found YouTube

videos that would aid in their students' understanding of concepts, several schools blocked access to YouTube. Terese related that she researched web links to share with students while she was at school rather than at home because of the difference in access. If she found sites through her unfiltered home access, many times those sites were blocked at school and she would need to find new ones that students could access.

The fourth rule extended from elementary to secondary: "School is not the primary place for students to learn technology skills". Over half of the interns related how poorly or unevenly their students worked with technology. They noted that they could tell which students had home access and knew about using folders and saving files and which had limited exposure. Brian described his tenth grade students,

> It's interesting to see where the kids were as far as their technology use and how vast the gap is. Some kids walk in here with video iPods and they know everything about everything. Whereas other kids walk in here who don't have a computer at home .... So we take them up into the library and find yourself working with kids like, "Ok, this is what Google is. This is how you do a search. This is how you save the file and download the picture." You know, some kids don't even know what PowerPoint was and how to use it.... (Brian Interview, p. 3)

While schools would not agree that these four rules are their stated rules, they are the rules perceived by the interns and by which many in the settings operated. In order to encourage preservice teachers to implement technology for learning content, the rules must be addressed in teacher education programs. Fighting Rule One regarding MEAP preparation is difficult because of district guidelines, but helping preservice teachers understand that technology projects facilitate learning as much as paper and pencil worksheets (Wenglinsky, 1998) will aid in their not being tied to the negative aspects of the rule. Discussing the importance, benefits, and varieties of ways to use only one to three computers in the back of the room will also equip preservice teachers to combat

infrastructural issues. Learning these possibilities will increase their TPACK and empower them and their students when there are few technological resources. In fact, collaboration can actually increase as students share resources. Design discussions in teacher education classes might also focus on how such use might be managed if the computer lab is not available. Rule Four highlights the social justice issue of access to technology and new literacies. If students are not learning how to use technology at school, and do not have access at home, they are not developing the skills for living in the twenty-first century. Realization of that fact could be a powerful mediating tool for teacher educators as well as preservice teachers.

Mediating Tool- Lesson Designing

Another component of the placement setting is the actual lesson planning and teaching that is required of interns. This concrete tool mediates the design process for instructional planning. While all of the interns gained pedagogically from their lesson planning, Ambrosia and Brian, the two who listed several implementations of technology, both talked about how the implementation of their designs and then their own reflection and feedback from others aided their TPACK development. "It came from this year- doing things this year" (Ambrosia Interview, p. 5). As described earlier, during his GRITS experience, Brian felt the lecture component of PowerPoint fit his needs well. His planning and implementation, however, taught him something else. During the interview I attempted to summarize Brian's design process.

> Interviewer: Tell me if this is accurate, that you try something when you know how to use it yourself. So you try using it with your students, you evaluate and say, "All right, these are things that I need to change," and then you try it again? . . .
> Intern: Yeah when, there's a step in between there that you missed because I hadn't told you this. I had my kids fill out a self-evaluation form and

> I asked the question, "What went well, what didn't, how can we change things in the future?"... to get their feedback on things that I hadn't caught. One kid pointed out, you know, why don't you, why don't you give options that kids have to sign up for as far as how to present it? (Brian Interview, p. 7)

Reflection in action (Schön, 1983) is a key component of the design process and is facilitated by the reflection on the lesson plans and their implementation. Brian related his learning from experience.

> But I just know that next time I do it, I really need to step back and go in with much better details for the kids... give more time and better, more pointed questions to answer. I think I kind of took it for granted that if you ask a kid to do research on Henry Ford they are going to automatically stumble upon a five-dollar day work day for a Model T. (Brian Interview, p. 6)

Not only did the interns' technology knowledge as design develop through experience, but also TPACK as they worked with content and the pedagogies necessary for working with their students.

Responses to the Settings

While their GRITS experience built their identity as tech savvy teachers, the interns' placement settings encouraged it verbally, but not always in policy, in rules, or physically with resources. In Lucy's school, "the kids recite [our mission statement] every morning before the pledge.... 'I'm a member of the [our school] society we use technology' . . . but I don't think they use technology at all" (Lucy Interview, p. 21). So how did the interns respond to their placement settings? Activity settings are so complex in terms of the layers of classrooms, grade level teaching teams, schools, districts, and states, so in this short dissertation it is difficult to discuss all the factors and how the factors interacted for each individual intern. Information regarding technology uses and

activity settings was limited in some cases, so my conclusions here are meant to be broad strokes rather than definitive categorizations.

Ambrosia best exemplified the resistance response. She was determined to use the SMARTBoard technology as often as possible and went on to explore other avenues of technology implementation in spite of her teacher's lack of faith in technology's pedagogical possibilities. She used the conceptual tools from her GRITS and technology conference experiences and pressed on with teaching with technology. Margaret also resisted the status quo and worked to use technology to engage her students. While her CT was supportive, Margaret dealt with lack of classroom projection equipment, scheduling a busy computer lab, and inconsistent Internet access. Lucy, too, showed resistance in pulling the document camera out of the closet and borrowing a projector to make it work. When it came to implementing her GRITS project, however, Lucy acquiesced to the difficulties of the setting and did not enter that realm of possibilities. It was a reluctant conscious decision on her part to forego the Google Map mashup of the school community and in doing so she acquiesced to "School is not the primary place for students to learn technology skills".

> What I would like to do is take a walking tour, well, I don't really feel safe in that area. And I'm not, I mean the kids might because they grow up there but I don't; I didn't look for any time to ever leave the school ground and to explore things. Um, besides that and the parent involvement, I guess I didn't really know, and then the computer lab time. Because the computer lab is available on Friday but umm by Fridays I mean we're scrambling to catch up on everything else that it just wasn't a priority. So I figured, you know, if we really want to do a project the kids would have to work in the lab on Fridays. Well, then they would be missing everything else that we need to do on Fridays . . . (Lucy Interview, p. 17)

With his well-equipped room, it might not seem Brian had anything to resist, but he did have to push against the stream to find ways to use the computer lab in student-centered

ways and to assist his high school students who had no experience with technology. He recognized the effort that it took to challenge himself to do more than lecture with PowerPoint presentations.

Accommodation, "grudging effort to reconcile personal beliefs" (Smagorinsky et al., 2002, p. 201) to the goals of the setting, describes Kelly, Malia, and Terese. Kelly talked about the necessity of using technology's affordances and showed resistance when she searched for images and more information for her students' fact of the day. She felt just presenting the fact of the day with no background information did not aid any learning. She did, however, show accommodation to the idea that her GRITS plan did not fit into the time allotted for instruction and that there was no time for using the computer lab outside of the assigned times. She also did not take advantage of her laptop in the room as a station to be used by individual students or small groups to work on the wiki. Malia, too, accommodated her teachers' last-minute style and emphasis on the MEAP. She abbreviated the podcasting lessons she had planned because there was no extra time after preparation for a field trip and the MEAPs. Terese resisted the status quo of the computer lab technician in designing webquests when possible, but accommodated her teacher's beliefs on using the computers in the back of the classroom for rewards. With more support, she may have resisted more because she begrudged the situation as it existed and showed openness to new ideas.

It's important to note that none of the interns completely acquiesced to their situations. Although they had prepared for rich technology integrations, with limited classroom resources and teachers uncomfortable with teaching with technology themselves, all of the interns looked for ways to incorporate at least some technology.

These responses to the activity settings raise the possibility that the GRITS experience made a difference in the development of interns' identity as a teacher who uses technology and feels confidence in implementing it in the face of opposition or complacency. The teacher education program's message, however weak, of the importance of incorporating technology probably also played a role. The responses among the participants varied, just as their placements varied, but the placement didn't seem to make as much difference as did the interns' comfort with technology as a tool for instruction. Perhaps when preservice teachers begin to identify that a well-trained teacher uses technology to help his or her students' learning, then we may begin to see more conviction and resistance to the status quo of scattered implementations.

It should also be noted that those interns who resisted also exhibited the most TPACK. The two probably work together, the TPACK encouraging and enabling resistance and resistance fueling TPACK development.

Online Communities

Activity settings overlap and interweave with one another and those characteristics apply especially to the online communities. While interacting within the teacher education program, GRITS, their daily life, and their placement communities, many of the interns also interacted in online communities. Although none listed the online communities as contributing to their learning to teach with technology, evidence from their planning and conversations suggest these communities played a role in developing TPACK components.

The rules of the online communities are simple: "Share and share alike", but most of the preservice teachers at this early point in their career retrieved rather than

contributed. Terese described her lesson designing processes that included searching lesson plans online. She searched others' ideas for ways to teach the curriculum content to her students and combined others' ideas into plans that fit her situation. She did not explain how she evaluated others' ideas or which lesson plan sites she found to be the best, which begs the question of the quality of the pedagogical knowledge being built. Margaret subscribed to a foreign language teachers' forum, FL Teach, from which she gained many ideas. Margaret also belonged to FaceBook groups connected to foreign language instruction, teacher education, and the Student Michigan Education Association. She also listed the Tech & Learning web site and Apple's Learning Interchange as sources for lesson ideas. Brian's LinkedIn account connected him with his university friends and other professionals. "It's kind of a way to keep in touch but also a professional level to see... what people are doing.... It's very central to our teaching" (Brian Interview, p. 1).

Recognizing the power and influence of online communities, helping preservice teachers locate and evaluate them might be a good step in ensuring their continued TPACK development. Another possible course of action might be to initiate an online learning setting with goals of TPACK development and assisting preservice and new teachers in using technology.

Individual Passion and Interest

Several interns spoke of their TPACK developing out of their own passion and interest in technology, not tied to any activity setting, but acting as a mediator across all settings. Ambrosia's inquisitiveness and love for learning new ideas as well as exploring new technologies pushed her TPACK development. Brian noted that he challenged

himself to work more on developing lessons that engaged his students. Lucy effused how she loved to work with technology and explore new technologies as they became available. Margaret also noted that her interest in technology was there from the beginning; she doesn't remember it really growing out of anything. She revealed, "I guess I'm not really afraid to try to explore, so if I don't feel prepared with something I'll try to find out more about it, try to learn it" (Margaret Interview, p. 3). Terese compared how she "just kind of picked up on the computers" (Terese Interview, p. 4) to her sister who did not at all. For Kelly, "I feel very comfortable naturally doing it, and just seeing how it fits into the lesson. I really like to try and pull anything to make that connection with students" (Kelly Interview, p. 6).

Does this mean that individuals who do not have interest in technology will not be able to develop TPACK? I do not think that conclusion can be drawn from this study. Kelly and Malia felt comfortable with technology but did not express the passion of Lucy or Margaret, yet they exhibited TPK and some TPACK. Personal interest affects how an individual values an activity or task. Learners tend to process more deeply and remember more when they have a personal interest, an interest that they bring to a situation (Mitchell, 1993; Phillips, 2006). The effects of personal interest on preservice teachers' valuing educational technology could be varied depending on whether the personal interest lies in computers or other digital technology, in literacy, in content, or in pedagogy. Even if they do not possess substantial knowledge about the topic, individuals may still show interest (Phillips, 2006), but to hold interest, meaningful learning needs to take place that empowers them to meet their personal goals (Mitchell). When using technology to teach content in pedagogically sound ways connects to preservice teachers'

goals of becoming an effective teacher, perhaps preservice teachers might express more personal interest in educational technology.

Summary

In summary, the GRITS program, which aimed to develop TPACK, was perceived by all the participants to be a major contributor to their TPACK development. As noted previously, several mediating factors were activated to bring about the stronger TPACK. The two that stand out the most, however, are the lesson design process, and the working with the coordinator to discuss the lessons and technology implementation. The trial and error and the designing the lesson to fit the constraints of the situation produced stronger TPK and TPACK depending on the intern. The strength of the lessons and the identities built through the GRITS experience impacted the placement settings as well, enabling the interns to continue their TPACK development in settings not nearly as conducive as the GRITS program. These interns' experiences affirmed the complexity of placement settings and the complexity of learning to teach as the interns navigated resource issues, CTs' confidence and skills, school policies and unwritten rules, and students' varying skills and needs.

The examination of the placement setting highlighted interns' needs to tap into their teachers' PCK and the teachers' need for the interns' TK. TPACK development could spring forward if both would use the other's knowledge to scaffold their own knowledge development.

CHAPTER 5

A DIFFERENT VIEWPOINT: TWO CASES OF TPACK AND ITS DEVELOPMENT IN ELEMENTARY SETTINGS

Case Studies of Elementary Interns' TPACK Development

TPACK becomes evident when it is enacted. The settings in which it is put into action also impact the enactment. Even though an individual may express the components of TPACK within a discussion of possible solutions to a content lesson problem, it is the enactment within a setting's complexity that reveals the TPACK depth and breadth and also the factors that prohibit or encourage its expression.

In order to take a closer look at how the activity setting impacts TPACK expression, four case studies will be presented, two in this chapter, and two in the next. These four interns portray the complexities of TPACK engagement within complex settings. They were chosen for case studies because of their differing teaching placements, secondary and elementary, and for their differing points on the developmental trajectory. In this chapter Ambrosia's and Terese's cases will be presented.

Ambrosia interned in a fourth grade classroom in a low-middle income arts magnet school and Terese, the other elementary intern, was placed in a third grade low-income school. These elementary cases illustrate the difficulties of learning to use technology for teaching in multiple subject areas in a self-contained classroom given the affordances and constraints of the school's infrastructure. The cases flesh out how activity setting resources and collaborating teachers as well as mediating tools like "Technology is the tool", and identity contributed to Ambrosia's and Terese's TPACK in different ways. The cases show how Ambrosia's and Terese's experiences differed from

each other and from the secondary interns. The cases also enlighten how the interns wield mediating tools across activity settings, adding more complexity to the TPACK development process.

Ambrosia

> To do that [help students learn to evaluate web sites] could you almost look at something and actually . . . look at different websites and actually analyze how, like, how do you tell, but also the processes you go through to figure it out? (Ambrosia Interview, p. 7).

Ambrosia continually sought out ways to learn more about teaching and teaching with technology. She believed that her students learned best when they were actively involved and sought ways to encourage their involvement. Her secure identity as a new teacher who taught with technology enabled her to continue to grow in her profession. Even when I interviewed her she was open about what she did not know, asked questions to clarify that which she was learning, and tried out new ideas about teaching with technology in order to get my feedback. That attitude and desire to learn enabled her to gain the most from ideal and less-than-ideal settings.

Personal Technology Use

Ambrosia depended on digital technology. She depended on her laptop to organize her activities and aid in her lesson planning. She used her laptop for watching movies, listening to music, and the Internet. On the Internet she connected to others via email and social networking sites. On FaceBook she communicated with a church group and stayed in touch with friends. She used instant messaging to talk with her mother and with a friend across the country and found it worked well for her because she could talk with her buddies and still continue with her work. Technology Knowledge, that

knowledge of how to apply technology to everyday life and to continue to adapt to changes (Koehler & Mishra, 2008) was clearly seen in Ambrosia's every day life. In terms of transferring the technology knowledge to her teaching, Ambrosia asserted that she knew how to use the equipment, but was not so sure about ideas for educational implementation. "I'm not sure I feel like I'm that prepared in the sense of I'm not sure about ideas to be able to use it. I think the majority of it is, ideas of how to use it" Ambrosia Interview, p. 4).

Teacher Education

As was the case for all the interns, the teacher education community could be broken down into several different settings, such as field instruction seminar community, graduate classes community, and the teacher education program (Grossman et al., 1999). In the four cases outlined in this and the next chapter, however, all the different teacher education settings were combined into one, with the understanding that overlapping communities with differing goals and rules could be part of the whole. The teacher education community shared the same goal with the school placement community of helping the interns learn to teach, but the language of interaction in the teacher education community dealt more with the theories and big picture of education than the language of the school.

According to Ambrosia, she did not gain many ideas of how to use technology for teaching from the teacher education program. She described the explicit message from her teacher education teacher education program as, "Technology's good! You should use it!" (Ambrosia Interview, p. 14). The implicit message, however, communicated that, as good as technology is for education, teacher educators did not have the time to learn it

and then they did not have the time to examine it with their preservice teachers so they threw it in at the end as a project. In other words, technology was added work. Such was the case in two of Ambrosia's four senior teacher education classes, with no mention of technology in the other two. In terms of guidance from her teacher education with learning to teach with technology, she felt that, although they *talked* about using technology in their junior and senior level classes, "it just goes in one ear out the other....in that case, we weren't even using it, it was just, show us what the technology can do. Well, you're not even using it." (Ambrosia Interview, p. 14). She asserted it would have been more helpful to have a class that concentrated on *learning* the technology and how to use it. She suggested that the practical tool of designing lessons with technology that she had used in GRITS and in her classroom would be beneficial for such a class. She felt strongly that it was not enough to hear ideas; planning and implementing lessons with technology would better equip preservice teachers to teach with technology. "Whereas, if you have a class, especially if they're doing it senior year when they're already in a classroom for a year, make them do a lesson or two with it. You know, so obviously then, they're using it" (Ambrosia Interview, p. 14).

During Ambrosia's internship year, two of the four instructors in her classes, social studies and science, provided a platform for sharing what other interns were doing with technology, while one of them required using a blog and a wiki as part of their class work and introduced them to delicious, a social bookmarking tool. In talking about how prepared she felt for using such tools with her students, however, she admitted, "When it comes to doing blogs, I'm not sure I feel like I'm that prepared in the sense of I'm not sure about ideas to be able to use it" (Ambrosia Interview, p. 4). Even though she used a

blog in her teacher education class for her own learning, she did not have ideas of how to use it in her own classroom with her students.

The field instructor for Ambrosia's internship seminar group, unlike most of her other instructors, had not talked at all about technology up to that point in the school year. Ambrosia, therefore, asked in her interview if I could come to one of the weekly meetings and talk about or guide the interns' work with educational technology. In her asking, she attempted to move one of the GRITS mediating tools, the GRITS coordinator, to another setting and exhibited her continued desire to learn more about technology in teaching.

GRITS

Ambrosia participated in the summer GRITS mini grant program prior to her internship. She focused on preparing for her internship in a fourth grade classroom, in a midsize city Kindergarten through eighth grade arts magnet public school where about 60 percent of the 560 students qualified for free or reduced lunch. About half of the school's students were categorized as African American, a quarter White, and the remaining quarter, Hispanic, Asian, and American Indian (Great Schools, 2009). For the mini grant, Ambrosia requested and received the use of a SMARTBoard with a projector for her classroom, plus payment for the time to learn the software and hardware and plan lessons using the SMARTBoard for her internship year. As described in Chapter Four, Ambrosia first questioned me in many different ways in order to gain an understanding of the role of her SMARTBoard in her teaching. She approached her plans from the technology perspective as shown in Chapter Four (Figure 12), beginning with the SMARTBoard as a tool and then using it with her pedagogical perspective. In her GRITS application,

Ambrosia expressed her belief in active student learning, "The experience I have had with students and teaching has taught me that students who are more active in their own learning are more likely to absorb the information and be able to recall the information better" (Ambrosia Application, p. 3). Her lessons, therefore, strove for active student learning. Although she originally submitted ideas for four content areas, given the time frame, she narrowed to plan geography lessons on United States and Michigan landforms, the Great Lakes, rivers and watersheds, the Soo Locks, and an introductory lesson on how to use the SMARTBoard.

For the United States landforms lesson, Ambrosia planned to invite individual students to draw one of the 11 landforms on the SMARTBoard, with subsequent students filling in more of the drawing if they knew more. Ambrosia presumed that would give her a good idea of their prior knowledge and she could fill in the gaps as they talked about each landform in turn. After the introduction of each landform, Ambrosia planned to show photos of the landform plus any previously discussed in order to give practice and assess the students' abilities to differentiate and identify the landforms. In the third portion of the lesson, Ambrosia planned to help students locate the landforms using Google Earth on the SMARTBoard, an appropriate tool giving students access to landforms in their settings.

Ambrosia located animations on the Internet that represented land formation processes so she planned to use them on the SMARTBoard for one of her lessons. She made her own animations to illustrate the movement of glaciers across Michigan for the Michigan landforms. She also used that animation to discuss the formation of the Great Lakes. For each lesson that involved the SMARTBoard she constructed a SMART

notebook presentation file that she planned to use for the lesson. Although Ambrosia based her GRITS lessons in digital technology, she also moved to other technologies when appropriate, illustrating how Pedagogical, Content, and Technology Knowledge works to influence instructional choices. Ambrosia used water and clay in demonstrating a watershed rather than just showing an animation. Since a watershed can be demonstrated without a lot of equipment (unlike a volcanic eruption), her choice of a real versus virtual representation shows Pedagogical and Technological Knowledge of the Content. Even though her GRITS work began with technology, as evidenced in Ambrosia's Map of Integrating Knowledge (Figure 12), sometimes content and pedagogical concerns demanded first attention and determined the technology that would best fit Ambrosia's setting.

While working on so many lessons, Ambrosia faced some blocks. She emailed, "I am having difficulty coming up with a good assessment without using the same ideas from the previous lesson. If you have any suggestions, they would be greatly appreciated" (Ambrosia Emails, p. 6). Later she requested more assessment assistance,

> I am not sure how to have the students demonstrate their understanding of how the locks work with an assessment. For this reason, the assessment section is blank. Any suggestions here would be GREATLY appreciated. :) (Ambrosia Emails, p. 9)

She freely asked for help and considered my suggestions but also worked hard on her own. She struggled with making an animation of the glaciers covering Michigan using the SMARTTools, but finally decided to make one in PowerPoint and link to the file from the SMART notebook presentation.

Many of Ambrosia's projects illustrated her Technological Pedagogical Content Knowledge. When a lesson dealt with glacier movement, Ambrosia composed an

animation to show the movement so that her students could better visualize the process and understand how the glaciers impacted landforms in Michigan. She learned the affordances of the SMARTBoard, e.g. being able to highlight, mark up maps and other images, the ability to move objects on the screen, and she used those abilities in her lessons when appropriate. She projected Google Earth and used the SMARTBoard tools to zoom in and out and highlight land forms in the United States.

The GRITS experience gave Ambrosia time in the summer to work on lesson plans that used technology. She felt she would not have had the time during the school year to develop such lessons because of the technology learning time and the slide production time.

Ambrosia gained a new perspective on educational technology through her GRITS experience.

> While writing these lesson plans, I have also learned about using other tools for teaching, but keeping the focus on the lesson content. Sometimes, the new tools used to implement a lesson can become the focus of the lesson. If this occurs, then the students do not learn the content, instead they learn the teaching tool. (Ambrosia GRITS Reflection, p. 1)

"Technology is a tool", not the content, became a mediating conceptual tool for Ambrosia that she implemented in later activity settings.

In addition, Ambrosia appreciated the difference that came from working one on one with a mentor, even judging the experience to have changed her perspective on the teaching profession.

> This experience has taught me the importance of colleagues and mentors. For many years, I believed that the teaching profession is one of individual effort on the part of the teacher, but this experience has demonstrated how wrong I was. . . . I have learned a great deal more from the GRITS advisor.... She has taught me the importance of keeping the focus of the lesson on the content and not on the technology, as well as giving me many different ideas in how to use the SMART

> Board in my lessons. Throughout the entire experience, she has demonstrated the importance of keeping an open mind about new ideas and always considers new things. I have realized more than anything else, the importance of sharing ideas and working with others to enhance lessons in many different ways. I have learned that as a teacher, there is not just one person responsible for the education of a classroom of students, but many people that work as a team to teach the upcoming generations. (Ambrosia GRITS Reflection, p. 1-2)

For Ambrosia, the GRITS setting seemed ideal for learning to teach with technology, with the hardware provided and a mentor on hand for discussing solutions to design, software, and hardware problems. Her internship placement, however, proved to be less than ideal for her development of TPACK.

Internship

Setting. Beginning in the fall, Ambrosia began her internship in the fourth grade, bringing her SMARTBoard with her. The school classrooms shared a laptop cart and a computer lab adjacent to Ambrosia's classroom. Ambrosia reported that about one-third to one-half of the laptops on the cart worked. In the computer lab, Ambrosia observed the a sixth grade elective typing class one day and noted that about a third of the students had their hands in the wrong places on the keyboard and were looking at the keys as they typed. She asked the technologist about a typing program for student use, and he explained that when the computers were re-imaged, the typing program disks could not be found so it was not reinstalled.

Even though Ambrosia had recorded prior to the mini grant that there were three computers in the back of the classroom, ten months later at the interview there was only one computer in the back of the room into which the teachers input grades and students used to complete unfinished research. Not all of the students had Internet at home so Ambrosia did not assign homework or share work on the Internet. The school also had

digital cameras for teacher use and a projector for checkout. Ambrosia's assessment of her setting: "from what I've found of technology in a sense in this school is really not a big priority" (Ambrosia Interview, p. 3).

Ambrosia's collaborating teacher tried to use the SMARTBoard once and it did not work the way she wanted it to, so she chose not to use it again. Ambrosia felt that she needed to convince her collaborating teacher of the benefits of using technology because her collaborating teacher viewed the SMARTBoard as an obstacle that took up classroom space. Some other teachers at the school expressed amazement at the SMARTBoard, but asked no further about using it or learning more about it. Another intern in the building, however, frequently borrowed the projector from Ambrosia for sharing online information with her students.

Classroom technology use. Ambrosia implemented most of her GRITS lesson plans early in the school year as planned, even though the SMARTBoard arrived later than expected. Ambrosia's Technological Pedagogical Knowledge was evidenced in her recognition of the need to introduce the SMARTBoard to her students in a lesson separate from those she planned for the landforms. She understood that it was such a novel technology that her students would need to deal with the new technology first rather than dealing with it and the content at the same time. Although Ambrosia completed her GRITS lessons early in the year, she was determined to use the SMARTBoard as much as possible. She explained that the GRITS setting had impacted her lesson designing in her placement setting, "It kind of kept getting my mind thinking on technology and how to fit it in" (Ambrosia Interview, p. 9). That impact evidenced in how she continued to work with the SMARTBoard and moved into other technologies.

Ambrosia used the SMARTBoard for subsequent lessons in social studies and science. It was not clear why she did not expand into other subject areas as she originally indicated in her GRITS work. Typically she would display a diagram on the board and students would take turns filling in the blanks as part of the discussion. Plant diagrams and lighthouse diagrams were two such applications she mentioned. In addition to diagrams, she also projected pictures and maps for labeling purposes. While the lessons she had developed in the GRITS program took advantage of the representations and information afforded by the Internet's and PowerPoint's animations combined with the SMARTBoard's amplification affordance, these later lessons that she planned on her own only took advantage of the SMARTBoard's amplification abilities. The amplification was richer than a traditional overhead because of the color and clarity, but it did not essentially change the students' learning opportunities.

Ambrosia branched out to technology beyond the SMARTBoard. "[My collaborating teacher] kind of handed me the lighthouse unit and said, 'Here, you can do what you like,' and I wanted to do something with technology and computers because we haven't used the computer lab much" (Ambrosia Interview, p. 9). In moving away from the SMARTBoard, Ambrosia was able to implement more student-centered instruction and engage her students in collaborative work. Ambrosia elaborated on the lighthouse assignment. "[My collaborating teacher] commented saying that when she's done research with them, with 4th graders in the past on lighthouses, she ran into the issue that they would just say the information and have no idea what it means" (Ambrosia Interview, p. 4). Although Ambrosia did not recognize it, her teacher shared with her an

important bit of Pedagogical Content Knowledge regarding the difficulties students had with studying lighthouses as part of Michigan history content.

In spite of not recognizing her teacher's contribution, Ambrosia took this problem as a challenge as she designed and implemented her lesson. Her Pedagogical Knowledge was evident in how she prepared the students for the work. "I paired them up and they did lighthouse research. . . . They had to answer their questions that they had [from me], and then they had to come up with three interesting facts they found out about their lighthouse" (Ambrosia Interview, p. 2). She knew she needed to help her students learn to research and she scaffolded it in such a way that they could succeed. She created informational web pages on each of the lighthouses appropriate for their grade level and then provided links to additional information that fit their level of understanding. As Ambrosia described her thinking and preparation for the lesson and the scaffolding needed for her students to succeed in research on the Internet and in learning about lighthouses, her TPK and TPACK shone through.

> I chose main lighthouses they could use in Michigan that would give them more information. . . . I had made a website on Google, and, um, so, because when kids do research, you can't just send them on the Internet, you know. Because then where are they gonna end up, and what they're going to find they're not gonna understand and all that because with lighthouses you've got lots of big terminology. So they had a word wall with them on paper with their lighthouse folders, and they carried that with them to the computer lab, along with those questions. (Ambrosia Interview, p. 2)

By designing web pages students could understand and developing a portable word wall with her students, Ambrosia addressed the difficulty with the content that her collaborating teacher had expressed.

While Ambrosia voiced concerns with Internet safety, she did not abandon having her students work on the Internet. Instead she scaffolded their research by producing web

pages and providing screened links in order to provide the means for them to safely and productively use the Internet's resources. Her knowledge as design enabled her to problem-solve and get beyond the issues. With the scaffolding in place, Ambrosia's students were able to research and transform the Internet information into a product for others' learning. She recognized her students needed to build their collaboration skills and that a product that they could share with others would aid in their motivation.

> And then they and their partner would go on to my website which had some information, usually about three or four paragraphs about their lighthouse, and then from there they had three or four links at the bottom that they could follow and take them to other sites. . . . And then they created—I'll show you—amazing brochures. (Ambrosia Interview, p. 2)

The brochures included the history, a picture of the lighthouse, two more interesting facts about the lighthouse, how to get to the lighthouse, how to contact the brochure producers, and the references for the information. Ambrosia chose to have the students draw pictures and handwrite text on the brochures because her students' beginning typing skills would have lengthened production time. She found her students initially had a difficult time working collaboratively on their lighthouse research and brochures, but by the end they were pleased with and excited about the work they had done together. "And this history was incredible. These two [students] are not alike—the one's a strong, semi-strong writer, and the other one has good ideas but she has a hard time putting them down on paper." (Ambrosia Interview, p. 9).

It is important to note that in order to use the computer lab, Ambrosia had to learn the procedures for reserving the computer lab and coordinate with others who might be reserving the shared computer lab. She also needed to work out the logistics of moving her students from the self-contained classroom into a shared space. She managed both

well, as evidenced in her finding times that worked for the lighthouse research and in constructing a word wall that students could move between spaces.

Another project Ambrosia implemented beyond her GRITS plans centered on fast change topics in science, e.g. tornadoes, earthquakes, hurricanes. In semi-book club groups the fourth graders studied a fast change topic of their choice, and then reported their learning to the rest of the class. Ambrosia explained how she influenced her collaborating teacher's choice of reporting. "Normally she did posters, and I convinced her to do PowerPoint" (Ambrosia Interview, p. 12). Instead of going to the computer lab to produce the PowerPoints, the students used the laptop cart, highlighting again how Ambrosia navigated within the school's infrastructure. Each group member created one slide of the group presentation, with the last slide showing a scanned version of a hand drawn picture of the group's particular event.

Ambrosia and her fellow intern used the SMARTBoard each week for their after-school class that studied various cultures. They used the SMARTBoard Jeopardy game with their students and discussed images and maps. Ambrosia depended on her fourth grade students who were in the class to set up the board, connect it to her laptop, and orient the board to the laptop. Entrusting her students with the setup allowed them to gain confidence with technology, but the after-school activities with the SMARTBoard focused on the amplification affordances of the SMARTBoard again.

When asked a brainstorming question of how to use the Internet for a science lesson on animal habitats, Ambrosia questioned whether the goal focused on animals or habitats and whether habitats or biomes were the unit of study. Her Content Knowledge of animals and habitats evidenced in her questions and then integrated with her

Technology Knowledge as she talked about using the SMARTBoard to display pictures of animal habitats and make comparison lists of what could be seen in the habitats. She noted that she would need to find out what students already know and would scaffold Internet research of animals and their habitats by providing links to kid-friendly web sites. The assessment product could be a PowerPoint presentation, or a digital story, including the setting, of an animal. She continued with other ideas for products, listing pros and cons of each. She also expressed the limits of such a project. "That whole time I'm thinking in my head, 'Man, that would take a long time to do in a classroom" (Ambrosia Interview, p. 15). Her experience had taught her how much time project learning might take.

Ambrosia felt that her experience with working with technology in the classroom and seeing others' work prepared her for teaching with technology. "To use computers, I feel like I am prepared because of what we did with this [pointing to the lighthouse brochures], and what I've seen other people do with the science webquests and things like that" (Ambrosia Interview, p. 4). In talking about how prepared she felt for using educational technology, Ambrosia related, "Digital cameras, somewhat prepared, I'm not really sure how to use them, but when it comes to using ideas I think I can. Digital cameras I think I am" (Ambrosia Interview, p. 4). Her hesitation with digital cameras probably stemmed from the fact that while she used the school digital camera to take pictures of the students when they were performing a play, she had not used the camera in her teaching.

Ambrosia had gained and adapted some ideas, such as the use of GooglePages, from the college of education's annual technology conference, from the new literacies

project in her senior literacy methods class, and from a classmate in one of her senior classes. While her peers in her teacher education class shared their ideas of their internship technology use, Ambrosia had not implemented any of their ideas because they did not fit her situation. Even though she had not implemented the ideas, hearing from others at the technology conference and in class had raised her comfort level with using technology in the classroom. She felt some uses would require time for her to explore more, but her confidence would allow her to try them without further external training.

The Purpose of Technology in Education

Understanding the role of technology is part of knowing what technology is and how it can be used. Ambrosia spoke of several different roles which fell into three of the four broad categories named by the other interns as illustrated in Table 4: general pedagogy; teaching and learning content; economic efficiency and utility.

First, Ambrosia cited general pedagogical reasons for using technology. "Technology provides different ways of teaching, different ways to present material... You can't just stand up and talk the whole time. . . . I think it just throws out another way of presenting the material, which, with multiple intelligences, is definitely a big thing" (Ambrosia Interview, p. 11). Technology afforded video, audio, text, social collaboration, music, and other modes. Even tactile needs could be met with the SMARTBoard touch screen and computer keyboard and mouse input.

Ambrosia also believed that technology could aid in teaching and in students' learning content. In her GRITS application Ambrosia asked for a SmartBoard to help her "students become involved in their learning" (Ambrosia Application, p. 3) because "students who are more active in their learning are more likely to absorb the information

and be able to recall the information better. They gain a stronger, more solid, grasp on the required knowledge and are able to apply what they learned to various situations" (Ambrosia Application, p. 3). "In some instances this could be hands-on experiences, active listening, or discussing topics" (Ambrosia Reflection, p. 1). "Students will absorb more information if they can be a part of the teaching process and I feel that the SMARTBoard is an excellent tool to implement this teaching philosophy" (Ambrosia Reflection, p. 1). Technology could make things easier, "could make things better for kids" (Ambrosia Interview, p. 14).

Near the end of her internship, however, Ambrosia questioned the benefits of the SMARTBoard for younger students. In her placement classroom she noted that students were not always actively involved in using it. She knew that students learned more when they actively worked with content in concrete ways. With the SMARTBoard, however, she felt she was working with content more than her young students were. She "could see older kids definitely getting into it even more, because they're more capable of using it, so they're more capable of coming up with presentations to do on it" (Ambrosia Interview, p. 8). She did not question the role of all technology in education, but whether this particular technology and how she was using it fit her goals for classroom technology use. Although she did not recognize it, this evaluation of the technology as a teaching tool was another step to her learning to use technology in teaching.

Ambrosia addressed the economic efficiency and utility purposes for technology in education when she stated that "becoming familiar with a computer in general" is necessary (Ambrosia Interview, p. 12) for "livelihood" when students "get out into the working career" (Ambrosia Interview, p. 13). She saw beyond her classroom and the

skills that her students would need for other activity settings later in their lives. Ambrosia connected her daily life of checking email and looking online for resources with the students' need to have experience with technology. She noted that once they left the classrooms and moved into a career, they would be surrounded by technology and needed to know how to use it.

Mediating Tool- Lesson Designing

Ambrosia's self-described process of designing lessons using technology illustrated how the activity settings built on each other and how important it is to repeat cycles of the design process. She traced her learning to teach with the SMARTBoard through the technology conference, teacher education, GRITS, and internship settings. Ambrosia described her design process as beginning with learning how to use an application or hardware, and all the affordances and constraints of the application.

> I really have to be able to see it a lot and use it a lot to get it. For example, with the SmartBoard, I saw it at the technology conference once, ... did a presentation on it for my senior year for my class because my instructor wanted my friend and I to do that. . . . and then applied for the GRITS grant and got it. So it was, see it, see it again more in depth, try it once, get some ideas with it, and then try it on my own. (Ambrosia Interview, p. 10)

She talked about the next step in her process of looking for ways to use it educationally. In this process again, design elements can be seen, the fitting the technology to the context and the needs of the users.

> I learned how to use the SmartBoard, then thought, "Is there any point in my teaching that I could fit this in? Well, I might be able to use it here, because I want to show them maps with the SmartBoard" (Ambrosia Interview, p. 10)

She narrowed the process with the specific content to be taught with the application. "Well, in this case, how do I want to fit it in?" . . . Then you decide what maps you want to use, how you want to use them." (Ambrosia Interview, p. 10).

Ambrosia stressed that the process involved in learning to teach with technology involved more than just one round of designing. She felt it would take more than planning just one lesson in a class.

> It really takes a process to be able to know . . . how to use the technology, and then be able to know how to apply it. That's a process and it's not really . . . something to do in just one lesson, because you really need a lot of practice with it. (Ambrosia Interview, p. 14)

In addition to practice, Ambrosia emphasized the importance of reflection. "I mean after I used it one lesson here, I was like, 'Huh, that didn't work well, let's try this.' You know? Or, so this worked well, this didn't, you know" (Ambrosia Interview, p. 14). Completing one lesson design cycle immediately led into the next for Ambrosia, enabling her to tweak her design for the next lesson. Interning in an elementary self-contained classroom meant that Ambrosia did not repeat the same lesson to another group of students, only that she could implement similar design features in later similar lessons.

Identity

Ambrosia's conception of her identity also operated across the activity settings. "Most people for some reason seem to turn to me for technology. I think because they know that I have a SmartBoard, so it's ingrained in their mind that apparently I'm into technology" (Ambrosia Interview, p. 4). "So many people . . . in my intern class right now . . . are asking me questions on . . . some of the craziest things, I mean, digital cameras, and . . . they just don't have any idea how to use it" (Ambrosia Interview, p. 10). Ambrosia expressed surprise at how her simple integrations impressed others. "And I'll just even explain how to use PowerPoint in a class with, like, the animation, and they're going, 'Oh wow! That's a really good idea!'" (Ambrosia Interview, p. 10).

Not only did Ambrosia view herself as a technology expert with her peers, she also believed that part of being a new teacher involved helping inservice teachers with technology. "As a new teacher, I feel that one of our obligations to the teaching world is to introduce new ideas about teaching and I feel that technology is a strong point" (Ambrosia Emails, p. 3). She recognized the work involved in dealing with technology in the classroom, especially as others saw it and rejected it as too much work.

> "When you bring up the concept of it, or the idea of it- it's the same thing I think even with the teachers here—they shy away from it because they have to learn it. Because it's like, oh, well, I have to learn it, and then figure out how to use it, and then actually create it and use it." (Ambrosia Interview, p. 10).

Due to her well-developed reasons for using technology, however, Ambrosia worked to learn the new technologies and design lessons with them for her students' learning.

Indications of Ambrosia's strong teaching identity evidenced in her willingness to ask questions and to admit not knowing applications or technologies. Just as during the GRITS program, in the interview Ambrosia continued to ask questions of what she did not know. She easily stated when she did not know something and asked questions to learn more. While she related that she did not gain ideas from her classes and instructors, the message to use technology and the excitement that colleagues showed, coupled with her GRITS experience and ready-made plans certainly carried her to not bow to the attitudes of her school placement.

Summary

In summary, Ambrosia developed her TPACK amidst ideal conditions in the GRITS mini grant with its provision of hardware and a mentor and emphasis on teaching with technology, and less than ideal conditions in her placement with its ill-maintained resources and ambivalent attitude toward teaching with technology. Her strong

conceptions of technology's purposes in education and how to learn a technology in order to use it in her classroom helped her knowledge as design develop for her students' and fellow interns' benefit. She not only used the lessons that she planned through the GRITS mini grant, but also developed other projects to aid her students' content learning and collaboration skills. Ambrosia exhibited eagerness to continue learning how to use technology to help students learn. In the interview she kept asking me questions even though "this is probably not going to help you [your study]" (Ambrosia Interview, p. 7). She used her knowledge as design to work out solutions for helping her students learn in authentic, engaging, collaborative endeavors, in spite of the self-contained classroom's restraint on opportunities to repeat lessons. She pushed against her contextual constraints, and took advantage of the resources available. The limits of Ambrosia's TPACK were seen in her need to broaden her knowledge of affordances and how to take advantage of them, and to broaden her technology integration beyond science and social studies lessons, in addition to expanding her content-specific uses of technology. She, however, was well on the way to exhibiting and acting on her TPACK.

Terese

"My teacher gives me complete freedom but there's times, if I'm not really sure, I don't have somebody that I can ask. . . . I think that's the biggest challenge" (Terese Interview, p. 8). Terese contrasted with Ambrosia in the way she approached teaching with technology. Whereas Ambrosia experimented with teaching with technology in spite of her teacher's doubt in its effectiveness, and within her infrastructure in order to make the most of her resources, Terese expressed doubt in her own knowledge for teaching with technology and did not take advantage of the resources she had. In the settings in

which Terese had mentoring support for teaching with technology, her TPACK developed. Her TPACK, however, still lacked the knowledge as design component that enables teachers to creatively use knowledge within new settings. Her identity as a teacher who uses technology to teach, too, was not developed enough to give her the confidence to implement widespread uses of technology in her teaching.

Personal Technology Use

Outside of the classroom Terese used email, MySpace, and FaceBook to connect with friends. She watched video on YouTube and surfed the web for entertainment. She also used her digital camera for taking pictures and uploaded photos to her computer as well. She downloaded music from iTunes and transferred it to her iPod and CDs to play in her car. For her professional work, Terese typed up her lesson plans in tables and typed up newsletters for parents, task and clue cards for instructional activities, and rubrics for her students' use. She also searched the Internet for images to use with her students. Terese's Technology Knowledge was evident in her broad understanding of technology that promoted productive use both at school and every day lives. She recognized the difference between her home and school Internet access in terms of firewalls, and therefore checked links for students at school to ensure they would not be blocked. Terese displayed a broad understanding that continued to adapt to changes in technology. When she heard of new technologies she took it on herself to explore them and implement them in her personal life.

Terese named her mediating tool "playing around" with technology in order to learn technology. When she was a child her parents did not teach her or her siblings how to use the home computer, so Terese "played around" with it and learned how to use it. "I

think because my parents don't know how to use technology either. . . . We had a computer, but if we wanted to know how to use it, we just- I guess I just sat there and played with it... (Terese Interview, p. 4). That method continued to assist her learning. Although there must have been some mediating tools within that "playing around", Terese did not or was not able to articulate them. "A lot of things I just play with. I don't sit there and read the directions, I just go ahead and start setting it up and I figure it out" (Terese Interview, p. 4).

Teacher Education

In the teacher education classroom, although some instructors attempted to use the classroom LCD projector, their lack of preparation and bumbling mediated negative reactions in Terese. She felt she had not learned anything about how to teach technology from her teacher education program. I cannot determine if her disdain of her instructors' lack of technological expertise is reflective of a general cultural belief that teacher education is not important (Grossman et al., 1999) or if it is specific to technology or if she did not recognize technology integrations as such. She shared that she used the teacher education advocated complex instruction model each week for math lessons, so the teacher education program had influenced her in some areas.

The negative reactions to the instructors' limited and poor use of technology did not, however, discourage Terese from using technology. Her problem centered more on how she needed help from her instructors on using technology to teach her students and they were unable to provide it.

GRITS

When asked about preparation for using technology in educational ways, Terese was not so sure of her abilities. In her GRITS application she expressed her insecurity.

> I am excited and interested in this technology grant but am slightly hesitant in that I am not sure how to fully implement the technology into my lessons or my classroom. I feel that if I had had more guidance I would feel better about implementing and using it. I am also unsure of all the technology there is to use in the classroom to enhance learning" (Terese Technology Survey, p. 5).

Terese's GRITS experience reveals her TPACK component knowledge, the setting's mediating tools for building the knowledge, and Terese's developing identity as a teacher who uses technology.

The summer before her internship, Terese participated in the GRITS mini grant program. She planned to intern in a third grade classroom in a mid-size city school. About 65% of the 275 students qualified for free or reduced lunch, with the student body predominantly African-American students and the remaining third about an equal mix of Asian, Hispanic, and White students (Great Schools, 2009). For the GRITS grant application, she researched software, consulted her collaborating teacher on third grade curriculum content, and then requested assistance of the GRITS coordinator.

> I didn't know if it would be possible to get some guidance. I have tried looking at all sorts of different things and I am just really, really struggling. I have talked to my CT for next year and she told me to do whatever I want with whatever technology. I will be in a 3rd grade classroom next year. (Terese Emails, p. 1)

Terese described the technology in her room to give the context.

> They do have high speed Internet in the room, but only a couple of computers and they do not have any means of transmitting what is being seen on the computer for the whole group to see. They do have a computer lab, but not every student will be able to have a computer. But we can rent out the computer lab as needed she told me. . . . (Terese Emails, p. 1)

As shown in Terese's Map of Integrating Knowledge (Figure 13), Terese was concerned with content and wanted to be able to use technology to teach the content. She just was not sure which content to choose.

> The sorts of things that will be covered in science is [*sic*] - Earth materials, Lights and Shadows, Force and Motion, Plants. In Social Studies - economics, core democratics, regions. In Math - regrouping, multiplication and division and problem solving.
> Are there any ideas you could help me with? I am so lost! I am highly interested in this grant. Thank you very much. (Terese Emails, p. 1)

I responded with ideas to borrow a projector, with reassurance that one computer per student was not required and perhaps even not always desirable, with suggestions of online activities around the topics, and then with a suggestion of a software that had come up on an Internet search. Terese decided to use that software, Science Simulations, which included several simulations on several different topics, for example, force and motion, plant growth, and light and shadows. She recognized the power of technology to aid student learning with representations and scientific processes.

Terese chose plant growth as the content for her lesson plans and then began to explore how the software might aid her students' learning. Terese read the software guidebook and the Michigan Grade Level Content Expectations regarding plants in order to see how the two coincided. The plant growth simulation required the user to adjust sunlight, water, and temperature and observe how much the plant grew each day until it reached its full height. In Terese's reflection written at the end of the summer, she revealed the complexity of her work and how it mediated her TPACK development, "I soon realized after beginning my exploration of this program that I was not only learning how to use the program itself, but I needed to learn how to use it as a tool in my classroom which was somewhat difficult" (Terese Reflection, p. 1).

After further investigation, Terese realized that only one type of plant growth was simulated, not multiple, and the software helped more with scientific method than plant growth.

> The program addresses the basic needs of a plant, but every plant has different needs. It would be important for the teacher to address with the students that the particular plant in this program has different needs then another. The program does not identify the particular plant the students are working with. (Terese Reflection, p. 1)

Terese's TPACK alerted her to the fact that the software could build observation skills, but not show the nuances of plant development. She revised her plans, therefore, to fit with the strengths of the software and chose other grade level content expectations. She recognized that the software was helpful in building scientific experimental skills, so she emphasized that instead of plant growth. Engaging her developing TPACK, she formulated lesson plans for exploring the software, for developing observational and data recording skills instead of plant growth knowledge, and debriefing following the work with the software.

As Terese worked with her plans and the software she recognized the benefit of the time-lapse plant growth to speed up the process of observing multiple trials with changing variables but noticed that each simulation stood on its own and did not maintain observational data. She wanted her students to be able to review and compare their data from multiple trials so she designed a paper science journal for each student in which they could record their data. She realized a paper supplement to the software would enhance her students' learning.

Another issue with the software surfaced as she thought about her future students' interactions with the simulation.

> With this program, I can find the possibility of a child becoming bored with it after a little while. You, as the user of the software, do manipulate the conditions but then the software really just calls for the user to sit back and watch. For some people this is ok, for others it is not. So it would be my attempt to keep the child's interest intact so that they will pay attention and learn what they should from the software. (Terese Email, p. 7).

Terese planned for students to work together, charting the results of their trials in order to increase their learning and maintain their interest.

In her lesson plan Terese illustrated knowledge of how students construct knowledge and new knowledge's relation to prior knowledge, a mark of Pedagogical Knowledge. "Have them think about personal experiences when writing hypothesis" (Terese Lesson Plan 2, p. 2). Her Pedagogical Knowledge is also evident in her planning to have students help each other with the simulation work. Terese's Content Knowledge of science became clear in her lesson plans as she directed her students to behave as scientists.

> As students are exploring question number one remind students that scientists will continually write down their findings and learn from them. Also tell them that scientists when running experiments will change only one variable at a time instead of all three. (Terese Lesson Plan 2, p. 3)

Terese's direction to students to work as scientists do in manipulating only one variable at a time showed that she understood how scientific knowledge is developed and sought to train her students in that disciplinary way of knowing.

To help her students with the Celsius temperatures and the milliliter liquid measurements, Terese created posters illustrating the conversion of milliliters to cups and Celsius to Fahrenheit to aid her students' visualization of the two amounts. Terese's PCK limits can be seen in her creation of the poster illustrating the conversions of metric to English measurements. While she tried to help her students with the conversions,

scientists use metric measures, and the grade level content expectations for third grade included using metric measurements. It would have been more pedagogically effective with this content to have actual metric measures available for visualization.

For her debriefing lesson Terese built a three slide presentation with three different plants and the optimal growing conditions for each slide. She intended to discuss them with her students in order to combat the impression the software gives of "the idea that all plants need 100% sunlight, 300ml of water a day and needs to sustain 86 degree Fahrenheit in order for the plant to thrive" (Terese Written Description, p. 2). If her TPACK had developed further, she might have made the slide show of plant pictures more effective with animations that would show the picture first, allowing discussion of the plant's context and conjecture of optimal growing conditions before seeing the growing conditions information displayed.

In discussing the GRITS mini grant program in her interview, Terese cited gaining ideas from the other participants as the greatest benefit. She told about hearing fellow GRITS participants using web pages with their students. "I had made web pages before and I just never thought of making a web page for them and having it accessible in the computer lab, but I had heard a couple of interns say they had done that. And I thought, 'Oh I could do that too'" (Terese Interview, p. 3).

Another insight she offered regarding her participation in the GRITS program dealt with how she approached new technologies. "But it's one of those things that sometimes I don't think to ask. . . . And I'm just like, 'Well let me look for something that I sort of do know'" (Terese Interview, p. 7). She had decided a different route for upcoming opportunities. "In the future, if I needed a program in my classroom I would

look to see if others had used the program, and to what extent it was effective" (Terese Reflection, p. 1).

Although it will become evident later that Terese lacked support in her placement for learning to teach with technology, interestingly, Terese abided with the norms of the GRITS mini grant program that confined it to the summer. Other participants, on the other hand, continued to email the coordinator for assistance, whether with their GRITS plans or other technology questions. The time limits of the GRITS community (Grossman et al., 1999) cut Terese from a main mediation in learning how to teach with technology.

Internship

Setting. At the end of the summer, Terese began her internship in the third grade classroom and began to learn more about technology at the school. One of the first grade teachers served as the technology teacher who searched out new technologies for the school. Another non-certified teacher acted as the technologist who taught the computer classes in the school. Terese explained that her class went to the computer lab for one hour once per week. There the technologist supervised their 20-25 minutes of learning keyboarding by working with the software Type to Learn and then provided some other activities for students on the Internet connected with the month, such as Valentine's Day in February. Periodically the technologist had a project, such as creating a poster of a famous African American for Black History month, for students to complete. Terese expressed frustration with lack of clarity regarding the setting's rule of who was in charge of the computer time. Terese said the technologist seemed to be in charge, but then some times at the last minute the technologist would turn control over to the classroom teachers. Terese related that she and her collaborating teacher both felt that students were

not learning much from the computer lab times with the technologist. When the technologist did teach, she went over the new skills very quickly and then expected the students to be able to immediately use those skills. With the computer time coinciding with the days Terese spent at the College of Education for class, Terese's working with the students and the computers was severely limited. Open computer lab times existed, however, for classes to use the computer lab since the computer teacher did not teach five days a week. Although a projector was connected in the computer lab for classroom instruction, there were no additional projectors for check out and use in classrooms.

Terese related that it had taken some effort, but the Science Simulations software had been installed on all the computer lab desktops. The building principal showed excitement and pushed to have the software installed as soon as possible. The principal's response fit her admiration of computer use. Because the software included several simulations, Terese told other teachers in the building about the software in order for them to use it with their science programs, but she had not received any reports of usage.

In Terese's classroom, only two of the three classroom computers worked. Terese's classroom's rules of computer use fit with the unwritten Rule Two that was outlined in Chapter Four, "Technology only happens in the computer lab during computer time." First, if students needed time to research outside of the computer lab, Terese explained who could use the classroom computers. "For the students that we know have no access whatsoever outside of school, they are allowed to use the computers" (Terese Interview, p. 2). The other use Terese described as a reward for reading. "They use them to play on when they, they have Book It[10] every month, so if they read 300

[10] Book It is a reading incentive program sponsored by Pizza Hut restaurants.

minutes, they have a free time and they can use the computers for that time too" (Terese Interview, p. 2). Terese said students fought over who got to use the computers during the reward time. By stringently limiting student access to the classroom computers, Terese and her collaborating teacher revealed their views that technology happened in the computer lab and technology was not an integral part of their students' classroom experience.

The classroom had a traditional overhead projector although its useful space was limited; its location blocked views of the screen and Terese found it difficult to make graphic organizers large enough on which to write. She described how the overhead was in the way and that the chalkboard was much easier for students to see, so she and her collaborating teacher used the chalkboard technology more than the overhead.

In the school placement a few roles differentiated Terese from her collaborating teacher. As the teacher-in-training, she produced for her collaborating teacher the lesson plans and her collaborating teacher helped her in adjusting the design. The collaborating teacher also gave feedback following the implementation of the lessons. A change in the division of labor from the typical process of the collaborating teacher helping the pre-service teacher learn was seen in the pre-service teacher helping the inservice teacher learn how to compose email. Terese described her collaborating teacher as being "technologically illiterate" (Terese Interview, p. 3). Although her teacher knew how to reply to emails, Terese had to teach her how to compose a new email and send it. She said her principal was much the same and the other teachers knew just the computer basics. Terese's collaborating teacher was very supportive of Terese, however, and encouraged her to try whatever she wanted with technology in her teaching.

Although a technologist worked at the school, she did not fill the role of helping teachers use technology in their instruction. The technologist was "not a certified teacher. . . . , just technically an aide" (Terese Interview, p. 4). The classroom teacher who knew a lot about teaching with technology, the "technology guru" as Terese described him, was on an extended sick leave. Late in the school year, Terese found out that one of the first grade teachers was the technology resource person for the school. "She's supposed to be a resource for the teachers for technology but I don't see that happening. In fact I just found out last week that she was the technology teacher and so I was shocked with that" (Terese Interview, p. 12). As will be seen, the lack of this role impeded Terese's TPACK development.

Classroom technology use. Terese displayed TPACK as she explored and planned for her GRITS software implementation, but her TPACK components did not evidence as strongly in her classroom. She readily listed the ways that she used technology in preparing materials for teaching such as rubrics, task cards, and newsletters. At the time of the interview, however, she still had not implemented her GRITS plans, and her additional reported educational technology implementations with her students were minimal.

One of the technology implementations involved a biography mobile project her students just completed. Terese had created a web page with links to biographical information for her students' use. During their assigned computer lab time, her students accessed the web page and used the links to research their assigned person. Following their research they wrote about their person and constructed a mobile to hang in the hall.

The web page of links also served as a resource for other research, but Terese did not elaborate on the content of that research.

When she related how she had learned to use web pages of links for her students' use, Terese revealed limits to her TPK as design and how it developed. Previously she had made web pages to showcase her portfolio work, but she had never thought of web pages in an educational way until she heard other interns talking about making web pages for their students' access. Once she heard their idea, however, she quickly adapted it to her situation, creating a web page of links for students' research. "They can just go to my webpage and . . . use the links there to . . . get them to pages where I know they'll have meaningful information, versus them trying to go from scratch and try to locate" (Terese Interview, p. 2). Her TPK aided in designing the page for her particular context, taking into account her students' experience with the Internet. "Because many of them, because of the economic status of these students, a lot of them do not have the computer or the Internet" (Terese Interview, p. 2). Her TPK can also be seen in how she addressed the infrastructural difficulties involved with firewalls. "I always . . . create the links here, that way I know, because the firewalls that are set up are different than at my home. So I don't want them to be blocked when they attempt to use it" (Terese Interview, p. 2).

Terese reported that during her lead teaching, when she did not leave the classroom to attend the teacher education classes, she was able to introduce the Science Simulations software to the students and they worked through the questions for the Light and Shadows portion of the software. Exploring that portion of the software remained an option for the assigned computer lab time, and Terese noted that many students chose the science software or researching over following the technologist provided monthly links.

It should be noted that Terese introduced the Science Simulations software during the students' assigned computer time, not during classroom science instruction time. She knew the computer lab schedule. "The computer teacher is not here five days a week. So the lab is open otherwise, and even throughout the day when she is here, we are able to go into the lab" (Terese Interview, p. 2). Yet she did not reserve time to use the computer lab resources as part of her instruction. Although the interview took place well into the second semester, Terese reported, "So we're going to *start* looking into reserving times and stuff" (Terese Interview, p. 2, emphasis added). While Terese had figured out how to work with the school's filter and the school's technologist, she had not navigated the infrastructural schedule to find times to teach with technology. She still followed Rule Two from Chapter Four, "Technology only happens in the computer lab during computer time".

Mediating tool- lesson designing. In her reflection on the GRITS lesson designing, Terese expressed her frustration with not knowing the students with whom she would be working or other aspects of the context. Knowing how to design the lesson depended on the particular situation. In her discussion of her lesson planning with technology for her placement classroom, she related her process for designing lessons. She searched online resources where other teachers had posted their lesson plans to locate various lesson plans and then combined the ideas into an appropriate plan for her situation. She related how just prior to the interview she had been tweaking a lesson design. "I was looking up- for pulleys because I wasn't really sure what I wanted to deal with it. And I was initially thinking- [but] based on today I thought, 'This isn't really

going to work.' So I needed to change it" (Terese Interview, p. 4). Like Ambrosia reported, reflection played an important in designing lessons that fit the context.

When brainstorming how to use technology to teach one of the grade level content expectations regarding concept maps, Terese's TPK knowledge as design for particular settings shone. Terese told how she would use the overhead projector to build a Venn diagram with her students. She then went on to elaborate that if she had an LCD projector, she would use her computer instead to make tables or Venn diagrams because then they could fit the information much more easily. She explained that it was difficult to write large enough on a Venn diagram on a traditional overhead for students to see and small enough to fit everything in. With the computer she could adjust the size easily and zoom in or out. She complained that the overhead also blocked vision of the screen and with her laptop she could sit off to the side and type while students gave their input and all easily could see the screen. This discussion of the differences between the overhead projector and the laptop combined with the LCD projector gave indication that as Terese designed instructional plans, she considered how different technologies aid or disturb teaching and learning.

Although later she remembered using Kidspiration, a concept mapping computer software, in a teacher education science class, she did not mention it when brainstorming concept maps. This disconnect illustrated the limits of Terese's TPK but also how Terese's experience in the teacher education activity setting did not provide the conceptual tools for transfer of the Kidspiration tool to other activity settings. Another factor might have been her perception of the time required for technology. Terese expressed concern that, with her students who had so little experience with computers, it

would take them long to learn how to use something new like Kidspiration. This may have been some indication of her discouragement with the time and preparation involved with teaching with technology.

Responses to activity setting. The activity theory framework enables the user to watch and listen for resistance, accommodation, or acquiescence to any of the communities' norms. Terese's actions gave input into her response to her placement setting. She struggled with the norms of the school placement regarding technology use in the computer lab, but did not seem upset with her collaborating teacher who did not incorporate digital technology into her teaching. She acquiesced to the norm of classroom computer use as reward time and only viewed it as an instructional tool for those who did not have a computer at home and needed more time than the computer lab schedule allowed. She did not address the potential of students using the classroom computers for individual or group learning. Terese did, however, press against the norms in designing the biography mobile resource web page and introducing her students to the Science Simulations and she planned on using the computer lab more during her lead teaching. In spite of thinking she did not want to look like her instructors when she used technology, she used the LCD projector and computer to walk her students through the Science Simulation software.

The principal's excitement about computer use may have trumped the status quo inputs from others in the community. With the teacher education program's endorsement of technology, even if it was not used well, and the GRITS preparation to use the Science Simulations, Terese's previous activity settings encouraged use of technology. While

Terese generally accommodated the placement setting's goals, she did express resistance in some aspects but accommodation in others.

The Purpose of Technology in Education

When asked about technology's usefulness for education, Terese focused on the economic efficiency and utility purposes noted in Table 4, which fit with her teacher purposes. She listed speed in terms of the fact that handouts and newsletters could be quickly produced and disseminated. She looked more at student vocational uses in her response than technology as learning tool uses.

> I think that it's [technology in education] important because technology is advancing so much so for them to start being exposed to it now and learning how to use it. And it's something that I think is a useful tool because it increases speed or like lag times so like handouts that I can give them. . . . I can just type it out really quick, get it copied, and it's in their hands versus however many years ago the handouts . . . they couldn't necessarily adapt them like I can now. . . . So just like the newsletters that we are able to send home . . . every week real easily because we can just type it up. It takes, you know, 10 minutes. (Terese Interview, p. 8).

In her GRITS application and reflection she had noted the teaching and learning content benefits of technology in education. "I would like to bring technology into the classroom to show the students how it can be used as a tool to help learn subject material" (Terese Application, p. 1). She had also noted the motivational aspect of technology. "In addition, I hope that by using technology in association with a subject, the students will find interest in the subject material that perhaps they would not have found otherwise" (Terese Application, p. 1).

It is possible that the learning aspects of technology from the GRITS setting did not come to mind in the interview or that "Technology is a tool" was not a strong enough conceptual tool for her. It might also be that her placement activity setting's perspective

had influenced her in thinking that technology was not about aiding in accessing subject matter. Instead "Technology is a tool" for aiding teachers' efficiency may have taken hold as well as the perspective that technology was a subject to be learned.

Online Communities

Terese exhibited ways to find communities of practice. Beyond her placement community and the teacher education community, she joined the GRITS community and she used the greater online teaching community for mentoring and resource support. For her teaching, the lesson plan sites provided the primary benefit. Labor on lesson plan web sites is divided according to the users' desires. The user can decide how much to interact with or read others' postings and how much to post him or herself. Users post their lesson plans and other users retrieve them as often as they wish. Terese found lessons online posted by others and depended on their ideas and expertise as she crafted her own lesson plans. She did not discuss how she knew whether to trust one or another as a good resource, relating instead that she just used the ideas that seemed appropriate for her situation. Although Terese found the lessons on an online resource, the lessons themselves did not necessarily involve students with any digital technology.

Identity

Terese wanted to use technology in her teaching. "When I hear other things from other interns in TE, I really think, 'Wow, I wish I could do that in mine' (Terese Interview, p. 8). She attributed her not teaching with technology to a lack of resources in her classroom, not having time in the computer lab, and lack of support. She heard from others in her teacher education class about their classroom digital cameras, LCD projectors, and SMARTBoards, while a DVD player was what she considered the most

advanced technology her classroom sported. She realized that the computer lab had the resources and she needed to get her students there. "I'm hoping in this last month now that I'm lead teaching that I can get them into the lab more and actually using it" (Terese Interview, p. 9).

Terese viewed herself as a person with fine technology skills, but she lacked confidence in her own thought processes with technology for student learning. As her words that began her case expressed, her biggest challenge in integrating technology dealt with not knowing whether her ideas would work and the fact that her CT could not assist her. "I wonder if I could make this work. I'll ask her and she'll go, 'I don't know'. . . . She lets me do whatever I want but she not really able to help me with it" (Terese Interview, p. 8). Even other teachers in the building were "completely unsure" (Terese Interview, p. 8). Terese considered asking the other interns in the building, who were "ok with technology but . . . they're still really unsure" (Terese Interview, p. 8). Without technological support in the building, she looked for help elsewhere. "I don't have somebody unless I use email. I do email some of the other interns sometimes, . . . like Ambrosia because she's a really good resource for me when I'm unsure" (Terese Interview, p, 8). Terese's lack of confidence in her teaching with technology kept her from learning through lesson designing and reflection. If she and her CT would have shared their knowledge, they both might have integrated more technology in educationally sound ways.

Summary

In summary, Terese was very much an apprentice, one who desired to learn from others and check her ideas with others before implementing them. While she expressed

confidence in her abilities to learn new technologies, she still required the guidance and suggestions of others to use technology in new ways for teaching her content. In the GRITS setting she showed promising development of her TPACK. Unfortunately, her placement setting lacked the support Terese wanted and therefore her TPACK did not develop as fully as it might have under more positive conditions. She felt quite constrained by her context and did not have the knowledge to take advantage of the two computers in the back of her room and the additional times that the computer lab was available. In terms of TPACK, knowledge as design, Terese still needed to develop the ability to see how to use the technology she knew well to design lessons that took advantage of technology's affordances for student learning.

Complexities of Learning to Teach with Technology in Elementary Settings

The contrasts between Ambrosia's and Terese's experiences highlight the complexities of learning to teach with technology. Both dealt with few computers in their classrooms and both of their placements provided a computer lab. Ambrosia's identity and her mediating tool, "Technology is the tool", along with the flexibility of her TPACK allowed her to expose her students to new technologies and aided her navigation through the school infrastructure. Terese, too, successfully navigated through some of the infrastructural difficulties of her placement, but she had not yet figured out how to use the computer lab as her classroom. Terese's identity as a teacher who employs technology for instruction was not developed well enough to serve as a mediator for her lesson planning. Ambrosia placed enough confidence in the "Technology is the tool" mediator that she worked to convince her collaborating teacher of the benefits of technology in teaching. Terese, on the other hand, did not need to convince her collaborating teacher, but Terese'

mediating tool was not developed enough to give her confidence that lessons she planned with technology would be appropriate.

The GRITS hardware and software played differing roles in the TPACK development of Ambrosia and Terese. Ambrosia received the SMARTBoard, an amplification tool that enabled her to share representations with her students. The SMARTBoard could be used across subject areas but, in terms of how Ambrosia understood its affordances, did not offer transformational opportunities for students, so Ambrosia began to look elsewhere for richer technology implementations. While she tapped the informational affordances of the Internet, she did not employ technologies with the affordances of transformation or collaboration. Terese's chosen software, Science Simulations, on the other hand, dealt with science content and particular topics. Its representational affordances allowed transformation of student interaction with the content as well, but did not extend across the curriculum. Terese expanded to take advantage of the Internet's informational affordances but in a limited amount. In other words, Ambrosia's wider tool, in terms of range of options, allowed her to transfer her knowledge to other uses, while Terese's deeper tool, in terms of probing a topic more fully, promised richer learning for her students but did not encourage transfer to other areas. It is important to recognize the differing contributions technologies make and the difficulties of transferring knowledge across technologies.

In spite of their differences, both of these interns faced the task of preparing instruction for students in all subject areas, with no opportunity to repeat lessons and revise their use of the tools based on their prior experience, as was the case with secondary interns (which will be discussed in the next chapter). They both worked with

collaborating teachers who knew little of teaching with technology, yet they both implemented technology-infused lessons beyond the GRITS plans. They also both worked in schools where many students would not learn to use technology at home so they both dealt with students' lack of technology skills. While they both recognized the need for their students to learn to use technology, that recognition did not drive their lesson designing to include technology in their teaching.

Both cases illustrated the need for continuing assistance in learning to teach with technology and the differing methods interns employed to meet that need. Ambrosia needed help with broadening her uses, and Terese needed feedback on the appropriateness of her plans. Terese expressed the need explicitly and sought help in ever-broadening circles from her classroom. Ambrosia expressed the need through her questions, seeking answers from experts whenever possible. Their difficulties with finding assistance highlight an important role that is waiting to be filled.

CHAPTER 6

A DIFFERENT VIEWPOINT: TWO CASES OF TPACK AND ITS DEVELOPMENT IN SECONDARY SETTINGS

Case Studies of Secondary Interns' TPACK Development

This chapter continues the case studies to better illustrate the complex settings in which TPACK is enacted. While Chapter Five revealed how two elementary preservice teachers learned to teach with technology, this chapter examines two secondary preservice teachers, Brian and Margaret. Brian taught social studies in a low-middle income high school and Margaret interned in two placements in high school French classes. Her first was a suburban high school and the second a rural high school.

These two cases illustrate how learning to teach with technology in the secondary setting is different from the elementary setting. Both the differences in the teacher education program and the settings themselves contributed to the varying depth and breadth of the interns' TPACK. The secondary education program focuses on a single subject major and learning to teach that major topic of study, allowing more time and in-depth study in one subject area. The secondary internship settings also deal with one subject area and working on the same topic with more than one section of students in a day. It contrasts with the elementary settings' multiple subject areas each day with no opportunity to repeat lessons.

The differences between the subject areas will also be apparent as Margaret taught French courses, an aspect of literacy focused on language development, and Brian taught social studies courses. With so many new technologies enabling communication in a variety of ways, new technologies fit well with literacy courses while a bit more exploration is required for finding social studies specific technologies. Both interns,

however, shared the pressure of covering the curriculum within the prescribed number of school days, connecting them to the pressure described in Chapter Four's Rule One and the view of technology projects as extra, and not involved in the rigor of instruction.

Brian

> You're going to have kids [preservice teachers] who say, "I want to teach in Detroit where there's no technology." Well, ok, you might do that for your internship year... but you might end up in [an affluent suburb] the next year, or you know, you might end up in [my school] where your stereotype is having no technology but ... take a look at my room; look and- seek and you'll find. It's... bogus when people throw that out, but I think that was my mentality last year, "I'm not going to need this." I didn't need to know how to make a transparency. (Brian Interview, p. 10)

Brian's honestly shared how his view of teaching with technology changed over his internship year. Although he used technology in his personal life, he did not realize the impact it could make on instruction, whether positive or negative, until he implemented it himself. Brian's TPACK growth was evident in his changed understanding of student learning.

Personal Technology Use

Brian listed his iPod, PlayStation 2, and the Internet as his personal technology uses. His iPod provided music in his car and his PlayStation 2 provided entertainment when he was not consumed by teaching. He used the Internet for tracking sports, researching for teaching, and social networking via Linked In. While Brian used technology for entertainment and connecting with others, he also recognized when using it might impede his goals of becoming a professional teacher. With so many of his high school students using FaceBook, Brian chose to remove his profile to protect his privacy. In the past he had blogged, but at the time of the interview he related he no longer blogged because "I don't have anything interesting to offer for a blog" (Brian Interview,

p. 1). Brian's personal uses displayed his knowledge and comfort with technology. He also recognized the limits of his technology knowledge. "That's another thing I have to learn: how to expand my knowledge with things because . . . I can use a lot of different stuff but I don't know how to use it to its full potential" (Brian Interview, p. 3).

One avenue for learning more about using technology in the classroom came through Brian's relationship with his fiancée. He related how she, a preservice teacher in deaf education, opened his eyes to students' varied learning needs and how technology could assist in meeting those needs. She also served as a mediator of new ideas as she introduced him to webquests, telling him the basics of creating a webquest for student use. This significant relationship impacted his classroom teaching setting as well as his personal life.

Teacher Education

From Brian's perspective, his teacher education program explicitly taught little about teaching with technology. He wrote, "Technology was only seriously discussed in my [undergraduate senior methods] classes when we, the students, brought it up" (Brian Reflection, p. 4). When asked about technology projects in his teacher education classes, Brian reflected, "Not that I can remember. Which looking back it's like, 'That would been kind of nice', you know, knowing what a webquest is before trying to [make your own]" (Brian Interview, p. 7). The lack of mediation in this setting impacted Brian's teaching with technology, as will be noted later.

GRITS

"This grant really provided some excellent resources to grow in my use of technology" (Brian Reflection, p. 4). Helping interns use technology to its full

educational potential within the context of their internship comprised the primary goal of the GRITS mini grant setting. Brian was assigned to a large public mid-size city high school for his internship. About 51 percent of the 1714 students were eligible for free or reduced lunch and nearly half were African American students, about a third were White students, and about one fifth were Hispanic, Asian, or Native American students (Great Schools, 2009). Although Brian responded to the GRITS informational session invitation, he did not attend the session. During the application process early in the grant program he requested two extensions to the application deadline but did not submit an application because of commitments with classes and work. Late in the summer he emailed the coordinator, wondering if he could still apply for a grant. He had finished his classes and his work was slowing, so he felt he could dedicate some time to working on his project. Because funds were still available, Brian was granted money to work on his ideas.

As previously noted in Chapter Four, Brian's ideas centered on pedagogical concerns. He believed technology would enable him to reach a class of diverse learners and that it would enable them to work in groups in different ways. The equipment Brian requested for the grant did not fit any particular subject and included audio, photo, web and video editing software as well as video and audio hardware. In our first meeting Brian and I discussed open source software and the software and hardware built into the MacBook laptops. He agreed that the MacBook provided everything that he required. We then discussed possible subject matter to which the hardware and software's affordances would open students' learning.

In order to equip Brian with GarageBand and iMovie, the GRITS program loaned him a MacBook for exploration until he purchased his own laptop. While it was a new platform for him, he responded to my query, "It's a bit of an adjustment but I've read a few tutorials and I'm figuring it out just fine" (Brian Emails, p. 4). As previously noted, the GRITS program encouraged the participants to learn as much about their technology as they could on their own in order to build confidence and exploratory skills for later, newer technologies.

For his project, Brian worked on three areas of technology implementation. All of these technology implementations illustrated Brian's Technology Knowledge that enabled him to quickly learn new technologies by exploration or tutorial consultation. They also showed his Technological Pedagogical Knowledge that enabled him to connect the technology to his classroom's perceived needs.

In the first area Brian planned lessons on immigration that incorporated Google Earth into his PowerPoint presentations, in order to "provide a more visual context of where something is" (Brian Reflection, p. 1). In reflecting on his GRITS work, Brian wrote, "This grant . . . has challenged me in my approach to teaching" (Brian Interview, p. 4). As noted in an earlier chapter, I emailed Brian after reviewing his lesson on immigration, "I would like you to consider making this lesson more interactive. Technology screams interactivity and too often lessons become lectures with pictures rather than really involving students. So think about that as you continue working with this. (Brian Email, p. 5). Brian responded with his reasoning.

> I have choose [*sic*] to stay away from group work on this for a variety of reasons, mainly that I only like to use it when it's constructive.... I prefer to stay away from animations in PPT. I think they have a role and I will add them in prior to

> teaching the lesson. I tried adding some in but ended up in a mess so I will finish that after the next phase of my project. (Brian Email, p. 5-6)

Brian did make some revisions and added slides to his PowerPoint on which he could record students' ideas and connect their prior knowledge to the content of the lesson. My questioning served as a mediating tool to begin his questioning of how best to use PowerPoint and whether it was an effective tool for his students' learning. The questioning continued into his placement setting and even in the interview he related a suggestion to improve GRITS. "I think it would be interesting to research how effective PowerPoint is and how . . . pictures and multimedia things can be incorporated with that and how it can actually impact students' learning" (Brian Interview, p. 10).

For the second part of Brian's project he planned the lessons and materials for helping his students video record a question for the YouTube Presidential Nominee Debate. He video recorded his own question and posted it on YouTube as an example. Brian's TPACK was evident in this planning as he planned for his students to get involved in the social sciences by engaging in the political work of the presidential election. By exploiting YouTube's offer to add voices to the debates, Brian combined content, technology, and the pedagogical concern for authentic work.

For his third component, using iWeb, Brian developed a web page for classroom use. There he planned to post class notes, plus additional readings and photos for students' continued learning. He described his web page as, "a very frustrating component of my grant. The program iWeb was fairly difficult to navigate for the fact that it was almost to [*sic*] basic" (Brian Reflection, p. 3). On the other hand, he felt that "iWeb worked just fine over a program such as DreamWeaver" (Brian Reflection, p. 3).

Brian concluded that his GRITS experience opened him to "the fact that technology is not that difficult of a thing to master. It also is not that expensive as for every expensive professional program that exists, there is a free version available for download" (Brian Reflection, p. 3). In his interview, Brian described the GRITS experience as, "big, just for the fact that it really got me thinking about how to use it [technology] in a classroom. . . . It was helpful to feel pushed in that way (Brian Interview, p. 9). He clarified, "I think I would've done it any ways but I don't think I would've thought about it as critically too, as what I do" (Brian Interview, p. 9).

The goal of the whole mini grant program, therefore, also served as a mediating tool. Brian believed that the push to integrate technology combined with the mediation of questioning enabled the development of his knowledge for teaching with technology.

Internship

Setting. A secondary social studies major, Brian worked with tenth graders in his internship placement teaching United States history. He estimated that about half of his students did not have computer or Internet access at home and reported that their technology knowledge varied greatly.

Brian had learned of two computer labs in the school. The library housed one computer lab that was not available to students after 2:30 p.m., which meant students without home Internet access could not work there after school. The other lab could be used after school if a teacher monitored the students' behavior and technology needs. Brian also thought that the music room had Mac computers that he might possibly be able to employ for recording podcasts. He described his classroom as well-equipped with technology, even though not all of it worked. "We got a receiver, a DVD, a VCR, a

projector, that's my Mac back there. We got a couple of different of Internet outlets.... None of the computers in the back work. It would be nice if they did" (Brian Interview, p. 1).

Classroom technology use. Moving from GRITS to actual classroom implementation revealed to Brian that his setting was not as he had anticipated. In terms of software and hardware, instructional time, and student engagement, he needed to make adjustments.

Brian reported that his school used Edline and GradeQuick for grading and web site communication, which rendered his GRITS iWeb project impractical for his setting. He found there was not storage space for his site, or any need, given the capabilities of Edline. Brian was probably relieved to use Edline given his described difficulties with iWeb. Brian's situation points out the varying infrastructures that preservice teachers face and the unknowns of the software that they may be required to use.

Brian also related that during the election debates he felt so far behind in his United States history classes that he could not take the time to enact the GRITS YouTube video debate question lessons. He had thought about using them with some of the government classes but did not want to leave his history classes when he was so far behind. Brian did not share whether he had discussed this decision with his collaborating teacher and what his collaborating teacher's stance on such projects might be. Like the other interns, Brian experienced the pressure to cover the curriculum in the prescribed time. In addition, he expressed frustration with the school district's treatment of social studies classes.

> There's just so much to cover. You know throw in snow days, throw in the fact that next week I lose my hours three through six to sex Ed. for an entire week, . . .

> and then the week after I think the counselor wants all my classes for one day to schedule for next year. And then he wants them again in April for, umm, to do career cruising. It's like you get picked on in social studies. . . . They just totally marginalize everything we do. . . . it shows you how the district values us. (Brian Interview, p. 9)

Brian faced lack of time not only for implementing technology, but also for teaching his social studies content.

Brian did, however, implement his PowerPoint/Google Earth lessons that he had planned as part of his GRITS mini grant. He not only used Google Earth for those lessons, but also found it effective "any time I had to go outside the country, like World War I again. This is where this country is. This is where Germany is, France, all these different countries" (Brian Interview, p. 8). Brian's TPACK shone in his use of Google Earth for helping students locate historical settings in today's world. He could point out how the places related to the United States and Google Earth offered a better sense than flat maps might give. His geography Content Knowledge combined with his Pedagogical and Technological Knowledge to make good use of the Google Earth tool for his content. Once he had planned for it in the immigration lesson as part of the GRITS setting, he recognized effective uses in succeeding lessons.

Beyond his GRITS projects, Brian employed YouTube videos as discussion starters, such as the one surveying young people about women's suffrage (Vardr, 2007) and the Karl Fisch and Scott McLeod twenty-first century skills movie called "Did You Know?" Brian managed to work around the infrastructural barrier of the district's blocking of YouTube by downloading the videos at home and embedding them in his PowerPoints so he could switch easily from one medium to another. In addition he downloaded candidate interview podcasts from iTunes and shared them with his students

in their discussions about the elections because he considered it important for them to stay informed. Sometimes he employed more traditional technology like the classroom television to watch the news, for example, when "Serbia and Kosovo split up" (Brian Interview, p. 9). Switching back and forth between new technologies such as podcasts and older technologies such as television news allowed Brian to use the most effective technology for his class's particular needs. He could pull podcasts from the Internet that recorded earlier news interviews for use when they fit in his class period, but he could also adjust to use the immediate playing out of democracy on television. His Content Knowledge regarding the importance of current events and recognizing social studies themes in them again combined with the Technological Knowledge of podcast and television and how they could be used to enhance instruction.

PowerPoint drove Brian's classroom presentations. His collaborating teacher, a photographer before he became a teacher, helped him hone his text and photo balance by giving him tips on picture placement.

> One thing that's been interesting to learn from him is, umm, design of PowerPoints and, umm, pictures and the way if you look at a picture of a person and they're looking this way I should have it facing the text so that way, their nose is facing the edge of the screen. The kid's eyes gravitate towards the nose and so they're not looking at the text as much, but if you're looking where the nose is ending and that's where the text begins, you know. (Brian Interview, p. 5-6)

His description of image placement in PowerPoints evidenced his TPK as did his embedding various media in his PowerPoints so that he did not have to spend time changing modes in class.

The GRITS questioning of PowerPoint lectures received bolstering by the mediation of his students' responses. "The kids were just getting frustrated because like

all we do is PowerPoints" (Brian Interview, p. 5). By the time of the interview Brian had answered to his students' needs by changing his instruction from primarily PowerPoint-based. "I felt that I was becoming complacent a little bit so I was like, 'Ok, I really need to figure out different ways that hit the kids.' So that's where I got the idea for the project" (Brian Interview, p. 5).

The project required students to research a famous person from the 1920s using online resources and then present their findings to the class. Brian gave them free reign over their presentations, but while one student sang a song by Bessie Smith, most of the others used PowerPoint or posters in their presentations. The most frustrating result of this project, Brian expressed, was the plagiarism, the taking words directly from Wikipedia and other sources. He felt he could not reduce his students' grades because he had not addressed such concerns before the project began. Based on his own high school experience he expected students to know about copyright and plagiarism issues and to be able to work within the guidelines.

The varying depth of Brian's TPK manifested in the 1920s biography project. He knew he wanted to do something different to engage his students and offer them differentiated instruction. His TPK was evident in his combination of online research, his assistance as needed, and students' sharing products with each other. His developing TPK can be noted in how he had assumed his students knew and cared about plagiarism, especially with digital text so easy to copy. Brian's TPK was limited by his lack of understanding about the scaffolding necessary for online literacy. His teacher education program could have equipped him with mediating tools for dealing with such issues.

Brian also recognized he needed to give more guidance with products instead of allowing most of the students to make PowerPoints. He did not tell what kind of sites he chose for student research, so we do not know whether he drew upon the primary sources as a social studies discipline expert or if he referred his students to online encyclopedias. From his complaints about students' plagiarism, "I mean you could sit there and look at Wikipedia and follow along with their presentation" (Brian Interview, p. 6), it is unlikely that his students dealt with primary sources. Because of the lack of digging into primary sources and lack of doing the work of social scientists, this example does not appear to be an example of TPACK. Again, guidance from the teacher education program's social studies content area could have assisted Brian in developing a repertoire of primary source sites for student use.

Brian also created webquests for his students at the suggestion of his fiancée. He enlisted his librarian's aid in posting links for student clicking rather than their using papers with links that they would need to type into the Internet browser. Brian did not talk about the contents of his webquests, only their structure, so I chose to categorize his webquest implementation as TPK. Here his developing TPK can be seen. While webquests usually center around an authentic inquiry task using web pages for research and aim for higher order thinking (WebQuest.Org, 2007), Brian described them as, "you just find the web sites and ask questions and make sure that they all kind of link together" (Brian Interview, p. 5). It is evident that a more knowledgeable teacher education instructor, field instructor, or collaborating teacher could have aided his conception of webquests to enhance his students' inquiry process.

Brian's implementations took advantage of all five of the broad categories of technology affordances. He used the projector's amplification to share his PowerPoints with his students, he took advantage of the representational affordances of Google Earth, the Internet afforded information for his students' webquests, his plan for students to create a video podcast question for the presidential debate would have transformed learning for his students, and it would have required collaboration as they filmed each other.

The complexities of Brian's learning to teach with technology included student technology skills as well as ease of use within the infrastructure. In discussing the webquests. Brian related how he needed to adjust to his students' keyboarding skills and printing issues in providing a means for answering the questions of the webquest.

> First time I tried it I had them typing in to a Word document and that was a disaster, so with the printing and everything it just got really ugly, real quick. So last time we did it, I gave them a handout. (Brian Interview, p. 5)

Brian's adjustment revealed his flexibility in dealing with barriers and willingness to continue implementing technology.

During our interview Brian brainstormed several technology options for his students: develop a MySpace profile for Ben Franklin; write digital storybooks; create a YouTube student podcast; put together a local Lansing map mashup like Lucy's; build a World War II podcast of a battle or part of life; study propaganda and produce propaganda using a media. He connected technology and content quite quickly, but the implementations required working through the infrastructural difficulties, contextual constraints, pedagogical concerns, and necessary student scaffolding. Brian's

brainstorming and limited student implementations demonstrated more of the complexities of learning to teach with technology.

In an earlier chapter I raised the question as to why interns had not transferred their social networking technology knowledge to their classrooms. In Brian's case, infrastructural impediments provided some of the reason. Brian related, "A lot of things that could be accessed that way are blocked by the district. . . . To tell you a few . . . , YouTube, MySpace, FaceBook, . . . pandora.com, so basically it's like anything that streams in some way is blocked" (Brian Interview, p. 4). Brian did not share what the districts' reasoning involved, but in any case, the district made it difficult for students or teachers to communicate and collaborate beyond the classroom. Brian talked about how he and other teachers worked to prevent the district from blocking even more. "We found out that C-Span is not [blocked], but we're trying not to use it too much because we don't want the district to, like, pick up on it and block it later" (Brian Interview, p. 4). Thus, while Brian believed his GRITS his projects "teach the students things not limited to the schools walls" (Brian Reflection, p. 1), the school district worked to maintain the barriers of the school walls.

At the time of the interview, Brian was still working through another infrastructural/contextual issue with his students' varying technological knowledge and the computer labs. He described his tenth grade students as varying from "kids . . . with video iPods and they know everything about everything on the computer" (Brian Interview, p. 3) to "other kids . . . who don't have a computer at home and. . . . You find yourself working with kids like, 'Ok this is what Google is. This is how you do a search.

This is how you save the file and download the picture'" (Brian Interview, p. 3). He explained how their skills impacted him.

> It's frustrating, but it's understandable. But it also made me step back and kind of adjust my expectations of the kids because I couldn't expect them all to email me something when half the kids don't have email access at home but the computer lab closes at 2:30 [p.m.]. (Brian Interview, p. 3)

Instead of giving up, Brian searched for other options and had recently discovered "that there is another lab in the building that I can go monitor . . . . After school, I can open it up for my kids to come in" (Brian Interview, p. 3). He talked about scheduling after school time even before the next project in order to help those students who needed to build some basic computer literacy. He talked, too, about scheduling after school time during the project "a) for the special Ed kids who need more time b) for the kids who just don't know what they're doing" (Brian Interview, p. 3). Brian expressed surprise at even having to teach his students the basics because he himself had grown up using computers and he had assumed the same for everyone.

Mediating tool- lesson designing. Brian listened to his students' input on his instruction as was noted earlier in his reasons for departing from primarily PowerPoint-based lectures. He also used their input in the lesson designing process. His process for teaching with technology was to learn to use the technology himself, then try using the particular technology with his students. He would then reflect on the implementation and note the elements that needed to change. Part of his reflection involved his students. "I had my kids fill out a self-evaluation form and I asked the question, 'What went well, what didn't, how can we change things in the future?' . . . to get their feedback on things that I hadn't caught" (Brian Interview, p. 7). As a designer he sought input from the users and adjusted. In activity setting terms, his students' input served as mediators of his

creation of mediators for the students' learning. Like Ambrosia, his experience and reflection served as contributors to his developing TPACK.

Response to activity setting. Brian resisted the strictures of the infrastructural constraints of his placement activity setting. He found ways to get around the filtered YouTube site and pondered ways to help his students gain access to computers beyond the classroom time. Brian also pushed himself to try other instructional methods that involved technology in order to engage his students more in their learning. Although he made himself sound rather apathetic about technology in his undergraduate work, by his actions he showed that he had discovered that he did need to and could integrate technology into his teaching.

The Purpose of Technology in Education

"My use of technology is rooted at the core in serving a function of accommodating students with special needs" (Brian Reflection, p. 1). While Brian focused on the accommodation aspects of technology in his GRITS application and reflection, he also emphasized the economic efficiency and utility purposes of technology in K-12 education as outlined in Table 4. "It prepares them for the real world. My inspiration for this [YouTube presidential debate question] project comes from a friend who had to make a presentation for a job interview. The only requirement was that he use technology in some fashion" (Brian Reflection, p. 2, 3). Brian talked about the work of his father and friend, remarking, "Everything we do in life is becoming absorbed into technology. . . . The competition around the world is just growing and you know I think the kids have to learn how to do this stuff" (Brian Interview, p. 9). He explained that it was important to teach "them how to find these different websites because if you don't know how to do that you're just so far behind

everyone else" (Brian Interview, p. 10). He viewed his YouTube presidential debate question as aiding his students' learning of technology. "This project will teach them how to use a laptop, a video camera, several of the programs on an iMac, a projector and other necessary life skills such as how to speak clearly and properly" (Brian Reflection p. 2, 3). Although Brian talked a lot about the necessity of teaching students how to use technology, he recognized that he had not done a lot of it himself. "I've only done one full project, but I've done webquests up there and stuff" (Brian Interview, p. 9). He talked about his plans, however. "And we'll do another project and you continue expanding their ideas of what's capable on the computer" (Brian Interview, p. 9). It seemed that Brian was beginning to understand how students' computer experience varied and the role he as a teacher could play in building their digital literacy.

Brian also alluded to the motivational benefits of using technology. As noted earlier, he adjusted his PowerPoint usage in order to better reach his students. In reflecting on his GRITS work, he noted, "I had a lot of fun using the different programs and can only imagine how much fun the kids will have using these programs" (Brian Reflection p. 3).

While Brian's TPACK evidenced in four different enacted lessons, three of the four examples from Brian's practice were based in Google Earth. They just dealt with different historical settings, so his TPACK had not spread across many applications. In discussing the purposes of using technology in education, Brian did not list technology as an aid to teaching and learning content except in referring to pictures in PowerPoint as aiding student comprehension. If he conceptualized the learning aspect as well as the market and motivational aspects, he might be more inclined to make even more implementations happen.

Summary

In summary, Brian exemplified developing TPACK as some of his lessons took advantage of technology to aid his students' learning. Other lessons, however, would have benefited from some more expert pedagogical guidance for Brian that would have enabled him to encourage student learning to go even deeper. The questioning begun in the GRITS setting continued into his placement setting and aided his development of TPK as Brian showed interest in what research had shown about certain applications' effectiveness. Brian's placement activity setting illustrated the complexities with which preservice teachers deal as they navigate infrastructural blocks and varying student computer literacy. Brian himself showed a resistance response to such a setting. As a secondary intern, Brian dealt exclusively with social studies content, yet his particular pedagogical content uses of technology did not outstrip his general pedagogical uses of technology. His colleague, Margaret, however, illustrated a more robust development of TPACK.

Margaret

> I think people just have to be willing to try it. I think that technology is frustrating for so many people because it's something that they haven't always had their entire lives. . . . [You have to] be willing to take the time to stumble through it all. I think that takes a lot out of people. . . . I think a lot of it is [attitude]. And knowing who to ask is crucial. (Margaret Interview, p. 7).

Margaret's TPACK grew because of her willingness to ask for help and share ideas with others. Her two placements varied greatly in terms of collaborating teacher support, but she still worked to aid her students' learning with technology. Her subject matter seemed well suited to the latest digital technologies and she took advantage of the technologies' affordances.

Personal technology use

Margaret related, "Well, I use my computer for pretty much everything" (Margaret Interview, p. 1) and proceeded to list both personal and professional uses. Margaret paid her bills online because she was trying to go paperless and she purchased online when she had the finances to do so. She received Photoshop for Christmas so she edited her own digital photos for personal and classroom use. Margaret's computer provided music by playing CDs, through purchasing music on iTunes, or through her iPod. Margaret and her fiancée also played video games online through their Xbox Live. She used FaceBook in addition to instant messaging and email for personal communication.

Margaret used the Internet for researching and also participated in online collaborative groups. On FaceBook Margaret belonged to several professional groups such as those focusing on teacher education, foreign language instruction, and the student state teachers' union. The FLTeach forum offered her many ideas for teaching French.

Margaret's extensive uses of technology in her personal life illustrated her Technology Knowledge. The collaborative work in which she engaged online did not, however, translate into online collaborative work for her students in her language classroom.

High School

Margaret reported more educational uses of technology from her high school experience than the other interns did from theirs. She recalled learning how to program her graphing calculator in high school and then working with another student to graph the letters of the alphabet in upper-case and lower-case. They also videotaped presentations

for their classes. Although Margaret did not relate how these experiences impacted her view of teaching with technology, it appeared she had some models for using technology in learning that the other interns did not.

Teacher Education

Unlike Brian, Margaret had gained some mediating artifacts from her teacher education program that assisted her teaching with technology.

> In just my teacher education training, we've been taught to not assume that anyone knows anything. We start from square one and really structure it, and I've had to do that with, I don't always remember, but for example with the site we went on yesterday, um, I made sure to give them the site, I made sure to give them the flow of what links they're clicking. . . . Just kind of walking through step by step and not just assume that they all know how to get from A to D without those steps in between. (Margaret Interview, p. 4)

She learned the importance of scaffolding and employed it when working with her students.

Margaret described her methods instructor as "very into technology" (Margaret Interview, p. 2). The instructor set up a wiki, a mediating tool, for Margaret and her foreign language group members in order to stimulate collaboration. Margaret shared how she and her fellow foreign language group members used the wiki to share ideas, questions, and problems with lessons and classroom management issues. The instructor also mediated planning for instruction. "So she's kind of given us some ideas, she pushes us to use technology a lot" (Margaret Interview, p. 2). Margaret did not elaborate on the ideas she had received from her instructor, but she interpreted the instructor's push to be motivationally based. "The kids that we work with are very technologically based; they use it everyday. We need to be able to, you know, hold their attention, so we do that with technology" (Margaret Interview, p. 2). This pedagogical emphasis on keeping students

motivated could be seen in the way Margaret planned her instruction beginning with pedagogy and then adding in content and technology.

Beyond the methods instructor, Margaret described the message from the other instructors regarding technology in the classroom as, "'Not really that important.' They haven't pushed it, but they haven't said, 'Don't do it'" (Margaret Interview, p. 6). As will be seen, Margaret responded to the conflicting messages of the teacher education department regarding technology in instruction by following her methods instructor's advice and building on her learning from other activity settings.

GRITS

Mediating tool- lesson designing. Margaret entered the GRITS activity setting with general pedagogical reasons for using a digital camera, and photo and video editing software for her French language placement in a suburban high school of 1411 students in grades 10-12. About one-fifth of the students qualified for free and reduced lunches. The student body was predominantly White, with nine percent African American, two percent Asian, five percent Hispanic, three percent multiracial, and less than one percent American Indian (Great Schools, 2009).

> I would like to use technology in my classroom to change how students think about learning a foreign language. Too often languages are taught out of a book through repetition, and kids become bored and lose interest. I want to show students how language is a part of every day life, and their lives are heavily influenced by technology. (Margaret Application, p. 1)

Her reasoning for implementing the technology reflected the motivational purpose she assimilated from her methods instructor.

Margaret's grant included money for time to develop plans and the use of ten MacBook laptops, a digital camera and camcorder. She then developed a plan to produce

a web page plus lesson plans for three projects: a video commercial, an audio interview, and an audio podcast of French words for student listening. In the end, however, she developed a web site and four lessons for use in her French classes, as described below. Her CT was "very excited to learn new ways of incorporating technology" (Margaret Application, p. 1), but he was out of the country for the summer and therefore unable to collaborate with Margaret on her GRITS lessons. He planned to help Margaret throughout the school year with technology integration.

With Margaret's pedagogical emphasis on motivation, she planned her lessons to be stimulating ways for the students to use technology to learn French. For each of the plans Margaret created a sample of the product she expected from students so she could work through the process herself and address any difficulties. The first lesson planned that students would produce a video weather forecast. They would write the script in French, use photos, clip art, video and audio clips and would be able to perfect their pronunciation of French words by practicing for their video. Margaret's TPACK was evident in this project as she helped her students focus on the content. "In your forecast you should: . . . Introduce yourself and your country/region. . . . Describe the weather conditions (Il fait du soleil). . . . State the temperature(s). . . . Suggest appropriate clothing. . . . State if this weather is typical of your region" (Margaret, Meteo Assignment Sheet, p. 1). Her choice of video as the tool for her students to practice their French vocabulary exhibited her technology knowledge integrated with her content knowledge and pedagogical knowledge. Video would require her students to speak and use motions and facial expressions and learn more about the places where French is spoken, all important components in learning a foreign language. Her understanding video as a

motivational tool, the scaffolding materials she produced, and the choice of working in groups to produce the video highlighted her pedagogical decisions connected to the content and technology.

The "Google Earth- A Day in Paris" lesson aimed to help students dig into French life by requiring trios of students to plan a virtual tour in Paris using Google Earth. Margaret specified using the Metro for transportation and recording the time needed for travel to five of ten possible destinations. She encouraged students to use spreadsheets or tables to track their information on landmarks' hours of operation, fees, and importance. Margaret required each group to submit their final itinerary with a page for each destination that outlined the transportation to travel to the location, the reason for visiting that location, the time allotted, photos, fees, and three interesting facts about the location. Again, the planning of the project illustrated Margaret's TPACK in her recognition of Google Earth's possibilities to facilitate her students' understanding of an important French city and culture.

Margaret's next plan, the conversation comic lesson plan, could be used at various times in the curriculum as students added new phrases to their vocabulary because it aimed to "allow students to see how conversations flow and will also give them a chance to practice using different phrases in different contexts" (Margaret Conversation Comic Plan, p. 1). Margaret planned two possible variations, one in which she produced the comic framework and the students filled in the words, and the other in which the students took pictures, added them to the comic application, and then added the text. The flexibility of Margaret's TPK was evident as she noted possible adaptations and multiple times for using this plan.

In the implementation of the fourth lesson plan, the magazine lesson, students would choose "a specific aspect of modern French culture [to research] and then create a magazine article about their findings using Comic Life" (Margaret Magazine Plan, p. 1). They would take or find pictures to support their articles that they had written in French and then combine the two using Comic Life. Again, Margaret's TPACK enabled her to exploit an engaging suitable medium for students to explore and share French culture.

Margaret created some supplementary lessons as well. She recorded her reading of vocabulary words for phonetics listening and speaking practice and posted them on her web page for student access. She also planned student recording of reading French passages for interpreting stories. For use prior to her research lessons, she produced an Internet Research Awareness handout in which she addressed copyright, fair use, Internet searching, web site evaluation criteria, and citation of sources. In addition she prepared a brief lesson to assist her students' awareness of the affordances and constraints of Babelfish, on online language translator.

The breadth of Margaret's TPACK can be seen in the multiple affordances of technology that she exploited in her lessons. Creating video would transform students' learning and require collaboration, Google Earth and Comic Life would aid with representations, while students would access weather and travel information through the Internet. She did not display breadth across subject areas because her instruction did not require it.

Ambrosia, Terese, and Brian wrote their lesson plans and then created additional aids, such as PowerPoint and SMARTBoard presentations for Brian and Ambrosia and posters and student journals for Terese. Margaret, however, created student materials

first. Her first set of materials for the weather forecast video project that she emailed to me included the assignment description and requirements, a group evaluation form, and a grading sheet, but no lesson plan. Her first set of materials for the magazine article assignment consisted of an assignment sheet giving a timeline and brief description of the project, a grading sheet, and a project guide to help groups through the process, but again, no lesson plan. In response to Margaret's materials I requested that she write the lesson plans to help her focus on how the lessons connected with content and her purpose for doing them. I also asked her to prepare samples to help her work through the possible difficulties students might face. When she wrote the plans, Margaret chose to list broad standards in her lesson plans rather than the more specific benchmarks. Her written lesson plans gave broad strokes of her plans and ideas instead of specific questions and actions she planned to use to guide the discussions and activities. Her objectives spoke more of what the students would do than how she hoped their learning would be impacted. Unfortunately, I did not receive the plans until the due date so we had no time for further discussion and revision.

Margaret's materials relay considerable information about the goals for the lessons, such as "Think about what we have been learning in class: how to describe the weather, state the temperature, dressing for the weather, etc. You should address all of these things in your weather forecast." (Margaret Meteo Assignment Sheet, p. 1). It was surprising, therefore, to read so little in the lesson plan. "Objectives: Students will use their knowledge of weather to create a weather forecast using the program iMovie. Standards: Communication, Connections, Cultures, Comparisons" (Margaret Meteo Lesson Plan, p. 1).

Margaret's plan for her GRITS project when she still envisioned a commercial showed that she planned to begin with the lesson planning and then move to the project sample.

> June 20
> Begin Work on imovie commercial
> -Determine goals
> -Personal
> -Educational (what do I want students to accomplish?)
> -Determine assessment methods
>
> June 21
> Lesson plan (rough draft)
> Develop script
> Record commercial (rough draft)
> Make necessary changes to script/movie
> Record commercial (final draft)
> Lesson plan (final draft) (Margaret Plan, p. 1)

It is not clear why she adjusted her planned approach and skipped the lesson plan step.

Given Margaret's involvement in online forums and finding resources online, it may be that Margaret found and revised ideas online and then wrote lesson plans to go with them. That might explain why her own portions were not well developed. Or, it might be that she poured her energies into the student materials, thinking through her goals and objectives while she designed the lesson and then had little motivation to produce the written plan. Another possibility might be that she did not yet have the language to describe the complexities of what she envisioned.

In any case, Margaret, like the other interns, used a form of lesson designing. She gathered ideas, thought about the French content to be addressed for her students' practice, decided which technologies would best assist the learning, and then produced mediating artifacts for her students' guidance and for her own instructional processing as well.

In reflecting on the impact of her GRITS experience on her teaching with technology, Margaret noted, "I feel probably more willing to put time and effort into figuring out, you know, how to bring it [technology] in to my lessons, and I feel like it's more important" (Margaret Interview, p. 4). She had spent a lot of time making a video, a web site, a podcast, a magazine article, and a tour of Paris, plus time figuring out how to post the web site and podcast for her students' access. She had learned more about the complexities of preparing for teaching with technology, the time and effort it required.

Internship

Settings. Margaret interned in two different placements. She planned her GRITS lessons based on her fall semester placement in the suburban high school. Her classroom there was equipped with a desktop computer and document camera and she felt all her students had computer and Internet access at home. On her GRITS application she reported software that accompanied the class textbooks, but she did not refer to using it in any correspondence or her interview. She also responded that her school did not have a computer lab.

For her spring semester placement Margaret transferred to a rural, small town high school where she taught 9-12 grade French with her collaborating teacher. A somewhat smaller school of 1093 students, fewer of its students, only 15%, qualified for free or reduced lunch. Two percent of the students were Hispanic, three percent multiracial, less than one percent was African American, American Indian, or Asian, and 94 percent of the students were White (Great Schools, 2009). Margaret missed the document camera in her new placement. The desktop computer in her room had "limited Internet access" (Margaret Email, p. 24), the overhead was old, and the TVs had a long

waiting list for checkout. There was, however, a computer lab. In both placements Margaret supplemented the schools' technology with the ten GRITS laptops as needed. Margaret's CT did not help her with technology ideas, but encouraged her to find ways to use technology in her teaching. She felt her second CT was more open to her technology implementations, whereas she perceived her previous CT felt they lacked rigor.

Classroom technology use. Margaret's developing TPACK evidenced in her classroom technology use and in her dealing with the resources and lack of resources in her placements. Margaret broadened her affordance exploitation with the document camera in her first placement. She grew attached to the ability to display objects and papers and her computer screen. As part of their lessons, Margaret's students took digital pictures to illustrate adjectives, video recorded invitations and responses, checked prices on French grocery web sites, created comics about themselves, and discussed French films and music video clips from YouTube. Margaret's Pedagogical Knowledge showed in her recognition that students are "captured by images" (Margaret Interview, p. 5) and her realization that new processes need to be scaffolded and competencies not assumed. Her TPK could be seen in her use of the document camera, the uses of video clips, audio recordings, and comic creation, all of which can be used with various content. Learning about a language and culture has so many components and Margaret used a variety of media to aid her students' understanding of French words, phrases, and culture, tapping into and exhibiting her TPACK. Her implementation of digital pictures for illustrate adjectives enabled her students to add a visual as well as textual connection to the new vocabulary, possibly enabling them to diminish the need to translate to English first, and instead remember a visual representation of the describing word. Her students' videos

inviting and responding to invitations took advantage of the ability to redo performances, incorporate actions with voice inflections and pronunciation, and review the recordings multiple times. By accessing French grocery store web sites with her students, she moved them from their school into an authentic French "place".

Margaret related how problematic it was for her at the beginning to only have ten GRITS laptops. She found it "difficult working with half the group on the computers, and the other half doing something else" (Margaret, p. 4). She explained that she tried to scaffold the learning of the technology but that the students just wanted to take it and get started on their projects. Here the limits of Margaret's TPACK can be noted. She needed the technological pedagogical input of her CT or other mentor to determine how to structure learning experiences for her students with limited resources because she was still developing that knowledge. In her interview she echoed that need. "I would . . . definitely encourage more collaboration with the mentors—with cooperating teachers. They can kind of give you that perspective that we don't have as far as time constraints and how to structure an activity like that" (Margaret Interview, p. 6). Margaret recognized the need for tapping into collaborating teachers' Pedagogical Knowledge even if they did not demonstrate Technological Knowledge.

The complexity of implementing lessons using technology in particular contexts became evident in Margaret's classroom experiences. In discussing how many of her GRITS lessons she implemented, Margaret admitted that she had been only able to use three or four implementations because of the restrictions of her activity settings. "I think I was ambitious with my lessons. And, they would take a lot more structure and time than we have in our trimester schedule, so time is definitely a restraint" (Margaret Interview,

p. 4). She felt using technology took longer than she originally envisioned. "To be able to structure it in a way for kids to use it effectively, it takes longer" (Margaret Interview, p. 5). She also felt that lessons implementing technology took longer at the rural school, illustrating the difference created by the context. She recognized how she needed to adapt to her students' technology skill level. "If I was at [the suburban school] and I need the kids to do something, I could skip a few of those steps and it would be okay" (Margaret Interview, p. 5). Margaret also tied her instructional time to time outside of the classroom, homework time, and noted the impact of students' lack of home access on her instructional time.

> And here, students don't necessarily have access to the Internet at home, where everyone at [the suburban high school] did. So anything that required them to go home and do research on the computer, I can't assume that anybody can do that here. (Margaret Interview, p. 4)

While Brian had talked about helping students in the computer lab after school in order to compensate for lack of home access, Margaret had not explored those possibilities in her new placement.

When Margaret was making the transition from the suburban to the rural high school, she emailed me requesting help. She felt the new activity setting changed what she could do with her GRITS lessons.

> I have been moved from my placement in [the suburban high school] to [the rural] High School. They have virtually no technological resources here and I was wondering if there is anything I can bring into this school. I wrote the grant based on the technologies that [the suburban high school] was equipped with and now the school I am placed in has an overhead projector that barely works. I think it would be awesome to get a smartboard in here. Would anything like this be possible? If not through [our university], do you know of anything we could do to get our hands on one with some fundraising? (Margaret Email, p. 22)

I responded that she could "check out a projector, camcorders, cameras, mics, all the things the [university has] to loan out, except for the SMARTBoards" (Margaret Email, p. 22). She decided that she would pursue a grant for a SMARTBoard through the school or some other educational foundation. When I checked back with her progress a few weeks later, she responded with frustration in her email.

> I'm trying to figure out how to incorporate the tech into the classroom. It's difficult because it seems that in order to use one thing I would have to use a bunch of others as there is literally close to no technology in the school. The little tech they do have is very hard to get ahold of. (Margaret Email, p. 24)

When I interviewed Margaret she talked about using the GRITS laptops for the students' filming of their invitations and responses, but she had not borrowed a projector from the university for her classroom. The limits of Margaret's TPK manifested in her fixation on getting a SMARTBoard rather than working with the available laptops, projector and other digital equipment. It might be that her student-centered projects had taken too much time so she viewed the SMARTBoard as a better option for whole group participation.

Margaret's struggles also illustrated the infrastructural difficulties that preservice teachers face. In her new placement she suddenly had to adapt her classroom teaching in order to compensate for her lack of a projector that could show objects and computer screens and the Internet. She also had the computer lab as a new resource that she needed to work into her existing instructional style. With the computer lab came more infrastructural frustrations, those of connectivity issues and Internet filters. "Yesterday we went down there, and for some reason we couldn't access the Internet at all and we could earlier in the morning. So we had to wait for about 20 minutes and have them reboot us" (Margaret Interview, p. 5). Margaret's experience illustrated another reason that technology projects are viewed as taking time. Twenty minutes of a class period is a

substantial portion. When the Internet did work, the filter stood in the way. "We unfortunately, aren't able to access certain sites. And that's actually quite a few sites . . . YouTube for example. There's lots of stuff that they don't want kids to see, but there's also a lot of really good stuff out there" (Margaret Interview, p. 5). She called attention to the benefit of linking students to other parts of the world, especially in a class learning another language used in other areas of the world.

Response to activity settings. In spite of the difficulties, Margaret resisted the status quo of her placements. While her first placement collaborating teacher used the document camera, he did not employ other technologies like video or Comic Life. In her second placement, Margaret resisted even more, contacting others and me in order to gain more equipment to enable her teaching with technology. She worked in the lab in spite of filter issues and Internet stability issues. She did not just acquiesce and teach French through more traditional methods.

The Purpose of Technology in Education

As illustrated in Table 4 in Chapter Three, Margaret envisioned many purposes for technology in education. The cultural benefits of classroom technology use were apparent to Margaret. She appreciated technology's ability to connect students to the world. She also hoped to connect her students with French students. "Ultimately I would like to use this technology to share and communicate with students of the target language" (Margaret Application, p. 1).

Margaret also related the economic efficiency and utility purposes of technology use in classrooms. "I think that will kind of prepare them later on if they're going to use any of that technology, . . . just opening doors for them to be able to say, . . . 'That might

be something I'd like to do later on'" (Margaret Interview, p. 5). She recognized how much technology is a part of life and wanted her students to be able to use it well. "I want to show students how language is a part of every day life, and their lives are heavily influenced by technology. I think it will give them . . . new ways to communicate what they've learned" (Margaret Application, p. 1).

As previously noted, Margaret viewed technology use as motivational to her students. "Too often languages are taught out of a book through repetition, and kids become bored and lose interest" (Margaret Application, p. 1). In addition, however, she recognized that technology could aid in teaching and learning. "Technology is not only fun, but necessary to use in a classroom to reach all learners" (Margaret Reflection, p. 2). In each of her lesson plans she noted the intelligences addressed in the plan. "I think it [technology] will give them new ways of learning" (Margaret Application, p. 1). She believed students' active learning was important. "I would like to implement technology that the students can use to learn and share their ideas. The technology I have requested will make students an active part of their own learning" (Margaret Application, p. 6). Margaret noted how essential technology was as a learning tool in the language classroom. "Especially in the language classroom, kids need to have the audio where they can speak and listen" (Margaret Interview, p. 5). With a broad base of purposes for technology, Margaret found many reasons to use technology in her teaching.

Summary

Margaret's creativity, Technology Knowledge, desire for student centered activities, and her content area allowed her to quickly connect French literacy learning opportunities with technology. Not only did her case illustrate her TPACK, but also how

quickly a lack of resources and fewer student technology skills can derail a preservice teacher who loves to incorporate technology into her teaching.

Complexities of Learning to Teach with Technology in Secondary Settings

Both Brian and Margaret illustrated the process of learning to teach with technology in the secondary setting. Although their teacher education program emphasized content, both Brian and Margaret focused on pedagogical aspects of learning content with technology before the content. It might be due to the nature of their high school students who needed to be motivated, or it might be that both Brian and Margaret connected pedagogy more easily to technology than content to technology particularly as a starting point.

Working with a form of literacy like French, Margaret may have had an advantage because of the communication technologies like video and audio podcasts. The international nature of the Internet also allowed her to easily connect her students with actual French web sites. For social studies, Google Earth connects easily with geographical studies, but other technologies do not so clearly exhibit connections. Brian needed to search for and repurpose YouTube videos. Both of them also have room to grow in their use of technology to teach to their content. With his emphasis on pedagogy rather than content, Brian missed the opportunity that the Internet offers for primary sources and viewing international perspectives on historical events. Margaret, too, missed the student learning opportunities afforded in communicating with native French speakers via blogs, email, wikis, and other interactive sites.

Brian admitted that in his undergraduate work he had not envisioned using technology in an urban school. He developed TPACK, however, through the GRITS

experiences' focus on content and his internship experience with students who needed variety in social studies instruction. Margaret faced the difficulties of changing internship placements, yet she sought help from her many resources to help her continue teaching French with technology. In any case, the three knowledge domains came together in their planning.

Elementary and Secondary Cases

Contrasting the secondary intern's experiences with those of the elementary interns, the four case studies make clear the advantages of being responsible for teaching in only one disciplinary area. As discussed in Chapter Three, the secondary interns' focus on one subject area rather than four enabled them to develop their TPK and TPACK as evidenced in the number of implementations. Their knowledge of one disciplinary way of knowing, recognizing the difficult topics within the discipline, and knowing the representation of disciplinary concepts, was beginning to facilitate their greater connection of technology to particular content than general pedagogical uses. Brian and Margaret were able to take what they had learned in one topic and transfer it to another topic within the same content area. Brian's use of Google Earth in social studies transferred easily from an immigration study to a World War I study and Margaret's use of video and Comic Life for French literacy transferred easily from one topic to another. It is possible that the knowledge of a single discipline also broadened their TPACK in terms of affordances. Both Brian and Margaret tapped all the affordances in more ways than Ambrosia and Terese.

The difference in age of their students also impacted the interns' view of educational technology's role. Although Ambrosia and Terese talked about the economic

efficiency and utility role for their students' future careers, Brian and Margaret worked with students only a few years away from their careers. They felt more pressure to help their students learn to use technology. While Ambrosia and Terese spoke of their adjusting to their students' technology skill levels, the technology skill levels of Brian and Margaret's students impacted their instructional choices and time in greater ways.

As previously discussed, motivating high school students with student-centered technology implementations played a larger role than the elementary interns' motivating their students with technology. Still in the early stages of their education, elementary students did not resist teacher-dominated lessons in the same way that Brian's older students did by expressing their displeasure with PowerPoint lectures.

These differences between these elementary and secondary preservice teachers demonstrate the important role disciplinary Content Knowledge plays in implementing technology for teaching content. Preservice teachers need the knowledge of the content and the discipline in order to effectively aid their students' learning. The differences also demonstrate the importance of helping elementary preservice teachers to recognize that students' technology skills are required for learning in elementary and secondary schools and not just for future careers.

TPACK Trajectory in the Cases

These four case studies showed the complexity of learning to teach with technology. These interns' settings impacted the interns' TPACK expression and development. Like their teacher education experiences, their placement setting experiences also were truly unique and complex and the interns' use of mediating tools built their TPACK to differing points on the trajectory.

The TPACK trajectory, as introduced in Chapter Three, takes into account three dimensions of TPACK. First, the number of technology infused lessons, those that exhibit the interns' TPK and TPACK, are considered. Second, the depth of TPACK is seen in how many of the lessons evidence the interns' TPACK, or how many lessons employ technology in pedagogically sound, content-specific ways. Third, the breadth of TPACK emerges in the breadth across content areas and employment of technology affordances.

Flexibility, breadth across content areas, expertise in one content area, expertise in one hardware, breadth across affordances, all these characteristics describe different interns, yet all the interns displayed TPACK in their classrooms. Such is the nature of TPACK, a multi-faceted, flexible knowledge that looks different across individuals, especially individuals who are at the beginning of the TPACK developmental trajectory. These interns were preservice teachers, individuals developing their pedagogical knowledge and skills and working on teaching content. They stood out from other interns because they also took on the additional challenge of learning to teach with new technologies in addition to the ubiquitous white boards, pencils, and textbooks.

These four cases displayed the complexity of understanding TPACK. All four developed additional ways beyond the GRITS plans to use technology in their classrooms, thus proving that they could exercise their TPACK outside of the GRITS program. It should be noted, however, that for all but Ambrosia, those lessons were just a small number of the total that they taught, showing the unevenness of the use of TPACK in their daily teaching.

In terms of sheer number of TPK- and TPACK- based implementations, Margaret placed highest on the trajectory with 15 uses (See Appendix C for all the interns' uses). She produced the most plans and reported the most implementations of technology in her teaching. Ambrosia and Brian followed closely behind with 13 and 11 uses respectively. Terese contrasted with the other three in reporting technology in her teaching only five times.

The depth of TPACK showed most clearly in Margaret also, with eight of her lessons including content-based technology for instructional purposes. She clearly understood how new technologies could assist her students' foreign language literacy. Brian and Ambrosia both evidenced four instances of TPACK-based instruction and most of those instances employed the same software, Google Earth. Terese's two TPACK-based lessons grew from her GRITS software, Science Simulations. Although Terese displayed incredible insight and Content Knowledge as she explored her GRITS software, the same knowledge did not come through as strongly in her other uses. One TPACK evidence did not necessarily ensure another.

The third aspect of TPACK, breadth in terms of affordances and content areas, gave another vantage point (Figure 7). Again, Margaret pushed further along the trajectory with all five affordances exploited: amplification, representation, information, transformation, and collaboration. Her lessons took most advantage of the representational affordance, but she also engaged the other affordances in teaching her students. Brian, too, took advantage of all five affordances, but not as often as Margaret and with more amplification examples. While Ambrosia and Terese each took advantage of three different affordances, Terese's breadth of affordances seemed richer because so

many of Ambrosia's uses involved amplification. Breadth in terms of subject areas showed the elementary interns, Ambrosia and Terese, farther along the trajectory than the secondary interns, but not by much. The secondary interns limited themselves to their single major content area. Ambrosia reported TPK- and TPACK-based lessons in science and social studies while Terese reported lessons in science and literacy, just one more subject area than the secondary interns.

What can teacher education programs learn from these interns' experiences? In the next chapter I offer some theoretical and practical suggestions.

CHAPTER 7

CONCLUSION: SUGGESTIONS FOR TEACHER EDUCATION THEORY AND PRACTICE

Studying a small group of seven interns does not provide generalizable knowledge, but it can suggest some approaches that merit further investigation. In this chapter I offer implications for theoretical frameworks and teacher education practice. Next, limitations of the study are listed, followed by suggestions for further research possibilities.

Theoretical Contribution

The TPACK framework of teacher knowledge plus Activity Theory for explanations of changes in knowledge and actions can be integrated to become a new framework of TPACKtivity. The TPACKtivity framework combines the "what" that is to be learned by preservice teachers with the "how" it is learned. It describes knowledge for teaching as interdependent knowledge of pedagogy, content, and technology and illumines how that knowledge is developed in settings through mediating tools that can transfer to other activity settings. These seven interns' experience revealed that when the mediating tools of teacher as instructional designer using technology were developed, they were able to use their TPACK, knowledge as design, to mediate their own learning and growth in settings whose subjects did not share the same identity or goal. Activity theory identifies factors and tools for knowledge development, including the knowledge itself as a tool, and TPACK provides definitions and examples of what the desired knowledge looks like. This study built on Cox's (2009) refinement of TPACK component definitions by applying those definitions to preservice teachers' implementations, resulting in more examples of TPACK components.

The trajectory of TPACK development suggested by these seven interns' experiences implies there may be scaffolding that is required for building TPACK. It makes sense that the individual knowledge components be constructed first of all, but there is some evidence that employing the design frame, which requires all components be drawn upon, empowers the more complex knowledge to develop, as shown in Ambrosia's case.

This study, using the TPACKtivity framework, sheds light on teacher learning with technology, but also raises some interesting possibilities for teacher educators to consider regarding teacher learning in general. It highlights the importance of designing for learning, the practical application of theoretical constructs. Although interns often complain about having to write lesson plans, this study shows how lesson planning from differing entry points aided these interns in solving the wicked problems that teachers face as they help their particular students in their particular context learn specific content.

The social nature of learning is also highlighted by this study. The interns revealed how much they learned from each other in a short technology conference presentation and from colleagues in their teacher education classes. They talked about how valuable the feedback and communication with the GRITS coordinator was for their learning to teach with technology, and Margaret related how her instructor's encouraging input motivated her to teach with technology.

This study also spotlighted that preservice teachers "hear" both the explicit and the implicit messages of their teacher education program. While this study did not measure the impact of the various messages, the incongruence of messages led some students to disrespect of their instructors.

This more complex and robust framework suggests come practical implications, conceptual tools, and areas requiring further research.

Practical Contributions

Ideas come more easily than enacting. While the interns did not offer a lot of technology integration stories, when asked to brainstorm one that taught the GLCEs and fit their students, they all easily came up with possibilities; some even came up with several possibilities. At first that puzzled me and made me wonder whether I was not giving them enough credit regarding their use of TPACK. I soon realized, however, that brainstorming did not take into account time or resources, two barriers that loomed large for all of the interns. The difference, I believe, lies in knowledge as design (Perkins, 1986), flexible knowledge that sees possibilities in complex contexts. The use of TPACK works to design instructional solutions in spite of (or because of) the constraints of time and resources. It pursues creative means to meet its design and instructional goals. The following suggestions from the study intend to build TPACK in several different ways, just as the interns listed multiple ways that impacted their TPACK development.

Entry Points into Lesson Designing

My suggestions for learning about technology in teacher education come from the TPACK components and build on the knowledge as design principles. As the interns' processing showed, educational technology implementation can be approached beginning with technology, content, or pedagogy, but all three will come into overlapping consideration as the design process unfolds.

For teacher education therefore, instructors can approach learning to teach with technology through differing entry points, although all knowledge domains intersect

throughout the process. Further research is required to determine the efficacy of one entry point over the others, but for now I would suggest the following learning possibilities, as depicted in Figure 15, Figure 16, and Figure 17. I suggest that instructors use the varying entry points in discussions or assignments that employ design of learning situations. It is important for instructors to call attention to the processes and instructor decisions (Boling, 2008; Fairbanks, Freedman & Kahn, 2000; Keating & Evans, 2001) so preservice teachers can realize and practice the bricolage (Turkle, 1995) nature of teaching with technology.

Instructors can begin with a particular technology (Figure 15), perhaps one from daily life in order to build on existing technology knowledge and to help preservice teachers engage in flexible, creative thinking. Looking at that technology, instructors with their preservice teachers can discuss the affordances and constraints of that technology. From these discussions it would be helpful to build a common database or resource listing to which they could later refer in other designing sessions. They can then discuss together the TPACK questions: Which difficult concepts can be represented more fully using this technology? To which processes of which discipline(s) does this technology give access? How can this technology build upon existing student knowledge? How can this technology develop new ways of knowing in particular disciplines? If the teacher education focus is on a particular content area, the above questions can address that content area rather than several. After considering affordances and constraints and content knowledge, instructors with their preservice teachers might brainstorm possible content applications and then determine the technology's pedagogical advantages for their particular contexts. While I've laid this out as a straightforward step-by-step

process, as with the interns, it is actually a bricolage (Turkle, 1995) process as each new choice brings up new implications for the previous choices and determines new routes to take in order to find a good solution to the particular wicked problem.

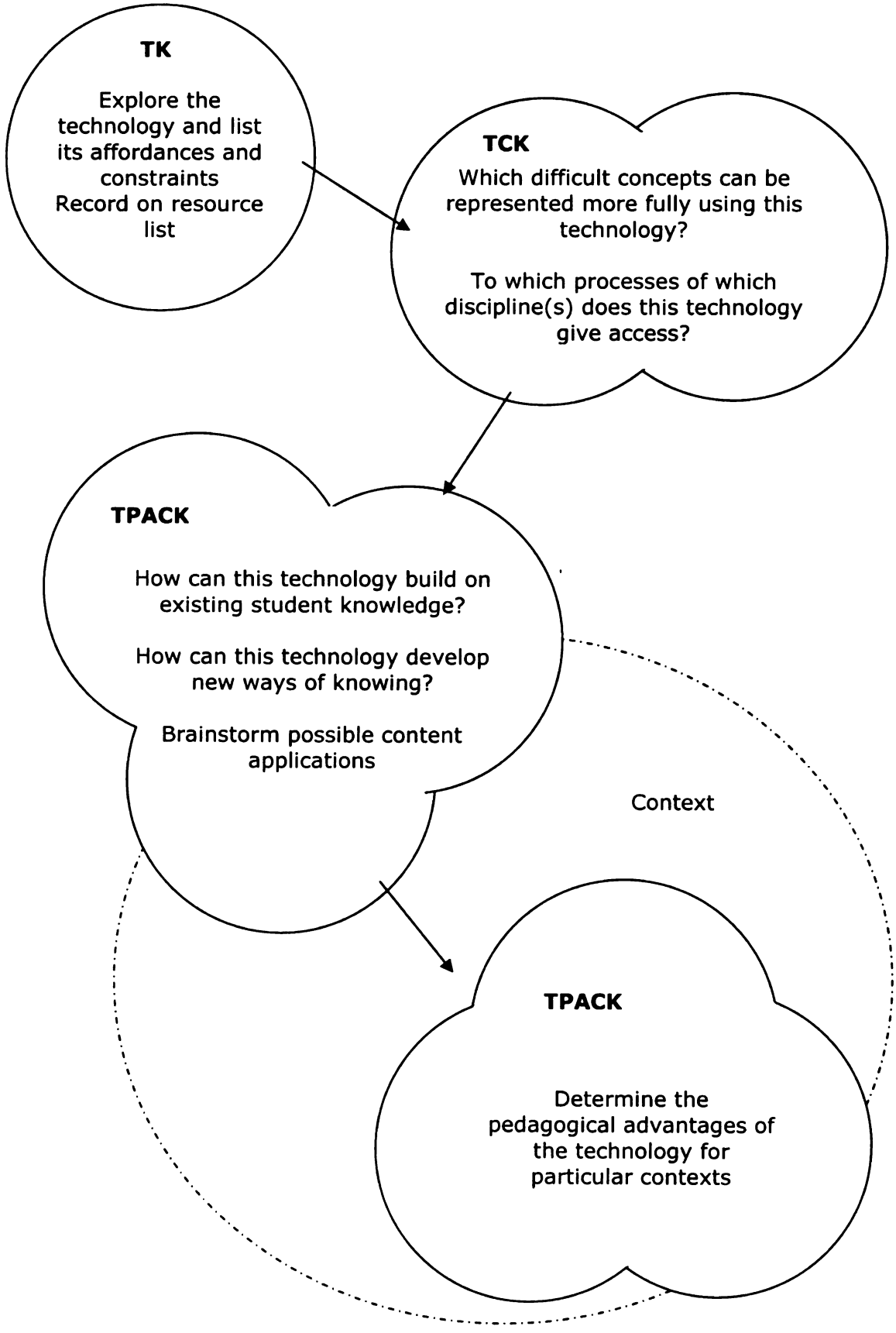

Figure 15. Technology Entry Point for Designing Lessons with Technology

Starting with content (Figure 16), instructors with their preservice teachers can identify concepts or processes that are difficult for K-12 students to understand. Together instructors and preservice teachers can discuss which pedagogical principles are important for this content and a given context. They might also brainstorm possible assessments of content knowledge. After integrating content and pedagogy, they might suggest possible affordances of technology (information, collaboration, transformation, amplification, or representation) that would facilitate K-12 students' understanding of the difficult content. Using their knowledge of technology (or their list assembled in previous sessions) and any available resource lists that tap others' technology knowledge, they can then brainstorm possible technologies with those affordances that would represent the content more fully or give access to the processes and fit the pedagogical principles. At the same time they can address pedagogical and particular student needs and, based on those principles, determine which of the brainstorming suggestions best fit so that students can engage the content in pedagogically effective ways.

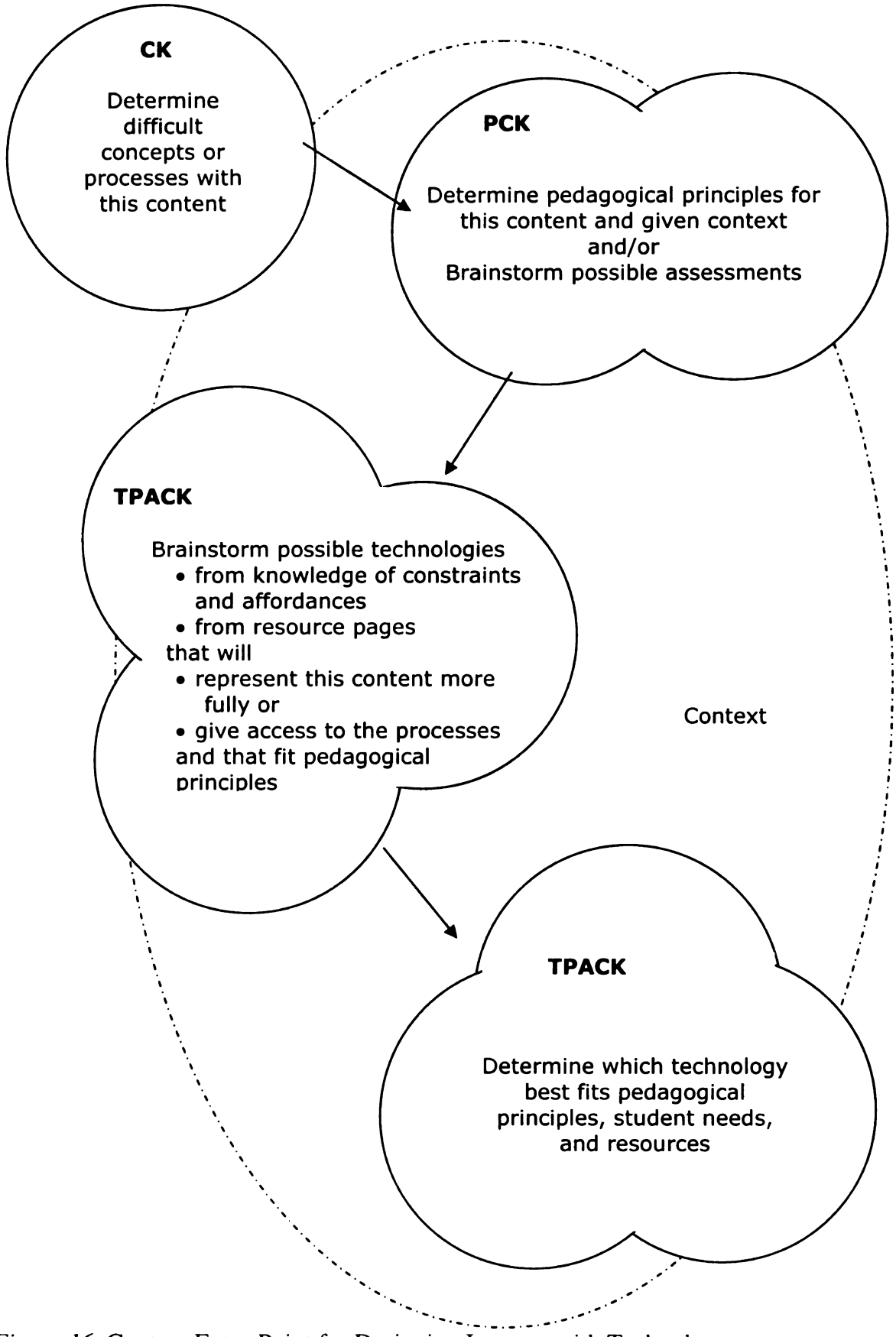

Figure 16. Content Entry Point for Designing Lessons with Technology

Pedagogy can also be the starting point for teaching with technology (Figure 17). Instructors might begin with a particular pedagogical starting point, for example, the need for student collaboration, authentic tasks or particular students' needs or a particular assessment. Preservice teachers might suggest particular student needs from their placements in order to connect the process more closely with their context. Their next steps would determine the content to be taught that would take advantage of or encourage the pedagogical considerations. From the content choice they could identify the difficult concepts or processes of the content. With their preservice teachers, instructors could brainstorm which technologies might fit the pedagogical and content needs in terms of representing the content more fully or giving access to the processes of the discipline. Instructors and preservice teachers might refer to previous discussions of affordances and constraints or their shared database. From their brainstorming they would then determine which technology best fits the pedagogical and content needs and is available to them.

It is important to note how interconnected all three areas, technology, content, and pedagogy become and how context-specific TPACK application is.

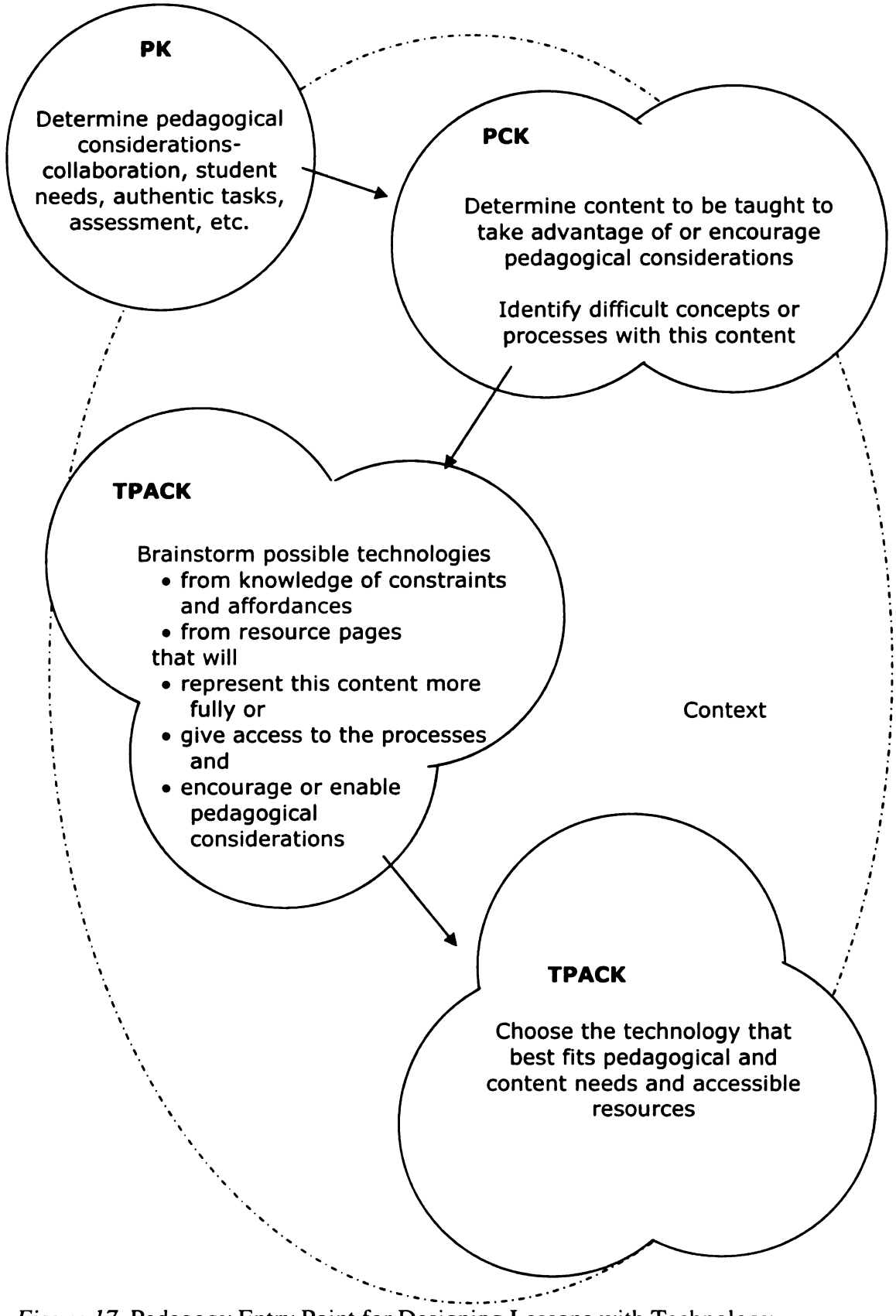

Figure 17. Pedagogy Entry Point for Designing Lessons with Technology

Content

While I think my assistance as GRITS coordinator aided in interns' TPACK development, their TPK development was much further along than their TPACK. They knew how to use technology in pedagogically in general ways, but not to the same extent in a content-specific manner. Preservice teachers need assistance from their content area instructors and their collaborating teachers to recognize how technologies can address difficult content and how technology can assist in coming to know particular content area knowledge. Preservice teachers are still developing their PCK. As they learn new technologies they could also be developing their TPACK as they seek to help their students learn.

The TPACK theoretical framework and this study emphasize how important it is to tie technology use to particular content. Teacher education programs discuss whether to offer an educational technology course or whether to embed educational technology into all the content methods courses. This study highlights the difficulties of both options. When a program seeks to embed technology into its content methods courses, it depends on a variety of instructors who may not have well-developed TPACK themselves. In order to build preservice teachers' skills with integrating technology effectively, the instructors will need to be comfortable modeling technology use and discussing particular technologies that fit well with their content area. If the program chooses to offer an educational technology class, the instructor will need to be well-versed in all content areas and be able to focus preservice teachers on particular content and not just technology in general. Not all technology implementations need to be uniquely content-specific just as all pedagogy is not content-specific. For the content that is more difficult

for students, however, such as force and motion on a roller coaster, using a technology like a roller coaster construction simulation (Funderstanding, 2008) to open the content for students changes an inaccessible knowledge into a new area for exploration.

Explicit Modeling and Discussion of Technology Implementations

As noted earlier, even though teacher education instructors modeled technology in their instruction, interns did not always notice. When an intern like Kelly said she was not taught anything in teacher education about technology and teaching but then later referred to her science teacher using Kidspiration, a concept mapping software, it was evident that the connection between using the technology in a college classroom and using it an elementary classroom was not made. Teacher education instructors can assist their students' learning by using the technology with their students, calling explicit attention to it, and then talking about the affordances and constraints. The next step, the design step, might produce even more results. Instructors can ask their students to think of other settings or content with which the technology seems very appropriate, enabling students to begin the process of design and repurposing technology. If a placement context is available, connecting it to that specific context might embed it further into the preservice teachers' repertoire of instructional possibilities for particular content. In order for preservice teachers to gain flexibility, another important exercise would be to brainstorm other possible applications for the technology, whether in the same content area or across content areas.

As noted earlier, instructors and collaborating teachers have much to offer preservice teachers in terms of their Pedagogical Content Knowledge. They need not shy

away from technology in education discussions because they can supply the necessary Pedagogical Content Knowledge that preservice teachers are still developing.

Collegial Student Sharing

One way to improve the GRITS experience would have been to meet with all the interns and the coordinator periodically in order to gain more from colleagues' work. The interns all talked about how much they learned from each other at the technology conference; their projects probably could have improved from having more input than from just the coordinator. Holding periodic meetings mediated by the coordinator could capitalize on the collegial learning but also ensure the pedagogical and content focus is not lost. In a teacher education program these same sorts of discussions could take place in methods classes, where students share their placement technology implementations and students and instructor discuss together whether the technologies support or hinder the learning process.

Conceptual Tools

Activity theory identifies mediators that aid in learning and pressing toward a goal. Conceptual tools are mediators that serve to scaffold or guide development and action. The first two conceptual tools I suggest below proved effective for interns in the study, the third I suggest to facilitate action that interns missed and the fourth I suggest to address the rules of the placement activity settings.

"Technology is a Tool"

Ambrosia wrote about using technology as a tool for student learning. This conceptualization enabled her to focus on what she wanted to teach and then she evaluated whether the technology facilitated student learning of that content.

"Technology is a Tool" keeps emergent technologies with older technologies in their rightful places as tools, means to learning, and not content to be learned. It moves the focus of learning how to use a technology to a form of literacy (Leu, 2001; Leu, Kinzer, Coiro, & Cammack, 2004; Wilhelm, 2000), as a means to express oneself and read others' communications in whatever forms their signifiers might take.

Because of the cultural-historical context, it may be that this conceptual tool is only explicitly necessary for the immediate future as the educational paradigm shifts from technology as content to be learned and to technology as a powerful tool that changes the processes of learning itself (ISTE, 2008). Perhaps this conceptual tool will eventually become part of the shared meanings of educational settings and will not require explicit attention.

Lesson Designing

Teacher educators should change the terminology of lesson planning to lesson designing to emphasize a design process. "Design keeps human concerns at the center" (Mishra, Zhao, & Tan, 1999, p. 225) so lessons become about facilitating student learning rather than planning lessons for teachers to teach. The design process includes examining the goals of the situation and the available resources and the needs of the students and designing lessons to fit those needs, goals, and resources. It also includes reflecting and revising the design, an iterative, "ongoing conversation" (Mishra, Zhao, & Tan, 1999) between student needs, content, and technology within the given context. Using the design frame captures the creative work necessary to plan learning experiences for particular groups of students. It becomes a dynamic interaction and professional activity that an expert in the field of learning undertakes after consulting with the student and

learning the students' needs. Design operates within the situation's constraints and takes advantage of the resources available in the classroom and via the Internet to best facilitate student learning of particular content. Lesson designing captures the complex process through which teachers navigate as they help their students explore their world.

Learning by design builds knowledge as design rather than just knowledge without purpose. When interns design lessons to teach content that take advantage of a particular technology's strengths, and practice using that technology, they build their practical as well as theoretical knowledge, their knowledge as design.

Learning as Collaboration

Another important conceptual tool for using new technologies views learning as collaborative and as taking place across learning communities. In their personal lives interns used a variety of communication and collaborative technologies but they did not transfer their uses to the classroom. K-12 education has traditionally been confined to the four walls of the classroom or the building in which it is housed and the hours of the school day, except for the occasional field trip. The web 2.0 and mobile technologies allow for student sharing of their products with others around the world, and allow for them to learn from others in a variety of cultures and places, whether across the city or around the world. Video chat enables students to share their classroom and their work with others in ways beyond written text. Collaboration within 3D virtual worlds and multiplayer games produces new types of artifacts (Johnson, Levine, Smith & Smythe, 2009). The emerging technologies also allow students to work beyond the hours of the school day, enabling them to add to their concept maps, wikis, nings, or documents as they think of new ideas and make them immediately accessible to their group members.

Technology Implementation is a Social Justice Issue

Both the literature review and the findings of this study illustrated the digital divide between the educational technology uses of low-income and higher-income schools. Creating a conceptual tool to combat the injustice could enable preservice teachers to change the status quo. The interns in the lower income schools reported how uneven their students' technology skills were and how their limitations hampered their technology use. If schools do not address the issue, the divide will only increase as students get older and those who have access at home develop their skills. Those without home access who do not have opportunity to develop necessary new literacies will lag even further behind. Recognizing and understanding how teaching with technology in their classroom can break down the digital divide can serve as a powerful mediator of learning to teach with technology. It is important that preservice teachers understand that their technology implementations can be learning experiences, more than just extra projects that can be omitted.

Implications for Further Research

This study is limited, first of all, by its small number of participants. Seven interns' experiences cannot generalize to the larger population. The study is also limited in that the data is largely dependent upon interns' recall and sharing on one particular day. In taking a retrospective approach, there is not as much access to the participants' thinking process and iterative design process. A longer, more in-depth study involving preservice teacher journaling, observation of classroom lessons and more frequent interviewing would yield richer data. Interviews with others such as teacher education instructors and collaborating teachers from the interns' activity settings would yield

further insights into interns' learning to teach with technology that the interns themselves might not recognize.

Another limitation of this study is its concentration on the Technology Knowledge, Technological Pedagogical Knowledge, and Technological Pedagogical Content knowledge of the TPACK framework and not the Pedagogical Knowledge, Content Knowledge, and Pedagogical Content Knowledge. Collecting data on all of them would reveal more about any trajectory of TPACK development.

This study, therefore, provides many openings into further research regarding the content areas and technology, design for education, teacher learning, and classroom technology.

Content Areas and Technology

The finding of greater concentrations of TPK and TPACK examples in science and social studies leads to several possible research questions. Some questions to be explored might be: Which technologies lend themselves better to some content areas than others? Does the testing and standards climate regulate literacy and math instruction so extensively that there is little room for using new technologies? If new technologies promote multidisciplinary learning, why are so many uses still single content based?

Another strong research movement in technology and education focuses on new literacies. How is that field related to the TPACK framework and does the conception of new literacies serve as a mediating tool for TPACK development?

TPACK is partially defined as "knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face . . . and knowledge of how technologies can be used to build on existing knowledge

and to develop new epistemologies or strengthen old ones" (Koehler & Mishra, 2008, p. 17, 18). What are the difficult concepts from each subject area? What technology affordances enable learning of those difficult concepts? How is existing knowledge in each content area built? How might technology open new ways of knowing for particular content areas?

Design

This study raises several possible avenues for further research concerning design as a tool for learning. How does a design-based course or internship impact preservice teachers' learning to teach with technology? How do the participants in a design-based course or internship talk about content? What does it take for preservice teachers to repurpose a daily life technology application into a classroom learning application?

Preservice Teacher and Inservice Teacher Learning

Further studies are needed of how distributed cognition impacts collaborating teachers' TK and TPACK and interns' PCK and TPACK when the two individuals work together to learn from each other's strengths. A study could also test whether explicit instructor noticing impacts student noticing and aids in TPACK development. What is the role of online communities in preservice teacher learning? How do preservice teachers evaluate the advice and mediating tools of online communities?

The proposed trajectory of TPACK development begs further research. Is this developmental trajectory reflective of other preservice teachers' TPACK development? Which comes first, TPACK or TPK breadth? Or is the development context dependent? How does TPACK develop over time as preservice teachers move into induction years and they have more control over their classroom setting?

Classroom Settings

Margaret's requests for help when she changed placement settings illustrate how technology resources impact teaching and TPACK development. This study focused on the factors of classroom settings but did not evaluate those settings. Further research on what classroom settings provide the best learning situation for preservice teachers would be helpful for teacher education programs.

Conclusion

> "The status quo does change—by slow, painful degrees, to be sure, but it does change. . . . New teachers can defy the odds by creating new odds . . . the status quo is not a reason to give up on teaching, but the reason **for** teaching" (Oakes & Lipton, 2007, p. 471).

In spite of the slow pace of educational technology integration, change can come, but it requires teachers with knowledge of how to teach with technology.

As Koehler and Mishra (2008) contend, teaching with technology is a wicked problem, with multiple components that are difficult to satisfy. Learning to teach with technology, therefore, is an even thicker wicked problem with complexities in contexts, knowledge, identities, and conceptual tools. It is a problem that will continue demanding attention and teachers with TPACK who can enable their students to work well within their democracy and its new global economy.

We can understand much about the choices the interns make regarding teaching with technology by looking at their cultural historical setting. For all of them, teaching with technology is a new phenomenon. They experienced little of it in their own K-12 education, in their teacher education, and their collaborating teachers seemed to be doing just fine without teaching with technology. They can thrive without TPACK because it is not necessary in schools, just as the saguaro cactus can thrive with little water in its desert

environment. Change forces are at work, however, as evidenced by state standards for teachers and by many researchers (Leu, 2001; Leu, Kinzer, Coiro, & Cammack, 2004; New Media Consortium, 2009; Wilhelm, 2000) advocating that students must be able to use technologies in literate ways and that classrooms are global rather than boxed in by four walls. Preservice teachers find their environment changing and will need to work on new adaptations, new knowledge for their new setting. Otherwise, they, like the saguaro cactus when it is moved to a new environment or its environment changes, may find the adaptations that previously worked so well in the old environment work against them and they fail to thrive.

APPENDICES

APPENDIX A

GRITS DOCUMENTATION REQUIREMENTS

GRITS Documentation Requirements

1. Discussion with Marj about technology uses considerations
    a. Why you are using this particular hardware/software
    b. What needs to be talked about with the students prior to implementing
        1. Internet safety
        2. Media Awareness
        3. Copyright Issues and Acceptable Use
    c. The training you will need to give your CT to encourage their learning and participation

2. Written plan for completing the project
    a. Timeline with goals for each progress check-in date
    b. Help you will need from Marj, CT, and others and how you will arrange to meet with them
    c. Your budget of your time- how much time for each portion of your plan

3. Sample of project you will be doing with students
    a. Script
    b. Completed sample as you would want to see from your students; if online project, a link to that web page
    c. Detailed lesson plans for when you will be using this project
        1. Rationale/Big Picture
        2. GLCEs
        3. Objective
        4. Procedures, including 1b, above
        5. Assessment

OR

4. Finished product
    a. Completed Product to be used in classroom
    b. Detailed lesson plans for when you will be using this product
        1. Rationale/Big Picture
        2. GLCEs
        3. Objective
        4. Procedures, including 1b, above
        5. Assessment

OR

5. Software or Hardware Exploration
    a. Written description of hardware or software uses. Include when it is most effective and for what purposes it should not be used.
    b. Detailed lesson plans for when you will be using this product
        1. Rationale/Big Picture

2. GLCEs
3. Objective
4. Procedures, including 1b, above
5. Assessment

6. Written reflection (progress report) on your GRITS mini grant work- due September 1, 2007.

7. Technology Conference Presentation- September 29
    a. Ten-minute presentation, two sections
    b. handout

APPENDIX B

INTERVIEW PROTOCOL

Attachment 1: Interview Protocol-Interns
[version submitted to SIRB, 1-2-08]

NOTE: We will use a semi-structured interview with questions such as the following.

We are trying to learn more about how interns and teachers learn to use technology, how they view technological literacy, how they use technology in their teaching, and what influence interns and collaborating teachers have on each others' technology use.

Use of Technology

1. To begin, therefore, tell me how you use computer technology outside of school. What sorts of things do you do on the computer?

2. How have you used technology in your classroom? Tell me how you as a teacher use it, and how you have used it with your students.

Learning of Technology

3. Where did these ideas for using technology in the classroom come from? Were these your ideas, or were they suggested by your CT, a fellow intern, a course instructor, or someone else?

4. How prepared do you feel to use educational technology like computers and the Internet with your students?
    a. Describe where, if at all, that preparation came from.
        i. (Probe CT influence, program influence, their own K-12 experience, their own experimentation, fellow intern influence)

5. In many 402 Literacy classes, students explored a new literacy and a new technology as part of their *New Literacies Exploration Project.* (To help you remember, here are your artifacts from that project.) Tell me what you remember about your project.
    a. What would you say you gained from that exploration?
        i. How would you say it impacted your view of literacy?
        ii. How would you say it changed your view of technology?
        iii. How would you say it changed the way you teach?

6. How would you define 'new literacies'? How prepared do you feel to teach new literacies?
    a. Describe where that preparation came from.
        i. (Probe CT influence, program influence, their own K-12 experience, their own experimentation, fellow intern influence)

7. For the COURTT interns:

a. What obstacles did you face in using technology-based lessons you planned?
b. What impact do you think the COURTT experience has had on your use of educational technology?
c. How could the COURTT program have better prepared you to use educational technology?

Improvement and Questioning of Technology

8. What kinds of technology do you feel are important to classroom instruction? (What's the place of technology in education?)
    a. Are there any that are necessary? Is it at all necessary?
    b. What obstacles do you face in the integration of technology into your classroom?
    c. How does your use of technology with your students position them to know and experience the world?

9. What suggestions do you have for improving the preparation of teachers and interns for using educational technology?
    a. What message did you receive from your teacher education instructors about using technology, whether explicit or implicit?

Technological Pedagogical Content Knowledge

10. I would like to learn how teachers learn to teach content using technology, so hopefully these next questions will open that up for us.

    a. Which subject area is your specialty? Suppose you wanted to use the Internet for a science lesson on animal habitats (or an literacy lesson on prefixes, or a social studies lesson on the Aztecs, or a math lesson on tessellations). What sort of lesson would you plan for it?
        i. How would you go about planning it?

    b. One of the Michigan GLCE's for fourth grade is W.PR.04.02. : Apply a variety of pre-writing strategies for both narrative and informational writing (e.g. graphic organizers such as maps, webs, Venn diagrams) in order to generate, sequence, and structure ideas (e.g. plot, setting, conflicts/resolutions, definition/description, or chronological sequence). How would you use technology in helping your students meet that expectation?

    c. How would you help your students improve their digital literacy? What ideas do you have for teaching new literacies?

11. I appreciate your help in learning more about how teachers learn to teach with technology. Do you have anything more to say that was not asked?

APPENDIX C

CODING OF INTERN CLASSROOM USES OF TECHNOLOGY

Table C1
Ambrosia's TPACK Evidence

Ambrosia			
TK	**TPK**	**TCK**	**TPACK**
Plus 6 personal evidences from Table 3	SmartBoard light house diagram (I1)		Soo Locks lesson-images and animation links for Welland Canal and Soo Locks (LP7-1, p. 1)
	Students group ppt slide of fast change topic in science and weather (I12)		US Landforms 2-SmartBoard and animations of earth formation processes (LP2-1, p. 2)
	webquest investigation of plants and seeds (I2)		US Landforms 1-SmartBoard and Google Earth zooming to landform on US map (LP1-3, p2)
	research lighthouses using given web page plus linked pages (I2)		Michigan Landforms-animation to show glaciers moving into Michigan (LP 4, I10)
	SmartBoard science lessons label images (I1)		
	SmartBoard Social Studies maps (I1)		
	SmartBoard plant diagrams (I1)		
	after school cultures class- maps and images and pictures on SmartBoard (I2)		

Table C2
Brian's TPACK Evidence

Brian			
TK	**TPK**	**TCK**	**TPACK**
Edline GradeQuick (I3)	pictures in PowerPoint- 1/2 text, 1/2 picture (I2)		podcasts downloaded from iTunes (I9)- Interviews with candidates
uploaded video to YouTube (E10)	YouTube- Did you know- shift Happens (to think about what the world is like and the competition students face (I9)		Google Earth- Ellis Island (GRITS planned) (I7)
Plus 6 personal evidences from Table 3	YouTube student podcast (I8)		Google Earth- WWI- (I8)
	research famous person from the 1920s, students' presentation PowerPoints (I3)		Google Earth- Spanish American War (I8)
	Videos in PowerPoint (I2)		
	Webquest 1 (I5)		
	Webquest 2 (I5)		

Table C3
Kelly's TPACK Evidence

Kelly			
TK	**TPK**	**TCK**	**TPACK**
Plus 7 personal evidences from Table 3	fact of the day- helps students connect content with their own lives using images, technology (I4)		video clip for moon rotation in science- difficult so this helped visualize (I4)
	story about tradition- type in Word (I3)		slide show and video clip from Africa for writing; played from laptop with students sitting around (I3)
	poem- type in Word (I3)		

Table C4
Lucy's TPACK Evidence

Lucy			
TK	**TPK**	**TCK**	**TPCK**
Plus 10 personal evidences from Table 3	digital photography- a picture is worth a 1000 words- student pictures in graphs (I21)		Google maps northeast region of US; pics and tours, zoom in to places- 3 or 4 times; e.g. Appalachian Trail (I7)
	doc cam- math place value blocks, arrays (I6)		Google Earth- southeast region of US; pics and tours, students chose 3 places to visit... zoom in to see (I8)
	webquests for classroom computer center 1/month- unit/M L King Day- webquests found online and adapted (I4)		Google Earth- southwest region of US; pics and tours, students chose 3 places to visit... zoom in to see (I7, 22)
	document camera display anything in room- textbook while reading (I4-5)		plan- Google Maps mashup (LP1)
	doc cam- note taking modeling (I6)		
	doc cam- worksheet display (I6)		
	webquests for classroom computer center 1/month-unit/ Halloween (I4)		

Table C5
Malia's TPACK Evidence

Malia			
TK	**TPK**	**TCK**	**TPCK**
saving documents as pdfs in Open Office (E1,2)	use classroom document camera- allows students to see others' work and specific things (I2)		
Mail merging (I12)	student typing instead of handwriting writing lesson (I8,9)		
Plus 8 personal evidences from Table 3	Podcast eval lesson (LP1 p.2)		
	Podcast lesson (LP 3-3, p. 2)		
	podcast lesson 2 (LP1-3)		

Table C6
Margaret's TPACK Evidence

Margaret			
TK	**TPK**	**TCK**	**TPACK**
Plus 15 personal evidences from Table 3	Document camera/projector- color documents (I2)		student digital pictures to illustrate adjectives (I2)
	conversation comic creation (LP1)		student videos of invitations and responses (I2)
	Internet awareness lesson (LP 4)		create French magazine article (LP8)
	Audio recording of reading (LP5)		weather forecast- iMovie GRITS lesson (LP2)
	comics about themselves (I2)		Google Earth- a day in Paris tour (LP3)
	video clips from YouTube- French videos (I2)		Phonetics Listening (LP7, I2)
	video clips from YouTube- Music Videos (I2)		Visit French grocery web site to check prices (I2)
			Babelfish (LP6)

Table C7
Terese's TPACK Evidence

Terese			
TK	**TPK**	**TCK**	**TPACK**
Works with firewalls that are different between home and school (I2)	images for lesson plans (I1)		Science Simulations- light and shadows (I2);
find lesson plans online (I4)	made web page of links to help students research and avoid inappropriate sites (I2)		Rationale for lesson- excellent program for data collection (LP5-1) Science Simulations- plants (I3, LP)
Plus 8 personal evidences from Table 3	biography mobiles (I2)		

APPENDIX D

INTERNS' TPACK COMPONENT TOTALS

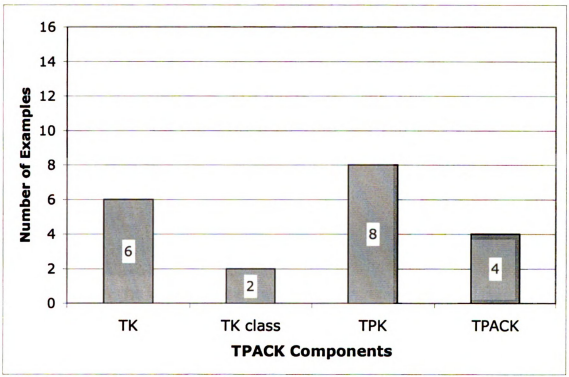

Figure D1. Ambrosia's lessons and uses exhibiting TPACK Components

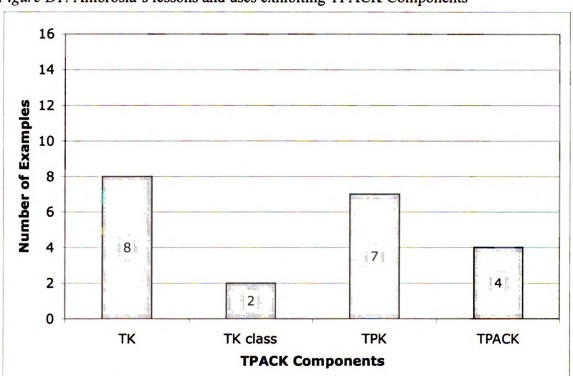

Figure D2. Brian's lessons and uses exhibiting TPACK Components

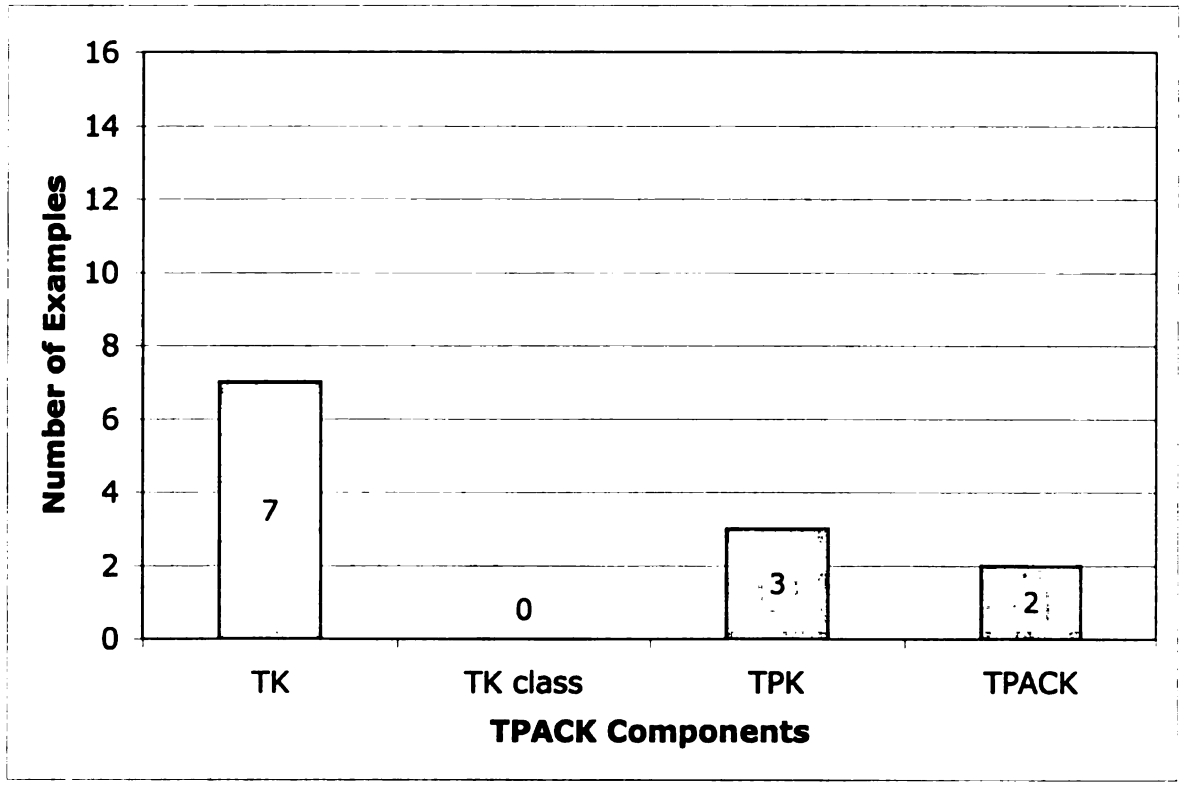

Figure D3. Kelly's lessons and uses exhibiting TPACK Components

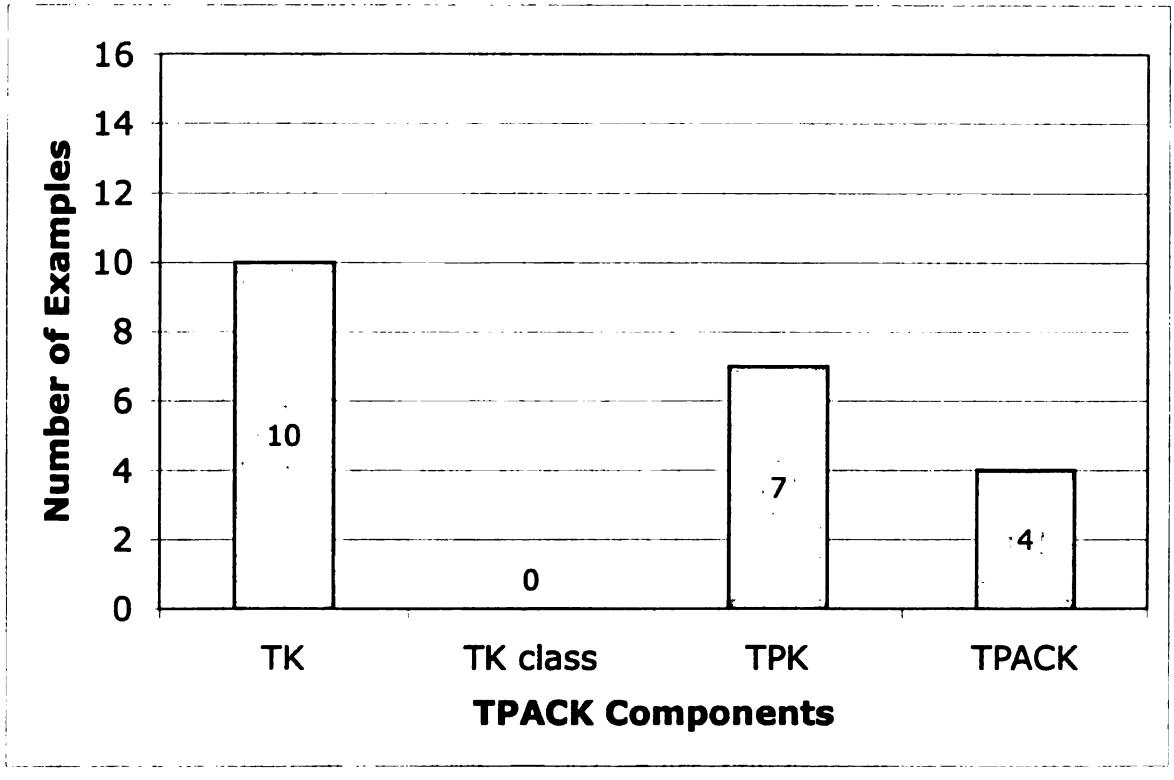

Figure D4. Lucy's lessons and uses exhibiting TPACK Components

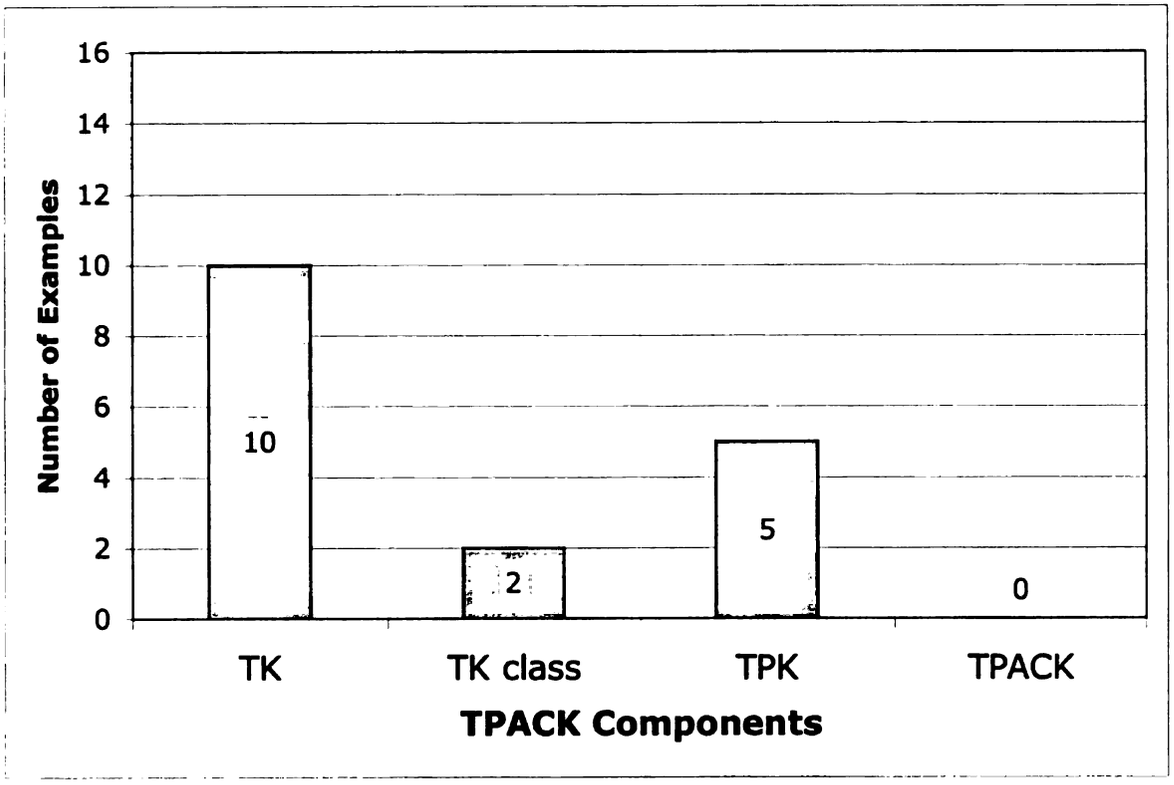

Figure D5. Malia's lessons and uses exhibiting TPACK Components

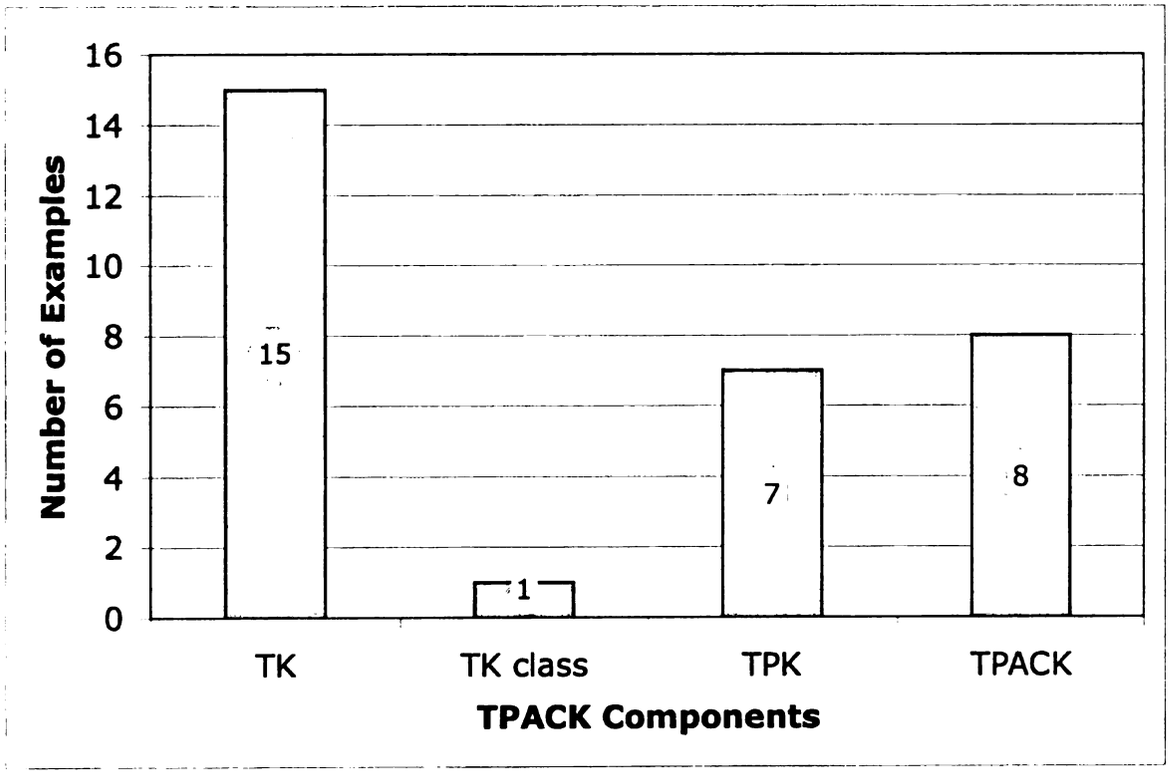

Figure D6
Margaret's lessons and uses exhibiting TPACK Components

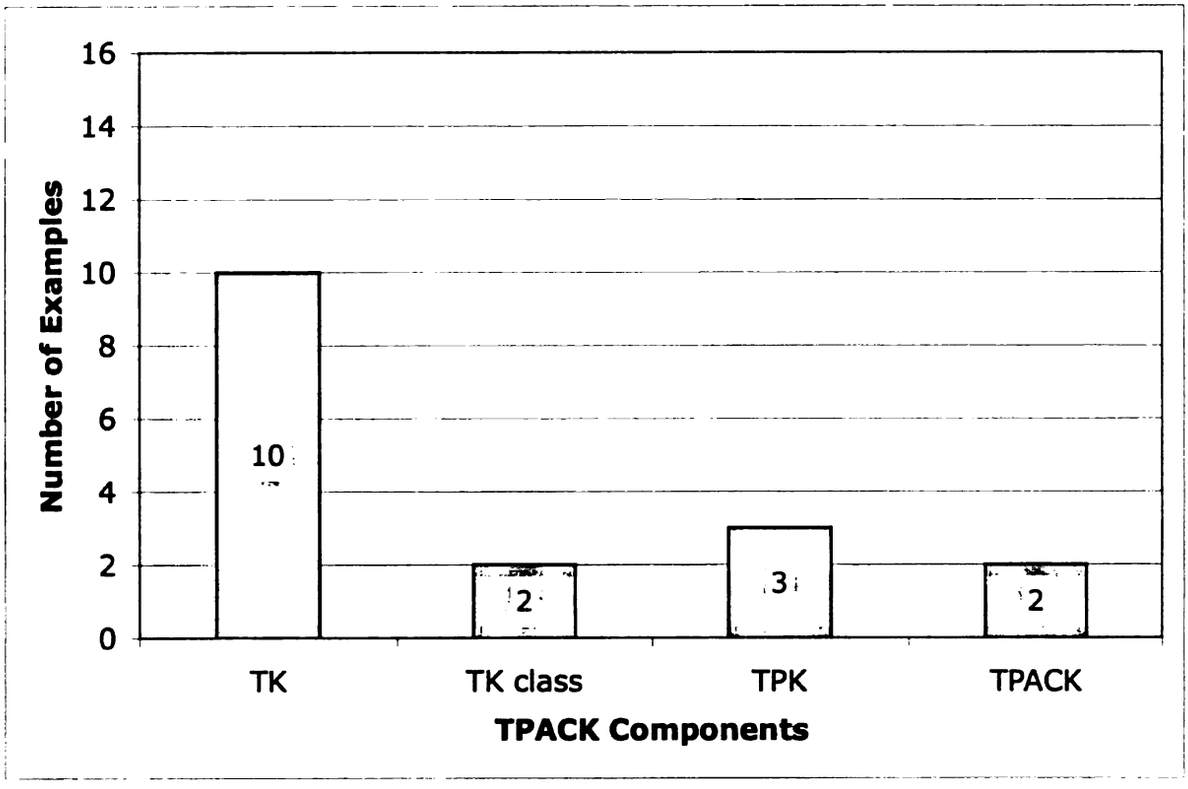

Figure D7
Terese's lessons and uses exhibiting TPACK Components

APPENDIX E

HARDWARE AND SOFTWARE RESOURCES

Accelerated Reader- http://www.renlearn.com/ar/

Apple Learning Interchange- http://edcommunity.apple.com/ali/

Babelfish- http://babelfish.com/

Blog- http://www.blogger.com

Comic Life- http://plasq.com/downloads/

Delicious- http://delicious.com/

Document camera- http://www.elmousa.com/

Edline Grade Quick- http://www.edline.com/

FaceBook- http://www.facebook.com/

FLTeach forum- http://www.cortland.edu/FLTEACH/

Funderstanding,- http://www.funderstanding.com/coaster

Galaxy Zoo- https://galaxyzoo.org/

Google Earth- http://earth.google.com/

iMovie- http://www.apple.com/ilife/imovie/

iPod- http://store.apple.com/us/browse/home/shop_ipod?mco=MTI3ODU

iTunes- http://www.apple.com/itunes/

iWeb- http://www.apple.com/ilife/iweb/

Lesson Labs- www.lessonlab.com/software

LinkedIn- http://www.linkedin.com/

MacBook- http://store.apple.com/us/browse/home/shop_mac/family/macbook?afid=p202|GOUSE10 0392046&cid=OAS-US-KWG-CPUMacBook-US

Oregon Trail- http://www.virtualapple.org/oregontraildisk.html

Photoshop- http://www.adobe.com/products/photoshop/compare/

PowerPoint- http://office.microsoft.com/en-us/powerpoint/default.aspx

Science Simulations- http://web.riverdeep.net/portal/page?_pageid=818,1383441,818_1383475&_dad=portal&_schema=PORTAL

SMARTBoard- http://smarttech.com/

Tech Learning- http://www.techlearning.com/

Voyage of the Mimi- http://www.bankstreetcorner.com/voyages_of_mimi.shtml, http://www.youtube.com/watch?v=0_Wqs_J0Fr4&feature=related

Webspiration- http://www.mywebspiration.com/

Wiki- http://pbworks.com/, http://www.wikispaces.com/

Xbox Live- http://www.xbox.com/en-US/live

YouTube- http://www.youtube.com/

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