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MAKING USE VISIBLE: A TEACHER-CENTERED STUDY OF
TECHNOLOGY-ENABLED WORK PRACTICES

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ABSTRACT

Many studies have examined the use of technology in education aimed at preparing students for the 21st century. Some studies have emphasized the importance of teacher attributes, such as attitudes, beliefs and self-efficacy, in predicting these professionals’ use of technology in schools (Dupagne & Krendl (1994), Marcinkiewicz (1994), Milbrath & Kinzie (2000), Vannatta & Fordham, 2004). Other studies have assessed whether technology improves students’ engagement as well as achievement (Schacter, 1999). Still others have investigated the development of online communities that may help teachers to become advanced users of technology (Carroll et al., 2003, 2005; Barab et al., 2003; Schlager & Fusco, 2003). In general however, many studies of technology in education consider teacher preparation as a peripheral concern. In contrast, Fullan (1991) suggested that researchers should consider the teachers’ perspective when studying changes that occur due to technology integration to understand their subjective experiences. Similarly, Laurillard (2008) argued that by taking into account the teachers’ concerns, specifically their points of view on whether and how technology can serve education, researchers will be able to first identify and understand the educational problems and then find technology solutions that address these problems. In this way, it can be ensured that issues are addressed from the teaching community’s perspective.

This study is grounded in the view that a better understanding of teachers and their daily work-related activities must be a central element in any programs aimed at enhancing the use of technology in teaching. This research begins with a review of literature on teachers’ professional community, teachers’ professional development, the opportunities that online communities are providing in the evolution of a professional development community for teachers and the challenges that lie ahead. Then, through qualitative research methodology, this study attempts to (a) better understand the social aspects surrounding the use of information technology in a school setting and (b) analyze barriers and supporting structures for using and learning technology practices among teachers.

The analysis of how the school teachers in a particular school are using and learning to use technological artifacts for their daily work practices has helped uncover useful findings - for policy makers, school leaders, teachers, providers of professional development and designers of information technology innovations for education. The findings from this study contribute to research in the fields of human centered computing, workplace learning and teacher’s professional development.
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Chapter 1

Introduction

The dawn of computer networks have brought forth extensive experimentation in bringing together otherwise isolated communities of practice across geographic boundaries. Although teachers in a school are co-located they are traditionally known to work in isolation. Information technology offers great potential to further the development of teachers’ local community of practice by providing an online platform to share and learn from each other as an additional support for their face-to-face interactions. From the literature, it is quite evident that attempts to use web technologies to support teachers’ professional development have been ongoing.

In the last two decades there has been a visible increase in the number of computers and internet access in American schools. However, teaching practices continue to evince only token integration of computers. Inhibiting factors such as lack of effective training, and need for collaboration and involvement in planning for computer use that were found in 1991 continued to exist in 2004 (Shi & Bichelmeyer, 2007). Earlier studies have also found documented minimal computer integration in schools (Cuban, 2001; Cuban, Kirkpatrick, & Peck, 2001; Ertmer, 1999; Peck, 2001; Rogers, 2000). The many studies of failed technology adoption in classrooms point to a gap between the expectations from the designers of computer hardware and software to the realities of computer use as part of teachers’ everyday practices. While many factors may contribute to this gap (e.g., lack of resources, insufficient infrastructure, schedules that are already too busy), Fullan (1991) argues that the teachers themselves are one factor that affects technology implementation in education. Most studies treat the role of teachers very peripherally. In contrast to these studies, Fullan suggests that researchers should examine the changes that occur due to technology integration from teachers’ perspectives and try to understand their subjective experiences in their work context. A better understanding of teachers and their day-to-day activities must be a central element in any programs aimed at enhancing the use of technology in teaching.

In a similar vein, and more recently, Laurillard (2008) argues that researchers must first identify and understand the educational problems and then find technology solutions that address these problems. Such an approach would make sure that issues are addressed from the teaching community’s perspective.
The teachers will then be able to make good use of technology by becoming experimental innovators and reflective practitioners. For example, they could become “action researchers” by collaborating and building knowledge about teaching with technology. However, to enable this, the teachers must be able to share that knowledge. Laurillard went on to propose an online learning activity management system for capturing and sharing the pedagogic forms that teachers design. This system relied on a “Conversational Framework” as a theoretical framework. Technology would be harnessed to the needs of education rather than searching for problems to which the latest technology is the solution.

Although a great deal of effort has gone into teacher training projects through online communities of education professionals, they have only succeeded in “putting the cart before the horse” (Schlager & Fusco, 2003). These communities have been created in isolation from the local professional communities in which the teachers practice. They have ignored the greater potential of the internet to help and support the local communities of practice. Brown and Duguid (2000) (as cited in Schlager & Fusco, 2003) state that “only by engaging in work and talking about the work from inside the practice can one learn to be a competent practitioner”.

The balance of this chapter is organized as follows. I will first review literature that bears on the issues of teachers learning and sharing work practices, and specifically how community interactions and online tools might facilitate this process. I begin by defining several terms that are used in these areas of research, such as, communities of practice, professional communities, professional learning communities and how these are related with teachers’ professional development. Against this backdrop, I will review some online communities for teachers’ professional development and discuss the role of such sites in fostering the development of a teachers’ professional development community. The equation below is a simplistic way to illustrate the relationship that may emerge between these concepts through the enabling power of information technology.

$$\text{Teachers’ Professional Community + Teachers’ Professional Development} \Rightarrow \text{Teachers’ Professional Development Community}$$

The balance of this chapter is organized as follows. First I describe relevant background research. Working from this analysis, I define the problem I will research as well as its scope, including a statement of research objectives and potential impact. Next I summarize the research methods I plan to use, including some of the details of my research and analysis plan. I close with a projected timeline.
Prior to formulating a set of research objectives and associated questions, I will first review literature that bears on the issues of teachers learning about and integrating technology into their classroom practices, and specifically how community interactions and online tools might facilitate this process. I begin by defining several terms that are used in these areas of research, then, review relevant frameworks, empirical studies, and online systems for community building.

1.1 Key Concepts for Teacher Communities

Several terms have been used to describe professional learning communities and related concepts. According to Grossman et al., (2001), the word community has lost its meaning. Every educational innovation is using the term “community” as an obligatory appendage. For example, it is not clear what features are shared across terms such as communities of learners, discourse communities, epistemic communities, school community, teacher community, or communities of practice. In attempts to replicate the so called “community” on an online space, researchers and virtual community builders have only succeeded in adding to the confusion. For example, in a virtual community, by paying a fee or typing a password, anyone who clicks on a web site automatically becomes a member of the community. In this section, I offer some definitions and relevant concepts from literature.

Communities of Practice (CoP)

In a community of practice, members interact, learn and work through participation in complex networks of shared expectations and norms. A CoP includes structures and roles that induct new members into core practices through legitimate peripheral participation (Lave and Wenger, 1991). CoPs cannot be designed as they develop according to the needs of their members (Wenger,1998). Hur and Hara (2007) reiterate this in the following words:

―CoPs are viewed as self-organizing, evolving, and self-sustaining entities that are connected by shared problems and specific areas of interest to members‖

According to Wenger et al (2002) the basic structure for all CoPs consists of a community of people who care about a domain of knowledge which defines a set of issues; and shared practice that they are developing. The domain provides common ground and common identity such as “What topics and issues do we really care about? How is this domain connected to the organization’s strategy?” Community fosters interaction and relationships based on mutual respect and trust such as “What roles are people going to play? How often will the community meet? How will members connect on an ongoing basis?” Finally, shared practice consists of the frameworks, ideas, tools, stories, and documents that are shared.
Some examples are “What knowledge to share, to develop, and to document? What kinds of learning activities to organize? How should the knowledge repository be organized to reflect the practice of members?” Developing all three elements is a balancing act.

Lave and Wenger (1991) extended the term community of practice (CoP) to underline the importance of activity in linking individuals to communities, and of communities in making individual practices legitimate. Moreover, learning follows a trajectory in which learners start from being legitimate peripheral participants and move on to becoming core participants in a community of practice. Barab et al. (2003) defined a CoP as a

“A persistent, sustained social network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise”.

Many of their ideas are based on the work of Wenger (1998). They (Barab & Duffy, 2000) listed CoP as having the following eight characteristics:

(1) shared knowledge, values, and beliefs; (2) overlapping histories among members; (3) mutual interdependence; and (4) mechanisms for reproduction; (5) a common practice and/or mutual enterprise; (6) opportunities for interactions and participation; (7) meaningful relationships; and (8) respect for diverse perspectives and minority views.

A key idea underlying the concept of CoP is that learning is a social process (Barab, 1999; Barab, Cherkes-Julkowski, Swenson, Garret, Shaw, & Young, 1999; Lave, 1997; Lemke, 1997). A community can start as an informal loose network that gradually becomes more connected. The activities needed also changes as the community develops. The CoP model supports collaborations among learners in working with others towards similar goals of building a community context that can best support the needs of its members and helps them in moving on their learning trajectory (Rogoff, 1990; Roth, 1998; Scardamalia & Bereiter, 1994). According to Westheimer (1998) some anticipated effects of CoP membership for individuals include “a sense of identity and belonging, affirmation, commitment to the group, strong bonds, and the development of both common purposes and collective responsibility” (p. 12). The community-based approach to learning has immense theoretical and practical potential but it is important that these environments be studied empirically. (Barab et al.) The figure below summarizes the key features of a CoP.
Thinking in terms of the context of my study and how I can draw from the concept of CoP, here are a few reflections. My study is grounded in the school teachers’ local community of practice. However, even at the local context, there are many networks of community. The teachers may be connected through formal structures such as department and other professional groups that they may be associated with on a long-term or short-term basis. For example, a biology teacher would belong to the biology department network. Some of them may belong to a small network of a group of biology teachers who teach the same subject. Since I will be following from the teachers’ perspective, I will be starting from them to see how they view and identify the different networks that they are a part of. Another point to note is that unlike many online communities, local communities of practice already exist even though they may differ in the degree to which they feel a sense of belongingness. Schools as a CoP have evolved over many centuries through a slow and steady self-organizing process culminating in a school system as it exists today with formalized structures. However, formal institutional structures are known to bring about artificial walls and promote
a top-down hierarchy that can inhibit and stifle the environment for innovation in teaching practices. Even though the members of the school may be co-located, they may still lack a sense of community due to these structures. Information and communication technologies (ICTs) have brought about a great change in breaking down these boundaries. However, their appropriate use in the school context is still not well understood.

**Professional Communities**

In this section, I describe from literature the closely related concept of *professional community*. While the concept of *communities of practice* is traditionally understood as a self-organizing mechanism and gives ways to recognize it by identifying its characteristics, literature on *professional community* show how communities of practice can be created by school authorities, and offer some indicators that can be used to build and measure the sense of community. Here I describe professional community from literature in the school teachers’ context.

According to Louis, Kruse and Bryk (1995), the most important task for school leaders is to create meaningful opportunities for teachers to work together on issues of common interest. Hence, school leaders have been taking steps to create professional communities in schools (Halverson, R. 2003). Halverson, R. (2003) studied the leadership practices of an urban elementary school to show how professional community was developed through the selective design and implementation of artifacts, such as policies, programs and procedures, in order to reshape the local system of practice. In professional communities, teachers have the opportunities to break down the traditional isolation of classroom by participating in collaborative, problem setting and problem solving activities (Halverson, R. 2003). Research findings have established the positive correlation between existence of strong professional communities of teachers and student achievement (Vescio & Adams, 2008).

Based on a literature review of professional and organizational support structures in school settings, Visscher & Witziers (2004) identified six concepts as the important indicators of professional communities: policy and evaluation, consultation and cooperation, consensus, decision-making, school leadership and departmental leadership. The figure below illustrates the key features underlying the concept of a professional community.

The *policy and evaluation* concept relates to the teaching policy of departments and is measured by variables such as arrangements made by departmental staff about their teaching activities and the number of common tests that the department takes in a school year. Thus this concept has a strong relationship
with the ‘standardization’ concept in organizations (Mintzberg, 1979; as quoted by Visscher & Witziers, 2004). Student achievement can be monitored by cycling the test results to the department for feedback and remedial measures. Communities of practice develop shared practices that guide the articulation of policies and rules leading to standardization.

The *consultation and cooperation* concept refers to the frequency of consultation, and the climate of cooperation. For example, how open are the lines of communication; what is the quality and degree of mutual cooperation and feedback among teachers and other staff members; do they develop learning materials cooperatively and engage in classroom observation?

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**Fig 1.2: Professional Communities**
The *consensus* concept refers to shared values such as to what extent do staff members think and act similarly about the tasks and function of the school, the goals about the subject matter, the teaching practices and the teaching content.

The *decision-making* concept is measured by two variables that show how far individual teachers can take independent decision on their teaching, and to what extent does the department play a 'collective' role. In professional communities, decision-making about teaching practices is shared among teachers.

The last two concepts, *school leadership* and *departmental leadership*, refer to the role of school leaders and heads of department in building professional communities and learning organizations. The literature highlights the benefits of facilitative leadership as opposed to directive leadership (Visscher & Witziers, 2004).

ICT can play a great role in increasing *consultation and cooperation* among teachers which has a great potential when it comes to disseminating knowledge learnt in offsite professional development programs as well as knowledge created in everyday practices.

**Professional Learning Community (PLC)**

A teacher professional community is oriented to the support of all aspects of teaching; a professional learning community (PLC) is a community specifically oriented to teachers’ professional development; such support has long been of central concern within the teaching profession. The concept of PLC is borrowed and modified from the idea of organizational learning from the business circle to suit the educational context (Vescio et al., 2008). The concept of learning organization became a learning community where teachers worked in an environment of collaborative work culture. PLCs are based on the assumption that knowledge is situated in the everyday lived experiences of teachers and that actively engaging the teachers in PLCs will result in an increase in their professional knowledge as well as student learning.

It is important to note that PLC reform currently is exclusively a school based reform and an important next step for schools would be to broaden this framework to the district level. Dufour (2004) highlights the struggles that schools have faced in establishing PLCs. According to him there is confusion about the concept of PLC. “PLC” has been used to describe every imaginable combination of individuals with an interest in education. It could be a grade-level teaching team, a school committee, a high school department, an entire school district and so on. Its usage is so ubiquitous that it is in danger of losing its
meaning. Hence, he offers a proposal aimed at more clearly defining a PLC for teacher development. According to him a PLC consists of three core principles. Firstly, of ensuring that students learn, which brings a shift from a focus on teaching to a focus on learning with profound implications for schools. Secondly, having a culture of collaboration that characterizes a PLC as a systematic process, in which teachers work together in teams to reflect on and improve their classroom practice. Thirdly, a focus on results where an effective PLC judges its performance based on results. Teacher teams can develop common formative assessments throughout the school year, compare how each class performed and call on their colleagues to help them reflect on areas of concern.

Based on a review of others’ work (Vescio, Ross & Adams, 2008; Halverson, R. 2003), Bolam et al. (2005) expand the analysis of PLCs for teachers. For instance they elaborate the earlier notion of culture to suggest that this should include an orientation toward inquiry learning and a willingness to “give up” their private ownership or control of their own practices and adopt a pervasive sense of collegiality. Such culture can be enhanced if there are clear opportunities for the teachers to have an influence on how the school conducts its activities and builds its policies. They also argue that the shared culture should have characteristics of inclusiveness and openness; this in term implies and reinforces mutual trust, respect and support. Finally, from a more operational standpoint, they argue that effective PLCs require some form of emergent leadership or management that can collect and optimize allocation of shared resources, and that can promote and evaluate sustained individual and collective learning within the PLC.

Newman et al (1996) describe 5 primary characteristics of a PLC (as quoted by Vescio et al., 2008):

a. Shared values and norms about children and their ability to learn, schools priorities for the use of time and space, and the proper roles of parents, teachers and administrators;
b. Clear and consistent focus on student learning;
c. Reflective and continuing dialogue among teachers about curriculum, instruction and student development;
d. Focusing on collaboration;
e. deprivatization of teaching practice;

Bolam et al. (2005) synthesized these characteristics and defined a PLC as

“a community with the capacity to promote and sustain the learning of all professionals in the school community with the collective purpose of enhancing student learning”.
They added three more characteristics to the above:

f. inclusive membership, networks, partnerships

h. mutual trust, respect and support

The figure below is an attempt to illustrate the key features underlying the concept of a PLC.

Fig 1.3: Professional Learning Community

They also added 4 operational processes:

i. leadership and management,

j. optimising resources and structures,

k. promoting individual and collective professional learning and

l. evaluating and sustaining the PLC.

Bolam et al (2005) have proposed the following provisional model as a useful basis for practice and research. It illustrates “a professional learning community operating within a school – the outer dotted line – influenced by two sets of inhibitors and facilitators – those which are external (Box A) and internal (Box B) to the school. The unbroken arrows linking the four processes (Box C) to the eight characteristics
(Box D) and the three sets of outcomes (Box E) indicate the presumed broad causal direction of PLC operation.”

Fig 1.4: Provisional Model of a School acting as an effective PLC

For the purpose of this research, I will draw from these ideas to reinterpret the qualitative data I obtain in my field work, using an interpretive lens. For example I will examine the functioning of individual departments to see how they operate as a PLC on these dimensions: (how) does the leadership facilitate a climate of consultation and coordination? How are their activities with respect to the use of technology being directed towards the goal of increasing student achievement? Is technology being used to increase teachers’ productivity, student achievement or both? How are they measuring these results?

Teachers’ Professional Development (TPD)

Recently there has been an increase in attention for teacher learning and teacher professional development programs situated in the workplace as compared with off-site programs. Examples of off-site programs include workshops, conference sessions, seminars, lectures, and other short-term training events. The effectiveness of these programs can be enhanced by lengthening their duration, connecting them with
teachers’ work context, focusing on subject matter, and emphasizing analysis and reflection (Smith & Gillespie, 2007). According to Guskey,

“teachers’ professional development can be defined as those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students”. (Guskey, 2000).

Traditional TPD is a top-down hierarchical model of the expert where teachers go to workshops, institutes, or seminars in which “experts” deliver pedagogically sound teaching skills to the teachers (Barnett et al., 2002). In a handbook designed for policy makers for developing countries, TPD is described as

“the tool by which policymakers convey broad visions, disseminate critical information, and provide guidance to teachers. Effective TPD begins with an understanding of teachers’ needs and their work environments—schools and classrooms. TPD then combines a range of techniques to promote learning; provides teachers with the support they need; engages school leadership; and makes use of evaluation to increase its impact. Essential techniques include mentoring, teamwork, observation, reflection and assessment” (Gaible et al., 2005).

Standardized TPD is the most centralized method. It is used to disseminate skills to a large teacher population. Site-based TPD involves intensive learning by groups of teachers to promote long-term changes in instructional methods. Self-directed TPD involves independent learning by teachers and may include computers and the internet. Standardized TPD programs that involve ICTs frequently use the Cascade model (Gaible, 2005). In this model, one or two teachers (champions) at a school attend centralized workshops to learn computer skills and integrating computers into teaching and learning. Once they return, these champion teachers provide TPD to their colleagues. However, site-based TPD address local needs and conditions and as such should become the cornerstone of teacher development across the education system (Gaible et al., 2005).

Many TPD programs start with the assumption that how to use computers is the same as how to teach with computers. While some degree of technical skill is necessary (basic keyboard and mouse skills, familiarity with the operating system and basic software applications), they are not sufficient to increase the teachers’ use of computers as a teaching tool. Hence most teachers need guidance on how to use them with students. Simply improving teachers’ computer skills may not necessarily lead to students’ use of computers as tools for learning. TPD should be learner-centered, designed so that teachers experience the types of instruction that they are asked to provide in their classrooms. In a learner-centered TPD, it is the voices and actions of teachers themselves, not of the TPD provider, that would be the focus. If teachers
don’t have the books they need, TPD should help them come up with strategies to develop learning materials. If teachers have 40 students and only one computer in the classroom, TPD must model, instead of simply talking about how teachers integrate technology given such a constraint.

Computers raise many concerns among teachers. Technical concerns raise questions like “How do I use the computer?”; functional concerns such as “What can computers help me do?”; logistical concerns like “How can I use so few computers with so many students?”; affective concerns such as “Will these computers replace me as a teacher? Will my students lose respect if they think the computer knows more than me?”; organizational concerns include questions like “How do I organize my classroom to support the use of computers? How can they be used as part of what I already do in the classroom?”; conceptual concerns such as “How can I learn from and with computers?”, instructional concerns like “How can computers help my students learn in different ways? How can they support the curriculum? How can they support my teaching? How should I teach using computers?”; evaluation concerns as reflected in questions like “How do I assess student learning in computer-based projects? How does this new way of learning fit with national exams?” (Gaible et al, 2005).

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoP</td>
<td>A persistent, sustained social network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise. (Barab et al., 2003)</td>
</tr>
<tr>
<td>PLC</td>
<td>Bolam et al. 2005 define a PLC as a community &quot;with the capacity to promote and sustain the learning of all professionals in the school community with the collective purpose of enhancing student learning&quot;.</td>
</tr>
<tr>
<td>PC vs PLC</td>
<td>A teacher professional community is oriented to the support of all aspects of teaching; a professional learning community (PLC) is a community specifically oriented to teachers’ professional development; such support has long been of central concern within the teaching profession. (Mississippi DOE,1996)</td>
</tr>
<tr>
<td>TPD</td>
<td>“Teachers’ professional development can be defined as those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students”.</td>
</tr>
</tbody>
</table>

Table 1.1: Relevant Concepts - Definitions

In this section I have described different concepts related to a teachers’ community of practice from literature. Table 1.1 & Table 1.2 provide a quick list of the definitions and characteristics of these concepts. As is evident, these concepts are broadly defined. So, it is not clear what the differences are. While they all seem to have similar characteristics, perhaps one difference is that they lay emphasis on different aspects. A teachers’ CoP may be primarily concerned with describing the components of such a community. A teachers’ professional community (TPC) provides specific indicators to identify the
existence and evaluate the strength of teachers’ professional community. Furthermore, a teachers’ PLC (TPLC) may be viewed as a subset of a TPC in the sense that it comprises primarily of teachers who are in a small group or network such as a department, a team, or school staff who provide them support from time to time. It lays emphasis on certain aspects such as a culture of collaboration, a focus on increasing student achievement and shifting a teachers’ approach from teaching to ensuring that students are learning. So the concept of PLC identifies a clear goal. A teachers’ professional development community (TPDC) may be viewed as a subset of a teachers’ CoP but it may or may not be a part of a TPC or a TPLC because it contains teacher educators and researchers who do not practice school classroom teaching but provide support from outside.

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoP</td>
<td>(1) shared knowledge, values, and beliefs;</td>
</tr>
<tr>
<td></td>
<td>(2) overlapping histories among members;</td>
</tr>
<tr>
<td></td>
<td>(3) mutual interdependence; and</td>
</tr>
<tr>
<td></td>
<td>(4) mechanisms for reproduction</td>
</tr>
<tr>
<td></td>
<td>(5) a common practice and/or</td>
</tr>
<tr>
<td></td>
<td>(6) opportunities for interactions and participation;</td>
</tr>
<tr>
<td></td>
<td>(7) meaningful relationships; and</td>
</tr>
<tr>
<td></td>
<td>(8) respect for diverse perspectives and minority views;</td>
</tr>
<tr>
<td>PLC</td>
<td>(1) a clear sense of shared purpose and collective responsibility for student learning;</td>
</tr>
<tr>
<td></td>
<td>(2) professional inquiry among staff to achieve that purpose, including opportunities for sustained</td>
</tr>
<tr>
<td></td>
<td>collaboration and reflection on practice;</td>
</tr>
<tr>
<td></td>
<td>(3) decentralization of teaching practice</td>
</tr>
<tr>
<td></td>
<td>(4) norms of collegiality among teachers and leaders;</td>
</tr>
<tr>
<td></td>
<td>(5) opportunities for staff to influence school activities and policies;</td>
</tr>
<tr>
<td></td>
<td>(6) inclusive membership, networks, partnerships</td>
</tr>
<tr>
<td></td>
<td>(7) openness and</td>
</tr>
<tr>
<td></td>
<td>(8) mutual trust, respect and support</td>
</tr>
<tr>
<td></td>
<td>Ensuring that students learn</td>
</tr>
<tr>
<td></td>
<td>A culture of collaboration</td>
</tr>
<tr>
<td></td>
<td>A focus on results</td>
</tr>
<tr>
<td>PC</td>
<td>(1) a clear sense of shared purpose and collective responsibility for student learning;</td>
</tr>
<tr>
<td></td>
<td>(2) professional inquiry among staff to achieve that purpose, including opportunities for sustained</td>
</tr>
<tr>
<td></td>
<td>collaboration and reflection on practice;</td>
</tr>
<tr>
<td></td>
<td>(3) decentralization of teaching practice</td>
</tr>
<tr>
<td></td>
<td>(4) norms of collegiality among teachers and leaders;</td>
</tr>
<tr>
<td></td>
<td>(5) opportunities for staff to influence school activities and policies;</td>
</tr>
<tr>
<td></td>
<td>(1) Policy &amp; Evaluation</td>
</tr>
<tr>
<td></td>
<td>(2) Consultation &amp; Cooperation</td>
</tr>
<tr>
<td></td>
<td>(3) Consensus</td>
</tr>
<tr>
<td></td>
<td>(4) Decision making</td>
</tr>
<tr>
<td></td>
<td>(5) School Leadership &amp; Departmental Leadership</td>
</tr>
<tr>
<td>TPD</td>
<td>(1) a shared vision with goals for improving student performance;</td>
</tr>
<tr>
<td></td>
<td>(2) a planning process which fosters team building and shared decision making;</td>
</tr>
<tr>
<td></td>
<td>(3) a variety of learning options essential to enhance individual growth and organizational</td>
</tr>
<tr>
<td></td>
<td>improvement, and</td>
</tr>
<tr>
<td></td>
<td>time and structure for demonstration, practice, reflection, and sharing</td>
</tr>
</tbody>
</table>

**Table 1.2: Relevant Concepts- Characteristics**

The relationship among these concepts, as discussed, is shown below with the help of a diagram (Fig 1.5).
My study will borrow from these various concepts related to CoPs but specifically from the concept of PLC. My intention is to find out how the teachers are learning from their peers about the different ways and goals for using technology in their everyday practice; how current communication and collaboration technologies can help in this process; how other professional development programs are entering and being disseminated through PLCs and how the teachers are voicing their concerns and helping shape the professional development programs. Additionally, ICTs have the potential to break the boundaries between CoPs, TPCs, TPLCs and TPD.

![Diagram of Professional Development support for Professional Community of Teachers](image)

**Fig 1.5: Professional Development support for Professional Community of Teachers**

1.2 Technology in the Classroom

Pedagogical differences result in different learning outcomes for the same content with the same technology. Teaching about technology through professional development programs may not readily transform into teachers’ practice. Even if it does, the practice may differ from one teacher to another. Information technology is a complex tool and as such, it can be used in a variety of ways. Schrum et al. (2007) note that

“different technologies have unique pedagogical affordances and the effects of these affordances can only be understood in the context of a specific content area, their related learning outcomes, and a specific pedagogy. For example, science teachers can use planetarium software such as Starry Night to teach astronomy concepts in many different ways. Some teachers may take students to the computer lab to use the software, but they assign worksheets guiding students to merely confirm concepts stated in the textbook – still a somewhat traditional pedagogy. Other teachers may employ the same software to facilitate inquiry, engaging students in making and testing predictions and discovering astronomical pat-
Perhaps a better approach to learn about technology practices would be to have an ongoing interaction among teachers for sharing practices with each other in their own workplace. They may then be able to readily discover the difference in how each of them is using technology and then converge towards using it in a more uniform way so that the students experience similar learning outcomes. Due to lack of time for face-to-face meetings, an online place may provide just the right support.

Technology offers unique opportunities but at the same time, it also brings about new challenges associated with it. The Learning in Networked Communities (LiNC) project was established to promote collaborative teaching in geographically distributed science classrooms (Dunlap, Neale & Carroll, 2000). A major outcome of this project was The Virtual School, a networked learning environment that linked four middle and high school classrooms. The environment included real-time chat, email, videoconferencing, and shared collaborative notebooks (Isenhour, Carroll, Neale, Rosson & Dunlap, 2000). While the main goal of the project was to bring together students in different locations to work together on group projects, it brought to attention the new tensions associated with teacher collaborations such as problems related to differences in awareness and assessment of student activities and progress, communication among teachers, scheduling and planning, as well as pedagogical differences. These problems vary according to the local context. One way to address these challenges could be ongoing teachers professional development practice where teachers share their problems routinely. Such knowledge can be discussed, codified and disseminated online from time to time using light-weight communication technologies. Once the teachers’ voices are heard, the school administration will understand and take some steps to work with the teachers to solve these problems. Another outcome of this study was the gradual development of participating teachers in this project from a peripheral role of practitioner-informant to a more active role as analyst and designer and then becoming skilled enough to coach other teachers/colleagues in their school (Carroll, Chin, Rosson & Neale, 2000). In this study, the participatory design method succeeded not only in developing a learning environment but also in the technology being adapted by the teacher-participants. Thus, a teacher-centered approach resulted in a positive outcome.

It is important to recognize that “technology” is an omnibus term that can support different aspects of teaching practice. Through interviews with the IT staff at the high school, several categories emerged. Technology productivity tools are those that increase the teachers’ efficiency. For example, word processing, spreadsheet, graphs, powerpoint, can all be used to simplify construction, sharing, and reuse...
of materials. Technology communication tools are important for interacting with students, peers, and other staff; examples include, phone, email, IM, text chat, wikis, blogs, audio and video conferencing, Facebook, School 2.0, etc. Technology research tools (e.g., the Internet in general, specific digital libraries) might be used to search and collect information from multiple sources. Educational technology tools are specific to a subject, for example, Math teachers use Geometer’s Sketchpad while Geography teachers use Google Earth. Finally, there are also course management tools (e.g., Angel, Moodle) that are used to deliver lesson plans and other course materials, broadcast information to students, and so on. As I continue my work, it will be important to distinguish between the different types of technologies and the unique affordances they bring in supporting teachers in a school context.

1.3 Teachers Collaborating about Teaching Practices

Literature points to an increasing trend towards a shift in teachers’ professional development process from individual to collaborative activities. Grangeat & Gray (2007) state that

“Teaching as a professional activity is in the process of a shift from individual knowledge use to collective knowledge generation where enhancements in teaching are produced through dialogue and collective enquiry within the world of teaching rather than by external research”.

In other words, teachers’ professional activity is shifting from a passive application of knowledge towards the generation of knowledge through the activity itself. Even as early as 1982, Little found that schools with relatively high achievement and extensive staff development had four practices in common. In these schools, teachers talked about their teaching, were observed and critiqued by their peers, designed and planned teaching materials together, and taught each other.

Information technology offers great potential to further the development of teachers’ professional communities by providing an online platform to share and learn from each other. From the literature, it is quite evident that attempts to use web technologies to support face-to-face professional development have been ongoing (Carroll et al. 2005 & 2003, Barab et al., 2001 & 2003, Dunlap 2004, Hew & Hara, 2007, Hur & Hara, 2007, Isenhour et al., 2000 & 2003, Green & Cifuentes, 2008, Najafi & Clarke, 2008). Some have been successful and some have not achieved the desired goals. These efforts provide us with rich information to gain lessons for the future.

According to Guskey (2000), follow-up to a teachers’ professional development program can enhance a teacher’s feeling of competency. With online environments teachers have the convenience of accessing follow-up to professional development in their own time. Green & Cifuentes (2008) have shown that
professional development programs alone cannot bring about changes in teaching practices without a follow-up. But it is a big challenge for teachers to find the time for a follow-up meeting during the school day. They are generally not inclined to moving learning to meeting time after school. Moreover, providing substitutes so that teachers can meet during the day is a costly proposition. Information and communication technologies offer professional developers a great opportunity to provide a follow-up to their face-to-face workshops. The results of the study strongly indicate that teacher educators are well advised to provide online follow-up with peer interaction in their professional development programs.

However, Najafi & Clarke (2008) found that a similar attempt was not successful. In a case study conducted in a school board in a western Canadian city, an on-line component called the Online Literacy Project (OLP) was added to a successful professional development program called the Literacy Project. This component was developed based on input from a Literacy Project mentor. The research team developed a resource Web site with a discussion forum for online communications. Later, the site was revised based on reflections and feedback of other mentors. The research team kept close contact with the participants to observe how they used a Web-based structure to further the opportunities for professional development. Unfortunately, it was found that the current form of OLP did not bring any significant enhancement in the professional development of the Literacy Project teachers, even though many of these teachers initially acknowledged the potential of online communications. It would be hard to generalize from this study because the sample of participants was too small. Nevertheless, some of the findings can serve as a useful guide in future attempts.

Teacher continuous professional development, at its core, is all about teachers sharing knowledge with each other to improve their practice (Hew & Hara, 2007). Knowledge sharing approaches can be both formal and informal. However, formal knowledge sharing approaches such as training workshops are criticized because they are removed from the workplace and hard for teachers to transfer or apply to their workplace. On the other hand, informal knowledge sharing approaches such as participation in informal social networks, such as, a community of practice, have been found to be a powerful catalyst for change (Schlager & Fusco, 2003).

In another study (Khe & Hara, 2007) researchers identified some motivators and barriers for teachers’ online knowledge sharing as an example of a community of practice mediated by computer networks. They conducted an empirical investigation on how teachers on the Literacy Education listserv were using this technology for sharing knowledge. They found that the key motivators for sharing knowledge were collectivism and principlism while the main barriers were a lack of knowledge and competing priority.
“Collectivism is a motive that aims to increase the welfare of a group” (Batson et al., 2002) while principlism is a moral feeling for giving back help because one has received help from the community in the past (Cheung et al., 2004). The study also suggests that motivators for knowledge sharing may be practice dependent. For example, in another study (Wasko & Faraj, 2005) on knowledge sharing practices of legal professionals, in an online network supporting a professional legal association, it was found that they were driven more by egoist motives as they felt that it enhanced their professional reputations. Thus collectivism and reciprocity were hardly the motivators for the legal professionals. Hence, the study suggests that their results may not be generalizable to Math and Science teachers.

According to them the motivating factors were generally internal and related to teachers’ professional judgment, attitudes and relationships. On the other hand, the restraining factors were generally external and related to the school day, year and lack of time. The authors suggest that in the short term it may be easier to encourage knowledge dissemination by reducing the restraining factors rather than the motivating factors. The full list of motivators and barriers for teachers’ online sharing behavior is summarized in the table below. The results for this study were derived from data that was obtained in an analysis of online sharing.

<table>
<thead>
<tr>
<th>Motivators</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collectivism</td>
<td>Lack of time</td>
</tr>
<tr>
<td>Reciprocity</td>
<td>Lack of knowledge</td>
</tr>
<tr>
<td>Personal Gain (reputation)</td>
<td>Risk of being misunderstood</td>
</tr>
<tr>
<td>Personal Gain (knowledge)</td>
<td>Not wanting to cause a fight</td>
</tr>
<tr>
<td>Personal Gain (support)</td>
<td>Negative attitude of the seeker</td>
</tr>
<tr>
<td>Respectful Environment</td>
<td></td>
</tr>
<tr>
<td>Altruism</td>
<td></td>
</tr>
<tr>
<td>Anonymity</td>
<td></td>
</tr>
<tr>
<td>Interest of seeker</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.3: Teachers’ Online Knowledge Sharing

Yuen & Ma (2004) pointed out that many organizations understand the importance of knowledge sharing among their employees. As a key element of organizational learning, knowledge management life cycle comprises: (1) knowledge capture; (2) knowledge sharing; (3) knowledge application, and (4) knowledge creation (Liebowitz, 2001). In order to make sure that knowledge captured through any training program
can be applied to the workplace, the actual sharing of the knowledge is a prerequisite step before moving any further in the knowledge management life cycle. An employee can get new knowledge from different sources such as training. However, it is doubtful whether this captured new knowledge can be fully externalized into the workplace.

Thus technology offers great opportunities for continuous professional development by supporting and enhancing communication among teachers for sharing knowledge. However to make this effective, one needs to be aware of the external and internal factors for motivating and restraining the sharing of knowledge. Among other concerns, this study will also attempt to identify the barriers and motivators that currently exist in the school among teachers for sharing teaching practices with respect to technology integration in the curriculum.

1.4 Online Tools for Teacher Knowledge Sharing

It seems clear that online technology can make knowledge sharing easier and more effective. However, the real issue is to choose and implement a suitable technology that provides a good fit between people and organizations. The American Productivity and Quality Center (APQC, 2000) identified four CoP types and their corresponding needs by conducting a study involving 40 companies. In help communities members supported each other on everyday problems and shared ideas on an ad-hoc basis. The best practice communities developed, validated and shared best practices. The innovation communities sought breakthrough ideas and the knowledge stewarding communities maintained the body of knowledge for day-to-day use. The unique requirements for each community provide a guide for identifying the best technology features that support these needs. For example, “light weight conversational technologies” seem to be least suited for the knowledge steward communities. In this context, lightweight conversational technology would include computer-mediated communication (CMC) channels like chats, wikis or blogs. Because a knowledge steward community needs technology that supports document management and portal development and maintenance, these simple CMC tools are not likely to be sufficient. However for other CoP types, conversational technologies might provide a suitable medium for knowledge sharing.

Conversational technologies succeed by leveraging the communal knowledge and social capital of groups by supporting the natural process of conversation and by documenting its results; reducing the negative effects associated with knowledge capture in systems, such as large development time or skill requirements, while amplifying the positive effects, such as knowledge sharing, or knowledge search;
being lightweight and relatively inexpensive; satisfying the needs of several types of communities of practice such as daily question answering, access to a diverse group of experts, and incremental knowledge refinement mechanisms (Wagner & Bolloju, 2005).

Wagner & Bolloju (2005) argue for two paradigms that might be used in the sharing and distribution of knowledge: dialog and broadcasting. In the dialog mode knowledge is created by questions and answers among the community members. Tools for the dialog mode are discussion forum and wiki. These can be also considered as many-to-many communication tools. In the broadcasting mode, a single author can post his/her knowledge or information to the entire community. An example tool would be weblogs. This can also be considered as a one-to-many tool.

Carroll & Rosson (2005) investigated the knowledge-sharing practices among public school teachers and identified three levels of knowledge sharing. At the lowest level, teachers shared tangible resources such as pointers to web sites, lego construction kits, lab equipment, etc. At the second level, they shared classroom plans and objectives such as lesson plans for labs, worksheet templates for peer mentoring activities, grading policies, etc. and at the third level, they shared artifacts produced by students (in progress or completed) such as on-line lab reports, web sites with project summaries and photos. Based on these three levels of sharing, the researchers went on to describe four different frameworks for representing and accessing this knowledge: place, time, people, and use. This design vision for teachers’ knowledge management was realized in the TeacherBridge project (http://teacherbridge.cs.vt.edu) — an online community network for teachers to build websites and other online resources for their class activities (Kim, Isenhour, Carroll & Rosson, 2003; Carroll & Farooq, 2005; Carroll et al., 2003). Teachers in this network can build websites and other online resources for their class activities (http://teacherbridge.cs.vt.edu). In place-based knowledge, a teacher can interact with an online map of a place of interest and browse associated documents. In a use-based knowledge, a teacher may access an object based on usage statistics of that object. An object with a higher usage frequency may suggest more value. Time-based knowledge gives a history of when an object was revised or updated. For example, if a lesson plan was not updated in ten years, a teacher interested in using that object may be prompted to revise it. This study offers a valuable lead in understanding how knowledge can be visualized and organized in multiple ways for teachers’ sharing and accessing professional resources. This study will greatly benefit by following this thread and investigating the different rubrics that the teachers in my study are using to organize and access knowledge.
Another study (Asllani, 2008) suggested that knowledge sharing and retention rates can increase by combining blogs and discussion boards with traditional face-to-face communication methods. This comparative study showed that blogs are more successful in communicating tacit knowledge to a general audience whereas discussion boards are more successful in communicating explicit knowledge to a specialized audience. The world-wide web offers a rich resource of online professional development communities. Some examples are described in the following section.

1.5 Online TPD Community Overview

Some teaching PLCs may exist and operate entirely or at least partly through the support of online services and activities. Such a structure has been termed a virtual learning community (VLC; the phrase online learning community or OLC is also used for this same concept). According to Gan & Zhu (2007) a VLC is

“a virtual learning environment in which a group of learners, who join together with common interests and the same learning objective, communicate, interact, discuss, and collaborate on a problem that has arisen from active learning, collaborative learning, and knowledge building, and then share each other’s opinions, ideas, resources, knowledge, experiences, and collective wisdom. A VLC therefore fosters the advancement of knowledge building and collective wisdom, and learners ultimately achieve learning targets and acquire the abilities of learning how to learn to a higher level (Gan, 2005, p.39).”

Barab et al., (2003) point to the confusion about the definition of a virtual community. It has been known to include “anything from a tight-knit group of people who share important parts of their lives on a day-to-day basis to an amorphous chat group that can be joined (and left) by anyone with a valid password”.

In a VLC, people may communicate using text, audio or video. Most literature talks about online learning communities as environments that support and act as communities of practice. Several types of VLCs exist, such as, e-learning where participants interact solely through technology and blended learning where both face-to-face and technology are used as a means of interaction. Whether creating a community for e-learning or one that supports a blended learning approach, when creating an online community, builders must consider a variety of factors related to people, group processes, and technology. Educators are enthusiastic about the possibilities it opens up and are exploring the “community” model for supporting learning.

Online modes for TPD parallel the three methods of TPD listed earlier. These modes can be grouped as online courses, online communities and self-directed learning. However, boundaries between the different types of online TPD are more flexible. For example, a teacher, while browsing an online teacher resource
center (self-directed TPD) may discover a course that he/she finds useful. The teacher then completes the online TPD course in several sessions, and then signs up for the course’s list-server discussion (Gaible et al., 2005).

Based on the different types of online TPD, online professional development sites may be categorized according to features such as online course offerings, online sharing of lesson plans, online community (forums, groups and chats) and offerings for self-directed learning. Online courses refer to the courses that are put on the website for teachers to learn. Online sharing refers to the resources and material shared by other teachers. Online community refers to online forum, chats using which teachers can communicate with each other, sharing their thoughts and proposing new professional development ideas. Self-directed learning involves independent learning by teachers over the internet. About ten professional development sites were analyzed using the above mentioned features. Alexa was also used to get information about their usage. [Refer to Table 1.4]

*Teacher focus* is an online forum where everyone can participate in the discussion. Teachers can also submit their lesson plans and share them with other members of the forum. The *Inquiry Learning Forum* (ILF) give teachers an opportunity to connect with other teachers who have varying degrees of expertise, diverse interests, and who are interested in better understanding the value of inquiry. More specifically, the ILF supports teachers in learning more about student and teacher inquiry through participating in discussions with other teachers, scientists, and educators, gathering and sharing inquiry-based lesson plans and resources, examining videos of other teachers' classrooms, developing their own personalized professional development plan. *Tapped In* offers TPD providers and other organizations the latest in online technology, along with the online learning strategies and support needed to use online technology effectively. Through Tapped In, organizations can develop, implement, and manage online courses, workshops, seminars, mentoring programs, and other collaborative activities that supplement, or function in lieu of, face-to-face activities. The goals of *Teacher Bridge* center on using online tools for supporting teacher professional resource management for Montgomery County and Giles County Public School teachers at Pennsylvania. While the project focuses initially on science and mathematics teachers, it is not limiting participants to these disciplines. The hope is that the resources developed will be usefully disseminated to a wide variety of other teachers in the region and possibly beyond (Kim et al., 2003). According to its founder Nate, *We the Teachers* “it is a website where teachers can share, rate, and discuss their lesson plans, but it is also a place where they can meet, talk, and network. You don't just find a lesson plan you like, you can meet the person who wrote it!” *The Math Forum* is an online community which includes teachers, students, researchers, parents, educators, and citizens at all levels who have an
<table>
<thead>
<tr>
<th>Name</th>
<th>Online Sharing</th>
<th>Online Courses</th>
<th>Online Community</th>
<th>Online Collaboration</th>
<th>Self-Directed Learning</th>
<th>Online since</th>
<th>Daily Avg # visitors</th>
<th>Alexa Rank in US</th>
<th>Daily Page views/user (past 3 month avg)</th>
<th>Time on Site (minute)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teach-nology</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>19-Apr-1999</td>
<td>48,000</td>
<td>8,106</td>
<td>2.8</td>
<td>1.9</td>
<td>Web portal for educators. Includes lesson plans, tools, worksheets, articles and tips for teachers. Teach-nology.com is visited more frequently by females who are in the age range 45-54, have children and browse this site from home.</td>
</tr>
<tr>
<td>Teacher Focus</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>2001</td>
<td>660</td>
<td>2.9</td>
<td></td>
<td>2.0</td>
<td>Teacher forum and discussion boards. Includes directory of resources for teachers, plus free lesson plans and teaching-oriented newsletters.</td>
</tr>
<tr>
<td>Inquiry Learning Forum (ILF)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>16-Dec-1997</td>
<td>1,440</td>
<td>4.6</td>
<td>NA</td>
<td>Connect and interact with other teachers share inquiry-based lesson plans and resources see videos of inquiry-based classrooms develop your own personalized professional development plan. <a href="http://ilf.crlt.indiana.edu/">http://ilf.crlt.indiana.edu/</a></td>
</tr>
<tr>
<td>TappedIn</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>16- Dec-1997</td>
<td>1,440</td>
<td>4.6</td>
<td>2.9</td>
<td>Teacher Professional Development Institute (tappedin.org): An online community of over 2800 K-16 teachers, staff, and researchers engaged in both formal professional development programs and informal collaborative activities. Members hold real-time discussions and classes and interact via mailing lists and discussion boards all in a single on-line venue: <a href="http://tappedin.org">http://tappedin.org</a>. tappedin is visited more frequently by females who have children and are graduate school educated.</td>
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<tr>
<td>We the Teachers</td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td>4-Aug-2005</td>
<td>480</td>
<td>3.2</td>
<td></td>
<td>2.9</td>
<td>We the Teachers.com is visited more frequently by users who are in the age range 35-44, are graduate school educated and browse this site from work. Sold rights to VIP Tone.</td>
</tr>
<tr>
<td>The Math Forum</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>02-Jun-1997</td>
<td>63,000</td>
<td>6,487</td>
<td>1.9</td>
<td>1.775</td>
<td>Mathforum.org is visited more frequently by users who are in the age range 18-24 and browse this site from school. <a href="http://mathforum.org">http://mathforum.org</a></td>
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<tr>
<td>Education with New Technology (ENT)</td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td>02-Jun-1997</td>
<td>63,000</td>
<td>6,487</td>
<td>NA</td>
<td>A networked learning community designed to help educators develop, enact, and assess effective ways of using new technologies <a href="http://ent.web.harvard.edu/ent/home/">http://ent.web.harvard.edu/ent/home/</a></td>
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<tr>
<td>The Getty Arts Ed</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
<td>Art teachers</td>
</tr>
<tr>
<td>NSTA Online Learning Center</td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td>2006</td>
<td></td>
<td></td>
<td></td>
<td>NA</td>
<td>Site has extensive collection of information about the teaching of science <a href="http://learningcenter.nsta.org/">http://learningcenter.nsta.org/</a> nsta.org is visited more frequently by females who are in the age range 35-44 and are graduate school educated.</td>
</tr>
<tr>
<td>Teachers.net</td>
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<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td>18,000</td>
<td>18,438</td>
<td>2.96</td>
<td>2.4</td>
<td>Teacher discussion boards and chatrooms. Lesson plans, project ideas and teaching tools. Searchable teacher job listings and career resources. Teachers.net is visited more frequently by females who are in the age range 35-44, are college educated and browse this site from home.</td>
</tr>
</tbody>
</table>
interest in math and math education. Through the growing collection of mailing lists, Web-based discussion areas, and ask-an-expert services, the Math forums give users places to talk, to reach others with similar interests, make math-related web resources more accessible and to find answers to your burning questions. The ENT project at Harvard is more focused on education technology training. It gives users access to thoughtful colleagues, interactive tools, detailed examples of technology-enhanced education, and a valuable collection of on-line resources. The site helps users navigate the expanding territory of new educational technologies with guidance from established principles for teaching and learning (e.g. Teaching for Understanding) through processes for integrating new technologies. The Getty Art Ed project is aimed at helping art teachers develop their lesson plans by offering them Getty Art’s collections. It also offers workshops and professional development programs (offline) that help teachers incorporate the study of art into your classroom. The Learning Center is NSTA’s e-professional development portal to help teachers address their classroom needs and busy schedule. Teachers can gain access to more than 4,000 different resources that cater to their preference for learning. Over 1,200 resources, such as journal articles, science objects and web seminars are available for free. A suite of practical tools such as My Library, My Transcript, and My Professional Development Plan and Portfolio tool help teachers organize, personalize, and document their growth over time. The Carnegie Foundation for the Advancement of Teaching focuses on K-12 teacher education through several programs. One of them is Goldman-Carnegie Quest Program, which built a website called “Inside Teaching”. It is an online "living archive" of practice, which include a collection of K-12 and teacher educator Web sites; perspectives on the use of K-12 Web sites in teacher education; a "reading room" with related articles and Web sites; and a "workshop" designed to invite others to engage with the archive and make contributions of their own. Some of these sites have been described by Riel & Polin (2004).

An analysis of features offered show that online resource sharing is provided on all the TPD communities reviewed here. The resources shared are usually lesson plans, pointers to online documents, and puzzles. Online resource sharing is perhaps the easiest way to build a TPD community. However, the drawbacks of simple sharing are obvious. Such materials are usually collected by the organizer of the TPD community and some of the resources may not be applied to the practices to the teachers in the real world.

Online courses are only provided in two of the TPD communities. The advantages of online courses are that courses are usually well organized and well-structured to deliver knowledge to teachers who want to develop themselves. However, online courses are usually expensive to conduct. It takes much more time.
and money to open online courses and teachers usually need to pay registration fees in order to access the online courses.

In the TPD sites reviewed here, the concept of “community” is very loose. Although most of the TPDs have some kinds of online community elements in play, like online forums, mail lists and chats, it turns out that there are few residents here and the level of participation is low. From the data collected from Alexa, it shows that most visitors to these TPDs stay for a very short period of time on these sites. For Tapped In, the average length of time each visitor stays on the website per visit is only 1.6 minutes. The ENT project at Harvard keeps visitors relatively longer, but is still less than 3 minutes. The short length of time visitors spend on these TPDs indicates to a great extent that the attractiveness of these TPDs to teachers is relatively low.

While online TPDs abound and some of them like Tapped In try to emulate all the features of a TPD, designers have been baffled by the lack of “community”. They have begun to question their own presumptions about how they had approached the design and development of their web offering. They realize that they should have taken into consideration and tried to understand the local context where the teachers actually practice. Thus research is needed to understand the teachers’ professional community in their local context to find out how knowledge gained through professional development programs as well as knowledge created in their daily practices are shared among each other; how TPD programs are addressing the concerns that teachers have about technology integration in the classroom; how are the TPD programs being made more learner-centered. In a paper reflecting on their experience in developing Tapped In, Schlager & Fusco (2003) confess that although they have called Tapped In an online education community of practice, they have struggled with the choice of this label. They still question if the users of Tapped In environment constitute a community of practice. They even struggled to define the practice. Based on other studies done on Tapped In, they summarize that the members of Tapped In appear to belong to many and sometimes overlapping communities of practice inside and outside of the Tapped In environment. This suggests that Tapped In may be better described as a network of practice, a constellation of practices, or a crossroads of multiple educator communities. At first thought, such distinctions may appear like splitting hairs, but they are important in that they can have significant design implications.

According to the designers of ILF, one of the main challenges that it has faced since its inception is that its global reform agenda does not meet the local needs of the teachers when looking at the problem with Wenger’s (1998) local/global duality. For example if a classroom teacher achieves a series of successes
with his or her children how can he or she share the local experience and insights in a way that it will have global relevance to others who have a different context? (Barab et al., 2003).

All these examples point to the many gaps that exist in using ICTs for teachers’ professional development programs.

1.6 Toward a Professional Development Community for Teachers

Information technology offers great potential to further the development of teachers’ professional communities by providing an online platform to share and learn from each other. Effective TPD begins with an understanding of teachers’ needs and their work environments—schools and classrooms. TPD then combines a range of techniques to promote learning; provides teachers with the support they need; engages school leadership; and makes use of evaluation to increase its impact. Essential techniques include mentoring, teamwork, observation, reflection and assessment. Perhaps Fig 1 could be expanded to show how the gap between professional community of teachers and the professional development they receive can be bridged.

![Diagram](image)

Fig 1.6: Toward a professional development community of teachers
From the literature, it is quite evident that attempts to use web technologies to support face-to-face professional development have been ongoing (Carroll et al. 2005 & 2003, Barab et al., 2001 & 2003, Dunlap 2004, Hew & Hara, 2007, Hur & Hara, 2007, Isenhour et al., 2000 & 2003, Green & Cifuentes, 2008, Najafi & Clarke, 2008). Some have been successful and some have not achieved the desired goals.

These efforts provide us with information on the best practices as well as the challenges. Of the various TPD communities we reviewed, there are many different features on their websites that can provide professional development for teachers. Some of them just provide online resource sharing. Some of them offer online course, some of them build online forums for teachers to communicate with each other. Some of them provide sophisticated tools for teachers to track their professional development status like NSTA online learning center. While it is clear that those various features can help with teachers professional development, yet how effective these various features are is still uncertain. It is important for researchers and practitioners to know from teachers’ perspective what they like about these various features and which is more effective than others. Research should address how professional development sites could be grounded to the local context. Studies that describe teachers’ workplace learning practices could inform the design of technology that could best address their needs.

1.7 Activity Theory as an Analytical Framework

In this section, I will review literature that list some analytical tools used by researchers who have conducted studies similar to what I am planning to propose. This would guide me in choosing the best combination of methods. I believe that by using similar methods as already employed before, the findings from this study can be compared and used by subsequent studies and thus be a useful addition to the body of knowledge.

In one study, researchers (Kim, Isenhour, Carroll & Rosson, 2003; Carroll & Farooq, 2005; Carroll et al., 2003), describe the Teacher Bridge project. The teacher bridge authoring environment was designed to help teachers build their own online activities as well as share them with their colleagues. The researchers used a combination of scenario-based participatory design and a community-building model of seeding and evolutionary growth. For over a period of three years they recruited a core group of 12 teachers from two counties (Montgomery and Giles County Public Schools) in southwestern Virginia, USA. Each year they held a workshop to introduce Teacher Bridge. The workshops were followed by visits to the teachers’ work settings to provide further help in analyzing and building Teacher Bridge content. These personal visits were an important element in the scenario-based design process, because the researchers
could observe and integrate the more situated and tacit aspects of teachers’ practice in their workplace context.

Najafi & Clarke’s (2008) study describes a failed attempt to adding an online component to a successful Literacy Project. One suggestion he offers in the end is using a practical approach citing a study by Merkel et al. (2004) for developing a Web-supported teachers’ professional development community. Here the financial and technical support is temporarily provided by universities and research groups, who employ a participatory design method for face-to-face communities. This method may have the potential to empower a community to identify the issues that can be facilitated by technology and also to identify the suitable technologies that might address these issues. When teachers become more knowledgeable about what kind of web technologies can facilitate their professional development and interaction, the outcome may be more effective.

Barab et al., (2003), who developed the ILF recommend some analytical tools for designers-researchers for understanding community life. They recommend ethnography guided by a couple of analytical frameworks - socio-technical interaction networks (STIN) and Activity Theory. Ethnography is the traditional methodological technique employed in anthropological circles for studying community life. This would involve extended engagement with the community being researched, collecting field notes, examining artifacts, interviewing community members, recording observations and so on. Once the data are collected, they are sifted and organized into codes and categories from which emergent themes and patterns are identified (Geertz, 1983; Marcus, 1998 as cited in Barab et al., 2003). However, this type of qualitative research can benefit a lot if used within a framework that would help in both guiding the observations and then providing a useful lens through which the data can be interpreted (Schwandt, 1997 as cited in Barab et al, 2003). Such a combination of methods can be tried in research that is already starting with a well-documented literature base and also where researchers are also designers of the work (Barab et al., 2003). The STIN model was developed by Kling et al. (2001) (as cited in Barab et al, 2003). It focuses on the interactions between people and technologies by including all the actors, artifacts, resources, technologies, and relationships among members both inside and outside the community. When analyzing within the STIN framework, one looks at resource dependencies between actors, between actors and artifacts, and between artifacts. The technology-in-use and the social world are viewed as co-constitutive.

The second framework they (Barab et al., 2003) used refer to core tensions that are the hallmark of any system activity. Engestrom (1999), whose work is grounded in Activity Theory, described tensions as
characterizing system activity and driving system innovation. Barab et al. found tensions to be a useful analytical lens to characterize participant behavior. In a similar way, Wenger (1998) described four dualities as central to understanding community: participation/reification; designed/emergent; local/global; and identification/negotiation. Extending on this thread and given that we are talking about online communities, Barab et al. have added the additional tensions of online/face-to-face, and for empowerment of all teachers they have added the coherence/diversity tension as well. Barab used these six dualities to guide their data collection and data interpretations for characterizing a web-supported professional development community.

These examples provide some alternative directions for choosing the appropriate method. Participatory design approach was used for those studies where the outcome was to build a tool that would be used by the teachers. This method is a better guarantee for teachers’ technology adoption because having participated in the design process they feel a sense of ownership. However, this method would require a lot of time commitment on the part of teachers who participate. Since the participants in this study were high school teachers, they may be less flexible as compared with middle and elementary school teachers. So, during the preliminary field visits, it became apparent that this method would not be feasible. Moreover since the goal of this study was not the iterative development of a tool, but rather, the development of an understanding of technology adoption from the teachers’ perspective, this method was less applicable.

The STIN approach that was developed by Kling (2003) is “an emerging conceptual framework for identifying, organizing, and comparatively analyzing patterns of social interaction, system development, and the configuration of components that constitute an information system” (Scacchi, 2005). This approach borrows from Social Construction of Technology (SCOT) approach associated with Bijker, Pinch and others, and Actor-Network Theory (ANT), which is associated with Latour, Law, Callon and others. Since my study is user-centered, the STIN approach with its emphasis on human and non-human network interactions may not be the right fit. Myers (2006) states several weaknesses in the STIN strategy. One of the weaknesses is that it has mainly been adopted by close colleagues and former students of Rob Kling. Hence, for new researchers, there are not enough studies to draw from. Another weakness is that there is a need to more clearly articulate the methods and tools needed to use the STIN strategy. Hence this results in a practical problem for graduate students who are new to research and would rather use a more concretely defined approach.
Murphy and Rodriguez-Manzanares (2008) have synthesized several studies that have used AT, especially contradictions as a lens for studying information and communication technologies (ICTs) in educational contexts. They found a limited number of studies, altogether 8 (Barab et al., 2002; Basharina, 2007; Berge & Fjuk, 2006; Dippe, 2006; Fähræus, 2004; Hardman, 2005; Murphy & Rodriguez-Manzanares, in press; Peruski, 2003; Russell & Schneiderheinze, 2005 cited in Murphy & Rodriguez, 2008) that had used contradictions as the underlying approach for the study. Case studies were the most favored research design in these studies. They could be single or multiple case studies. The data collection techniques included interviews, group interviews, video recordings of classes or meetings, chat room conferences, emails and online discussion forums, instant messaging sessions, online journals, observations, field notes, questionnaires, documentary evidence, student assignments, analysis of artefacts and recall analysis. These studies combined various sources of data, for example, interviews with class observations and documentary data. Majority of the studies of research within an AT framework relied on qualitative methods. However, quantitative methods have also been used (Russell, 2001). Murphy and Rodriguez-Manzanares (2008) conclude that

"AT is a versatile tool to inquire into various aspects of educational technology use, taking into account individual and institutional perspectives as well as evolution over time".

Activity Theory is an established framework that has stood the test of time. It has been used at multiple levels of analysis and across a range of domains. It is well known in the field of education. AT can offer insights into a community of practice while, at the same time, keeping the individual at the center. However, it still lacks clarity when applied to research in the new field of information sciences. For these reasons, I will be employing and testing the limits of Activity Theory as applied to my context of study. In the process, it is expected that the framework may have to be adapted and modified. Thus, it is hoped that a more practical framework for analysis may emerge as an important contribution from this study.
Chapter 2

Research Objectives and Significance

I have described a number of approaches and concerns regarding teachers’ development and sharing of technology-enhanced teaching practices. In this section, I will focus on the specific objectives and questions that I am addressing in my dissertation work, including a brief discussion of the impacts I expect to have.

Traditionally, teachers have been known to work in the isolation of their classrooms. This has prevented them from learning from each other. In one study Leiberman (2010) argues for making teachers’ practice public. He cites several studies on how teacher isolation had a negative correlation with their continuous professional development (Lieberman & Miller, 1984; Lortie, 1975; Sarason, 1982). He cites studies that have found that the teachers themselves are the primary stakeholders in any reforms that are needed in the professional development practices (Darling-Hammond & Bransford, 2005). Researchers have agreed with teachers’ perceptions of professional development as being fragmented and disconnected with the real problems of their classroom practice (Ball & Cohen, 1999; Borko & Putnam, 1995; Hatch et al., 2005; Lieberman & Miller, 2001).

The increase in the availability of information and communication technology in the schools have provided them with the new opportunity to reduce the information sharing gap that exists even among the teachers in the same school. While the opportunity exists, they have still not been able to tap the potential of information technologies. They still continue to work in isolation. This study will attempt to identify the barriers and motivators that currently exist in the school among teachers for sharing teaching practices with respect to technology integration in the curriculum. Is technology helping teachers to talk about their teaching? Are they using technology to observe and critique their peers? Is communication technology helping them design and plan teaching materials together? Do they use email, online discussion boards, IM or web 2.0 technologies to follow-up with each other regarding how they are applying lessons learnt in a professional development workshop? and so on. The study will also try to get a sense of what kind of communication technologies the teachers are currently using to stay connected. These concerns have led me to the following high-level research objectives:
I. Better understand the social aspects surrounding the use of information technology in a school setting.

II. Analyze barriers and supporting structures for learning technology practices among teachers.

2.1 Research Questions

Due to increasing access to internet in the schools as well as homes of school teachers, information technology is breaking down the barriers of time and space. This heralds a great opportunity for teachers to overcome their traditional isolation inside their classrooms and make their practice public. Although school leaders are making efforts to create meaningful opportunities for teachers to work together on issues of common interest (Halverson, R. 2003), there is much less focus on the use of technology to help this process. Teachers may connect with friends worldwide through social media but while in school their classroom doors remain shut. They have begun to use technologies to improve student learning, but the deployment of the same tools for their own professional learning has been limited (Leiberman, 2010).

This study proposes to investigate both non-technological strategies used by school leaders and teachers to build PLCs and also the sorts of technologies being used by school teachers in a particular school to develop and share teaching practices with respect to integration of technology into their curriculum. This will help uncover useful findings - for policy makers, coordinators and providers of professional development, school leaders and teachers. More specifically, this dissertation proposes to investigate the following questions:

RQ1: How are teachers integrating technology into their daily practice?

1.1 How are teachers integrating technology into their classroom activities?

1.2 How are teachers integrating technology into their general work practices?

1.3 What are the relevant personal, social, technical and organizational factors that inhibit or enable technology integration and/or curriculum integration?

RQ2: How are teachers learning to integrate technology in their daily practice?

2.1 How are teachers learning through professional development practices?

2.1a self-directed professional development (formal/ informal, online, other).
2.1b site-based professional development (school-wide/district-wide/department-wide, online, formal/informal, other).

2.1c standardized professional development (school-wide/district-wide/dept-wide/off-site, online, other).

2.2 How are teachers learning from each other?

Although I have reviewed literature discussing teacher learning practices in general, it is critical to ground my design ideas on a solid understanding of current practices. By developing this understanding I also hope to contribute to the broader literature on practices for technology integration into teaching and how such innovations are shared and adopted by peers. Thus this general research question can be decomposed further as follows:

2.2a when sharing is meaningful, how is it now taking place?

2.2b have the practices being shared adopted by the teachers?

2.2c what are teachers’ current practices if any regarding online sharing?

2.3 What are the relevant personal, social, technical and organizational factors that inhibit or enable learning?

My answers to these questions will guide my attention to the types of technology innovations that are most likely to be shared as well as help me to understand what is now being done to do this sharing. At the same time I will develop an appreciation of obstacles in these two aspects of the sharing process that I can attempt to address with technology interventions.

2.2 Research Methods

Drawing from the studies described in chapter 1 section 1.7, I propose to use multiple methods with AT as the primary framework. I will start with grounded theory approach to analyze the data collected, through initial interviews, meetings and observations of technology training workshops, by coding and categorizing the data to identify emergent themes. In this way, my analysis will not be colored by the lens I use. Since GT is grounded in the data, there are no preconceived notions that affect the results of the analysis. Once the categories emerge, I will then apply them or fit them to the AT Framework when I
develop my final coding scheme (section 3.4). Please note that the grounded theory approach the way I used stops short of discovering a theory. Only emergent themes, categories and codes are identified. Please note that at this preliminary phase, I used AT only for analyzing tensions or difficulties that were expressed during the interviews or observed during the meetings and training sessions. This would bring to light the systemic tensions facing the teachers as they apply technology to their practice. The preliminary analysis would lead to further refinement of the interview questions and the coding scheme. Table 2.1 below provides an overview of the research method.

<table>
<thead>
<tr>
<th>Introduction</th>
<th>Research Objectives</th>
<th>Research Questions</th>
<th>Methods</th>
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<td>Data Collection</td>
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<td>Preliminary analysis</td>
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<td>Literature Review</td>
<td>1 Better understand the social aspects surrounding the use of information technology in a school setting</td>
<td>RQ1 How are teachers integrating technology into their daily practice?</td>
<td>Interviews</td>
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<td>RQ2 How are teachers learning to integrate technology in their daily practice?</td>
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*AT Framework initially used to analyze difficulties/tensions only

Table 2.1: Research Method Overview

Activity Theory

Theories and frameworks provide researchers ways to describe the world we observe and a common vocabulary for comparison. Studies have compared the different theoretical approaches in HCI. For example, Nardi has presented a comparison between situated action (SA), distributed cognition (DCog), and activity theory (AT). He concludes that activity theory offers “the richest framework for studies of
context” and users’ engagement with artifacts. What sets AT apart from other theories is its focus on intentionality. Baumer and Tomlinson (2011) compared AT and DCog by applying them to the same object of study - a video analysis of ad-hoc interactions of groups of participants learning to use a novel system. He found that while AT was more structured and as such provided researchers with a common vocabulary, DCog was more focused on processes and as such was suitable for a lower level of analysis. Hence, DCog may offer a more direct approach to aid design because it presented data at the right level to be translated into the design of representations and processes. However, the low level focus in DCog resulted in overlooking the higher level process. Moreover, the lack of theoretical names made it difficult to bring it up to the higher level without requiring more descriptive work on the part of the analyst. Similarly, SA provided a framework for a very low level of analysis at a moment by moment basis.

When comparing AT with DCog, Halverson, C.A, describes four attributes that are important when considering the use of a theory. Please note that this was in reference to CSCW research. However, lessons from this article are relevant in general. Theories should be judged on the basis of having rhetorical, descriptive, inferential and application power. These are described in more detail below:

Descriptive power: theory should help us describe the world and make sense of it by providing a conceptual framework. For example, describing a work setting and critiquing an implementation of technology in that setting.

Rhetorical power: theory should help us talk about the world by providing a vocabulary for important aspects of the conceptual structure and how it maps to the real world.

Inferential power: regardless of whether theories are true, or only falsifiable (Popper 1992), we want a theory to help us make inferences. These inferences may be about phenomena that we have not yet understood sufficiently to even know where or how to look. We may only hope that inferences would lead to insights for design. Or we may want to predict the result of introducing change into a particular setting.

Application power: Theory should help us inform and guide system design. It should lead us to describe and understand the world at the right level of analysis that would allow bridging the gap from description to design. (Halverson, C. A, 2002).

Based on these metrics, we can say that AT provides descriptive, rhetorical and inferential power. While it is possible, it may not be easy to bridge the gap from description to design. More studies are needed to provide evidence of application power using an AT framework. Halverson concluded that AT can be applied to a range of domains and levels of analysis and that the perspective of the individual is at the center. The focus is on the individual cognitive process as it is situated within a social, cultural, historical, and artifactual world. For these reasons, I will be using AT as a framework to guide the analysis of the study.
**Basic Concepts of AT**

AT focuses on activities in which individuals and groups engage (*subjects*). *Subjects* engage in *actions* (dialogue, construction, search, etc.) in order to achieve the *object* (also called *objective*) of the activity which leads to some *outcome(s)*. Activities are mediated by tools (technical or conceptual) and other artifacts available to the subjects. Activities take place in the context of the *community* which exerts influence on the activity through established *rules* (values, norms, trust, spirit of inquiry, commitment, etc.), *tools* that have been institutionalized in the community, and *division of labor* through allocation of roles and responsibilities (Schlager & Fusco, 2003). AT is not a theory but a “set of basic principles which constitute a general conceptual system which can be used as a foundation for more specific theories” (Kaptelinin, Kuuti & Bannon, 1995). It can enable us to zoom in from individual activities to group activities and then zoom out to view those activities in the context of the larger community of practice.

Engeström (2001), one of the leading proponents of activity theory, has discussed how AT has evolved from an early focus on individuals to its current focus on systems. These systems are conceived as having internal contradictions, multiple perspectives and voices and as interacting with other activity systems in the networks.

Engeström compares community of practice and activity systems. He likens the two phenomena in the following way (as quoted in Hodkinson, 2005, p.4):

“An activity system is a complex and relatively enduring ‘community of practice’ that often takes the shape of an institution. Activity systems are enacted in the form of individual goal-directed actions. But an activity system is not reducible to the sum total of those actions. An action is discrete, it has a beginning and an end. Activity systems have cyclic rhythms and long historical half-lives (Engeström et al., 1995, p. 320)”

![The Activity Triangle Model (Engeström, 1987)](image)

**Fig 2.1: The Activity Triangle Model (Engeström, 1987)**
Engeström (2001) has shown how activity theory has evolved from its focus on individuals to a focus on systems. These systems are conceived as having internal contradictions, multiple perspectives and voices and as interacting with other activity systems in the networks as shown in the matrix below. A defining feature of Engeström’s approach is his emphasis on the role of ‘horizontal interaction’ and how workers learn and create new knowledge through the solving of problems collaboratively.

Engestrom proposed these four questions to examine the theory of expansive learning (Engestro¨m, 1987) developed within the framework of cultural-historical activity theory:

(1) Who are the subjects of learning, how are they defined and located?
(2) Why do they learn, what makes them make the effort?
(3) What do they learn, what are the contents and outcomes of learning?; and
(4) How do they learn, what are the key actions or processes of learning?

He related these questions with five principles that are central to activity theory. The four questions and the five principles form a matrix (Table 2.2).

The first principle is that an activity system is the prime unit of analysis as seen in its network relations to other activity systems.

The second principle is the multi-voicedness of activity systems. An activity system is a community of people with multiple points of view. The division of labor in an activity creates different roles for the participants. The multi-voicedness is a source of trouble and a source of innovation necessitating actions of translation and negotiation.

The third principle is historicity. Activity systems take shape, evolve and transform over long periods of time. The problems and potentials of the activity systems can only be understood against the background of their own history. For example, medical work should be analyzed against the history of its local organization as well as against the more global history of the medical concepts, procedures and tools adopted and accumulated in the local activity.

The fourth principle is the central role of contradictions as the driving force behind change and development. Contradictions should not be confused with problems or conflicts. Contradictions are structural tensions that have accumulated historically within and between the activity systems. Engestrom (1987) described four levels of contradictions (Turner & Turner, 2001):
Primary contradictions are found within a single node of the activity. These actions are typically poly-motivated which means that the same action may be carried out by different individuals for different reasons or by the same person as part of two different activities resulting in breakdowns.

Secondary contradictions appear between the nodes or elements of the activity system. When a new element is introduced in an activity system (for example, a new technology), it can lead to a secondary contradiction where some old element (for example, the rules or the division of labor) collides with the new one.

Tertiary contradictions are found when an existing activity is remodeled as a new way of working. Hence these contradictions occur between an existing activity and a more advanced form of the same activity.

Quaternary contradictions appear between the different co-existing and concurrent activities.

Such contradictions generate disturbances and conflicts, but can also result in innovative attempts to change the activity. Thus, primary and secondary contradictions may give rise to a new activity which then results in tertiary contradictions between the old and new activity and may be compounded by quarternary contradictions among the concurrent activities.

The fifth principle is about expansive transformations in activity systems. As the contradictions of an activity system become more and more pronounced, some individual participants or subjects begin to question its established norms. In some cases, this results in a collective change effort (Engestro¨m, 1987, p. 174) and the creation of a more advanced activity system.

When the five principles outlined above are cross-tabulated with the four questions, we arrive at the following matrix (Table 2.2).

Mwanza developed the *Eight-Step-Model* (ESM) as a requirements abstraction tool within the Activity-Oriented Design Method (AODM) – a requirements capture methodology grounded in activity theory (Mwanza, 2002). Mwanza used this method to gather requirements data in a way that it elicited human activity centered teaching and learning scenarios that were relevant to the targeted context of application. Story-like descriptions or narratives of user practices were abstracted as teaching and learning scenarios (Carroll, 2000). These scenarios elicited user roles that helped envision current and future relationships between subjects involved in teaching and learning activities. Based on the information about user roles and activity elements a conceptual model of user practices and mediating relationships was constructed.
Table 2.2: Matrix for the analysis of expansive learning (Engestrom, 2001)

<table>
<thead>
<tr>
<th>Who are learning?</th>
<th>Activity system as unit of analysis</th>
<th>Multi-voicedness</th>
<th>Historicity</th>
<th>Contradictions</th>
<th>Expansive cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why do they learn?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What do they learn?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How do they learn?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mwanza developed the *Eight-Step-Model* (ESM) as a requirements abstraction tool within the Activity-Oriented Design Method (AODM). He operationalized the activity triangle model by working through a list of open-ended questions (Table 2.3) presented in the Eight-Step-Model (Mwanza, 2002). To suit my study, I have added some modifications to the questions in the original scheme. Also, unlike Mwanza who used ESM at the data collection phase, I have used it at the data analysis phase only. Please note the changes in steps 6, 7 and 8. In step 6, I have emphasized “formal” roles in the division of labor. That is, these roles are already part of the rules or policies laid out by the organization. In step 7, I have laid emphasis on the “informal” roles that are still “emerging”. In step 8, I add “actual outcome” to the plain and simple “outcome” as originally stated. Originally, “outcome” has been implied and used to mean “expected outcome”. This would help the analyst better identify the contradictions.
Thus AT can also be a useful framework for outlining some of the major issues that need to be considered when developing design ideas for online support for a professional development community of teachers. AT will not tell you how the interface should look, or what specific technology to use, but it will provide you with a list of issues the technology should address and a clearer sense of the social framework in which the technology will be used.

<table>
<thead>
<tr>
<th>Identify the:</th>
<th>Question to Ask</th>
<th>Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Activity of interest</td>
<td>What sort of activity am I interested in?</td>
<td>What kind of activity is being described by the subject?</td>
</tr>
<tr>
<td>2 Objective</td>
<td>Why is the activity taking place?</td>
<td>What is the goal of this activity?</td>
</tr>
<tr>
<td>3 Subjects</td>
<td>Who is involved in carrying out this activity?</td>
<td>Who (individual only) is carrying out this activity?</td>
</tr>
<tr>
<td>4 Tools</td>
<td>By what means are the subjects performing this activity?</td>
<td>By what means (focus on IT tools) are the subjects performing this activity?</td>
</tr>
<tr>
<td>5 Rules</td>
<td>Are there any cultural norms, rules or regulations governing the performance of activity?</td>
<td>same</td>
</tr>
<tr>
<td>6 Division of Labor</td>
<td>Who is responsible for what, when carrying out activity and how are roles organized?</td>
<td>Who are the other individuals or groups involved in this activity formally? How are their roles formally organized?</td>
</tr>
<tr>
<td>7 Community</td>
<td>What is the environment in which this activity is carried out?</td>
<td>Who are the other individuals or groups involved in this activity informally? What is the environment and what are the emerging roles?</td>
</tr>
<tr>
<td>8 Outcome</td>
<td>What is the desired Outcome from carrying out this activity?</td>
<td>What are the expected and actual outcomes from carrying out this activity? If the actual outcome was unsatisfactory, what are the contradictions?</td>
</tr>
</tbody>
</table>

Table 2.3: The Eight-Step Model (Mwanza, 2002) With Modifications

2.3 Research Scope and Context

This study focuses on the teachers’ perspective about technology as it is situated in their organizational context. How are teachers’ work practices developing with respect to technology is a relatively poorly understood phenomenon. One of the main strengths of AT is its descriptive power in helping us make sense of and describe the world, for example, describe a work setting and critique an implementation of technology in that setting. In a case study Boever and Grooff (2009) conclude that “AT is a mature, comprehensive framework to collect and understand relevant data about users in their real meaningful contexts.”

AT can be a useful framework for outlining some of the major issues that need to be considered when developing design ideas for online support a professional community of teachers. AT will not tell you
how the interface should look, or what specific technology to use, but it will provide you with a list of issues the technology should address and a clearer sense of the social framework in which the technology will be used. For these reasons, the AT framework has been utilized to analyze a set of interviews with teachers about their technology use and experiences, using a qualitative and interpretive approach.

The context of the study is a high school in a college town community with a population of 42,000, had 200 teachers and 2540 students with a teacher student ratio of 12.5 (all approx. numbers). Teachers at the High School had access to shared laptop carts for classroom use. English and Social Studies classrooms had laptops available for every class period they needed. Most other subjects shared laptop carts with other teachers and scheduled them for specific assignments or projects. Those subject teachers that did not have laptop carts could use two open access desktop labs (one in each building). Some specialized courses such as Tech Ed or Business, for example, had dedicated desktop labs for their curriculum. A limited number of laptops were available for students for educational purposes during study halls or lunch periods. Students could also check out a laptop through the school library for up to a week at a time.

Based on the preliminary study and observations, I identified three activity systems that had a direct influence on teachers’ professional development in technology practices and, as such, define the scope for the field of research - the technology activity system, the individual teachers’ activity system and the group activity system. While there are many networked activity systems, I chose the above three as the field of my study because I started out by observing groups and interviewing individual teachers. From their comments I had the understanding that on a daily basis, the teachers were mostly in touch with these three activity systems for technology skills development. Fig 2.2 below illustrates how the three activity systems are working towards a common goal.

At the individual level, the teacher’s activity system, as the name implies, focused mainly on how the teacher approached his/her own professional development in building technology skills. For example, a teacher could take his/her own initiative by contacting other teachers to learn new ways of teaching with technology. They could make use of online resources to plan a lesson or to troubleshoot a technology related issue.

The group activity system focused on how the teachers collaborated with each other to learn and use technology in their daily practices. For example, the teachers discussed and shared practices during department meetings and in-service days. They also worked together to develop lessons and curriculum with the use of technology.
The technology activity system represents the IT department of the school district through Instructional Technology Specialists located at each school site. The high school where this study was conducted staffed two IT Specialists who were easily accessible to the teachers and staff. The other staff members in the IT department were located at the school district’s administrative building in downtown. Instructional Technology Specialists worked closely with the faculty and staff to bring the benefits of technology through continuous staff development and training. They acted as the liaison between the district and the school. As such, they were the first to present information regarding upcoming changes, outages, or information that impacts the technology and its use in the district. Other than the two IT specialists

Fig 2.2: Research Scope
located at the high school, there were two at the two middle schools and two who covered the 9 elementary schools. In the following paragraphs, I describe the larger context within which the IT Specialists were situated.

The entire Computer Services Organization of the school district was managed by the Director of Computer Services & Telecommunications. The Computer Services Organization of the school district was dedicated to planning, promoting, and supporting technologies in the School District in order to enhance the district's goal to prepare students for lifelong success through excellence in education.

The Computer Services Organization was comprised of three groups, namely, Information Systems, Network Services, and the Computer Support Helpdesk. These groups worked closely with six building based Instructional Technology Specialists and six lab assistants. They all worked together to support 8 open computer labs, 11 classroom based labs, 130 wireless laptop labs, 4600 computers, 800 tablet devices, 450 printers and multiple other technologies and systems that are used by administrators, faculty, staff, students and guests of the School District.

The Computer Support Helpdesk comprised four Information Technology Support Specialists who responded to the requests which came through to the School District’s Helpdesk. For instructional based support, the teachers could contact their building Instructional Technology Specialist. They provided support for software use in the classroom, staff development, and other building specific needs. They were also responsible for establishing, maintaining and updating labs, office, and classroom equipment. They were the first point of contact when a user had a technical request or question.

The five Information Technology Operations Paraprofessionals provided support to other staff members within Computer Services. They maintained laptop carts and computer labs district-wide. They also processed new incoming equipment, equipment going to repair and other miscellaneous logistical aspects as needed.

Four Information Systems Specialists worked to plan, build, maintain, and support the various systems used by the school district such as Food Services, Library catalog, document imaging, Type to Learn, Financial, FileMaker, SuccessMaker, Teacher Access Center, Moodle, Active Directory, File Server storage space, web services, and eMail.

The smallest group was responsible for all district network operations and infrastructure. They planned, updated, maintained and supported the district’s data, video, and telephone networks.
In order to understand how the technology activity system interacted with other activity systems (individual teachers’ professional development (PD) activity system and group PD activity system), data was collected through interviews and observations of Instructional Technology Specialists who worked at the high school. For a complete understanding of how these IT Specialists were situated, I also interviewed their counterpart in one middle school and the manager of user support and staff development in the main office.

**Fig 2.3: Relating Concepts with Research**

Fig 2.3 is an attempt to tie together all the concepts and the activity systems that comprise the scope of the research. The IT Staff’s activity system interacts with the individual teachers’ activity system through site-based training and workshops and also directly as needed, for example, if a teacher approaches them with a problem. The individual teachers can also access professional development opportunities through self-directed approaches. Apart from these, the school district may require individual teachers to take standardized courses or training programs. The individual teachers can influence other teachers through networks comprising different groups of teachers. These groups may be comprised of department teachers or teachers forming a group such as STEM initiatives etc. These groups can also be envisaged as a PLC or networks of PLCs.
Chapter 3

Data Collection & Analysis

3.1 Preliminary Interviews and Observations

Since the project began officially (e.g., after receiving IRB approval, including enrollment of the teacher-participants as researchers), I began attending meetings and conducting individual interviews with the teachers and disciplinary groups. The teachers began by forming groups that meet to identify their technology needs and learn from each other about their technology practices. With the help of a teacher advocate, three disciplinary groups were formed. One group consisted of technology teachers; another included math teachers; and the third comprised science teachers. Each meeting was observed, with field notes taken and the time and an audio recording made for later analysis; interviews were also recorded. One classroom where two teachers collaborated was also observed. The teachers who participated in this collaboration were interviewed specifically about how they planned and organized this class and how they were going to share this experience with others. These interviews were unstructured. The interviews marked as “specific” refer to those interviews that were taken as part of observation of a series of classes taken by two teachers who combined their students in one classroom to cover a common topic on “savings & investments”. These interviews were focused on their motivation and experience in planning and executing this class in collaboration. The interviews that formed the core of this study were semi-structured, consisted of the main questions with a set of general questions expanded through probes that were customized for the discussions with individual teachers (and IT staff members). The questioning began with some simple background issues (e.g., experience, teaching subjects, technology expertise), then investigated in detail how teachers were using technology in their daily practices and if they were experiencing any difficulties. The interview questions are included in Appendix A and their mapping with the research questions is shown in Appendix B.

Altogether 9 interviews were conducted (7 main interviews and 2 specific interviews). The observations of meetings, training sessions and classroom provided the researcher with more familiarization of the context. The table below shows the research activities and amount and type of data collected at the preliminary phase of the study.

46
<table>
<thead>
<tr>
<th>Date</th>
<th>Data Type</th>
<th>Department</th>
<th>Data Source</th>
<th>Number of Participants</th>
<th>Duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-08</td>
<td>Observation</td>
<td>Math</td>
<td>Meeting</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>Sep-08</td>
<td>Observation*</td>
<td>Science</td>
<td>Meeting</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Oct-08</td>
<td>Observation</td>
<td>Science</td>
<td>Meeting</td>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>Dec-08</td>
<td>Interview</td>
<td>CTC</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Dec-08</td>
<td>Interview</td>
<td>Science</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Jan-09</td>
<td>Interview</td>
<td>Math</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Jan-09</td>
<td>Observation*</td>
<td>Math</td>
<td>Dept Meeting</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Jan-09</td>
<td>Interview</td>
<td>Math</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Feb-09</td>
<td>Observation</td>
<td>Science</td>
<td>Meeting</td>
<td>2</td>
<td>45</td>
</tr>
<tr>
<td>Mar-09</td>
<td>Observation</td>
<td>CTC &amp; Social Studies</td>
<td>Collaboration</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Mar-09</td>
<td>Observation</td>
<td>CTC &amp; Social Studies</td>
<td>Collaboration</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Apr-09</td>
<td>Observation</td>
<td>CTC &amp; Social Studies</td>
<td>Collaboration</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Apr-09</td>
<td>Interview (specific)</td>
<td>Social Studies</td>
<td>Teacher</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Apr-09</td>
<td>Interview (specific)</td>
<td>CTC</td>
<td>Teacher</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Apr-09</td>
<td>Interview</td>
<td>IT Staff</td>
<td>IT Coach</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>May-09</td>
<td>Interview</td>
<td>Math</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>May-09</td>
<td>Interview</td>
<td>Science</td>
<td>Dept Head</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>May-09</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Training Session</td>
<td>12</td>
<td>300</td>
</tr>
</tbody>
</table>

*notes provided by teacher advocate who conducted the meeting

**Table 3.1: Preliminary Data Collection (Sept 2008 to May 2009)**

In the first meeting observed of mathematics teachers, the subjects were 6 high school math teachers located at a High School. They discussed how technology can improve student learning and how they have been using technology to deliver instruction for improvement in students’ learning. They also expressed some difficulties they had been experiencing with some new technologies. They came up with a combined list of tools they had been using in their classrooms (Calculus in Motion, Google Docs for data sharing, Moodle, Smartboard, Smart View, MathCad and Differential Equation Software). They discussed the goals, some ideas and problems related with the use of the different types of tools and the need for assessment of the effects of the tools on student learning. In their next meeting they talked about inviting an information technology staff to tell them about existing online tools and other information technology resources within the school for teachers.

At the first chemistry meeting, discussion revolved around the nature of the project and how the theme of animating science concepts integrates into the project and collaborative work groups. There was some
confusion as how this will be accomplished/facilitated by me. The participants worked closely with each other in proximity and in terms of relationships. It was unclear as to how technology will aid the participants improve communication. The Chemistry teacher advocate shared a short Powerpoint presentation from Dr. Meghan Knapp of Georgetown College (Georgetown, Kentucky) demonstrating how Powerpoint can be used to animate certain difficult science concepts.

The goal of the second chemistry meeting was to demonstrate how animations can be used in classrooms to enable student learning of abstract concepts through visualization. The teachers would then build some animations using Powerpoint. They also worked on identifying concepts to be animated and explore how Powerpoint can be used as a tool for animating. However, there were some issues regarding the different features in the tool on the PC and Mac platforms.

During this phase I made note of issues and reflected on some observations. For example, I found that technology is used for many different purposes. It is used as productivity tool, a teaching tool, a learning tool, a communication tool and a collaboration tool by the teachers and students. The teachers are not only teaching with technology but they are also teaching about technology to the students by carefully scaffolding them into the lesson plan. While observing a collaboration class on the topic of Savings and Investments which was common to both the economics and the business curriculum, I found that the teachers were using a classroom with computers for each student. The assignments were collected in a folder shared by both the teachers on the computer network. This network is also accessible to the teachers and the students from home. The instructions for the assignments were projected on the screen as well as on each student’s computer. The students learnt about technology by using them for assignments. They were required to use Google Docs for collaboratively making their presentations. They used iMovie to make their commercials and they used Excel Spreadsheets to create graphs from the survey data. The teacher also had plans for holding this class again with 4 classes collaboratively. One problem they had was regarding storage space these large assignments needed. The school offered them only 2 GBs which was hardly sufficient. So the teacher approached his own department to (Business Department) provide funding to buy server space which was being set up and maintained by a teacher who volunteered his services. This teacher taught computer network courses at the high school and had an office in the same hallway as the Business department.

Another issue that came up from time to time was the familiar problem of incompatibility that came about because of the school’s policy of using Macs. Many programs or files could not be opened in the classroom that the teachers had developed at home. This hurdle was enough to discourage any teacher
from using technology. Another problem was that some teachers felt that they could not rely on the network to be functioning when they most needed it. One crash during a class was enough for some teachers to go back to the good old-fashioned way of teaching. These problems were compounded by the fact that teachers don’t have any downtime built into their daily routine.

For communication, the teachers mostly used email. They did not have much use of blogs or discussion boards. Even for collaboration, the two teachers had used email to exchange files and plan for their class.

Each department has a coordinator who has regular meetings with the teachers to discuss new policies and changes as well as hear the teachers’ concerns to take to the next level. So the question is - do we really need an online place? Would technology add only redundancy to the pre-existing processes in place?

There were some pointers to the increasing role that technology can play in enhancing this process. As in one interview with the subject coordinator, I found that he was using Google Docs in novel ways to gather ideas from the teachers. He would set up the agenda for the meetings in advance which allowed the teachers to think ahead. During the face-to-face meeting, the teachers contributed their thoughts directly on the Google Doc after the discussion. He felt that in this way he was getting more feedback and input from the teachers than ever before.

In the next section I will describe the qualitative analysis in an exploratory way of the data gathered through interviews and observations, starting with grounded theory and then mapping the emergent themes to an Activity Theory framework. Activity Theory framework was also used to identify and analyze problems and issues described in the initial interviews and observations. I will also roughly sketch some triangles using the AT framework to visualize the elements involved in an activity and their interactions as well as contradictions to gain deeper insights.

The study would use an interpretive lens. Interpretive studies assume that “people create and associate their own subjective and inter-subjective meanings as they interact with the world around them” (Trauth, 2001). Interpretivism is based on an ontological assumption that the construction of reality and our knowledge of it are shaped by social influences. Interpretive methods, in IS research are focused on understanding the context within which an information system resides and how it influences and is influenced by this context (Walsham, 1993). An interpretivist epistemology would help us to construct the social reality of the phenomenon under study (Mason, 2002).
3.2 Preliminary Data Analysis

A qualitative analysis method was used, beginning with initial coding and comparing emerging themes and refining categories in the data. The process of developing coding categories was iterative. Initially, 6 interviews were analyzed (3 science and 3 math teachers). Each of the interviews was organized into “snippets” of interview, corresponding to the interviewees’ answers to a given question, but on occasion dividing a response into multiple segments when the main topic of discussion shifted. For the 6 interviews initially coded, this resulted in 77 snippets, with a range of 10 to 16 across the 6 individuals. Additionally, one interview of an IT Staff member was also analyzed to add contextual reference for a better understanding of the norms and rules that governed the teachers’ use of technology. This interview contributed 8 additional snippets. This bottom-up approach to analysis produced 8 themes representing issues at varying levels of abstraction (Appendix K). Below I give examples of some of these themes and how they could be integrated within an AT framework.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Details</th>
<th>Transfer to AT constructs</th>
</tr>
</thead>
<tbody>
<tr>
<td>different understandings about technology integration</td>
<td>Technology integration, curriculum integration</td>
<td>Object</td>
</tr>
<tr>
<td>different types of technologies that are currently used by school teachers</td>
<td>general tools, subject specific tools</td>
<td>Tool</td>
</tr>
<tr>
<td>different ways of categorizing technologies</td>
<td>by roles, by tasks, by offline/online, by functions</td>
<td>Tool</td>
</tr>
<tr>
<td>different ways of integration of technologies</td>
<td>educational technologies, instructional technologies, content development technologies, course management systems, collaboration/communication technologies</td>
<td>Tool, Community, Division Labor</td>
</tr>
<tr>
<td>difficulties faced in using technology</td>
<td>self-efficacy, attitudes, beliefs, technical issues, transfer of learning into classroom context, lack of access, lack of time, etc.</td>
<td>Subject, Outcome, Rules/Norms</td>
</tr>
<tr>
<td>professional development resources</td>
<td>informal, formal, off-site, on-site,</td>
<td>Object</td>
</tr>
<tr>
<td>collaboration</td>
<td>affordances, conveniences provided by technology</td>
<td>Tool, Community, Division Labor</td>
</tr>
<tr>
<td>rules/norms</td>
<td>IT Department norms</td>
<td>Rules, Tool</td>
</tr>
</tbody>
</table>

Table 3.2: Mapping Emergent Themes onto AT Framework

For example, one theme was “different understandings about technology integration”. When asked the question, “how do you integrate technology in your practice?” teachers were unsure of what it meant. They approached it in different ways as they developed an answer. Sometimes they talked about
integrating different hardware and software. This was interpreted as technology integration. Sometimes they talked about what they do with different types of technologies in their lessons. This was interpreted as curriculum integration. Within the AT framework, this theme was incorporated into the Object or Outcome construct. For example when a teacher adopted a technology recommended by IT Staff, the Object or Outcome is coded as “technology integration”. Another theme was difficulty faced in using technology. If teachers said “I am wary of technology” it was coded under the Subject construct within the AT framework and in a sub-category of “attitude”. Table3.2 illustrates some more examples of migrating themes onto AT constructs.

**Preliminary visualization within an AT framework**

Having observed several activities such as math teachers’ meetings, science teachers’ meetings and an IT training session, I used the AT framework to visualize these activities in a sort of an exploratory analysis. The first figure is based on a meeting organized by a math teacher-advocate. As mentioned earlier, this was a group of 6 math teachers. Using an AT terminology, the subject was a group of 6 math teachers, including the teacher-advocate. The object of this meeting was to discuss how to use technology for classroom instruction as well as to explore idea on how to share these practices among teachers. The expected outcome was teachers’ professional development in technology practices. The tools used in conducting this activity were email (to share attachments, notes, etc.), on-screen projection, Microsoft Word (to write and project meeting minutes) and some educational technologies that were demonstrated (Smartview, MathCad etc.). The division of labor in this activity was that of a teacher-facilitator who organized and led the meeting and the teacher-participants who took the time out of their busy schedules to attend and actively participate in the meeting. Their time was limited and constrained by the rules governing their school which was probably one of the reasons why only 6 teachers could participate. This contradiction between the rules and the subject is a secondary contradiction as highlighted in yellow. One teacher simply did not believe that technology had any benefits to offer and did not see the need to make any changes. This was a primary contradiction in the subject node. Although the teachers were constrained by the rules, the teacher-facilitator leveraged the sense of community and the norms of collegiality that existed among the members of the math department to organize an ad-hoc meeting for their professional development in technology practices.
Fig 3.1: Math Meeting Activity

The next figure illustrates the science teachers’ professional development activity. The goal or object of this activity was to demonstrate how animations can be used in classrooms to enable student learning of abstract concepts through visualization. The teachers would then build some animations using powerpoint. The final outcome would be teachers’ professional development in technology practices. The tools used to mediate this activity was on-screen projection and talking. The tools used for demonstration was Flash. The teacher-facilitator also used the internet to show examples of animations. The remaining elements followed a similar pattern as in the Math meeting activity. For example, the teachers were constrained by the rules that did not allow built-in time for this kind of activity. However, the teacher-facilitator leveraged the norms of collegiality as well as the sense of community that existed among this group of teachers. The contradictions noted here was a primary contradiction in the Tools where inconsistency existed in the features provided in Flash. The teacher-facilitator used his Windows platform to build animations in Flash. However, the participants were using Flash on a Mac platform and could not find one of the features in the tool. This brought into focus the fact that some teachers or subjects had a preference for Windows because it was cheaper and more popular. This would be a primary contradiction.
in the Subject node. A secondary contradiction that impacted these subjects was the school’s policy regarding Mac as the platform of choice. Most teachers used Windows at home and were more comfortable with that platform.

Fig 3.2: Science Meeting Activity

The third illustration shows some contradictions gathered during the observation of a training session held by the building’s IT specialist. Apart from the stated goal of the training session to provide teachers with training in different technologies, the sessions also became a forum where teachers voiced their experiences and difficulties with technology. For example, one teacher talked about her experience in using Google Docs for collaborative assignments in class. She never had trouble using Google Docs as it existed before on the internet. However, since the school adopted Google Docs, she found that it froze frequently. This was discouraging her from using it in her class. The figure below also shows how the individual teacher’s activity system relates to the IT department activity system. The Tools node in both
the activity systems are related because this contradiction can only be solved through the IT department who have set up

and configured Google Docs for use within the school’s network. Another teacher had trouble keeping track of homework submissions. Now that there were so many different channels for students to submit their assignments, it had become very challenging task for a teacher to track who did not submit their assignments. Some students handed them in paper, some through email and some students uploaded them on the schools CMS (course management system using Moodle).

By this time, I created a more refined visualization as illustrated in the Figure 3.4 below. In this figure, color codes are used to differentiate between the secondary and the primary contradictions. Comments in blue describe the secondary contradictions and those in red explain the primary contradictions in the homework collection activity. Secondary contradiction between tool and norms are due to pre-existing
norms of homework submissions through email, lead server and hard copy. These still exist and add many levels of confusion. Another secondary contradiction is between tool and community. Students may not have access to internet at home, so may prefer to submit a hardcopy. Students may also find it hard to keep track of the different modes of submitting homework for different teachers. A third secondary contradiction may be between the subject (individual teacher) and the norm in their lack of realization that they may need to enforce their own rules in the classroom for homework submissions. Perhaps they should be enforcing only one mode of submission.

There is also a primary contradiction- the newly introduced rule for using Moodle for homework submissions competes with pre-existing norms of submissions and so students continue to use a variety of modes according to their preference/convenience. Thus, the introduction of this new tool for the same activity has given rise to primary and secondary contradictions.

Understanding these contradictions can lead to several alternative solutions. For example, one way would be to integrate the tools so that teachers receive an email for all submissions (except hard copy which they can key in themselves). For this solution, the IT dept. will have to be involved. Another solution would be to retire the competing technologies. But this would be hard to achieve. For this solution too, the IT dept. will have to be involved. For the uneven access to technology at home, the state and the IT dept. could be involved to provide access at home. The only option on which the individual teacher has control is to enforce a rule for their own class.
3.3 Data Collection

The preliminary phase lasted about six months (Table 3.1) and the data was subsequently subjected to analysis to ascertain the viability of the research method and instruments. Interview questions were refined and better aligned with the research questions. Figures 3.5 and 3.6 show the final number of interviews and observations respectively, along with the departments that the interviewees/observations belonged to. The participants for interviews were drawn from Math (5), Science (5), CTC (3) and other
(3) departments. There were interview participants from IT Staff (4) which helped in gaining contextual information. This included one building IT Staff, one middle school IT Staff, one IT administrator and one external trainer. “Other” department participants consisted of one Social Studies teacher, one English teacher and one Art teacher who doubled up as a KTI (Keystone Technology Integrator). 10 interviewees were females and 10 were males. Apart from general technologies, Science and Math teachers used subject-specific technologies also which is why most interview subjects were from these departments so as to help capture most of the technology related themes. Interview of the IT Staff helped in deriving the technology related context surrounding the teachers’ practice. Three of the teacher interviewees were also department coordinators which provided information on the department and other organizational context. It was also important to interview teachers from English and Social Studies department because they were the first to be introduced to the Moodle classroom management system. The average years of service of interviewees in the school district was 13.6 years ranging from a minimum of 1.5 years to a maximum of 35 years.

The researcher also observed some meetings of Math (3), Science (3) teachers, training sessions (8) conducted by IT Staff and a classroom (3 consecutive days) conducted by two teachers in collaboration. However, the observations were not coded or analyzed. They formed the basis for reflection to familiarize the researcher with the context of the study and, as such, were used for auxiliary purposes only. These meetings and training sessions also helped in recruiting participants for interviews. Table 3.2 shows complete information on the data collected post preliminary phase.
Table 3.2: Data Collection (Oct 2009 to June 2010)

<table>
<thead>
<tr>
<th>Date</th>
<th>Data Type</th>
<th>Department</th>
<th>Data Source</th>
<th>Number</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct-09</td>
<td>Interview</td>
<td>Math</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Oct-09</td>
<td>Interview</td>
<td>Math</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Oct-09</td>
<td>Document</td>
<td>Math</td>
<td>Google Docs</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Oct-09</td>
<td>Observation</td>
<td>Math</td>
<td>In-service</td>
<td>12</td>
<td>45</td>
</tr>
<tr>
<td>Oct-09</td>
<td>Document</td>
<td>Math</td>
<td>Google Site</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Nov-09</td>
<td>Interview</td>
<td>IT Staff</td>
<td>IT Coach</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Nov-09</td>
<td>Interview</td>
<td>IT Staff</td>
<td>IT Staff</td>
<td>1</td>
<td>78</td>
</tr>
<tr>
<td>Nov-09</td>
<td>Document</td>
<td>IT Staff</td>
<td>Training Schedule spreadsheet</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Nov-09</td>
<td>Document</td>
<td>IT Staff</td>
<td>Support ticket spreadsheet</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dec-09</td>
<td>Interview</td>
<td>CTC</td>
<td>Teacher</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>Dec-09</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Training Session</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>Dec-09</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Training Session 1 (External Vendor)</td>
<td>11</td>
<td>300</td>
</tr>
<tr>
<td>Dec-09</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Training Session 2 (External Vendor)</td>
<td>16</td>
<td>300</td>
</tr>
<tr>
<td>Dec-09</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Training Session (Just got laptop carts)</td>
<td>3</td>
<td>300</td>
</tr>
<tr>
<td>Jan-10</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Training (3rd and last yr of training)</td>
<td>9</td>
<td>300</td>
</tr>
<tr>
<td>Jan-10</td>
<td>Interview</td>
<td>Science</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Jan-10</td>
<td>Interview</td>
<td>Science</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Jan-10</td>
<td>Interview</td>
<td>SocStudies</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Jan-10</td>
<td>Interview</td>
<td>Science</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Feb-10</td>
<td>Interview</td>
<td>ESL</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Apr-10</td>
<td>Interview</td>
<td>CTC</td>
<td>Teacher</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>Apr-10</td>
<td>Interview</td>
<td>Art</td>
<td>Teacher (Keystone Integrator)</td>
<td>1</td>
<td>73</td>
</tr>
<tr>
<td>May-10</td>
<td>Interview</td>
<td>IT Staff</td>
<td>IT Coach (follow-up)</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>May-10</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Sharing Session</td>
<td>8</td>
<td>300</td>
</tr>
<tr>
<td>Jun-10</td>
<td>Observation</td>
<td>IT Staff</td>
<td>Sharing Session</td>
<td>5</td>
<td>300</td>
</tr>
</tbody>
</table>
3.4 Developing a Coding Scheme

Altogether 20 interviews were conducted; these consisted of 5 science teachers, 5 math teachers, 3 IT staff, 3 CTC teachers, 1 social studies teacher, 1 English teacher, 1 tech-savvy art teacher and 1 external trainer.

10 interviewees were females and 10 were males. Apart from general technologies, Science and Math teachers used subject-specific technologies also which is why most interview subjects were from these departments so as to help capture most of the technology related themes. Interview of the IT Staff helped in deriving the technology related context surrounding the teachers’ practice. 3 of the teacher interviewees were also department coordinators which provided information on the department and other organizational context. At the same time, we did not want to miss out on any important data, so interviews of accounting, social studies, tech-savvy and the only computer network teacher in the school was also added.

The initial coding of the interviews (as described in the previous section) followed a bottom-up approach to finding themes that emerged from the data. Following this, 6 interviews were analyzed within an AT framework, in a more top-down approach. Out of these 6, 3 interviews were the same as in the first analysis. In this phase, 6 primary codes were used, corresponding to the primary constructs from AT. Within these higher-order categories, each snippet was also tagged or sub-categorized using the tags/themes that had emerged in the first phase. Additional tags/sub-categories were identified when new themes emerged. Thus, the sub-categories were organized within the AT framework. For example, when teachers talked about the technologies they used, they described the functions provided by the tools, such as communication, sharing, course management, course delivery, and so on. These tags were used to annotate a “tool function” sub-category that was part of the “tool” category within the AT framework. In this way the coding scheme was developed using both a bottom-up (as described in the section on preliminary analysis) and a top-down approach. It was hoped that this would help in coming up with a comprehensive set of coding categories that were also tied to and motivated by the AT framework. The final hierarchical framework that emerged was used to code 15 interview data. The figure below shows the coding scheme as fitted to an AT framework along with examples from the interviews. This was used as the key to analyze and code the data collected through the interviews. A detailed version is included in the Appendix C.
Fig 3.5: Coding Scheme Visualization within an Activity Oriented Framework

**Tool**
- **Name**: Word, Building, Symposium, Logger pro, Excel, etc.
- **Type**: Email, phone, blog, chat, online discussion, list serve, observation, al talk tool, etc. online resource, web chat, online forum, list serve, file server, collaboration tool

**Use Function**: productivity, communication, research, collaboration, front-end serving, sharing, administrative, sharing, course delivery, meeting management, TPD, Subject

- **Level analysis**
  - team, group, or individual
  - length of service, self-efficacy, attitude, preferences
- **Valence**: positive, neutral, negative

**Subject**
- **Organizational norms**: (policy, procedure, protocol)
- **Depts norms**: (leading, technology, curriculum alignment, etc)
- **District Funding**: (funding, insufficient funding, available)
- **Meetings**: (offices, building meetings, faculty meetings, dept meetings)
- **Assigned duties**: (job duties, study, research, values)
- **Valence**: positive, neutral, negative

**Community**
- **Where did they share?**: on-site (site, online, email, direct, district, etc.)
- **Sharing activities**: (Collaborative activities, observation, evaluation, reflection, assessment, informal sharing)
- **Who did they share with?**: team, group, or individual
- **What did they share?**: (data, evidence, observation, etc.)
- **Valence**: positive, neutral, negative

**Div Labor**
- **Who?**: (IT, Staff, Teachers, Department, etc)
- **What did they do?**: (on-site training, off-site training, self-directed, group-directed, online, in-class training, classroom teaching, teacher training, etc.)
- **Valence**: positive, neutral, negative
**Tool**

More than simply identifying the name of a tool, it was important to know what type of tool it was or what the function of the tool was. For example, teachers talked about using Word, iMovies, Sympodium etc. They also talked about using email, phone, chat, online discussions and list serves for communication and collaboration. They could be using these tools at different levels of frequency. This would help determine the level of adoption for a tool. The table below shows how the coding scheme for the Tool element was organized.

<table>
<thead>
<tr>
<th>Name</th>
<th>Word, iMovies, Sympodium, Logger pro, Excel, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Email, phone, blog, chat, online discussions, list serves, observation, edl tech tools, cms tools, online resource web sites, online forums, list serves, file server, collaborative tools</td>
</tr>
<tr>
<td>Use/function</td>
<td>productivity, communication, research, edl technology, cms, multimedia/learning enrichment, student collaboration, teaching, club advising, Administrative, Sharing, Course delivery, Meeting management, TPD, Subject tool, Listing homework, teacher meetings, teacher collaboration, submit assignments</td>
</tr>
<tr>
<td>Use frequency</td>
<td>depends on availability, not often, all the time, daily, weekly, throughout the year, etc.</td>
</tr>
<tr>
<td>Developmental level</td>
<td>not used, entry, adoption, adaption, appropriation, innovation</td>
</tr>
<tr>
<td>Valence</td>
<td>positive, neutral, negative</td>
</tr>
</tbody>
</table>

**Table 3.3: Tool Coding Scheme**

**Subject**

Teachers as individuals were the subjects of the activity. If it was a group or organizational activity, it became apparent when there were associated actors in the Community or Division of Labor elements. Hence, the teachers remained as the subject of all activities in the analysis. It was also necessary to identify some characteristics of the teachers. For example, gender, length of service in the school district. Please note that the teachers were not required to disclose their age. This information could be approximated from their length of service in the district and other work experience. It was also important to know their technology self-efficacy, attitudes and preferences that had a bearing on using and learning to use technology. All these factors could have a positive, negative or neutral influence on their technology practices. Table 4 below shows the coding scheme for Subject.

<table>
<thead>
<tr>
<th>Level of analysis</th>
<th>individual, group, organizational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
<td>technology background, age, gender, length of service, self-efficacy, attitude, preferences</td>
</tr>
<tr>
<td>Valence</td>
<td>positive, neutral, negative</td>
</tr>
</tbody>
</table>

**Table 3.4: Subject Coding Scheme**
Object

Several objectives could be abstracted from the data. These would serve as requirements gathering for designers of IT tools for teachers. Technologies, as they stand today, have not been specifically made for the teachers. Rather, the IT Staff is going out there to see what the latest tools are and how they can be used in teaching. Once they introduce these tools to teachers at training sessions, it is up to the teachers to transfer the knowledge in their practice by first identifying the goals that could be fulfilled. Teachers used technology for various tasks or goals. For example, they used it for professional development (TPD) such as online courses, online forums; for curriculum integration, for enriching the students’ learning experience, for sharing resources, etc. Sometimes they succeeded in their effort, sometimes they did not. Table 5 shows the coding scheme for Object.

<table>
<thead>
<tr>
<th>Objective</th>
<th>TPD, student learning enrichment, student learning, problem solving, curriculum integration, technology integration, curriculum completion, sharing resources online.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective Valence</td>
<td>positive, negative, neutral.</td>
</tr>
</tbody>
</table>

Table 3.5: Object Coding Scheme

Outcome

It was important to know if the activities had the desired outcome. These were directly related to the Objects. Outcomes could be as expected or desired on the one hand or fraught with difficulties or breakdowns on the other. The difficulties could be encountered when using the tool or even when learning how to use the tool. If they were successful, documenting them would be a good way to disseminate them as best practices. If they encountered difficulties, it was helpful to record these as

<table>
<thead>
<tr>
<th>Teachers’ Professional Development</th>
<th>self, on-site, off-site, formal, informal, online, in-class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology Integration</td>
<td>satisfaction, frustration</td>
</tr>
<tr>
<td>Curriculum Integration</td>
<td>satisfaction, frustration</td>
</tr>
<tr>
<td>Difficulties encountered</td>
<td><strong>Tool learning difficulties:</strong> learning curve, transfer of learning, lack of time, low self-efficacy</td>
</tr>
<tr>
<td>Contradictions</td>
<td><strong>Tool Using difficulties:</strong> technical issues, version problem, usability, low chance of availability, home internet access, lack of in-class time</td>
</tr>
<tr>
<td>Valence</td>
<td><strong>Primary (TT, SS, RR, CC, DD, OO), secondary (ST, SR, SC, SD, SO, TO, RT, and so on)</strong></td>
</tr>
<tr>
<td></td>
<td>positive, negative, neutral</td>
</tr>
</tbody>
</table>

Table 3.6: Outcome Coding Scheme
primary or secondary contradictions which would lead to identification of alternative solutions. Please note that tertiary or quarternary contradictions were not identified in the coding. Table 6 shows the coding scheme for Outcome. Here the elements/nodes are abbreviated as T for tool, S for subject, D for division of labor and so on.

**Rule**

Several themes that related to rules emerged during the initial coding. These were incorporated into the coding scheme for Rules as shown in Table 7 below. Organizational norms, department norms, budgetary constraints, etc. had significant impact on the availability and use of technology by teachers. For example, how much work was assigned to teachers determined if they had time to play around with technology. It was important to know if there were any rules that were negatively or positively impacting adoption of technology.

<table>
<thead>
<tr>
<th>Organizational norms</th>
<th>shared values, state-dist relations, quid pro quo, IT training norms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept norms</td>
<td>leadership for technology, curriculum assignments, not focused on IT</td>
</tr>
<tr>
<td>Classroom norms</td>
<td>submit assignments thru Google Docs, thru email, thru Moodle, etc</td>
</tr>
<tr>
<td>District Funding</td>
<td>no funding, insufficient funding, funding available</td>
</tr>
<tr>
<td>Dept Funding</td>
<td>no funding, insufficient funding, funding available</td>
</tr>
<tr>
<td>Meetings</td>
<td>inservice, building meetings, faculty meetings, dept meetings</td>
</tr>
<tr>
<td>Assigned duties</td>
<td>STEM initiative, bus duty, study hall, lunch duty, etc</td>
</tr>
<tr>
<td>Valence</td>
<td>positive, neutral, negative</td>
</tr>
</tbody>
</table>

Table 3.7: Rule Coding Scheme

**Community**

Perhaps this was the element that experienced new developments such as new ways of sharing practices,

<table>
<thead>
<tr>
<th>Where did they share?</th>
<th>on-site (Hallway, in-service, online, dept meetings, IT training sessions, office, building, lunch, morning bus duty, afterschool bus duty, study hall, online community, conferences, workshops), off-site, on-line (list serves, forums, blogs, chats)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharing activities</td>
<td>Collaborative activities (mentor/mentee, observation, teamwork, reflection, assessment, formal sharing), Informal sharing</td>
</tr>
<tr>
<td>Who did they share with?</td>
<td>tech savvy teachers, tech savvy students, Dept peers, other dept teachers, same subject teachers, students, teachers in other schools, teachers in other districts</td>
</tr>
<tr>
<td>What did they share?</td>
<td>day to day practices, conference lessons</td>
</tr>
<tr>
<td>How did they share?</td>
<td>Email, f2f, phone, blog, chat, online discussions, Google Docs, list serves, observation, etc</td>
</tr>
<tr>
<td>Valence</td>
<td>positive, neutral, negative</td>
</tr>
</tbody>
</table>

Table 3.8: Community Coding Scheme

63
new ways of collaborations and emergence of new roles and orders. So it was important to capture these in detail using the codes as shown in Table 8 below.

**Division of Labor**

Most organizations have a formal way of dividing work among their employees. The school also had a dedicated team of IT professionals that supported the adoption of technology in education. At the same time, they also allowed departments to take the initiative in seeking help from external vendors. Table 9 below gives examples for coding.

<table>
<thead>
<tr>
<th>Who?</th>
<th>IT Staff, Teachers, External providers, dept coordinator, subject teacher groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>What did they do?</td>
<td>On-site training, off-site training, self-directed, group-directed, online, in-class training, classroom teaching, coaching/advising, admin work, informing parents</td>
</tr>
<tr>
<td>Formal training</td>
<td>on-site, online, off-site, external providers</td>
</tr>
<tr>
<td>Div Lab Valence</td>
<td>positive, negative, neutral</td>
</tr>
</tbody>
</table>

**Table 3.9: Div of Labor Coding Scheme**

Across the 20 interviews, a total of 442 snippets were coded, ranging from minimum of 15 snippets from 2 individuals to a maximum of 36 from 2 individuals. One interview had only 12 snippets because due to background noise, all of it could not be transcribed. 3 snippets in each interview were not coded because they were regarding background information. So the 442 snippets that were coded did not include these 60 snippets.

A research assistant was trained to code this interview data set. She was provided a coding key along with an example interview that had been coded by the researcher; the researcher guided the assistant through this example, explaining why each snippet had been coded in a specific way. After she coded her first interview on her own, it was compared with the same interview coded by the researcher for a reliability check. For this case, we had 61 disagreements, out of 920 cells (on an Excel spreadsheet), for an agreement percentage of 93.3% of the time. Every interview, once coded by the assistant was also checked by the researcher and any concerns were discussed. The coding assistant was also allowed to add new tags if needed.
Chapter 4

Technology Use in Daily Practice

In this chapter I address the first research question which investigates how the teachers are using technology in their day to day practices. The teachers at the high school described the use of several technologies for their work practices. These practices can be broadly categorized as out-of-class or general work practices and in-class or classroom practices. This chapter is an analysis of technology practices for general activities outside of the classroom. The following chapter will provide the analysis of technology practices closely related to activities in the classroom.

Many activities in the teaching profession occur out of the classroom. Teachers have administrative tasks such as managing attendance, grading, applying for vacation days, etc. to name a few. They also spend significant time of the day in planning activities such as lesson planning and resource planning for their classes. An ongoing task is communicating with colleagues about ideas and to request or provide help, and also with students and parents about their progress. At times teachers collaborate with their colleagues when developing new course materials or exams and so on. The availability of information technology tools provided the teachers with unique affordances as was evident in responses during the interviews. The following paragraphs describe how teachers used technology in their daily activities that happen outside the classroom. Each section contains a table and the related AT triangle summarizing the findings.

4.1 Planning activities

For planning tasks, teachers used tools that helped them develop and organize their lessons, such as the Sympodium’s notebook software and the Plan Book (I5.37, I9.06). They also used resources and online forums on the web to gather materials for their lessons. Moreover, the school provided laptops for each teacher gave them the convenience to work anytime anywhere. Some teachers were participating in STEM meetings to plan inter-disciplinary lessons facilitated due to the availability of technology. However, teachers mentioned a variety of technology related issues that made planning more difficult.
They needed to factor in the availability of technologies such as laptop computers, logger probes, etc. while planning their lessons. The paragraphs below further elaborate on these findings. In this sub-section I start with examples of successful use of technology, followed by examples of contradictions.

Technology was a great enabler when it came to the planning task for teacher simply because they could work anytime, anywhere:

“I think that getting a laptop - before that we had desktop computer. I was a little wary when they told us that we were getting a laptop at first, but I take it home with me and now I have access to all of my records when I want them no matter where I am. I went to Detroit past weekend and sitting in my sister-in-law's apartment, I was able to work on my school work while my wife and sis-in-law went shopping. I have my school work handy at all times now and so I think that helps a lot. And then having that makes it easier to share files and stuff like that with other colleagues too. So while I was a little wary at first, I was actually glad that they gave it to us.” 9.18

“The Sympodium comes with note book software on my laptop. So I can work on it at home also”. 9.02

For planning lessons with other colleagues, e-mail was used and later the finalized document were stored and shared on the network lead server. This was described by one biology teacher:

“I work most closely with other environment science teacher. We email, develop materials together, send it back and forth. Once it’s finalized, I keep it on the desktop, sometimes on the network space.” 10.11

Some teachers also used online forums as a resource to plan and store/share lessons. As one teacher who used CISCO’s online forum noted:

“There are a lot of teachers – it’s (the forum) global, it’s around the world. There’s a forum that we can all access. If I am having a trouble in my lab, I go right there and type that this is not working and you know, and there are times that certain labs won’t work and they will put updates through the curriculum because of what the instructors have said.” 13.05

This forum also provided information on State standards for STEM. So it was a very convenient one-stop shop for this teacher.

“I needed to find the math, engineering and science standard for the state so I went to this website to get my standards alignment for the state of PA.” 13.06

Among the productivity tools, Microsoft Word was cited as a popular planning tool with the Math teachers because of its ability to create equations:

“I use Word- to create note packets because it has MS equation. I also use Word for making tests.” 11.03
Once the materials had been gathered the teachers used various tools to organize them. Some biology teachers found Plan Book a great tool to help them organize their lessons on a calendar while a Math teacher found the notebook software on Sympodium similarly useful:

“Plan Book is great, it keeps me organized.” 5.34

“Well I’m able to, we have note packets - I'm able to take snapshots of those and put into this notebook sw, it has panels to click on from one panel to the next. I like it because I can put graphs on there, I can make some graphs on the calculator and transfer into that, find something on the internet, take a snapshot and put it right there. It’s useful, for example, in Calculus later on when we get to slope fields, I found a slope field calculator on the internet and so I can do something on that on the internet and then take a picture of it and use that in class to show how to use a slope field to approximate what a function would look like if you can’t solve a differential equation.” 9.06

Teachers regularly used web resources to gather materials for their lessons. As one biology teacher commented:

“Biologycorner.com and other web resources – I use regularly for an activity or a lab. Most of the time, it’s just going on Google and look-up images. The vast majority of the time it’s just the general search.” 6.19

Technology also enabled a Math teacher to gather data in advance in novel ways which helped him focus more on student learning and less on making students do mundane data entry:

“I use Google Docs for new students to take a survey to gather data on Google form and they can do analysis when they come to school. I first get all their email from school district. I create Graphing calculator programs from those data that are just efficient storage of data. So they can get the data and do the analysis when they come to school. It saves lots of time for the students. From the survey I put it into a spreadsheet to Minitab to Graphing Calculator programs. This takes away the pain of entering data for the students. I have to do some work and put more time for me to set it up and prepare. I put it into the calculator program that they can automatically run the program and have the data put into their list just put the data that need into their calculator". 8.05

Table 4.1 summarizes some of the major impacts of technology within teachers’ planning activities, organized by the 6 constructs of AT. As suggested, there appears to be a broadening of the community as seen in examples of individual teachers reaching out to online communities such as the CISCO’s online forum and list serve for AP statistics. We also found evidence of a group of teachers who informally organized themselves to work with a tech-savvy teacher who was willing to take the lead on technology issues. However, while there were many benefits that technology brought into the planning activity, it also caused some tensions (see the negative entries in the Table I and the illustration in Fig 4.1 below).
<table>
<thead>
<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>Div of Labor</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesson Planning</td>
<td>Individual teachers</td>
<td>Laptop for teachers, word processor, Notebook (Sympodium), online textbook, Pennsylvania DOE website, -logger probes, -laptop for students</td>
<td></td>
<td>-logger probes and training provided by external vendor</td>
<td>-lack of funds</td>
</tr>
<tr>
<td>Sharing/ storing materials</td>
<td>Individual teachers</td>
<td>Email, lead server, online forums, list serves, cms</td>
<td>Local teachers, online communities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizing lessons</td>
<td>Group of teachers</td>
<td>Online calendar (Plan Book)</td>
<td>Same subject teachers</td>
<td>Tech savvy teacher, other teachers</td>
<td></td>
</tr>
<tr>
<td>Gathering materials</td>
<td>Individual teacher</td>
<td>Web resources, online surveys (Google Docs)</td>
<td>students, teachers</td>
<td></td>
<td></td>
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</tbody>
</table>

**Table 4.1: Planning Activity**

One of the principles of AT is the central role of contradictions or tensions as the driving force behind change and development. Contradictions should not be confused with problems or conflicts. Contradictions are structural tensions that have accumulated historically within and between the activity systems (Engestrom, 1987; Turner & Turner, 2001). Such contradictions generate disturbances and conflicts, but can also result in innovative attempts to change the activity. Thus, primary and secondary contradictions may give rise to a new activity which then results in tertiary contradictions between the old and new activity and may be compounded by quarternary contradictions among the concurrent activities. Here I focus only on primary and secondary contradictions.

**Contradictions**

The figure below illustrates Table 4.1 with its associated contradictions:
For the teachers we interviewed, the availability of technology support added convenience to their planning and organizing efforts, but the lack of adequate technology in the classroom brought forth fresh challenges that affected the planning activity even though the teachers were skilled users. Due to budget cuts, a university outreach program for biology teachers was diminished. One biology teacher commented on the use of logger probes and other materials which had been provided to them through such a university program:

“We can't be sure that they will still drop off the materials next year, so we can't be sure enough to start building it into our curriculum. Like this year we were not expecting it but they never returned our calls and they just showed up when we were in the middle of our lab in a very low tech fashion.”  1.23

This is a secondary contradiction between the Rule (allocation of funds) and Tool (availability of technology) constructs affecting the Object of curriculum integration. Similarly, another teacher
commented on the lack of adequate laptops for classrooms and how the uncertainty affected planning for curriculum integration:

"See the problem is - we only have two laptop carts being shared by 6 teachers. So the chance that you are getting a laptop cart when you need it is slim to none. So to have students turning in the assignments and doing it in Google Docs you have to just plan ahead and make sure that you have it available so that's a problem. Maybe if we had more - I would definitely be using the laptop more if we had more available to us. Lot of times its schoolwork you are doing and you can't expect all students to have internet access at home. You have to give them in-class time. You are restricted in doing these projects because of the laptop availability." 6.09

4.2 Administrative activities

Teachers described the use of technologies for administrative purposes at various levels – organizational, group/departmental and individual. Some of these technologies were provided by the school and some were recommended by the IT Staff and adapted by the teachers while some technologies were chosen by individual teachers. In this subsection I describe how teachers are using technologies to fulfill their responsibilities at various levels.

At the organizational level, teachers used tools for administrative work such as grading, attendance, applying for sick leave or vacations, keeping track of inventory, room reservations, budget, etc. The school provided a database system (File Maker Pro) which teachers could access for such tasks. The grading system was a different system and was available through the web. These tools were provided by the school district and were uniformly used by all teachers:

"Attendance, grades, course recommendations, mundane bookkeeping, applying for sick days/vacation days. ... I use grading software, just a spreadsheet type database. File Maker Pro for record keeping, attendance, keeping track of calculators, etc." 3.03

The district also used a gentle persuasion approach to gradually bring all teachers on board:

"Up until 2 yrs ago some teachers had the option to take paper attendance but couple of years ago the administration said that if they don't use File Maker Pro system they will consider that they had not taken attendance." 16.18

Other than the system provided for the school district, teachers also discovered use of other tools for administrative purposes at the group/department level such as scheduling meetings (doodle.com), managing courses (Plan Book), conducting meetings (Google Docs, Skype), etc.
“Brian uses Doodle. We are going to have a little dinner for a farewell. So he uses that to set it up. He also used it for scheduling for PAML”. 4.28

A group of Biology teachers used Plan Book - a calendar that allowed them to attach documents for students to download directly from the calendar.

“We were trying to figure out how the 3 of us who teach the same course edit the same calendar. We went to Jane but found that it can't be done. So as we have it right now only one teacher is editing for all of us”. 5.30

Teachers even used list serves for administrative purposes:

“... a lot of times if we have questions for each other we use the Bio List serv. For the biology department, for example, setting dates for mid-terms, setting questions, etc”. 6.20

One coordinator enjoyed experimenting with Skype to broaden participation of art teachers in departmental meetings. This exercise indirectly brought over other teachers on board the technology wagon. Having a coordinator who was excited about technology brought entire department teachers under regular exposure to technology. As peripheral participants in the beginning, they would be on the right track to grow as skilled users.

"... a pretty recent example as coordinator newly this year – we have a big sprawling district – e.g., when we have middle school art meetings – which are 9 miles apart and so it’s a hassle for half of the teachers to drive to the other school across the town, and also we have part-time art teachers who are done and gone home by the time we actually start the meeting, so we have started to encourage the part-time teachers to join our meeting online on Skype. I use Skype but the school is planning to buy Elluminate (a web conferencing software) – still looking/exploring other such technologies. I have offered to pilot whatever they get.

This coordinator was also a KTI (Keystone Technology Integrator). She was aware of teachers’ apprehensions as beginner users of technology. Her approach was having a significant impact in broadening teachers’ participation in computing.

‘Largely the idea is to build teachers’ comfort level with technology and try to introduce it pretty slowly and honestly keep it fun e.g., some teachers appeared on Skype in vegan sunglasses.” 7.06

Similarly, the Math coordinator was also an avid user of technology. He described a very effective use of Doodle.com and Google Docs for setting up and conducting productive meetings:

“I set up a meeting with 12 middle school teachers - organized the day in one day - no emails back and forth. I use doodle for setting preferences - there are 2 sides to it- even for setting up breakfast things to bring for our last in-service day. I listed bagel and fruits...I use Google Docs for surveys (forms) - We are
getting some additional technology for Math - Sympodium is basically like a smartboard on the desktop. I put out google forms for getting people's interests and expectations for using those things and compiled it and made another one to get their preferences to rank who should get it first. I used Google Docs for working on things together last dept meeting, had to come up with particular areas within the curriculum that we do certain things - created a template in Google Docs like here are these areas - during the meeting I had the diff groups of teachers work on different areas - teachers type in their pieces in different areas of the document and watch the doc grow. We spent 3 hours on one piece of curriculum that everyone will do it together on 3 levels of teaching and by end of the meeting we have the document complete. ... The teachers are invested in it and have access to it.”

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<thead>
<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>Div of Labor</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admin activities for school district (grading, attendance, sick leave or vacations, inventory, room reservations, budget, etc)</td>
<td>Individual teacher</td>
<td>District database system (FilemakerPro), online grade entry system</td>
<td>School admin, School teachers, IT admin</td>
<td>Time provided during in-service days</td>
<td></td>
</tr>
<tr>
<td>Admin activities for group (updating calendar)</td>
<td>Subject teachers</td>
<td>Plan Book</td>
<td>Same subject teachers</td>
<td>Tech savvy teacher, other teachers</td>
<td></td>
</tr>
<tr>
<td>Admin activities for department (Scheduling, conducting meetings, setting exam dates)</td>
<td>Department head</td>
<td>Doodle, google docs, skype, list serve</td>
<td>Online support for local teachers’ community</td>
<td>Department head, department teachers</td>
<td>Monthly department meeting</td>
</tr>
<tr>
<td>Admin activities for individual teacher (grading and sending emails to parents)</td>
<td>Individual teacher</td>
<td>Grade book</td>
<td>Students, Parents</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2: Administrative Activity

At an individual level, one teacher, used her own Grade Book (as did other teachers in her subject group) which was different from the district grade program. It allowed her students access to view their grades and also allowed her to send emails to their parents:

“We use a separate Grade program. At the end I put it in the district system. I don't keep a paper grade book any more. It does all the averages. Students can access it from the web and keep track of. I can email parents. If other teachers are also using the same Grade Book program, the students can use the same password. I register the students. I can export all my classes through FilemakerPro.”

Table 4.2 and Fig 4.2 summarizes the above analysis.
4.3 Collaborative activities

Technology opened up new ways and opportunities for collaboration among teachers. With teachers who taught the same courses, it made developing materials together more convenient due to the affordances provided through the use of email or file server or online forums as a way to share files. For curriculum development, some motivated teachers were using the freely available Google Docs even before the school adopted Google Docs for the district. At times, teachers divided work among themselves. Generally, a tech-savvy teacher would emerge as the lead on providing help with technology issues. Sometimes, technology became the object of collaboration when teachers got together to figure out how to use a technology such as an online textbook or excel. In this sub-section I start with description of successful uses of technology followed by difficulties and breakdowns in the process of collaborative activities.

One science teacher describes how collaborates with his co-subject teacher to develop and shares materials using email and the lead server:
“Other environment science teacher most closely with - we email, develop materials together. Send it back and forth. Once it’s finalized, I keep it on the desktop, sometimes, on the network space - not necessary.” 10.11

Another biology teacher also mentions the use of emails and the school provided lead server for collaborations:

“file server, email attachments are the online ways of collaboration. I do not use it (file server) a lot, but I put stuff there also.” 11.16

A computer networks teacher used an online forum as a place to collaborate with teachers around the world to share materials with each other:

“Again, because it’s all the people I go - you saw the forums that I go to you could collaborate with anyone around the world. E.g., Packet tracer, we do file sharing - we upload/download files, Powerpoints, study guides, worksheets. I don’t get this type of help or sharing with the teachers here.” 13.19

For curriculum development and assessment, some teachers were using Google Docs. They were writing questions that targeted state standards:

“Yesterday a teacher was working on some curriculum development with another teacher. They are writing core assessments which are assessment questions that target state standards. We had teachers using the public Google. So some highly motivated teachers have already used it in the past.” 15.09

At times, technology became the object of collaboration when teachers simply collaborated on how to use technology like Excel for assessment or a newly acquired online textbook:

“I collaborated with some other business teachers on Pivot Tables. We used a pivot table to do a project that they were working on – they used this to track specific information about their students so we worked together to create a pivot table where they could track that information. They were tracking the hours that students worked at their jobs among other things.” 2.26

Using a common online textbook motivated a group of teachers to collaborate on learning how to use it. They did the bulk of learning over the summer on their own and continue throughout the year on an ongoing basis. This practice emerges as a productive learning strategy where teachers teaching the same subject collaboratively learn as a member of a professional learning community. School administration can save a lot by identifying and encouraging such practices.

“So over the summer, on our own, 3 of advanced biology teachers got together on 3 different occasions to figure out how the new online component of the new textbook worked. We had to go through redoing all of our lessons to work with the textbook. It was all IT - learning how the website worked, how to set it up,
how to make your own quizzes, choose your own questions, how to send out the announcements, etc. There was no manual. We do that in some respects on almost a daily basis as well.”

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<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>DOL</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop materials</td>
<td>Group/dyads</td>
<td>Word, email, lead server</td>
<td>Same subject teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share materials</td>
<td>Individual teacher</td>
<td>Online forum, lead server, email</td>
<td>Online community, school teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curriculum development &amp; core assessment</td>
<td>Group/dyads</td>
<td>Google Docs, SW program</td>
<td>Same subject teachers</td>
<td>Tech savvy teacher, other teachers</td>
<td>-Planning time not assigned, Teachers schedule their own time before, after, during school or during summer</td>
</tr>
<tr>
<td>Learning technology</td>
<td>group</td>
<td>Excel, online textbook, etc.</td>
<td>Same subject teachers</td>
<td>Tech savvy teacher, other teachers</td>
<td></td>
</tr>
<tr>
<td>STEM initiative</td>
<td>team</td>
<td></td>
<td>Bio teachers, Engg teachers, Comp Graphics teacher, IT teachers</td>
<td>-Planning time not assigned, -members assigned to teams, +middle school has time assigned</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3: Collaborative Activity

There was also evidence of informal development of division of labor among teachers who taught the same course or same topic. While redeveloping the curriculum, one math teacher developed the design while the other did the programming. In another example, one teacher took the responsibility of maintaining the online calendar for a group of teachers who used the same online textbook:

“The best collaborative moment was ~15 years ago, working with Melinda to sort of completely re-develop the curriculum for one of our courses- it included a software program that we developed together... I did the design and she did the programming.”

“We were trying to figure out how the 3 of us who teach the same course edit the same calendar. We went to the IT coach but found that it can't be done. So as we have it right now only one teacher is editing for all of us.”

Thus we see the emergence and development of a learning community where teachers take on different roles and set a division of labor. Once they have reorganized themselves, they can be provided the opportunities to share their knowledge with other department teachers. Here school authorities can facilitate activities that allow the knowledge to flow within and across departments.
Contradictions

Some contradictions were also noticed in teacher collaborations centered round technology issues. The high school had put in place a team to work on STEM program where teachers from different levels of biology collaborate to plan lessons with other departments:

"Our department and the IT department, engineering program, computer graphics are involved. We are looking at some lessons that are following this model."

This is a good attempt but probably may need additional leadership or time to make it successful. The teacher felt that part of the reason why the initiative did not have expected results as compared with their
middle school counterparts was the lack of time (a primary contradiction in the Rules section affecting the Object of planning):

“Actually the Middle School teachers are a little bit ahead of the game on this. They have done a little bit more; they work on teams and have collaborative planning time built into their schedules. We don't have that so we meet for a couple of hours every 3-4 months. We don't get much accomplished. So time is again the issue.” 1.29

Fig 4.3 is based on Table 4.3 along with contradictions.

4.4 Discussion

As is evident, there were no significant issues in technology-enabled administrative practices. The school provided built in time and technologies for teachers to fulfill administrative duties. At the departmental level, some particularly useful practices were developing in the math department at the initiative of a tech-savvy department head. School practitioners could note these developments and encourage adaption in other departments by sharing best practices. This is already happening as noted by the coordinator:

“Professionally I mentor new people in my position - in the last couple of yrs. coordinators of family studies and consumer sc. and another in social studies coordinator. And frankly, much of the mentoring with the social studies teacher is about how to use technology to make our job efficient - our jobs are way too big.” 8.23

At the individual level, some teachers were using their own Grade book instead of the school provided Moodle. Information system designers could look at this development closely to identify the features of the Grade book and try to integrate it with the other systems.

In most of the examples, with the exception of administrative activities (Table 4.2) where teachers were assigned time in the form of in-service days and monthly building and department meetings, time for collaborative activity was not built into the teachers’ schedules (Table 4.3); however, groups who taught the same subject often found a way around this issue by using their own time after or before school, or working together during the summer. In contrast, groups that included teachers from different departments experienced problems either due to the lack of built-in time or due to the group characteristics where teachers from different departments and levels had less of a common ground to function productively. These findings have important implications for school administrators and department heads who play a critical role in articulating the organizations rules and norms. Of special interest was the informal development of division of labor among co-located teachers who taught the
same subject and collaborated to plan their course using a newly acquired on-line textbook. In this example, teachers leveraged a pre-existing professional learning community of teachers who taught the same course and became a more tightly knit group, organizing their activity to include a division of labor with a tech-savvy teacher. For teams that do not have a pre-existing network to leverage or who are not co-located, there may be a potential for information system designers to develop online places to support group activities such as this. Again, this points to the need for school authorities to pay close attention to building time for the teachers for additional activities.

The secondary tensions that arose from inadequate funding of technologies impacted planning activities and also have important implications for school authorities (Table 4.1). Firstly, organizations may try to increase funding, but the current economic climate may not be favorable. Secondly, they may plan for better allocation of existing technologies. Information system designers may find a potential here to create an online inventory of laptop carts and other technologies where teachers could reserve the tools needed when planning their lessons (for example a science probe that can be checked out and trialed before bringing a whole set into the classroom setting). This inventory may also be accessed by school authorities to take stock of technologies that are under-utilized.

To sum up, the examples presented in this section demonstrate that teachers are using technology in creative and diverse ways. The general results of these interviews were largely encouraging. At the same time teachers are facing some amount of difficulty. While there was little evidence of problems with respect to technology support of administrative activities, there were some tensions noted in the planning and collaborative activities. It is no surprise that the administrative activities went more smoothly: teachers had school-assigned time in the form of in-service days and district provided systems to complete organizationally required tasks. In contrast, the education planning activities were negatively impacted due to uncertainty in the availability of requisite technologies which was again a result of inadequate funding. Thus, even if teachers are skilled users of technology and have had adequate professional development, the uncertainty in the availability of technology prevents them from planning into the curriculum. Within the AT framework, this would be defined as a secondary contradiction involving two elements, namely, tools and rules. The main problem for collaborative activities among teachers was lack of time (this is a primary contradiction involving one element, namely, the organization’s rules) and group characteristic (this is a primary contradiction involving one construct, namely, subject). The AT framework revealed contradictions which led to the identification of alternative solutions for school administrators, teachers and information system designers.
Chapter 5

Technology Use for Classroom Practices

Many studies have examined the use of technology in education aimed at preparing students for the 21st century. Some studies have emphasized the importance of teacher attributes, such as attitudes, beliefs and self-efficacy, in predicting these professionals’ use of technology in schools (Dupagne & Krendl (1994), Marcinkiewicz (1994), Milbrath & Kinzie (2000), Vannatta & Fordham, 2004). Other studies have assessed whether technology improves students’ engagement as well as achievement (Schacter, 1999).

Still others have investigated the development of online communities that may help teachers to become advanced users of technology (Carroll et al., 2003, 2005; Barab et al., 2003; Schlager & Fusco, 2003). In general however, many studies of technology in education consider teacher preparation as a peripheral concern. In contrast, Fullan (1991) suggested that researchers should consider the teachers’ perspective when studying changes that occur due to technology integration to understand their subjective experiences. Similarly, Laurillard (2008) argued that by taking into account the teachers’ concerns, specifically their points of view on whether and how technology can serve education, researchers will be able to first identify and understand the educational problems and then find technology solutions that address these problems. In this way, it can be ensured that issues are addressed from the teaching community’s perspective.

In the previous chapter I described teacher’s responsibilities as a member of the school organization. These included a set of activities that addressed teachers’ role in overall management of their responsibilities and how technology is supporting these activities. In this chapter I focus on teachers’ traditional role as a teacher and how technology is used to support activities that are directly related to the classroom. For example, there are administrative activities that are conducted for management of classroom or student activities. There are also classroom related collaborative activities. That is, teachers collaborate with each other to teach a class together. They may even have students from the same classroom or across different classrooms working on a lab or an assignment collaboratively. Finally, the teaching activity, which is the goal of all other activities driving the school system, is the focus of the
final sub-section. Each sub-section starts with an analysis of related snippets from the interviews and ends with a table and an AT triangle that summarizes the sub-section. At the end, there is a brief discussion.

5.1 Administrative activities

The school provided course management system (Moodle) was equipped with several features to help with classroom related administrative activities such as homework collection, communication with students, managing the course calendar, sharing lessons in advance, tracking student progress, etc. At the time of this study, Moodle was still introducing its gradebook. So for entering grades, the teachers were mostly using the district provided grading system to upload the final grades. It was not yet clear if there was any plan to integrate the upcoming Moodle gradebook with the district grade system. Prior to Moodle, Schoolwires also provided the teachers with space to share their course objectives and content. At the time of this study, a slow transition from Schoolwires to Moodle was taking place. Teachers were being trained and encouraged to adopt Moodle for classroom purposes while still keeping Schoolwires as a platform to post their course objectives for the parents/students and functioned as the district’s public website. Apart from Moodle, some teachers preferred to use other tools as well.

For collecting assignments, teachers used a variety of methods. Some collected them as hard copy. The math teachers preferred this method because it was easier for students to make figures and equations in hand. Before Moodle, teachers were accepting assignments through email and were still continuing to do so until they became more familiar with Moodle. Others also had students submit assignments on a hand-in box they created on the lead server. Google Docs was also gaining popularity due to its collaborative features.

A Biology teacher clearly preferred Google Docs:

“Google Docs is when the kids are doing various projects they will submit it to me that way. I have used it throughout the year.” 6.08

For feedback on assignments, one instance is noteworthy. An English teacher (ESL) had a novel approach of providing feedback on students’ assignments using an audio program:

“...there's a project that I do the grading through audio programs so the kids are able to listen to my edits through the earphones.” 20.05
For organizing the course, Moodle provided a course calendar. However, some teachers showed a distinct preference for other tools. A group of Biology teachers talked about how they edit their course calendar using the Plan Book software. These teachers taught the same course:

“We were trying to figure out how the 3 of us who teach the same course edit the same calendar. We went to our IT Staff but found that it can’t be done. So as we have it right now only one teacher is editing for all of us”.

The teachers preferred this course calendar to the one provided on Moodle because it allowed them to upload attachments directly to the calendar.

Grading or evaluation is an important activity that forms a huge bulk of teachers’ time commitment for administrative functions related directly to their class. Information technology has a huge potential for supporting this activity and teachers were finding new ways to take advantage of technologies that helped them make this process more efficient.

For administering exams, one teacher liked to use Exam View (which was not district provided software) which automatically graded the answers.

"I use grading software called Exam view. It allows you to post the grade and has some real nice reporting. It also allows you to put tests online and does the grading automatically. These are multiple-choice, True/False, not essay type questions.”

A Biology teacher used a different program for grading which even allowed her to email parents.

“We use a separate Grade program. At the end I put it in the district system. I don’t keep a paper grade book any more. It does all the averages. Students can access it from the web and keep track of. I can email parents.”

Email continued to be the way to communicate for most teachers:

Email - to communicate with parents, within the school. I don’t email students. And I use web page- for listing homeworks.”

Math teachers used Word for creating exams and note packets because it allowed them to create equations:

“I use Word- to create note packets because it has MS equation. Word- for making tests.”
Some teachers also taught each other to use Pivot Tables in Excel for tracking how much time students spent on a project.

“We used a pivot table …. to track specific information about students… we were tracking the hours that students worked at their jobs among other things”. 2.26

<table>
<thead>
<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>Div of Labor</th>
<th>Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grading</td>
<td>Individual teacher</td>
<td>Grade Book, Exam View, Filemaker Pro</td>
<td>Students, Teacher, Parents</td>
<td>Teacher, IT Staff</td>
<td>Final grades must be entered in the district system</td>
</tr>
<tr>
<td>Maintaining course calendar</td>
<td>Group of teachers</td>
<td>Plan Book</td>
<td>Same subject teachers</td>
<td>Tech savvy teacher, IT Staff</td>
<td></td>
</tr>
<tr>
<td>Communicating and reporting grades to parents and students</td>
<td>Individual teacher</td>
<td>Grade book, Email</td>
<td>Students, Parents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collecting assignments</td>
<td>Individual teacher</td>
<td>Moodle, Email, hard copy, Google Docs</td>
<td>Students, Teacher</td>
<td></td>
<td>Homework collection norms are set by teachers</td>
</tr>
<tr>
<td>Feedback on assignments</td>
<td>Individual teacher</td>
<td>Google Docs, Audio program</td>
<td>Students, Teacher</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1: Administrative Activity

The Table 5.1 above summarizes how teachers are using technology for classroom related administrative functions using an activity theory framework. Based on all the teacher’s comments, some Objectives were extracted, such as, grading, setting up and maintaining course calendar, communicating and reporting grades to students as well as parents, collecting and giving feedback on assignments. The Tools that were used to fulfill these objectives are also listed. The Community members in this activity consist of students, teachers and same subject teachers. The Division of Labor is between Teacher, IT Staff and Tech-savvy teacher. There are some rules associated with setting the mode for assignment submissions. The deadline for grade submission is set by the school district.
Fig 5.1 is a pictorial version of the table. Visualizing through the AT framework helps in analyzing the different possibilities of integrating technology and the processes associated with them. These can have implications for designers. It also helps identify the development in teachers’ community which can give important clues to school administrators or IT Staff when they are thinking of a best approach for professional development activities.

It becomes apparent that there are altogether three different tools being used for the objective of grading. FM Pro is being used by all teachers to enter grades into the district system. Exam View is being used by a teacher because not only does it allow him to set questions, it also automatically grades the tests. Gradebook is being used by some teachers because not only it automatically grades the exams, it also allows them to email students and parents. Pivot tables in Excel is used by some teachers to track the amount of time students spend on assignments to give them appropriate points for participation. If all
these features could be integrated into a single tool, say, the cms, it would save the teachers several steps in the grading process.

Similarly, another object that involves multiple tools is collection of homework/assignment. Teachers are having students use Moodle, email, hard copy, lead server and even Google Docs for this purpose (also see section in the preliminary analysis for more on contradiction related to tracking assignment submission). Once again, here is an opportunity for IT designers to integrate this process into a single tool so that it becomes easier for teachers to track the submissions.

The PlanBook allows a group of biology teachers who are teaching the same subject to collaborate together in organizing their course. Thus this tool is becoming a sort of catalyst in cementing or building a professional learning community. They did not use Moodle because the calendar provided in Moodle did not allow them to upload the lessons into the calendar. An interesting development to note is the emergence of the tech-savvy teacher as the lead in small professional communities of same subject teachers. Although they are not assigned this role by the district or the department, they are playing a very important role in the adoption and integration of technology. IT administration can leverage these spontaneous developments as a resource to share best practices. Additionally, information system designers can be informed such that this feature can be integrated in the cms itself so that other teachers can also take advantage of it.

5.2 Collaborative activities

In the classroom, teachers collaborated among themselves to teach a class and/or they had students collaborate in teams. They mentioned the use of Google Docs, online forums, vernier sensors, cameras, Office Live, Excel, Quickbooks, Powerpoint, iMovies, Sympodium, projector, laptop as some of the technologies used for collaborations.

Teacher collaborations

The availability of vernier sensors made possible a new way of collaboration among physics teachers in a classroom/lab. There was also a plan for them to collaborate with Engineering teachers:

“Physics department - they have acquired a whole lot of vernier sensors (for light, motion, sound) and they are incorporating that into the curriculum. There are 5 teachers finding useful ways of using that-real time data analysis with that. There are 4 classrooms. 3 are in proximity and 1 is up on the 2nd floor.
"But the students are together in one lab. Physics teachers collaborate with physics teachers and next year they will collaborate with engineering teacher.‖ 10.10

Teachers collaborated in solving problems related to a technology class. A computer networks teacher collaborated with teachers around the globe on an online forum to troubleshoot problems while teaching in his lab. He would generally get an answer within 15-20 minutes!

“Again, I guess through the online forum. Well if you have certain issues with the worksheets. They don't come out perfect, the lab don't come out perfect, for example, instead of me troubleshooting myself, I ask this question and get an answer within 15-20 min. In one situation we found that the IP address was messed up so we found the problem and fixed it.” 13.20

Teachers from different subject areas collaborated on a common topic. In the two examples that follow, there was evidence of informal development of division of labor among teachers who taught different subjects but the same topic.

A Business and Finance teacher collaborated with an Economics teacher to teach a class on Savings and Investments. The two classes were combined into one for about a week and students used several technologies such as Excel, Garageband and Powerpoint as part of their assignments. One teacher handled more of the technology part while the Economics teacher handled more of the content portion of the class. Students were asked to submit their assignments in the hand-in box on the file server. However, the teachers soon realized that there was not enough space on the network. They also found that the school could not increase the storage space for them. As a last minute resort, the teacher requested another teacher who taught computer networks to help out. The networks teacher provided them with adequate space on his file server and later bought a server also through department funding:

“...I provided the server space - we bought the server with our shared budget. I set it up for Fred. Its set up for all of Fred's classes. We gave them access to 100 GB. We are close to using it all up - so we'll have to throw another drive in there and re-share and make it to 200 GB. Fred is able to access my server because he has an ftp access. Only Fred and I used this resource. It cost us $300 for the hard drive. But the server was $1600.” 13.21

In this example we see an informal development of a division of labor among teachers - the tech-savvy Business and Finance teacher, an Economics teacher who was not comfortable with technology and an IT teacher (note that this is not the same as an IT staff) who was able to provide resources. Together they were able to integrate technology into the curriculum to fulfill state requirements.
Yet another example of how two teachers collaborated and used technology for students from different classes to collaborate on a project:

“...we actually got together and used his sports marketing class and my business law class to get together to write a contract for professional athletes. So his sports marketing class was used to market the athlete, and my business law class was used to do the business side of the athlete. That was an example that we've done this year already. It worked very well, we had two classes get together and they worked on it. Kinda cool to have assigned groups. You're in a group with kids that aren't even in the same class as you, and yet you're able to communicate. We communicated all over the computer. We created a Moodle group where two groups could chat. And we did Google Docs too. That's an excellent technology right there. It's outstanding.”

Technology made the class an enriching learning experience for students of an English teacher (ESL). She collaborated with a Social Studies teacher where she took care of the technical aspects while the Social Studies teacher interacted with the students.

“...well I did the lessons all on my own for the English class and then there was the culminating event with the awards show which was the combined class. We've done it for several years. It’s pretty simple. He (the social studies teacher) is the MC who runs the show and I do the technology part sort of organize such as you tube, sound, setting up online assignments ....

.... This wouldn't have happened if we didn't have the projector or the screen, if we didn't have the 2 of us because I couldn't be taking pictures, movies and being interviewing if I were the only one”

Table 5.2 summarizes the above analysis of how teachers are using technology for class related collaborative activities. Figure 5.2 illustrates the table. Collaborations revolved around common topics facilitated by sharing tools such as the lead server and Google Docs or around the possibilities created for combining bigger classes with new data collection tools such as the vernier sensors. A secondary contradiction is noted between the tools and rules. This became apparent in the example where teachers collaborated to teach a common topic in which they also tried to fulfill state requirements with respect to students’ use of technology in class. However, they experienced insufficient space on the school provided lead server (Tools) where students were to submit their assignments, parts of which were audio files which required more storage space. Due to insufficient funding (Rules), teachers could use only limited storage space. The teachers turned to an IT teacher (note, this is not an IT Staff) for help who provided him storage space on his server. It is important to note that such teacher collaborations are spontaneous and not enforced by the administration. Thus, the interactions and division of labor emerging through these activities are of an organic nature. Schools could benefit by encouraging these initiatives and sharing the emerging practices. Additionally, this example highlights the issue of storage space
requirements, costs and maintenance. Finally, the example of an IT teacher having his own online community for all his needs shows visions for the future.

<table>
<thead>
<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>DOL</th>
<th>Rules</th>
<th>Contradictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching a combined class</td>
<td>Individual teacher</td>
<td>Vernier sensors for real time data</td>
<td>Same subject teachers</td>
<td>District provided resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching a combined class to fulfill state requirements for technology skills development among students.</td>
<td>Individual teacher</td>
<td>Excel, Powerpoint, Garageband, lead server, Moodle, chat, Google Docs</td>
<td>Different subject teachers (but a common topic)</td>
<td>Tech savvy teacher Other teacher</td>
<td>Dept funding Teachers assign roles</td>
<td>Insufficient storage on lead server for student assignments Tool- Rule (secondary)</td>
</tr>
<tr>
<td>Troubleshooting</td>
<td>Individual teacher</td>
<td>Internet</td>
<td>Online community of same subject teachers</td>
<td>Teacher Online community members</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching a combined class to provide an enriching learning experience</td>
<td>Individual teacher</td>
<td>Online assignments, projector, screen, you tube, camera, video/ audio recording</td>
<td>Different subject teachers</td>
<td>Tech savvy teacher Other teacher</td>
<td>Teachers assign roles</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.2: Collaborative Activity (Teachers)**

**Student collaborations**

Traditional researchers belonging to the school of cognitivism argue that learner-content interaction is perhaps the most important goal of Instructional technology. Other researchers who believe in constructivism, argue that Moore's (1989) social interactions, (learner-instructor and learner-learner), are as important as learner-content interaction (en.wikipedia.org/wiki/Instructional_technology). In this section I focus on evidence of learner-learner interactions provided through technology use.

Technology opened doors for collaborations among students. The school recognized this and introduced Google Docs within the school’s technology environment. Students used it for group assignments, group labs and group discussions. Google Docs was the most popularly used tool by teachers for student collaborations. In fact some teachers preferred to use it over Moodle:

"But we also use computers now - they are using Google Docs in order to create presentations to summarize their lab. When I taught Zoology last year we used digital cameras to create a virtual"
Another teacher used Google Docs for storing his presentations and notes but was happy to note that it afforded some students the opportunity to use Google Docs for discussions:

“I use Google Docs. All my notes are up on Google Docs. A student, on his own, started a discussion on Google Docs. There are 4-5 who are contributing actively. It’s not possible to know how many are reading this discussion. I am not inclined towards mandating this type of activity”.  

An accounting teacher used Excel or Quickbooks for students to work together on the subject and later on Google Docs powerpoint presentation to share with the class.

“A lot of instruction results in us having to work on MS Excel so students open up Excel and work together or they open up Quickbooks – we do work together in Quickbooks.....We do use Google Docs in the classroom to create group presentations.”  

Another Business teacher also had students use Google Docs to build up a project collaboratively:
“I assigned a group of students to come up with an idea to make a contract. So we used Google Docs to create a contract where groups of 4 or 5 added their pieces of information to the contract, so at the end, it would be a total contract. So, person 1 is adding their part as persons 2, 3, and 4 can see that information, and perhaps generate more ideas, and have a final product. That would be a good example of using technology to accomplish a business-related task.”

However, there were voices heard about problems associated with Google Docs as one teacher described:

“Yes, kids do a lot of Google Docs. In bio they will build presentations. Most recent lab had them produce a Powerpoint presentation. Now there is problem in there trying to interface regular Powerpoint presentations with Google Docs. Google Docs has its own presentation Powerpoint program but it’s difficult to put their graphs together. Kids usually build their graphs in Powerpoint but it doesn’t integrate well with Google Docs. So they end up taking pictures of the graph and copy and paste it on Google Docs. The problem with that is if you have to go back and redo the graph or tweak it you just can’t do it. They cannot build it in Google Docs so they can’t manipulate it in Google Docs.”

<table>
<thead>
<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>DOL</th>
<th>Rules</th>
<th>Contradictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group assignment work</td>
<td>Individual teacher</td>
<td>Google Docs, Excel, Quickbooks</td>
<td></td>
<td></td>
<td>Incompatibility between regular Powerpoint and Google Docs Powerpoint. Tool-Tool (primary)</td>
<td></td>
</tr>
<tr>
<td>Group lab work</td>
<td>Individual teacher</td>
<td>Google Docs (presentation tool)</td>
<td></td>
<td></td>
<td>Can’t make graphs in Google Docs Tool-Tool (primary)</td>
<td></td>
</tr>
<tr>
<td>Sharing content with students on Google Docs (Group Discussion)</td>
<td>Individual teacher</td>
<td>Google Docs</td>
<td>Informal development of an online student discussion</td>
<td></td>
<td>Teacher does not believe in making online forum mandatory</td>
<td>Not possible to track who is reading the discussions. Tool-Tool (primary)</td>
</tr>
</tbody>
</table>

Table 5.3: Collaborative Activity (Students)

Another more advanced technology teacher also had trouble with Google Docs but was able to independently figure out a solution by finding another tool. He discovered a similar tool, Office Live, which did not have these issues:

“Actually I used Google Docs Powerpoint presentations. Now I am moving away and use Office Live. Its free it has a beta version. Google Docs Powerpoint gets messed up – it’s not what kids created.”
Table 5.3 summarizes the analysis and Figure 5.3 below illustrates the summary. Google Docs was the most popularly used tool for collaborations among students. The contradictions noted were of a primary type, related to tool. Google Docs was a giant step towards solving cross-platform and version issue, which used to be the primary concern for IT Staff and a major inhibitor in adoption of technology by teachers. Although Google Docs provided a great platform for collaborations among students, some remaining compatibility issues, especially with PowerPoint were causing a lot of inconvenience. Moreover, the Google Docs PowerPoint was not designed for making graphs. One teacher was already moving to Office Live as a better option. However, it is noteworthy that students were spontaneously creating group discussions in Google Docs. The teacher noted that all students could benefit from reading the discussion although there was no way of knowing who had been reading them. Hence, there are some implications for designers of Google Docs. Additionally, the professional development sessions could inform teachers about these problems to save them and students from getting frustrated.
5.3 Teaching (instructional) Activity

The teachers talked about several tools that helped in delivering their lectures. Basic technologies needed were an overhead projector and a laptop. A new instructional technology - Symposium – had been introduced among the Math and Science teachers but was very slow in being adopted. Then some of them (especially English and Social studies teachers who were the first ones to be introduced to it) used course management systems (cms) such as Moodle that was being supported by the district. Some teachers were using different systems that had many features of a cms. They had independently chosen these with the approval of the school’s IT Staff. These include Plan Book that was being used by a group of science teachers, Aris that was being used by Advanced Biology teachers and CISCO networking academy that was being used by a CTC teacher. Many teachers showed a preference for Google Docs over and above Moodle. The IT Administration had seen this trend and purchased a license for implementing Google Docs along with Gmail for the entire district. However, teachers were not entirely happy with Google Docs, especially its powerpoint feature and one teacher had moved on to Office Live instead. Other than these, software products in popular use were Powerpoint, Word and Excel. Teachers also used educational technology tools that were subject specific like Graphing Calculator, Calculator Based Lab, Geometer's Sketchpad, Fathom, Minitab and T1 Smartview for math teachers, Read Naturally for English teachers, Logger probes and Vernier sensors for science teachers and Quickbooks for the accounting teachers. Internet was used widely for gathering online resources, videos and images. Several other tools made it into this mix, such as, iMovies, Photoshop, iClicker to name a few. The IT staff routinely introduced the latest emerging technologies to the teachers during their training sessions.

In the following sections, I describe technology use for teaching activities. I have organized the analysis as enabling factors and inhibiting factors as they use technology for classroom teaching. This is followed by a summary table and associated AT triangle showing contradictions and a brief discussion.

Enabling factors in the use of technology for teaching

Technology offered several affordances that teachers found attractive to use. These features motivated them to use technology. Technology offered them a way to share materials with their students ahead of class, facilitate student collaborations during the class, hold online chats or discussions to further enhance student learning. Technology was convenient because teachers could work from anywhere anytime. Technology integration opened up many ways of delivering the lessons and resulted in smoother and efficient teaching. By reusing materials they developed, teachers could save time on future work.
Teachers used technology for enriching the learning experience and found many ways to integrate it with the curriculum. Different course management systems were being gradually adopted by some teachers. Although the school provided and supported Moodle as a course management system (cms), some teachers preferred to use online textbooks (for example, Biology teachers) or course websites (for example, CISCO teacher) that came with similar features. Some even used Google Docs as an alternative, although, with more limited features than a cms but with more user-friendly components for collaboration. Below, I describe the motivating factors that encouraged the teachers to use technology in the classroom.

Technology offered a platform for sharing where teachers could share lessons with students in advance of their lectures. Tools mentioned during interviews included Schoolwires (a web development tool), Moodle, Plan Book (a calendar) Google Docs, Lead server, Office Live and email.

Initially, the school had provided Schoolwires as a platform to build websites for teachers.

“Schoolwires- teachers can post stuff on the school’s official website. District is using it a lot - putting all their lecture notes.” 15.10

One group of teachers (biology) used a tool that provided them a sharing platform on its calendar itself. It was easy for students to download attachments directly from the course calendar. The teachers preferred using it over other modes of sharing provided by the school, such as email, Schoolwires’ website, Moodle and the lead server.

Teachers were also spontaneously using Google Docs for sharing and posting their lessons for students.

“I use Google Docs. All my notes are up on Google Docs.” 12.02

Some tools were popular because they provided a platform for collaboration among students. A biology teacher described how students used digital cameras and powerpoint on Google Docs for group assignments. An accounting teacher also used Google Docs for group assignments.

Another affordance provided through technology was a platform for discussion. Some teachers used chat rooms to get the students going and followed it up with face to face discussions. This was a good way to get quiet students on board as well.

“We use Moodle to create chat rooms. It is a different way to do a classroom discussion. The entire classroom together on a topic – no groupings. I give them some time to chat in class, look at it, respond to it so
that it encourages participation. Some students chat rather than speak. Then they can have f2f discussion.” 2.16

Technology offered a lot of convenience. It made it possible for the teachers to work at home or anywhere else and plugin the lessons for instant delivery in the classroom-

“I have a school issued laptop which I use in class and outside the class room. It has everything on it, grades, lesson plans and things I have made everything's on the laptop. So when I am teaching I also, I have the laptop plugged into the Sympodium and so that I can you know access everything.” 9.03

Moreover, the lessons could be reused. Increasingly, powerpoint slides were being included with textbooks for teachers. However, it is noteworthy that a history teacher preferred the use of Word because it allowed students to type their own notes to the lecture.

“I like Word better than Powerpoint because students can type notes during the lecture. The links take them to relevant maps. I am teaching about the Confederation of the Rhine.” 12.03

The Sympodium was the latest tool the Math teachers were enthusiastic about. It had also been introduced among the science teachers with less success. It made the running of classes smoother. It is important to note that teachers felt that technologies like the Sympodium and Smartboard helped them save time.

“More recently, the Sympodium has also made a big change made it easier to streamline lessons, so I don't feel rushed in 47 minutes period.” 9.19

“I think that's where the smartboard and sympodium has helped - It makes the class go smoother from one thing to another. It is more efficient, I can cover more material in a period of 47 min. It enables me to access the things that I need faster- I do have to set up ahead of time - but when I am teaching instead of drawing an axis on the board, I already have the axis right there, I just have to click on that and it's there. It's useful just that you still have to prepare, once that preparation is done. I have a class in the 7th and 8th period, so I can do everything for the 7th period and use it also in the 8th period. So it's definitely more convenient.” 9.07

However, not all departments found the Sympodium as useful as the Math teachers did.

“Some departments don't use it as much. It really depends on the way they deliver their curriculum. They don't do that much writing so they can use the Powerpoint. But if they do the writing like in Math, it's really nice.” 4.25

Technology also led to more advanced learning experience for students. A science teacher expressed pride in having kids use such advanced technologies that they were on par with students at the college level.
“Logger Pro - we like it a lot - it’s a pain in the neck but we like it a lot. When kids walk out of the lab where they have used this kind of equipment they can walk into any college level introductory lab like this.” 5.25

A Math teacher talked about the potential of making difficult concepts easier to understand by using simulations:

“Calculator explorations are a natural fit. Analysis with Minitab is pretty straightforward. Use of SW like fathom is sort of whatever I can find is that gives me a good idea - some simulations I can find that can explain some difficult concepts like the statistical concept of power. I found some interesting simulation and adapted it to do more for kids to understand what power is”. 8.07

Technology also made possible adding a variety of audio-visual learning experiences which enabled teachers to cater to different learning styles.

“Not only do I do the visual type of learning style, we have the audio too, you know lecturing to them, but then they can also read from the curriculum and so all different learning styles are integrated.” 13.10

The internet offered a great repository of resources to draw on to enrich a lesson.

“Lot of internet applications-primarily youtube clips because of great animations and video on them because it brings subjects to life for kids. I show a lot of websites with web graphics on it - still graphics. I find it really helpful with the material I teach. Lot of it is visual based - because science is a new language for these kids and so if you put a picture to words it really helps - I do it almost on a daily basis. I show the occasional science videos.” 5.02

Technology offered a platform to organize course materials. Although the school provided CMS tool- Moodle was used by many teachers, it was not the only one that served this purpose. For example, Biology teachers were using an online textbook that came with many of the features of a cms.

“We have chosen a new textbook that has several different online components. I can send class announcements, messages, develop tests, grade them (not used much), Powerpoints. Students can look at Powerpoints, look at video clips, practice tests, doing practice online labs. It’s a Prentice Hall book -Adv Bio by Mader and the online management tool is called Aris.” 5.14

Similarly, a CISCO networks teacher used the online CISCO academy to teach his students as well as interact with the online community for sharing problems and solutions related to day-to-day teaching activity.

“They are all integrated. For example when I go to the CISCO academy, they have a group of people that write the curriculum and distribute it to the different academies and everything is - we have lab exercises integrated, worksheets all integrated to the technology that’s online. So we don't have any books.
Thus, teachers were finding many reasons to engage with technology.

**Inhibiting factors in using technology for teaching**

*Primary Contradictions*

It was not surprising that teachers faced many difficulties while using technology. There were many instances where the tool itself was a problem. This may be due to **compatibility issues** between different tools or within different versions of the same tool; **usability issues** where it may be awkward to use the tool due to some flaws in the design of the interface; and **reliability issues** where technology may crash or fail during the class! Such contradictions fall in the primary category of tool (TT). Hence their solution lies outside the control of the teachers (perhaps a tech-savvy teacher may be an exception) and more in the purview of the IT Staff. A more serious problem was that of competing objectives. Teachers had to cover their curriculum which was of course a more important objective to achieve than curriculum integration if faced with a time constraint. This was a primary contradiction within the object of the activity (OO).

Teachers struggled with **compatibility issues**. For example, Science teachers were having problem using the Sympodium because it was incompatible with the logger probes software.

*“Logger pro software not compatible - version problem”.*  

Another science teacher was not able to use the powerpoints provided through his textbook in a manner that he would have liked. So remaking those powerpoints just so he could use it with the Sympodium seemed like a lot of time which is why he wasn’t using the symposium.

*“…. I can write things on powerpoint but unlike Sympodium, I can't save it.”*  

Sometimes updating to a new version of the same software had issues as in the case of a tech-savvy teacher who was using a technology regularly before but had to abandon it once the new version came around:

*“I actually like technology so I adapt. But the calculator emulator is a new version - freezes up on me - and I don't know why and that's frustrating (laughs) the old version didn't do that…”*
Although Google Docs was a big favorite and had been adopted independently by a lot of teachers even before the school district implemented it internally, some teachers were already finding issues, specifically with its powerpoint feature:

“Yes, kids do a lot of Google Docs. In bio they will build presentations. Most recent lab had them produce a Powerpoint presentation. Now there is problem in there trying to interface regular Powerpoint presentations with Google Docs. Google Docs has its own presentation Powerpoint program but it’s difficult to put their graphs together. Kids usually build their graphs in Powerpoint but it doesn't integrate well with Google Docs. So they end up taking pictures of the graph and copy and paste it on Google Docs. The problem with that is if you have to go back and redo the graph or tweak it you just can’t do it. They cannot build it in Google Docs so they can't manipulate it in Google Docs”  

Teachers also faced usability issues with technology. Some teachers found difficulty in using technology simply due to awkward design features:

“I use the Symposium but not that often. It’s difficult for the student to read when I write on the Symposium. I don’t like the stylus pen. Whereas if you type up the notes, it’s a lot cleaner. The handwriting on the Symposium is very sloppy.” 6.05

Technology was also perceived as having reliability issues. It often failed during the class prompting teachers to go back to the chalk and board. It impacted how far teacher would go in adopting it on a regular basis. As some teachers note:

“It’s a real pain in the neck. I really like it. I like most of it. But if it’s not working properly, give me a chalk and board. You can show the video, use the software, but if it’s not doing what it’s supposed to do, a simple thing like laptops running out of batteries so kids are scrambling to do stuff. All you need is cords but it’s attached to the laptop carts. As nice as it is, it can be a pain in the neck as well.” 5.09

Thus, even if teachers are skilled users, if technology cannot be relied on, or have usability or compatibility issues, they would be discouraged from using it. The IT administration can approach this problem by gathering information from teachers regarding the tool related problems, especially, each time a new update to an existing technology is made, or a new technology is introduced. They may even, as a preventive measure, gather information from their contemporaries in other schools where such technologies have been introduced. At times, a pilot test by having a tech-savvy teacher try out these changes may also reveal breakdowns before school wide implementation. Thus the AT framework helps in identifying that the initiative for solving tool related contradictions primarily lie with the IT Staff.

Another primary contradiction noted was between the competing objectives of curriculum integration and curriculum completion. One math teacher was fairly candid about the high teaching load she had due to which there was hardly any time to experiment with technology-
This problem is related to the lack of time that forces a teacher to choose between one over the other to the disadvantage of technology use in the class. Time had a ubiquitous influence in how it impacted the use of technology as described in the next section.

Secondary Contradictions

Lack of time was professed as a major factor in teachers’ uptake of technology. It didn’t matter whether they had a low or high self-efficacy in using technology. Teachers needed more time to learn about technology, more time to play around with technology, more time to transfer their learning of technology into the classroom context, more time to troubleshoot breakdowns in technology, and more time to teach students about technologies used in class. This was a secondary contradiction with rules that determine how much free time a teacher is assigned during the week, affecting the use of tools (RT). Thus the solution lies in the purview of the school administration.

Even though teachers were getting on-site training in new technologies, the school had not planned additional time for them that would be needed to transfer the learning. As a math teacher commented-

“As it happens, after you have learnt how to use a new technology, it takes some time to expand it how to use in class”.  8.08

A tech-savvy Biology teacher also faced this obstacle towards adopting a new technology-

“One thing that we are being pushed right now is the Sympodium .......I tried using it but found that it was more frustrating than helpful at this point. I know that there are other colleagues who love it, absolutely love it, but I don't have the time to play around with it - I hate to use that as an excuse but..”  1.11

Teachers did not have time to troubleshoot problems during the class. A tech-savvy Math teacher illustrates this point across with an example of calculator emulator that he had been using regularly-

“I actually like technology so I adapt. But the calculator emulator is a new version- freezes up on me, and I don’t know why and that's frustrating (laughs). The old version didn't do that and so I don't know why, and I don't have the time to find the answer - so time is an issue.  4.08

Not only did the teacher need time to get more adept in using technology, but when it came to curriculum integration, even the students needed that extra time to learn the technologies that they were to use. Although most of the students were taught basic technology skills before coming to the class, there were always some students who may have transferred from other schools or others who needed to be brought
on the same page. So the in-class time as scheduled does not factor in the additional time that is required to fit the technology into the curriculum.

For example, a biology teacher explains-

“‘It’s not that it’s difficult - for example to take time to learn iMovies. ...... To teach some of the students how to use iMovies and then to give them time to use it, requires huge chunks of time and we don’t have enough of it.” 6.11

An English teacher echoes the same problem-

"Time is a big issue. Not only to learn about the program yourself but to take the time to teach your students the process before you can actually get to the actual assignment...." 20.07

School administration, IT Staff should take cognizance of this issue of lack of time and help teachers to find ways to get around it. For example, teachers could be given more flexibility with their curriculum. In a follow-up interview with a Business Education teacher after observing a combined class on a common topic he shared with an Economics teacher, I found that they took more time to cover this topic with curriculum integration than they would have otherwise. He also commented that he could try this sort of collaboration because he had relatively more flexibility with his curriculum than other teachers. Apart from changes with the curriculum load, other alternatives can also be explored. For example, as stated by a Math teacher, reuse of materials with the Sympodium helped run her class smoother and saved time as well. IT Staff can identify and encourage the use of time saving devices and materials that can be reused. IT Staff could also provide training to teachers’ aids so that they can assist students in using technologies during class as well as help teachers to troubleshoot technology problems. This would help minimize the additional in-class time that technology use entailed. Sometimes, a tech-savvy student may also be encouraged to help. Students themselves may be organized as a resource to bring other students up to speed, say, during study halls or as an after-school activity. University partners could be utilized to design more interdisciplinary curriculum that integrates common topics across subjects. More such solutions could be brainstormed. This way, teachers could save time and devote the freed up time to learning better use of technologies.

Budgetary constraints were a major factor that determined the availability of tools. Some teachers who had already been using a technology for teaching in their class could no longer avail of those technologies when the budget was reduced. This was a secondary contradiction between Rules and Tools (RT) where availability of funds directly influenced the availability of tools.

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“I have used in the past, the Logger Pro before but not used for a few years now. They got it from a University Outreach program, the probes - it was not the best quality. And then there were issues with the external provider not having enough funding.”  6.02

Another science teacher also echoed the same idea:

“Equipment not enough for sharing with other teachers, accuracy goes down and expensive to get more”  1.32

A Maths teacher had her students use the Calculator based Laboratory (CBLs) as a group because there was not enough for each-

“The kids feed the CBL data into their calculators and model. We don't have enough CBLs for each kid but enough for groups”. 4.07

Schools are still far away from achieving one-to-one computing and sufficiency in other educational technologies. Until then, other ways to make technology available to teachers through sharing whatever resources are there should be devised by IT administration with the help of department and school leaders. University partners could also seek funding to help them provide educational technologies to schools in surrounding areas.

Some teachers also complained about insufficient training. The school provided on-site training several times during the year. The focus of these trainings was mainly the CMS tool called Moodle. Other than that they also threw in a mix of different multi-media and productivity tools such as iMovies, Photoshop, PageMaker and Office products. The Sympodium was a new tool that they had begun to introduce in the Math and Science departments. One teacher mentions the lack of sufficient training as a factor in its slow adoption. The amount of training was determined by the IT Staff. At the same time, they were fairly open to requests by departments or teachers for additional training for a specific tool (with the exception of a subject-specific tool). One teacher felt the need for more training:

“We have had only one training session. I tried using it (Sympodium) but found that it was more frustrating than helpful at this point.”  1.13

This is a secondary contradiction (SR) where the Subject is not feeling confident in his/her ability due to lack of enough training provided through the IT administration’s Rules. It is possible that some other teachers may be satisfied with this amount of training if they are more tech-savvy or have more time to play around with the tool.
Teachers’ beliefs and attitudes also acted as a barrier. They had their own views and beliefs about technology which could hinder the extent of its use. This would be a secondary contradiction where a Subject’s beliefs directly impact the use of Tools (ST).

“Technology fails, crashes, access to computers because other teachers are using the carts. Keep up to date with tech change.” 10.03

“I am not a believer in making Powerpoint.” 11.08

Sometimes teachers had deep philosophical reasons and questioned technology’s purpose in achieving the objectives of the teaching activity. This was a secondary contradiction between a Tool and Object of the activity (TO). For example, in trying to achieve the objective of teaching students concepts, a science teacher reflects how technology short circuits the process that is required for deep understanding:

“I started teaching w/o comp. I find them to be a double edged sword. I find them to be incredibly helpful, but at the same time there is disconnect between the technology and the concepts that you are trying to arrive at. I’m hoping I am making this clear. I will just use an example. If you asked the students to graph something, they can probably do it on a computer but they probably won’t understand scaling something. So scaling, well the concept would be lost because it’s taken care of by the technology and they’re like well how should I do this and they find it to be too much effort. So I think technology removes some of that thinking process, does it allow for a deeper thinking process? Potentially! But I think it depends on purpose.” 18.01

Similarly, in trying to achieve the objective of student engagement with the subject, some teachers find that technology can be a distraction:

“For most of what we do it isn’t necessary to use the probes, for example, I think that sometimes the students get too caught up with the technology and don’t really understand what was occurring with the actual lab itself.” 6.03

“I tried to use Moodle for discussion. It distracts from the content. Technology becomes the focus.” 12.04

An important objective for all teachers is to finish the lessons on schedule. As one teacher pointed, technology needs more in-class time:

“It’s difficult enough to get thru the curriculum. To teach some of the students how to use iMovies and then to give them time to use it, requires huge chunks of time and we don’t have enough of it.” 6.11

This is a secondary contradiction (Tool-Object) that exemplifies the problem that having students use technology may result in not achieving the objective of completing lessons on schedule.
<table>
<thead>
<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Comm.</th>
<th>Div of Labor</th>
<th>Rules</th>
<th>Contradictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching concepts</td>
<td>Teacher</td>
<td>Graphing with computer</td>
<td>Teacher</td>
<td>Teacher IT Staff</td>
<td></td>
<td>Tool gives short cut to solution Tool-Object (secondary)</td>
</tr>
<tr>
<td>Discussion and reflection (Curriculum Integration)</td>
<td>Teacher</td>
<td>Online discussion</td>
<td>Teacher</td>
<td>Teacher IT Staff</td>
<td></td>
<td>Tool causes distraction</td>
</tr>
<tr>
<td>Data analysis (Curriculum Integration)</td>
<td>Teacher</td>
<td>Calculator Based Labs (CBLs)</td>
<td>Teacher</td>
<td>Teacher IT Staff</td>
<td>Budget</td>
<td>Shortage of tech. Tool-Rule (secondary)</td>
</tr>
<tr>
<td>Data collection (Curriculum Integration)</td>
<td>Teacher</td>
<td>Logger probes</td>
<td>Teacher</td>
<td>Teacher IT Staff</td>
<td>Fixed Periods</td>
<td>Requires more in-class time Tool-Rule (secondary)</td>
</tr>
<tr>
<td>Curriculum Integration (vs. Finish lesson on schedule)</td>
<td>Teacher</td>
<td>iMovies</td>
<td>Teacher</td>
<td>Teacher IT Staff</td>
<td>Fixed Periods</td>
<td>Requires more in-class time Object-Object (secondary)</td>
</tr>
<tr>
<td>Teaching with technology</td>
<td>Teacher</td>
<td>Logger probes, Symposium, Google Docs, Powerpoint, calculator emulator</td>
<td>Teacher</td>
<td>Teacher IT Staff</td>
<td></td>
<td>Technical issues (unreliability, usability, version problems, compatibility) Tool-Tool (secondary)</td>
</tr>
<tr>
<td>Teaching with tech. (low efficacy)</td>
<td>Teacher</td>
<td>Symposium</td>
<td>Teacher</td>
<td>Teacher IT Staff</td>
<td>Amount of Training</td>
<td>Insufficient training Rule-Subject (secondary)</td>
</tr>
</tbody>
</table>

**Table 5.4: Teaching Activity**

Table 5.4 summarizes the discussion in this section. The Objects enlist the different tasks that teachers have attempted but not able to achieve the expected outcome with the use of technology. For example, when teaching concepts or for a deeper understanding, it is not always the best thing to use technology as the science teacher found while using the graphing program. The program did not help in understanding the concept of scaling, because technology tends to remove the thinking process that is needed to understand the concept (18.01). Teachers related several instances why they would be wary of integrating technology with their curriculum. They felt that sometimes students got too preoccupied or distracted with the technology and lost the real point of the lesson. Moreover, the use of technology required more in-class time and the length of the periods did not allow room enough to integrate technology with the lesson plan. Lastly, the shortage of technology due to budgetary constraints also prevented teachers from planning curriculum integration.
Another objective that is important for teachers is to finish the lessons or topics on schedule. However, they discovered that using technology required additional time. This prevented them from planning technology into the curriculum especially if they did not have the flexibility to modify their curriculum.

A common problem that teachers faced was the issues with technology itself. Technology could be unreliable, awkward to use, incompatible with other tools or with its other versions and so on. Such problems discouraged teachers’ use of technology for teaching.
Fig 5.4 further illustrates these points by visualizing the contradictions and associated elements within the activity theory framework. It is a pictorial description of all the elements and associated contradictions.

By viewing the discussion as a triangle, it is easier to locate the causes and effects of problems associated with teaching with technology and then brainstorm ways to reduce or eliminate the tensions and thus hope to increase the use of technology in the classroom. For example, how is technology accommodated in the classroom given the fixed length of periods? Can technology availability for teachers be increased without increasing the budget? How can the training needs be identified in time? How can the teachers leverage the resources within the community? If alternative solutions can be found to solve these issues, it would speed up the adoption of technology in teachers’ daily classroom activities.

5.4 Discussion

This chapter provided an analysis of teachers work practices with respect to technology use related to the classroom activities. The result was divided according to the broader categories of administrative, collaborative and teaching activities. The objects within each category were extracted from the patterns emerging from relevant snippets. Gazing through the analytic lens of AT, it was possible to identify, and thus, articulate several tasks/activities that teachers are finding ways to accomplish through technology. Several teachers had talked about the lack of time required to transfer the knowledge gained through professional development efforts to actual objectives. This list of tasks can be used by professional developers to make their training program more customized to the needs of teachers. Additionally, designers of technologies for education can also use these as a guide to make the technologies more useful for the teachers. Please note that this is not a complete list of tasks/activities but only those that emerged from 20 interviews. However, it provides a starting point from where more tasks can be elicited in a focus group, department meetings or training sessions. In the paragraphs below, I summarize the tasks/activities and the related tools as well as implications for designers and professional developers. Finally, I also give a complete list of objects which includes results from an earlier study (Sinha et al, 2012).

For classroom related administrative activities, the tasks identified were collecting assignments and giving feedback on assignments, grading, communicating and reporting grades to parents and students, maintaining course calendar. Except the last task, the rest are related to evaluation process. Thus, designers can think of integrating all these tasks. Currently, teachers are using different tools for grading related administrative tasks, such as, Grade Book, Exam View, Filemaker Pro, Email, Moodle, hard copy,
Google Docs. There is also the use of an Audio program for ESL for giving feedback to students who are learning to speak English. Designers could use this information to select the affordances that make them attractive to users for grading and integrate all these affordances into a single tool. Also, since the teachers are using multiple technologies for grading tasks, it results in lack of a common ground to share practices. It also makes more work for professional developers as they may have to unnecessarily train and support multiple technologies.

Another issue of tracking submissions of assignments through different modes (that is, through email, Moodle, Google Docs, hard copy) also needs to be resolved. A short term solution would be teachers enforcing Moodle or the tool of their choice as the only way of accepting submissions (a few students may request for exceptions). If they cannot upload, they could scan and upload once they are in school. It is also noteworthy that Math students are submitting assignments in handwriting due to lack of any tool that is easy to use with equations and graphs. A short term alternative would be to help them scan these assignments and upload on Moodle. However, Math teachers are not using Moodle because they like to use the Sympodium which allows them to write as they teach. It is not a cms tool. So, IT Staff may need to deliberate on how to integrate all the tools to flow through one system as far as assignment submissions are concerned. Students using Google Docs for collaborative assignments could always save the final document and upload on Moodle or place a link to their assignment in the relevant Moodle submission box. These solutions may slowly develop in building new norms of use of the cms tool for assignment submissions.

The possibility of keeping the parents informed about the grades is a positive step towards including them as partners in educating the child. The Biology teachers were using GradeBook which allowed them to email grades to the parents. By following the child’s progress, parents can put interventions at the right time at home. For example, they can provide additional tutoring, or watch out if the child is spending too much time in other activities like watching TV, playing video games, partying, etc. Designers can take note of this and integrate the grading tools to include this feature.

For classroom related collaborative activities, Google Docs was the dominant tool as far as student-student collaborations on assignments, lab work and student-teacher sharing of lessons was concerned. There were a few glitches noted in its compatibility with powerpoint and its inability to make graphs, but hopefully, subsequent versions of Google Docs should be able to solve them. For classroom related collaborations among teachers, the emergence of the tech-savvy teacher as a catalyst was noteworthy. So far these collaborations were mostly happening among teachers who taught the same topic in different
subjects (Savings & Investments topic in Business Education and Economics) or for enriching a class with new learning experiences (ESL and Social Studies) where teachers divided the labor according to their strengths with one teacher taking the lead in handling the technology aspect. Science teachers were finding that the new data collection device (vernier sensors) allowed them to combine multiple classes in a lab to collect data. School administrators should note these spontaneous collaborative activities among teachers and find ways to encourage such initiatives. For example, make sure that all technology needs are provided and an IT Staff is available should any glitches occur during class. It is more important to help such initiatives at the very beginning so that teachers may not get discouraged from attempting such collaborations again.

A different kind of collaboration was occurring online for a teacher who taught CISCO. This was completely online and available all the time. Unlike other collaborations which was planned and occurred for the planned duration of one period or several periods over a week, this online community was available every day and even during the class period when teacher had trouble with a lesson, he could expect to get an answer within 15-20 minutes of posting a question on this forum! Designers and IT Administration could take some ideas from here for an online forum where teachers could post a question and get a quick response from IT Staff or other tech-savvy teachers even in the local community.

The collaborations witnessed so far did have some contradictions. The storage limitation for submitting large assignment files could have been a major hiccup because the IT Staff, due to regulations, was not able to help. So, the tech-savvy teacher solved this on his own by using the server space on the IT teachers’ server who was a colleague in the same department (Community). Here, the role of the IT teacher is noteworthy who has the technology resources and may be amenable to provide help for colleagues out of collegiality. In order to continue holding more such collaborations in the future, the tech-savvy teacher bought additional server space on the IT teachers’ server with department funding. When asked whether he provided help to other teachers, the IT teacher said:

“Ya there are a couple of teachers who brought in their computers asked me to fix their computers or some advice on how to fix some things. Today the Social Studies teacher asked me this morning to help with power supply. I asked my students to do it. It’s mostly the students who do that - some people don’t realize that if you go to Geek Squad in Best Buy you are spending 150 dollars to fix their machine. IT Staff won’t do personal computers. So teachers bring their own PCs if they need help.”

Thus, not only the IT teacher, but his students (Community) can also be a valuable resource in supporting teachers’ uptake of technology. The IT administration can take note of this and identify tasks that students can do as part of their coursework in Information Technology.
Another contradiction in teacher collaborations rose out of scheduling class periods (Rules). To encourage more collaborations happening in the future, school administrators can provide some room for flexibility in assigning periods or even make some periods longer, especially when different subjects are combined in a class. Technology enhanced collaborative classes were typically taking more time to complete. As a chemistry teacher mentioned, if the two classes were scheduled back to back, more collaborations would occur. This was also echoed by an ESL teacher when asked what the motivating factors were behind her collaboration with the Social Studies teacher:

“We had a pretty large goal from the beginning that we wanted to accomplish and it would not be possible with one adult. We also needed more time and because we teach periods back to back it made more sense to take both of our class periods.”

At the same time, some steps may be needed to investigate why such collaborations were taking more time to complete. Is there a need to make any curriculum adjustments? If so, the school administration (Rules) can devise ways to tackle this by encouraging dialogue between department heads, within departments and same subject teachers (Community) to find ways to teach same topics such that the courses/topics may be covered faster. Or, is it due to the learning curve involved? If so, what kind of professional development interventions may be needed (DOL)? And so on.

Finally, the analysis of teaching activity revealed the motivating factors that drove teachers to experiment with technology as well as the inhibiting factors that prevented them from using it even when they had become skilled users. Some of the positive factors were features that offered them a way to share materials, a way to collaborate with students/teachers as well as facilitate student collaborations, a way to communicate with students/parents and hold online chats/discussions. Technology integration made delivering the lessons smoother and efficient. It also added convenience because teachers could work from anywhere and reuse the materials they developed. Teachers used multi-media for enriching the learning experience and engaging students with different learning preferences.

However, as expected, the teaching activity faced the highest number of contradictions in comparison to all other activities. The primary contradictions were related to Tools, such as usability problems, version problems, incompatibility and unreliability. This falls within the complete purview of IT Staff. Teachers do not have control over Tool related problems. Adoption of Google Docs was a great leap forward in getting rid of version and incompatibility issues. However, some problems still remained with Google Docs. The issue of unreliability such as technology freezing, crashing was still a deterrent for teachers’ planning for curriculum integration. All these resulted in adding to the time it took to finish a lesson in the
same time as it took without the use of technology. Hence, it is important for the IT Administration to place these issues on top of their list of priorities. As far as the problem of teaching concepts with the help of technology is concerned, it is the teachers who make the judgment.

The teaching activity also faced some secondary contradictions. Teachers had a low self-efficacy (Rule-Subject) with technology because it was a moving target and they were always lagging behind. This could be a constant struggle for teachers. Hence, IT Staff should pace the introduction of new technologies so that it does not become overwhelming. At the same time, there is a push towards using the latest gadgets out there that students are already using. So a balanced approach towards introducing new technologies is needed.

Another reason for low self-efficacy cited by teachers was that the professional development was not given to them at the right time when they needed it. Neither was it geared towards their specific tasks. So there was a knowledge transfer required before they could actually use it. So, professional development efforts can be designed for teachers with examples of actual tasks that they perform in the classroom with that tool. For example, to learn how to use Google Docs, they could work on a collaborative assignment using Google Docs in a training session and then grade it themselves. Alternatively, school administration could provide more time to teachers to play with technology. Or, encourage better use of department meetings or in-service days for building technology skills by sharing practices with colleagues.

Another secondary contradiction was the shortage of technology (Rule-Tool) due to budgetary constraints. Teachers were sharing laptop carts. If they were not sure of getting the laptops, they were not sure of planning it into their curriculum. Again this issue needs to be on top of the list of priorities for the IT Staff. Perhaps they could devise a better way of scheduling laptop carts so that teachers have some sense of their availability a week or two in advance. For example, a weekly availability report – sort of like the weather report.

Thus the teaching activity is where the rubber meets the road. As such, contradictions associated with this activity have the potential to cause major breakdowns in teachers’ adoption of technology and render the massive investment in the 21st century vision for education ineffective. Hence viewing it through an AT framework offers a useful guide to find the right people to start solving the problems. The table 5.5 below summarizes the enabling and inhibiting factors from section 5.3.
This study also adds to these contributions. Here I include the findings from the previous chapter for listing technology use by teachers for general work practices as well as technology use for classroom. This study builds on earlier contributions (Russell et al, 2003; Buzzard et al, 2011) by identifying different objectives for the uses of technology. Russell et al (2003) conducted a survey to identify teachers’ technology use. They identified 6 distinct uses, noting that they did have some amount of overlap. They found that teachers used technology for preparation, for delivery, for directing students’ use of technology, for special education and accommodation, for e-mail and for recording grades. More recently, Buzzard et al (2011) provided seven categories of educational activities based on response from a survey. They found that teachers used technology for course planning, course management, teaching, assignments, assessment, grading, and overall general needs. They concluded that in order to prepare teachers to teach with technology professional developers need to move away from focusing on teaching technology and instead focus on teaching with technology.

<table>
<thead>
<tr>
<th>Enabling factors</th>
<th>Inhibiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>share course materials with students</td>
<td>compatibility</td>
</tr>
<tr>
<td>facilitate student-student collaborations</td>
<td>usability</td>
</tr>
<tr>
<td>online discussions/chats</td>
<td>reliability</td>
</tr>
<tr>
<td>smoother and efficient teaching (saves time)</td>
<td>lack of time</td>
</tr>
<tr>
<td>work anytime anywhere</td>
<td>lack of availability</td>
</tr>
<tr>
<td>reuse of materials (saves time)</td>
<td>budgetary constraints</td>
</tr>
<tr>
<td>organization of materials</td>
<td>insufficient training</td>
</tr>
<tr>
<td>enrichment of learning experience</td>
<td>teachers’ beliefs, self-efficacy, attitudes</td>
</tr>
<tr>
<td>access to online resources</td>
<td>hard to teach concepts</td>
</tr>
<tr>
<td>caters to different learning styles</td>
<td>tool causes distraction</td>
</tr>
<tr>
<td></td>
<td>tool requires more in-class time</td>
</tr>
</tbody>
</table>

**Table 5.5: Factors affecting the use of technology for classroom practices**

related practices from this chapter. Table 5.6 lists the higher level activities with examples of related objectives. Please note that this is based on 20 interviews only and hence there is no claim of it being a complete list. However, this study does provide a starting point to gather more and more uses of technology by teachers and a framework to organize them in a way that designers can use as scenarios to build technologies more focused for teachers as users. Additionally, professional developers can use these as a guideline to provide training for teaching with technology instead of teaching about technology. Researchers have pointed out that since the early 1980’s teachers’ work tasks have increased and become more complex (Larson-Sarfatti, 1980; Apple, 1989; Hargreaves, 1994; Gannerud, 1999; Day 2000;
<table>
<thead>
<tr>
<th>Classification</th>
<th>Activity</th>
<th>Object</th>
</tr>
</thead>
</table>
| **Technology use for general work practices** | Planning | Lesson Planning  
Sharing/storing materials  
Organizing lessons  
Gathering materials |
| | Administration | Admin activities for school district (grading, attendance, sick leave or vacations, inventory, room reservations, budget, etc)  
Admin activities for group (updating calendar)  
Admin activities for department (scheduling, conducting meetings, setting exam dates)  
Admin activities for individual teacher (grading and sending emails to parents) |
| | Collaboration | Develop materials  
Share materials  
Curriculum development  
Learning technology  
STEM initiative |
| **Technology Use for classroom related practices** | Administration | Grading  
Setting up and maintaining course calendar  
Communicating and reporting grades to parents and students  
Collecting assignments  
Feedback on assignments |
| Teacher-Teacher collaboration | Teaching a combined class in the same subject  
Teaching a combined class across subjects  
Troubleshooting technology courses  
Providing an enriching learning experience |
| Student-student collaboration | Group assignment work  
Group lab work |
| Teacher-Student collaboration | Sharing lessons with students ahead of class; incremental feedback |
| Instruction | Teaching concepts  
Discussion and reflection (Curriculum Integration)  
Data analysis (Curriculum Integration)  
Data collection (Curriculum Integration)  
Curriculum Integration  
Teaching with technology |

**Table 5.6: Teachers’ technology-enabled work practices**
Grundy & Bronser, 2000 as cited by Aili C et al, 2007). Grante (2009) states that while new work tasks have been added, such as, those related to school development and work team activities, none have been taken away. Thus teachers have less time now to complete their tasks than before. The issue of time is the central theme in a study by Karasavvadis (2009) using AT as a framework to understand 51 teachers’ concerns about incorporating a CSCL innovation, specifically in their classroom. The findings were based on the teachers’ responses on an online forum. These findings match with my findings on the problems teachers face with respect to time. For example, teachers faced competing objectives of finishing lessons on time, that is, covering the already demanding curriculum on the one hand and the objective of integrating technology into the curriculum on the other which required more time. This matches the contradiction within the object of activity described in Karasavvadis’ paper. He also describes a contradiction between the meditational means (tool) and the object of activity, that is, curriculum coverage. Examples of these are also found in my study such as tools required more in-class time and caused distraction which negatively impacted the object of finishing lessons on time. However, he has linked time constraints squarely with the bulk of curriculum material that had to be covered. According to him, although teachers mentioned these two separately, they were, in fact, linked. Thus, according to this view, curriculum was the sole reason of lack of time in the classroom.
Chapter 6

Teachers’ Professional Development Practices in Technology

The Pennsylvania State Department of Education acknowledged the vital role of Professional Development as the key to success of the Classrooms for the Future Program. They stated that to create 21st century instructional settings, not only teachers but also administrators, technology staff and coaches needed to adapt to the changing environment. Although teachers needed to learn how to use the equipment provided as part of the program, more importantly, they needed to design learning experiences that fostered the development of critical thinking, 21st century skills and responsibility for learning, which lead to lifelong learning. Hence they recommended that all district applicants agree to participate in professional development activities for leadership, coaches and teachers. The following were listed as professional development components:

(http://www.portal.state.pa.us/portal/server.pt/community/classrooms_for_the_future/8911):

- Hands-on vendor provided professional development sessions
- On-line blended study group courses through eMBEDDED Learning Academy
- On-site instructional technology coaches
- Leadership sessions for administrative staff and technology staff
- Ongoing professional development opportunities

Against this backdrop, I describe below the findings from interviews about how teachers were receiving professional development. The interviews of 16 teachers, 3 IT staff and 1 external provider revealed two channels of receiving professional development in IT, namely, formal and informal.

The formal training were mainly provided through the school’s IT coach, the external providers who came to the school or even to the classroom to provide training, the mentors who worked closely with their mentees and the tech-savvy teachers who had been inducted into the Keystone Technology Integrators (KTI) program. However, we may consider Mentors and KTIs as semi-formal.
The informal learning was taking place within the department, for example, among department peers, among same subject teachers, with tech-savvy teachers or between new and senior teachers. Informal learning was happening even across departments, although there were very few instances of it. The following sections describe these in more detail.

6.1 Standardized Professional Development Practices

Ongoing professional development and support by IT coaches was the most talked about activity that was making an impact on the teachers. Other than that hands-on training by vendors in science classes was also making a difference. In the following sections, I describe the standardized or formal professional development experiences.

On-Site Standardized Professional Development

IT Coach->teacher groups

The school was heavily invested in training teachers to realize the vision of Classrooms for the Future (CFF). The IT administration provided IT training specialists for each school. The high school was staffed by two IT training specialists who provided training sessions at intervals throughout the year. Laptop training sessions were held at the staff development office located at an elementary school. Teachers who recently received a free laptop were required to attend two sessions at the Fall and Spring of the academic year for which they received a day off and were provided with a substitute. IT Staff would also offer additional training at the high school in using school supported technologies during in-service days that teachers could sign up for. On special request they were willing to offer training or answer questions at the department meetings. They also provided lunch time training which, they found, was mostly attended by substitute teachers. Almost all teachers interviewed had been to the laptop training sessions or were planning to take them and placed a high value to this facility.

Laptop training sessions

As a rule, the IT Staff provided training to diverse group of teachers, that is, the attendees were a mix from any departments. They could bring along their colleagues from their departments if they wished. The training was not meant to be provided to groups of teachers department-wise. Moreover, the IT Staff was cautious in its approach to get teachers to attend so that teachers would not feel pushed. They provided free laptops to them and in return expected them to sign up for the Fall and Spring training sessions to learn how to use them. Once they came to the training, teachers also learnt about other tools.
The Fall session introduced the teachers to many tools, especially Moodle and Google Docs. The teachers would be asked to set their technology goals. At the Spring session, these teachers demonstrated how they were using technology in their daily practices, especially in their classrooms. The IT Staff believed that it was not the subject that these sessions were focused on but the strategies that teachers could use with technology. Hence they did not teach about subject-specific technologies - as one IT Staff explains:

“We have always done some optional summer workshops - 1/2 day, 1 day programs. But when we started introducing laptops and other equipment then we required them to come to training. That's where we introduced the Keva Project. This required to give them 1 day in fall off and give them a homework to come at the end of spring - that's our model. It's not the subject but the strategies that they use.”

14.11

According to the IT Manager about 85% of the training happened in-house. The in-house training was technology-based. The teachers also attended other training sessions outside the district, which was mostly curriculum-based.

“I would say that the bulk of the training is local - inside the district - there are some external things that teachers can go to. When able we like to provide it ourselves, to give the teachers the flexibility and custom-tailored to the school setting. I would say 85% of the training is probably in-house. There are times, maybe, the university or another district may be having a workshop or training or maybe an IU. And a lot of that which is outside the district, I mean this is my perception of it, is curriculum-based not necessarily technology-based. Most of the technology based training that we do is here .... We are lucky to have the staff that we have.” 16.21

These sessions also provided time for teachers to set their own technology goals (Appendix D) as an IT Staff explains:

“For laptop - 2 training sessions. We ask teachers to set some kind of technology goals.” 15.02

All teachers that were interviewed highly valued the training sessions provided by the IT Staff:

“CFF - huge grant that brought laptops to the English and Social Studies department teachers and training offered to use it was a ton of professional development. I would say that I have been to 6 of these sessions in the last 2 yrs.” 20.10

“They are very good at making sure that we know how to use it (Sympodium) - providing us training on how to use these. When I was a student teacher, there was a time when teachers were provided with desktops, which was a big thing at that time but they never used it - it just sat and sat there under the desk. Now here we cannot do this - the attendance is online. Some of them never even took it out of the boxes.” 9.19
Lunchtime training sessions

Apart from the laptop training sessions, teachers also had the option to attend ongoing lunch time training. However, none of the teachers interviewed had been to these:

“They have lunch special session to show more advanced features of Moodle. I haven't been to any of those.” 9.15

The researcher was informed by an IT Staff that lunch meeting session was not well attended and if at all, only substitute teachers attended them.

In-service days training

In-service days were another platform to provide training.

"You have the option to attend IT training during in-service. ....... At the last in-service (in Oct) the teachers attended 2 workshops. Half day was on website development and then 2 workshops on Moodle. It was offered to all teachers in the high school.”       2.22      PD

“'Our in-service days are different - sometimes they are just department, sometimes they are building, sometimes they are records. We have 3 in-service days coming up next week. Each morning is the department and the afternoon of the first is records so that we have time to do our grades, the afternoon of the second and the third is the building where the building principals could choose different things that they would like to talk about, and sometimes that's training- technology training - and sometimes its district-wide where we usually have a lot of sessions to choose from and we have to sign up for it – it's almost like a conference where you would go to the diff workshops.”       4.17

Sometimes, departments could request special training for their members during the in-service days.

“The website training was offered to our department only. This was offered by an IT Staff who handles the website here.”       2.23

However, some teachers felt that the choices were limited and did not satisfy their needs. The school made decisions regarding the activities during in-service days and these were not focused on developing IT skills.

“'These are Act 80 days. You don't get to say what you want to do. You don't get to make your own choices. So if you wanted to go up to Penn State you won't be able to do that, because the school already has a set of activities designed for you. As far as the CTC is concerned, the entire school takes basically the Act 80 or the in-service days. You don't get to make your own choices. They decide the activities. For example in the last one they did PSSAs and how to deal with school absences. Not a real professional development tool. So - not really much of professional development. All the teachers have to go even if they know these topics - covers scheduling. Altogether, fifteen in-service days in a year - not much of IT.”
As with any formal on-site programs, they follow a schedule which may not fit the needs of all teachers. One teacher lamented,

“Here they don't necessarily teach us what we need to know. They don't teach us at an appropriate time - like just before we are going to use it.” 11.09

**External providers**

**University provided Job-embedded training**

School departments took the initiative when it came to technologies that were specific to the subjects they taught. On request the school district could provide the funds. In some cases, University education departments provided professional development services as well as all the equipment that were targeted to a specific subject area. They provided job embedded training, that is, they worked alongside the teacher as they taught in a classroom until the teachers could use the technology on their own. The biology department teachers described how they benefited immensely from this training. The school district had provided financial support but, unfortunately, the funds had dried up:

“Another source that we have had up until recently is Jillian College’s Science & Motion program. They bring materials to us - drop off stuff for a week. For example we have a lab in the back room right now where they have brought us 8 laptop computers, probes... so we've got the little modules that talk to the probe as well as the computer... they bring the instructions and how to use those materials also. The program is offered to school districts in this County. So you look up their website for labs that you are interested in and they will bring you the supplies for those labs if they are computer based, if there is some other new technology they will teach it with you until you feel comfortable using it. They work with the teacher as opposed to the district.” 1.20

**University provided Course offerings: University->teacher groups**

Sometimes, regional universities provided on-site training in general technology tools. Teachers were motivated to take such courses for fulfilling credit requirements for professional development:

“I have taken summer courses - one was Photoshop (2008) actually, another was web design (2007) using Dreamweaver. Dreamweaver was more than what I wanted to get into so I requested to use Schoolwires - they were University credit courses. Those were offered thru the IU program. They were offered by outside of school but happened at the school site. There were other teachers also attending from other districts.” 5.21

**Vendor provided training: Vendor->IT coaches group**

On-site training by external vendors for IT Staff was uncommon. The IT coaches themselves preferred to go to off-site conferences for professional development in the technologies that were implemented in the
school district. They learnt about emerging technologies and came back with new ideas for adoption in the school system. It was not common to have on-site training for them unless they felt the need for it. However, there was one instance of where an external provider came in to train IT staff about new and advanced features of Moodle. The vendor felt that the school could be benefited more if they asked for training as soon as they had implemented the Moodle system instead of waiting too long.

“We would like when a school hosts Moodle with us we would love it if they would do training. But it’s not common - we’ll buy the hosting and may... y... y be we'll add on the training - but most schools are picking up the training as they recognize the need. And this is true with technology programs schools all over the place – it's- we'll implement the technology, spend tons of money implementing these new programs and then not do training and then wonder why things didn't take off. So ya - the training programs - the school comes to us and says it’s time for training” 19.01

**On-Site Experts->individual teacher (one-on-one)**

**Mentor**

The school also assigned teachers as mentors for new or student teachers. Evidence of the teachers adopting what they had learnt from their mentor was particularly high.

An English teacher had learnt to use audio editing from her mentor during her internship:

“..... And I learnt how to do the audio editing on papers from my mentor when I was an intern and I shared that also and I know of 2 other people who were in grad school with me who use it now to edit papers.” 20.13

She also learnt a subject-specific tool from her mentor:

“I use a program called 'read naturally' which is a reading program, on our computers, where the students listen to the story, read the story, find keywords on the story and then read it back to me. I learnt about it from my mentor where I student taught. She retired and that's how I got my job.” 20.14

A department coordinator was assigned as a mentor to another department coordinator:

“Professionally, I mentor new people in my position - in the last couple of years, coordinators of family studies and consumer science and another social science coordinator. And frankly, much of the mentoring with the Social Studies teacher is about how to use technology to make our job efficient - our jobs are way too big.” 8.23

A history teacher substituted for two years. His mentor shared all her materials with him on a CD. This made it easy for him to download all the presentations on Google Docs.
“Last year's mentor had taught it the previous years. We had face to face, in-class discussions, and she put all her materials on a CD Rom. I downloaded all on Google Docs and modified them very little as I go along with my lectures.”

The role of mentors can be particularly important for professional development in subject-specific technologies. Since the standardized training provided by IT Staff has left educational technologies to the departments, mentoring has a great potential in providing one-on-one training in an informal way to teachers. Perhaps, this role can be expanded to include not only new teachers but junior teachers as well.

Keystone Technology Integrators

The state also encouraged the development of tech-savvy teachers through a program called the Keystone Technology Integrator (KTI) as a space for tech-savvy teachers to share practices and reflect on new technologies. It was hoped that developing this resource would be an asset for technology integration efforts in schools. The KTI interviewee related several examples of how teachers were adopting what they had learnt from her. These teachers could be from other departments or even from other schools in the district. This resource was not yet formalized and as such the KTI did not have any written directive from the school about what was expected of her. Hence, it may not be appropriate to place this in the standardized training section. Most of what she provided was through informal channels – a teacher would approach her if she had heard about her from colleagues. Mostly she would help teachers who were in her network.

Since the evidence of adoption was so high, schools can encourage the development of more tech-savvy teachers as a KTI. Most teachers interviewed were not aware that there was a KTI in their school. Even the IT Staff were vague about KTI and their general role on teachers’ technology adoption.

The KTI interviewee was a department coordinator and very enthusiastic about technology. She related several accounts of how teachers adopted things they had learnt from her.

“Yes, I was really surprised as time went on as there are departments within my building and beyond that we had a guest librarian who came to me for help with some project that she was doing in Photoshop. Now she works on the other side of the school district in an elementary school. She still comes back to me every year for help and ...”

Sometimes she would hear back if teachers had adopted technology after getting her help.

“Ya, periodically I get story about like oh thanks for this, a fairly recent one- Precis? Are you familiar with Precis? – I was just sitting in a meeting with an English teacher and he mentioned how to help his
students to visually organize their thoughts from the web into, out of their linear thoughts into a web like thinking that’s more natural. It could be a little too much movement for some. And he later on mentioned that he was using it. I see more in my students, my colleagues may not be as excited.” 7.23

Some teachers also requested her to bring their students up to speed with technology skills training if required by the curriculum.

“Another example – It’s been a recent thing that everyone wants their kids to make movies for their project but they themselves don’t have a great comfort level with it – they just think that their kids automatically know, but they don’t. So I have movie making help sessions for kids. If a student brings in a camera that’s not compatible with iMovie, I am usually the one they come to. Health classes are pretty big on movie making.

She also helped teachers who were lagging behind:

“I finally got my neighbor teacher to digitize all his slides – my goodness, its 2010 and he still had a slide projector in his room!!” 7.23

There were other miscellaneous kinds of support as well that she was willing to provide if needed:

And oh, I get a ton of requests from sports coaches for making end of season DVDs. There is a robotic DVD burner and a printer in my classroom because we do the senior video. A lot of them say they want to use it but a lot of times they don’t know, so I end up helping them.” 7.12

She was also very creative and innovative about technology uses:

“I share more candid stories in a more casual ways. Show off to people how cool this conference is. One of my favorites is you can take this remote control out of the Wii and make a Smartboard out of it out of any surface. I think that’s amazing. So I share things like that”. 7.22

She relates her understanding about her role as KTI and also mentions that there are no clear directives as to how she should go about it. This indicates a lot of flexibility in how this role will develop.

“I think there is an expectation that KTI will stay current with emerging technologies and find ways to integrate them. Personal, professional ways – someone who can offer a role model, there is no clear directive. KTI get invited to annual summit – could not go last year. At the summit, they bring vendors to demo new technologies and KTI’s share how they are using technology. They take back to school what new things they learnt at the summit. So far I have not been to a summit. I did hear a lot of anecdotes and experiences from those who attended”.

From the evidence, it can be inferred that the recognition provided to tech-savvy teachers by conferring them the title of KTI has a great potential. This practice should be encouraged to motivate more of them to act as a catalyst of change within their networks. Teachers feel comfortable approaching someone they
know or someone their friends may recommend and who can be helpful just-in-time. In some ways they can lessen the burden on the few IT Staff in the building.

Table 6.1 summarizes the key points in site-based professional development.

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<th>Object:</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>DOL</th>
<th>Rules</th>
<th>Contradictions</th>
</tr>
</thead>
</table>
| TPD     | Teacher | General technologies, workflow systems | Teachers, IT coaches, IT Admin, School Admin. | IT Coach, Teachers groups | CFF, In-service days, training schedule | -is not just-in-time
|         |         | Dept teachers, School district teachers | KTI Teacher | Attend annual summit (optional) | -KTI program not well known in the school
|         | Teacher | iMovies, DVDs, Photoshop, Precis | Dept teachers, School teachers, School district teachers | KTI Teacher | Attend annual summit (optional) | -KTI program not well known in the school
|         | Teacher | Subject-specific tools, Teacher management tools | Mentee Mentee | Assignment of mentors | +high adoption
|         | Teacher | Subject-specific tools, Teacher management tools | Teacher | Assignment of mentors | +high adoption
|         | Teacher | Google Docs, Moodle, other district supported tools | Group of teachers | IT Staff | Laptop training, In-service days, Dept meetings | -Lunch trainings poorly attended, -just-in-time training not provided,
|         | Teacher | Google Docs, Moodle, other district supported tools | Group of teachers | IT Staff | Laptop training, In-service days, Dept meetings | -Lunch trainings poorly attended, -just-in-time training not provided,
|         | Teacher | Subject-specific technologies | Subject teachers, Dept teachers | External Providers | Availability of funds | -Funds dried up
|         | Teacher | Self-directed PD to fulfill IU credits | External Providers | IU credit requirements | -Teachers may sign-up for irrelevant courses |
|         | Teacher | Self-directed PD to fulfill IU credits | External Providers | IU credit requirements | -Teachers may sign-up for irrelevant courses |

Table 6.1: On-site Standardized Professional Development

Off-Site Standardized Professional Development

The standardized professional development programs that were held off-site had the potential to fill an important gap that the on-site IT Coach provided training did not address. That is, since the off-site
workshops and conferences focused on content/pedagogy, they could also add subject-specific technologies on their agenda. So far, by most accounts, these conferences mainly focused on the subject’s content and/or pedagogy. Technology, at best, was a peripheral concern. The school had a funding process in place and would give time off to teachers if they wanted to go to these events. Nevertheless, cost was prohibitive and as such only a few teachers were selected to attend these conferences, hoping that they would share what they learnt with their colleagues. However, there was not much evidence of sharing in a meaningful way. The IT Coaches attended some conferences annually and were better equipped with time and facility to disseminate what they had learnt to the teachers in their ongoing training sessions at the school. However, as already mentioned, the IT coaches did not cover educational technologies as part of the program.

**Cascade Model for teachers**

Due to the cost, it was not possible for schools to send all teachers to conferences. Hence, by default, it was expected but not mandated that the selected teachers who went to these conferences would share their experiences with their colleagues. Teachers had the option of choosing their own professional development programs. Teachers could apply for funding from the school district. Every 5 years teachers were required to have 780 hours of training. Some teachers were filling these with technology related courses. At times, they tried circumventing this problem by attending programs that were within driving distance.

“In the past we have gone to National Science Teachers’ Convention and that sort of thing is seriously cut now. It used to be once every two years. Being here on the east coast was much easier to go than when I was living in the mid-west. A select group of teachers would go.” 1.25

Most of the time, the off-site programs did not cover technology for subject-specific areas. They continued to focus more on the content, as one Math teacher mentions:

“I went to a stat conference but that had nothing to do with IT. A lot of college stat teachers were there and not as many school stat teachers. But it was good sharing ideas because I taught AP stat which is equivalent to college stat.” 9.22

An English teacher echoes the same view:

"Involving technology I would say zero. Other than that I have attended the TESL conference in NY.

‘There was no technology?’"
“None, actually there were some sessions on how to use iMovie but the focus of the conference was not technology.” 20.11

**Cascade Model for IT Staff & KTIs**

Off-site programs were most productively utilized as a cascade model by IT Staff and KTIs (Keystone Technology Integrators). The KTI program offers a forum for tech-savvy teachers who are selected and then invited to conferences to explore emerging trends in technology and share their experiences. An art teacher who had been inducted explains:

“KTI is about leadership in technology. Find people in PA who are leading the way in technology. My own interest in becoming a KTI was prompted by some colleagues. That was this summer in a week long program where technology was the main focus. I made enough of an impression on a few of my colleagues there that I was pretty competent with technology and asked me to apply. They thought that art needed to be represented in that group of people. (I was accepted as KTI last year).” 7.04

If accepted, they are invited to the annual summit. Once these teachers go back, they share what they have learnt with other teachers.

“There is a conference every February in Hershey and it’s an incredible conference, the PETE conference Expo – I have been there twice because they show the very newest and amazing technology; and a huge no. of educators from every discipline who are there and excited about it and there is a keynote speaker that really keeps you grounded that all the technology is to serve the students.” 7.19

The IT Staff mostly went to conferences on technology in education:

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<tr>
<th>Object</th>
<th>Subject</th>
<th>Tool</th>
<th>Community</th>
<th>DOL</th>
<th>Rules</th>
<th>Contradictions</th>
</tr>
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<tbody>
<tr>
<td>Emerging technologies</td>
<td>IT Staff, KTI</td>
<td>Off-site conferences</td>
<td>Online communities; vendors; other attendees</td>
<td>External Provider</td>
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<tr>
<td>PD in content/pedagogy/technology</td>
<td>Teacher</td>
<td>Off-site conferences</td>
<td>External Provider</td>
<td>Availability of funds</td>
<td>- Not focused on IT; - No meaningful sharing + technology courses focused on IT</td>
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Table 6.2: Off-site Standardized Professional Development

“A faculty at the local university organizes a 1:1 Computing Conference once a year. Sometimes one of us will go to the National Educational Computing Conference. Generally try to go to the one on the east coast called the State Educational Computing Conference every Feb.” 14.07
Thus, off-site opportunities were useful for IT Staff, KTI’s and very few teachers (CISCO, Computer Science). But for those teachers who attended, the programs were not providing any professional development in educational technologies. They continued to be content/pedagogy based.

**Self-directed by teachers**

Off-site programs were proving more beneficial to technology focused or non-traditional courses such as CISCO and Computer Science. Teachers who taught IT related courses valued going to professional development programs. Please note that these teachers were the only ones teaching the courses. As such, they did not need to share practices with anyone. One CISCO teacher describes how the school supports professional development by funding his request and providing a substitute:

“You have to go to conferences. You need CCNA certificate to be renewed every 2 years by going to their testing site..... The school sent me to an educational session in DC on ethical hacking conference. It was a workshop. I asked the school and the school paid for it.” 13.13

The school also provided support to the teachers by giving them time off and providing a substitute:

“What I am able to do is and the school does support this. Suppose CISCO is sponsoring an ACT 80 activity I can go to that. For example, I went to the CISCO Harrisburg twice this year and the school gave me a day off - provided a substitute.” 13.15

“I also went to one in Montgomery county in Philadelphia. Both these were this year and were covered by Act 80. Both were self-initiated. Good thing is, I have so many contacts in the industry they tell me, they email me about these events.” 13.17

**Online Standardized PD**

**Self-directed by teachers**

There were quite a few instances reported where teachers, on their own initiative, took online courses. This was a way to fulfill IU credit requirements as well.

A business education teacher was taking 9 credits of online courses.

“"Well, you know, public education teachers are required to have 70-80 hours of training every five years. I think, other than the credits I've taken (I'm taking 9 graduate credits this semester) - I take credits every so often to refresh, to maintain, I attend conferences every so often. ..... You do what you can to stay atop of technology changes, and not just technology changes, for my business classes also.

“So, how do you do these 9 credits? Do you actually go to off-site campuses?”
“These particular 9 credits are online classes... 17.09

Non-traditional courses were having greater success with online courses. For example, a CISCO teacher found them so useful that he was willing to pay out of his own pocket:

“Ya actually there is a couple of courses I have taken online just to try to get examples on how to teach students specific exercises, it was pen testing for security class - again I had to pay for that out of my own pocket - $500. I didn't ask the school because our school has small budget. I learnt about this course through the online colleagues on CISCO forum.” 13.18

Online courses and forums attached to these were an effective way for teachers’ professional development programs. In some way, online forums were a way to develop an online learning community of teachers who were members of the same course but were coming from different places. However, such communities, although of great value, were active only for a short while as a follow-up to a course they may have taken.

“Well, in a course that I took last year I went to a forum, it was a course on Teaching Algebra with Geometer's Sketchpad and you could go to the forum with some questions and answers. We could also post our thoughts and people could read what you thought. It was all a part of the course.

“Did you ever go back to the forum?”

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<thead>
<tr>
<th>Provider</th>
<th>Attendee</th>
<th>Activity</th>
<th>On-Site</th>
<th>Off-site</th>
<th>On-line</th>
<th>Formal</th>
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<tr>
<td>IT Coaches</td>
<td>Teacher (group)</td>
<td>Laptop training</td>
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<td>Taking courses</td>
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<td>Teachers (individual)</td>
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<td>Vendor</td>
<td>IT Coach but open to interested teachers</td>
<td>IT Coach training</td>
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<tr>
<td>Local Experts (KTI, Mentor)</td>
<td>Teachers (individual)</td>
<td>Mentoring Helping</td>
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<tr>
<td>Conference Workshops</td>
<td>Teachers IT Coach</td>
<td>Content Pedagogy Technology*</td>
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Table 6.3: Sources of Standardized Professional Development
“Yes, I did because I couldn’t remember how to do one thing. That was interesting and helpful. It was good to see a broader viewpoint because participants in that course came from different districts, having different backgrounds, their clientele could be different due to different economic status, might be teaching at a high school level or middle or elementary, etc. so when you post a response it might be completely different from someone who has a different background. I enjoyed this but in a way we were forced to use the forum as part of the course but I don’t know if I would find the time for it otherwise unless I had an issue.” 4.31

**Self-directed by IT coaches**

The IT Staff members also found online courses on specific tools so that they could, in turn, teach them to the teachers and other IT Staff:

“We’re looking at Flash video cameras & I’m taking an online course to push myself to learn it.” 15.17

Table 6.3 summarizes the sources of standardized professional development.

![Figure 6.1: Standardized Professional Development Activity](image)

Figure 6.1 is a depiction of the different ways that teachers are availing of standardized PD programs. There are several secondary contradictions noted. First, due to budget constraints, teachers prefer to go to
conferences that are within driving distance. Hence, their choices are limited and the closest available conference may not necessarily be the best fit for their PD requirements. Second, most conferences are not focused on technology. They still continue to follow the old model focused on content/pedagogy. As a result, teachers may find themselves going to an event/course for content/pedagogy on the one hand and a different event for educational technology training on the other.

The cost is generally prohibitive and hence, teachers need to prioritize between which type of PD is more important (a primary contradiction between the competing objectives). Typically, it’s the technology related program that gets relegated. Lastly, teachers who tried out online resources for PD felt that the corresponding forums, list-serves and newsletters had a limited value or they were too overwhelming to keep up with.

6.2 Informal Professional Development practices

The informal learning was taking place within the teachers’ PLC. This could be between department peers or same subject teachers, with tech-savvy teachers or between new and senior teachers. Informal learning was happening even across departments, although there were very few instances of it. The following sections describe these in more detail.

Across Departments

There were many examples of informal learning taking place on-site. Most of these happened among teachers who worked in the same department. Some occurred even across departments although very rarely. For example, teachers would hear about department meetings where a tech savvy teacher would be demonstrating the use of a technology that they might be interested in exploring. One biology teacher tells how she first learnt about the Plan Book from the Math Department which she along with her subject teachers came to adopt.

“Math Dept. showed me the Plan Book that we have adopted.” 1.26

The Biology teachers were not using the Sympodium provided to them. When the researcher told one of them that the Math department was using the Sympodium a lot, he said that they were not aware about it, otherwise they would have liked to get some tips on this technology from the math department.
Within Department

Department peers

Departments that had a strong community feeling and peer sharing placed a higher value to learning and sharing technology practices at their department meetings than formal training provided by the school system. This was because they could learn about educational technology tools that were specifically built for math. The IT staff did not provide training for subject specific tools.

As one math teacher said that he found that more useful learning took place in their department meetings.

“We have 2 main areas... school-wide (in-service days) and math dept. More useful activities are those based around the math department (in his opinion). Certainly, other district-wide programs we know of, too. There are lots of other professional development activities”. 3.14

The math department was very active in informal learning among teachers. This department had a strong sense of community and the department head was a techno-enthusiast. One math teacher commented:

“I generally pick up things from other teachers.” 3.08

Another math teacher was in a unique position of having a tech-savvy colleague who was also his wife. He also expressed his willingness to share these ideas with other teachers.

"An example - I learnt the Sympodium last year, I had a chance to put it together over the summer.

“Did you do it with other teachers?” –

“I do it by myself. Uh.... I bounce it off my wife. The Sympodium comes with a notebook software on my laptop. So I can work on it at home also. “ 9.02

“My wife is really a technology junky. All the new gadgets she jumps on right away so I learn stuff from her as she figures it out.” 9.23

“The stuff that I discovered in the notebook in the Sympodium - I am willing to offer and some people like to figure it out on their own. I have learnt shortcuts on the Mac from other teachers.” 9.24
The Math department meetings had developed into a useful hub for professional development in technology:

“We have department professional development, I provide some of that and benefit some as well. Lot of peer sharing of ideas”  3.11

There were occasions when a couple of Math teachers designed a professional development workshop for their own department colleagues during in-service days.

“Well I would say when we first got our CBLs - the thing that connects to the calculator, Sunny and I and Chris Nair (he’s not with us any longer) designed an in-service day which was very challenging and we learnt a lot. It was very successful I think.”  4.22 PD

“Sunny had held a nice workshop to show how to use geometer’s sketchpad - 8 years ago. He had gone to a workshop to learn about it”  4.27

**Tech Savvy teachers**

Tech savvy teachers enjoyed sharing their ideas with their department colleagues. These happened during lunch time, department meetings, in-service days and also in the hallways. As one math teacher describes,

“I like to help with using computer technology. So I help with demonstrating the Sympodium, whatever neat thing I find - something about the graph, I demonstrate. Sunny and I in the hallway- have you seen this? He comes to me when there is an issue. For some time I was the youngest. But the youngsters are so much in tune with computers that I go to them with that (laughs). For example- the youngsters told me about the iPhoto I asked them something about modifying a picture. I asked her and she knew right away. One day I had told the teachers that when you scan a document it helps if you can do that at 150% so they can see that better and then another teacher came back to me and said hey do you know you can take this and stretch it? So we find little things that are helpful. Also at the lunch table, something will come up, for instance, we are supposed to take attendance in every class and if you are using the Sympodium, which is hooked up to the computer, the attendance shows up on the screen and if you are not careful you are not supposed to show that - confidentiality of Student Ids - so one person said I just freeze the projector and I said I just turn off the Sympodium - so we share that kind of stuff pretty readily.”  4.21

**Same subject teachers**

Teachers who taught the same subject would naturally get together to teach each other educational technology skills as a biology teacher described on the use of logger probes:

“We all learnt it together. We stayed after school, run the trial, figure out the bugs. If somebody is doing something in a class before me, I go and ask her if there were any bugs and vice versa. Last week with the
lab - this solution does not work, this computer not working, so keep one step ahead - we generally help each other out.” 5.26

“Talking to colleagues, see what lessons worked out what did not. Even with regard to our daily lessons - I collaborate a lot with Drew on our daily lessons. He teaches a class in the morning that I have in the afternoon and flip flop. So we give each other a run down - exchange what worked or not.” 6.16

Another successful example was when business teachers worked together to use Excel’s Pivot Table feature for student assessment.

"I collaborated with some other business teachers on Pivot Tables. We used a pivot table to do a project that they were working on – we used this to track specific information about students so we worked together to create a pivot table where we could track that information. We were tracking the hours that students worked at their jobs among other things.” 2.26

New teacher/Senior teacher

Informal mentoring relationships were developing spontaneously. New teachers benefited from informal tips from department seniors. Sometimes the roles switched where the boundary between mentor and mentee could be crossed. They often learnt from each other.

“When I first came here, the graphing calculator was very new for me which I learnt from my colleagues.” 9.25

A business teacher shared some tips with a new teacher in her department:

“‘I would say the use of the Mac. I do share some tips and tricks on how to use the Mac with a first year teacher who is new.” 2.28

A senior science teacher routinely depended on younger tech-savvy teachers in the department.

“Two younger people in my department, who are really good at it - one in chemistry and the other in environment science. They are here and answer my questions quickly.” 10.13

Tech savvy teachers also were willing to take on the role of informally mentoring newbies in their department as one math teacher mentioned:

“‘With the grades program if someone is new and they want to know how to create a report then I can help with that. I like to use MS Word a lot. So I show how to draw with MS Word.” 4.26
Fig 6.2 below describes the on-site professional development activity in an activity theoretical framework.

**Tools** learnt through formal programs that were mentioned by the interviewees were Moodle, Sympodium, Google Docs, iMovies and other standard softwares like MS Office, FM Pro, Multimedia softwares (garageband, iMovie, Podcasting, Comic Life, Drawing) and Schoolwires (for teachers and district - students don't use that).

Tools that were learnt through informal interactions that were mentioned by the interviewees were logger probes, Planbook, Excel, tips in using Mac, calculator, micro-grade program, MS Word, Photoshop, Precis, Powerpoint, Sympodium, Notebook, graphing calculator and vernier sensors.
It is not surprising that conversations about educational technologies were occurring only in the informal spaces. The informal spaces were very important because this is where the teachers could figure out the transfer of learning to their context that they shared with their close colleagues.

**Norms** that facilitated informal channels of learning among teachers were common lunch meetings, department meetings, shared office space. Rules that facilitated formal channels were organization of ongoing training sessions, department & building meetings, in-service days and assignment of mentors for student teachers.

Common lunch times:

Informal sharing was facilitated if opportunities for interactions were more. Math teachers were fortunate that they had common lunch time for a long time. Even though this was no longer true, the community feeling that it had generated still sustained:

“Usually the math teachers all eat together- a lot of ideas are shared during that time. We are pretty easy about sharing ideas, because we are professionals and we have respect for each other and we feel safe enough to ask a question and not be ridiculed for it.” 9.16

“We used to eat at the same time before but now due to scheduling, there are fewer teachers eating at the same time. But we still exchange ideas. This is a good department to work in. We learn a lot from other teachers. Some teachers have 20 years’ experience.” 9.17

Common Office spaces:

“I would say the use of the Mac. I do share some tips and tricks on how to use the Mac with a first year teacher who is new. We share an office so we just share f2f.” 2.28

There were other examples of informal learning happening among biology, English, Business and Math teachers who shared the same office space (20.16, 2.28, 3.16, 5.26, 6.14)

**Community** consisted of informal contributors and those who benefited through their interactions. They include same subject teachers, tech savvy teachers, department peers, new teachers and senior teachers.

**Division of Labor** consisted of formal contributors to teachers’ professional development in technology and those that benefited from it. They include teachers (beneficiary), IT staff, external providers, mentor, mentee and KTI.
The contradictions noted were of a secondary nature between rules and subject. Teachers felt that they had little say in what kind of activities they would like for in-service days. These were mostly decided by the authorities. Moreover, these activities were not focused on developing IT skills. One teacher also pointed out that due to the fixed schedules of the training programs, most often teachers don’t get the training just in time or just before they needed it.

6.3 Networking & Sharing practices

The analysis of interviews revealed many different modes of networking and sharing practices among teachers that built the foundation for informal learning to occur. Face to face was the most popular way of sharing practices. Teachers met in informal spaces such as shared office, hallways, lunch times, etc. They also met in formal spaces where they could make new connections and discuss issues on the side. Of particular interest was the developing use of ICTs for online modes of networking and sharing. Teachers reported using email, list serves, file server, online discussion/chat/forum and blogs.

Face to Face Networking & Sharing Practices

Face to face was the most common way of sharing and seeking answers to technical problems. These could be unstructured, that is randomly planned by teachers, or structured, as in, facilitated by IT coaches.

Unstructured

Teachers would meet with other teachers down the hallway, or plan to meet before or after school or, if they happen to have a common office or common prep/lunch time.

One teacher simply preferred face to face interaction:

“For any questions, we just speak face-to-face. I am very old-fashioned and prefer to talk to people. Or email.” 3.21

Another group of teachers made time before or after school:

“Whenever any one learns anything new about the new online component, they share with each other - hey, we learnt this. Maybe once a week we make time before school to map out the next unit. We make time before school. We don’t share a common prep time.” 5.34

For simple things, it is always handy to have face to face interaction rather than sending an email explaining the problem:
“Last week I couldn’t find the button that allows me to extend the page, so I asked others and looked and they had it so I knew that I could find it again so I used the help feature and found it. It was just a matter of time. So I’m not afraid to look at the Help. So then I share with other teachers - face to face if they ask or through email if I think it would help others.” 4.09

**Structured**

The training sessions offered by the IT Staff included a sharing session which was a great platform for teachers to showcase how they had implemented some of the technologies they learnt in the training. As one IT Staff explains:

“We call it the sharing session - so we may be doing training for a specific piece of software for example, iMovie - so I have my10 teachers who go out and come back several weeks later and then they’ll share what they did with the class. It’s not district-wide like a broadcast. Ya, there’s always been a talk of an intranet where we could share content and data. Right now it’s not available district-wide.” 16.25

**Semi structured**

Some departments were making good use of their meetings to discuss technology practices as part of their agenda. In particular, the Math coordinator and the Art coordinator were technology enthusiasts and used technologies like Google Docs, Surveys, Facebook, Skype, Doodle, etc. to support their meetings. In this way, they were modeling how these technologies were used. In one of the math department meetings that the researcher attended, the teachers shared how they were using the Sympodium and if any difficulties occurred, how they solved it.

**Online networking & sharing practices**

Email, of course, was the most popular tool for communicating and sharing practices.

“I remember several years ago, when we first started getting our grading software, there was a lot of back and forth email when we first were learning how to use the micro grading system.” 5.33
One teacher liked email but suggested some extensions, like, receiving prompts to check a posting:

“When someone needs help right now we do it by email to the department saying does someone know how to do this but if there is a place where you could go which might send you an email saying that there’s a post, would you like to look at it?”

List serves were also widely used. One teacher found a goldmine through a list serve:

“A really successful one is when I started teaching AP stat - guy who was in Massachusetts and I had never met him. I found him thru the AP list serv. He shared his materials and assignments and everything with me.”

Another teacher used list serves for sharing practices with relevant interest groups:

We have a list serve - you can send to just the Social Studies teachers or just who teach maybe European Hist., just the teachers who teach Physics, or entire school. But I don’t use it often, but only when you need to. I had been to a conference, so I sent it. I had some interesting websites I sent to those groups who I thought would be interested in it. I probably sent twice a month to the chemistry list serve, maybe, another, twice a month to the entire Science department. I share information I picked up from the science conferences, something I may have created - a new lab, I found a couple of interesting articles online, you tube.....

It would be worth mentioning how laptops made online sharing easier, as one teacher described:

“I think that getting a laptop - before that we had desktop computer. I was a little weary when they told us that we were getting a laptop at first, but I take it home with me and now I have access to all of my records when I want them no matter where I am. I went to Detroit past weekend and sitting in my sister-in-law’s apt. I was able to work on my school work while my wife and sis-in-law went shopping. I have my school work handy at all times now and so I think that helps a lot. And then having that makes it easier to share files and stuff like that with other colleagues too. So while I was a little weary at first, I was actually glad that they gave it to us.”

**ICT tools for supporting face to face interactions**

Teachers continued to meet face to face but followed up or continued relevant interactions through email as a way to share files etc. This way, the computer communication tools played a supportive role:

“The College Prep Math 4- there's 3 of us that teach the course. We get together frequently. We meet a couple of times at least during the summer, talk about where we are going to change the course; we are adding more algebra review and discussing more basic skills and how to do that. We work very well together..... It’s very informal - hey let’s get together. We usually put it down on a worksheet and send it over the email for review and any changes.”

A number of teachers reported using the lead server to share files with teachers and students:
“There is on the school district network, a place where the math department shares written resources. That is the most common way that we would share. Like tests/notes/lesson plans, so I do have some online stuff, but it is not online, just in the school network.” 3.20

Teachers used email as they developed materials iteratively. Once it was finalized, it would be placed on the file server.

“We email, develop materials together. Send it back and forth. Once, it’s finalized, I keep it on the desktop. Sometimes, on the network space - not necessary.” 10.11

ICT tools for online interactions

Temporary online forums

Online forums were also in use by some teachers. But not all of them persisted on a forum too long:

“Well, in a course that I took last year I went to a forum, it was a course on Teaching Algebra with Geometer's sketchpad and you could go to the forum with some questions and answer. We could also post our thoughts and people could read what you thought. It was all a part of the course. .... I enjoyed this but in a way we were forced to use the forum as part of the course but I don't know if I would find the time for it otherwise unless I had an issue.” 4.31

The same teacher was also on a list-serve of College Board AP program which got quite overwhelming as he explains:

“I like the forums - but you miss out if you are not there - and same with blogs. With the AP program there are a lot of list-serves. They are helpful but overwhelming, so I unsubscribed from it because I couldn't keep up with it.” 4.29

Persistent online forums

However, in the case of a non-traditional course, the online forum was the main resource for a CISCO teacher:

“There are a lot of teachers - its global, it’s around the world. There's a forum that we can all access. If I am having a trouble in my lab, I go right there and type that this is not working and you know, and there are times that certain labs won't work and they will put updates thru the curriculum because of what the instructors have said.” 13.05

“.....Now, because I'm an instructor I can go to the instructor community– It’s restricted to instructors only. .... Here we have March 30th - I actually did this. I needed to find the math, engineering and science standard for the state so I went to this website to get my standards alignment for the state of PA.” 13.06
He could even post a query and get an answer within 15-20 minutes:

“Well if you have certain issues with the worksheets. They don't come out perfect, the lab don't come out perfect, for example, instead of me troubleshooting myself, I ask this question and get an answer within 15-20 min. In one situation we found that the IP address was messed up so we found the problem and fixed it.”

The resources provided through the forum also had a rating system which helped in selecting best resources.

“You don't know. They rate them there’s a system that allows 1-5 rating. That helps in picking a good resource.”

Online Communities

The IT coach and the KTI were members on online communities. Some were formal online communities while some were created by the KTIs in this instance. For example, an IT coach was a member of a formal online community whose members were selected forming a distinguished forum:

“Apple is very educationally conscientious - Apple Distinguished Educators. 50 people are selected each year to be members. So I had the opportunity to be part of the group who advises them. Apple Learning Interchange is an online community. Also, Educational Technology Blog.”

An art teacher who became a KTI made good use of online blogs and forums to develop technology skills. She elaborated on various online communication tools she had used both formal and informal:

“We have a lot of really good communication tools for teachers to talk to one another. I am in the State’s Art Education Association. We have a Ming that we use to keep in touch. We are all on FB we have a group on FB. Those of us are interested in or excited about technology stick together and share things with one another. I have a pretty great network of friends and colleagues that communicate regularly about what we do with technology. I don’t know what I would do without FB. The way it has helped me professionally – we all were on Wiki before and on Ming for a while and a website for ages...”

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Table 6.5: Online Networking
The figure below illustrates how teachers are sharing and learning from each other using an AT framework. Teachers were sharing with each other to achieve several objectives, such as, professional development in content or technology, for gathering or sharing resources and for troubleshooting. One interesting pattern emerges from the experiences elucidated by the comments above. Face to face interactions were followed up through emails. After some back and forth exchange of ideas and materials on email, the final product was stored on a file server. So f2f => email => file server. Online forums were seen to be most effective in classrooms that used online course website. Otherwise, they did not sustain interest among members for long. List serves were useful, provided it resulted in connecting with an expert. Other than that they were used to send blurbs about interesting tid-bits. Face to face interactions were limited to physical space. If something was shared between two teachers, others would not know about it. Similarly, if email interactions happened between 2 people, it would be an extra step to share with others. Online forums provided a good way to cover a broader audience, but were not able to sustain interest of the users long enough.

Fig 6.3: Sharing Activity
6.4 Discussion

The on-site training provided by IT Staff was highly appreciated by teachers and the IT coaches recognized as a valuable resource. Nevertheless, some areas of improvement can be gauged from the data analyzed as in Table 6.1. The IT Staff did not provide training that was just-in-time for some teachers. This is a problem that would be hard to solve through the laptop training sessions. However, some other venues can be explored to provide such training on an as needed basis. For example, currently the lunch time sessions are not popular. If this could be tailored to the teachers’ requirements, the attendance might increase. Furthermore, this could also be tailored according to topics that are focused on a subject area using general technologies or even subject-specific technologies if a knowledgeable teacher could participate as well. These lunch sessions could be sort of become an informal sharing session facilitated by the IT Staff. It is possible that a common lunch time does not exist for interested parties. So perhaps, an afterschool snack hour may be an alternative. School authorities could encourage this by providing free lunch or tea. Another venue could be the department meetings where teachers could identify their training needs. School authorities need to encourage sharing of technology practices during department meetings and in-service days. These venues are not yet fully utilized for TPD in technology. It was noteworthy that the adoption rate for technology was very high when teachers learnt the skills from mentors, KTIs and job embedded training from external providers. This is because these modes tend to be one-on-one. The IT administration may explore this option as a useful resource to expand. School authorities may encourage tech-savvy teachers to apply for the KTI program and become a resource in their subject areas.

The off-site standardized PD (Table 6.2) for teachers were not only more expensive, but also not focused on IT (the only exception was when these workshops were offered in non-traditional courses such as CISCO). These conferences were still following the old model of training in content and pedagogy. Technology was very peripheral. Since these conferences/workshops were geared towards subject areas, it would be a natural extension to include training in subject-specific technologies. Nevertheless, cost was prohibitive, and since teachers did not have time after they came back, a cascade model would not be effective unless what they learnt there was documented in the form of videos and readily available for them to share with their colleagues. So, technological solutions for sharing these events should always be offered.
Once teachers had taken the online mandated courses required, the online course offerings were another resource that teachers as well as IT coaches were taking for self-directed standardized PD. This was convenient and a less expensive way to fulfill IU credit requirements for PD. Almost all these courses had a forum for online discussions among attendees. However, once the courses were over, these forums would have few visitors. Information System designers may look into the possibility of designing these forums so that teachers may be able to link it to an attendee’s local PLC. For example, attendees should be able to quickly link up with teachers from their own school district who had attended this course in the past and see his/her posts on the topic.

The data analysis also revealed some informal modes of learning. There was a lot of informal PD taking place among department peers, especially when the department coordinators (Math, Art) were enthusiastic about technology. There was less interaction of such nature across departments. Nevertheless, some positive impacts were reported about learning from another department as well (between Biology and Math teachers). Tech-savvy teachers within a department were another important resource. They generally took the lead if they were part of same subject teachers’ group. Two such teachers reported learning about technology from their spouse. Senior teachers were always willing to show the ropes to new teachers. Generally, such exchanges resulted in a high adoption rate. Hence, school administration should allow more opportunities or spaces for informal learning to take place. Some teachers did mention that there was less common time than they used to have before.

The analysis of interviews revealed many different modes of networking and sharing practices among teachers that facilitated informal learning to occur. Face to face was the most popular way of sharing practices. Teachers met in informal spaces such as shared office, hallways, lunch times, etc. where informal interactions were unstructured and covered only a few individuals. They also met in formal spaces such as during the laptop sessions where they could share practices in a more structured environment with a larger number of teachers but this happened only once a year. The monthly department meeting provided a semi-structured environment for sharing to take place among a large number of peers. However, such meetings did not necessarily focus on technology in all departments and varied according to the interest of the department coordinator. In order to encourage more networking and sharing among a larger number of teachers, school leaders should explore the possibility of making time for more common lunches and common free times and encourage discourses on technology in department meetings and in-service days when large number of teachers meet.
Of particular interest was the use of ICTs for online modes of networking and sharing. Teachers reported using email, list serves, file server, online discussion/chat/forum and blogs. Teachers used ICTs for supporting or following up on face to face interactions. For example, after developing materials iteratively over email, they placed the final product on the lead sever. They also used online forums. However, generally these would be temporary. Once the purpose was served, as in a course getting over, these forums did not persist. Only in the case of a CISCO teacher where the online community was an integral part of the online resource he used regularly for his class did he report using it daily during his lectures. Teachers also reported finding great resources from experts on a list serve. For example a Math teacher got his entire course materials from someone he contacted on the list serve. But once the purpose was served he unsubscribed from it because the emails were getting too overwhelming. An IT Coach and a KTI were the only ones who mentioned being part of an online community (other than the CISCO teacher).
Chapter 7

Conclusion

Although there has been a great interest in the implementation and use of technology in education, research in this field has been fragmented. Few studies have used a holistic approach that may bring some coherence in understanding the myriad interacting factors that impact the teachers’ uptake of technology. Most studies continue to treat teachers as peripheral to the paradigmatic changes occurring in the school system. This study places teachers at the center of an investigation into their work practices and professional development in technology. Several categories of use emerged and they have been broadly classified into technology use for general work practices and technology use for classroom related practices.

For teachers’ use of technologies with respect to general work practices, teachers reported using technology for administrative, collaborative and planning activities. It was evident that there were no significant issues in technology-enabled administrative practices mainly because the school provided built in time and technologies for teachers to fulfill administrative duties. At the departmental level, some particularly useful practices were noted in the math department at the initiative of a tech-savvy department head. School practitioners could note these developments and encourage such engagements in other departments as well for sharing best practices during department meetings and in-service days.

Some teachers were taking the initiative to request tools instead of using school provided tools that fulfilled the same functions. Information system designers could look such developments closely to identify the features of these tools and try to integrate it with the other systems.

Unlike administrative activity, school did not provide time for collaborative activity. This was not a major inhibitor for groups who taught the same subject. They found ways around this issue by using their own time after or before school, or working together during the summer. However, groups that included teachers from different departments experienced problems. These findings have important implications for school administrators and department heads who play an important role in articulating the organizations rules and norms.
It was noteworthy that new divisions of labor were emerging as teachers collaborated around technology especially among teachers who taught the same subject. In such instances, teachers leveraged their pre-existing professional learning community and organized their activity to include a division of labor with a tech-savvy teacher as the lead. For teams that do not have the advantage of pre-existing network to leverage or who are not co-located, there may be a potential for information system designers to develop online places to support group activities such as this. Again, this points to the need for school authorities to pay close attention to building time for the teachers for activities in technology use.

The education planning activities were negatively impacted due to uncertainty in the availability of requisite technologies which was again a result of inadequate funding. Thus, even if teachers are skilled users of technology and have had adequate professional development, the uncertainty in the availability of technology prevents them from planning into the curriculum.

This has important implications for school authorities as well as information systems designers. Organizations may try to increase funding, but the current economic climate may not be favorable. Alternatively, they may plan for better allocation of existing technologies. Here, information system designers may find an opportunity to create an online inventory of laptop carts and other technologies where teachers could reserve the tools needed when planning their lessons (for example a science probe that can be checked out and trialed before bringing a whole set into the classroom setting). This inventory may also be accessed by school authorities to take stock of technologies that are under-utilized.

For teachers work practices with respect to technology use related to the classroom activities the results were divided according to the broader categories of administrative, collaborative and teaching activities. Within each category, several tasks that teachers are finding ways to accomplish through technology were identified. Tasks related to general work practices were also identified. This list of tasks can be used by professional developers to make their training program more customized to the needs of teachers. Additionally, designers of technologies for education can also use these as a guide to make the technologies more useful for the teachers.

For classroom related administrative activities, the tasks identified were mostly related to the evaluation process (e.g. collecting assignments and giving feedback on assignments, grading, communicating and reporting grades to parents and students). Thus, designers can think of integrating all these tasks. Currently, teachers are using different tools for evaluation related administrative tasks. Designers could use this information to select the affordances of each tool that make them attractive to users and integrate
all these affordances into a single tool. Also, since the teachers are using multiple technologies for grading tasks, it results in lack of a common ground to share practices. It also makes more work for professional developers as they may have to unnecessarily train and support multiple technologies.

The issue of tracking submissions of assignments through different modes (that is, through email, Moodle, Google Docs, hard copy) revealed an unintended consequence of technology implementation. Looking through an AT lens showed several alternative solutions. In the short term, teachers could enforce a classroom norm or rule for accepting submissions. However, this may result in some confusion for students if there is no standard way for homework submission in the school. So, IT Staff and information systems designers may need to deliberate on how to integrate all the tools to flow through one system as far as assignment submissions are concerned.

Google Docs was the dominant tool as far as student-student collaborations on assignments, lab work and student-teacher sharing of lessons was concerned. These collaborations were mostly happening among teachers who taught the same topic in different subjects, or who taught the same subject, where teachers divided the labor according to their strengths with one teacher taking the lead in handling the technology aspect. Science teachers were finding that the new data collection device (vernier sensors) allowed them to combine multiple classes in a lab to collect data. It is important for school administrators to support such initiatives at the very beginning so that teachers may not get discouraged from attempting such collaborations again. For example, other than providing technology support on hand, they can consider modifying the schedules so that back to back classes can give a combined class more time together.

Only one example of an online collaboration existed. Yet it was a powerful example. For a teacher who taught CISCO this online community was available every day and even during the class period when he could use for troubleshooting. He could expect to get an answer within 15-20 minutes of posting a question on this forum! Designers and IT Administration could take some ideas from here for an online forum where teachers could post a question and get a quick response from IT Staff or other tech-savvy teachers even in the local community.

Since school resources for supporting IT activities are limited, the potential advantages of tapping existing natural resources such as a tech-savvy teacher, a tech-savvy student, the IT teachers and the IT students must be explored. As witnessed in the case of a collaborative class where a storage limitation for submitting large assignment files could have been a major hiccup. An IT teacher solved this on his own by using the server space on his server. Here, the role of the IT teacher is noteworthy who has the
technology resources and may be amenable to provide help for colleagues out of collegiality. Additionally, his students could also provide services to other teachers as part of their training. The IT administration can take note of this and identify tasks that students can do as part of their coursework in Information Technology.

Finally, the analysis of teaching activity revealed the motivating factors that drove teachers to experiment with technology as well as the inhibiting factors that prevented them from using it even when they had become skilled users. As expected, the teaching activity faced the highest number of contradictions in comparison to all other activities. Tools suffered from usability problems, version problems, incompatibility and unreliability. Such problems resulted in adding to the time it took to finish a lesson in the same time as it took without the use of technology. Hence, it is important for the IT Administration to continue to place these issues on top of their list of priorities.

Many teachers had a low self-efficacy with technology because, among other reasons, it was a moving target. This posed a unique challenge for teachers, given their time constraints. Hence, IT Staff should pace the introduction of new technologies so that it does not become overwhelming. Another reason for low self-efficacy cited by teachers was that the professional development was not given to them when they needed it and that there was a knowledge transfer required before they could actually use it. Thus, professional development efforts should be designed for teachers with examples of actual tasks that they perform in the classroom with that tool. Additionally, transfer of learning would be more possible if discussed within the teachers’ own PLC such as the department or the same subject teachers within. Perhaps, school administration can encourage the possibility of discourse in the department meetings directly after a teacher has attended a training session. Or, IT Staff can explore grouping training sessions by department or same subject teachers. IS designers may also explore an opportunity here for an online place where teachers, department colleagues and IT Staff can gather to answer questions and post problems, and share best practices related to the transfer of learning.

This study builds on earlier contributions (Russell et al, 2003; Buzzard et al, 2011) by identifying teachers’ objectives for the uses of technology. Through a survey, Russell et al (2003) identified 6 distinct uses, noting that they did have some amount of overlap. More recently, Buzzard et al (2011) provided seven categories of educational activities based on response from a survey. They concluded that in order to prepare teachers to teach with technology professional developers need to move away from focusing on teaching technology and instead focus on teaching with technology. This study also adds to these
contributions (Table 5.6). Professional developers can use these tasks/objectives list as a guideline to provide training for teaching with technology instead of teaching about technology.

Finally I would summarize the lessons learnt from the method used for the analysis of data. In this study, the Activity Theory framework for studying the use of technology has been described, extended and applied. Thus an important outcome of this study has been a demonstration of the use of the activity theory with the teacher-user at the center. It also showed that a relatively more contained and extended approach of Activity Theory would be sufficient to guide the analysis. For example, firstly, the contradictions were limited to the identification of primary and secondary contradictions only. This follows from Kaptelinin & Nardi’s (2006) claim that by analyzing the activity, opportunities for influence may be identified early in the lifecycle. Thus, this may lead to opportunities for preventing tertiary and quarternary contradictions from developing. Secondly, the subject was restricted to the individual user only (i.e. teacher) without compromising on using groups as subjects because if the activity involved a group or team, the information was captured in the other elements, Community or Division of Labor respectively. Lastly, the Outcome was extended so that it can be of a more practical use. For example, in the coding phase, outcome included both expected and actual outcomes. If the outcome was negative, contradictions were identified for brainstorming alternative solutions. If the outcome was positive, it became the stuff of best practices to be disseminated. By using this modified framework, AT can be the vehicle of change by providing actionable knowledge to bring about a smoother transition in the change process. Future work can be done to test this modified and practical framework (Fig 7.1) in other user contexts. Information Technology researchers have for long been interested in AT as a model that could be adapted for HCI research (Döweling, Schmidt & Gob, 2012). Thus this study would be another contribution to this growing body of work.

On a more practical note, the results from the study can be used as a foundation for ongoing work on this topic. For example, firstly, based on the contradictions, alternative solutions can be devised and fed back into the system to see its impact on the related objectives. Thus this study can be used as a benchmark for measuring the impact of different solutions applied to increase the use of technology by teachers for their daily work practices. Secondly, for information systems designers, the study provides a rich list of requirements, that is, activities and goals that are important for the teacher-user. This list can be used as a starting point to elicit more requirements. It also offers a list of softwares that are currently being used to fulfill those requirements. These tools or their relevant features can be integrated into a more manageable form. As it currently stands, teachers are using a toolbox with many different shapes and sizes of tools to
choose from. Choosing the right combination of tools can be an overwhelming task by itself considering that they have very little time. Hence, integration of technologies will also lead to its better and wider use. Thirdly, the list of activities and goals is a resource for professional developers. They can use it as examples of use in training sessions so that teachers get training in how to teach with technology instead of how to use a technology.

Fig 7.1: A Blueprint for Activity Theory Framework


Connaghan, K.M., Cultivating a Community of Practice Among Itinerant Educators http://cadres.pepperdine.edu/ccar/ar/c7/Connaghan/indexarp.htm


Designing the Tapped In case study. INNOVATIONS 2006: World Innovations in Engineering.


Moore, M.G. (1989). Three types of interaction. The American Journal of Distance Education, 3(2), 1-6


Tapped In. Available at http://www.tappedin.org


Appendix A: Interview Questions

A. **Background Questions**
   1. What teaching responsibilities do you currently have?
   2. How long have you been in your present post?
   3. How long have you worked in this school/district?
   4. How would you describe your own technology background? (qualitative self-efficacy)

B. **Technology Integration Questions** (These should bring out some barriers and supporting structures)
   5. What sorts of technologies do you use? Hardware, Software.
   6. Give examples of how you use it.
   7. Have you ever tried to integrate different types of technologies together? Were you satisfied? What were the difficulties?
   8. What kind of difficulties you have faced in learning or using technology.

C. **Professional Development Questions**
   9. How do you keep abreast of your field?
   10. What is the most significant professional development you have experienced that relates to the use of IT?
   11. How does your team of teachers generally use the time that is dedicated for school-based professional development? How much of it is dedicated to IT?
   12. What kinds of school-based professional development activities related to IT have you participated in?
   13. What kinds of off-site PD activities have you participated in that relates to IT?
   14. Do you spend time learning about IT on your own? Please give some examples.
   15. What kinds of things have you shared about IT use with other colleagues? What kind of help have you received from other teachers? Please give some examples.

D. **Teacher Collaboration with respect to learning or using IT**
   16. Describe both a successful and a challenging collaboration experience with another teacher.
   17. Think about a successful use of technology in your practice. Who would you to share this practice with? Why? How would you go about sharing it?
   18. What kind of practices that you have shared been adopted by others? Or, what kind of practices that others have shared with you been adopted by you?
   19. What kind of communication technology do you use for sharing practices with your peers? Describe what you do online with respect to sharing practices with other teachers.
   20. Suppose there was a place for you to stay in touch with your collaborators with respect to sharing the use of technology. What would you find there? (forums, wikis, blogs, chats, facebook, adobe connect, etc.)
### Appendix B: Mapping Research Questions & Interview Questions

<table>
<thead>
<tr>
<th>Interview Questions</th>
<th>Research Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Background Questions</strong></td>
<td>RQ 1 <strong>How are teachers integrating technology into their daily practice?</strong></td>
</tr>
<tr>
<td>5. What sorts of technologies do you use? Hardware, Software.</td>
<td>1.1 How are teachers integrating technology into their classroom activities?</td>
</tr>
<tr>
<td>6. Give examples of how you use it.</td>
<td>1.2 How are teachers integrating technology into their general work practices?</td>
</tr>
<tr>
<td>7. Have you ever tried to integrate different types of technologies together? Were you satisfied? What were the difficulties?</td>
<td>1.3 What are the relevant personal, social, technical and organizational factors that inhibit or enable technology integration and/or curriculum integration?</td>
</tr>
<tr>
<td><strong>B. Technology Integration Questions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>C. Professional Development Questions</strong></td>
<td>2.3 What are the relevant personal, social, technical and organizational factors that inhibit or enable learning?</td>
</tr>
<tr>
<td>8. What kind of difficulties you have faced in learning or using technology.</td>
<td>2.1 <strong>How are teachers learning through professional development practices.</strong></td>
</tr>
<tr>
<td>9. How do you keep abreast of your field?</td>
<td>2.1a self-directed prof development (formal/informal, online, other)</td>
</tr>
<tr>
<td>10. What is the most significant professional development you have experienced that relates to the use of IT?</td>
<td>2.1b site-based prof development (school-wide/district-wide/dep/t-wide, online, formal/informal, other)</td>
</tr>
<tr>
<td>11. How does your team of teachers generally use the time that is dedicated for school-based professional development? How much of it is dedicated to IT?</td>
<td>2.1c standardized prof development (school-wide/district-wide/dep/t-wide/off-site, online, other)</td>
</tr>
<tr>
<td>12. What kinds of school-based professional development activities related to IT have you participated in?</td>
<td></td>
</tr>
<tr>
<td>13. What kinds of off-site PD activities have you participated in that relates to IT?</td>
<td></td>
</tr>
<tr>
<td>14. Do you spend time learning about IT on your own? Please give some examples.</td>
<td></td>
</tr>
<tr>
<td>15. What kinds of things have you shared about IT use with other colleagues? What kind of help have you received from other teachers? Please give some examples.</td>
<td></td>
</tr>
<tr>
<td><strong>D. Teacher Collaboration w.r.t learning or using IT</strong></td>
<td>2.2 <strong>How are teachers learning from each other?</strong></td>
</tr>
<tr>
<td>16. Describe both a successful and a challenging collaboration experience with another teacher.</td>
<td>2.2a When sharing is meaningful, how is it now taking place?</td>
</tr>
<tr>
<td>17. Think about a successful use of technology in your practice. Who would you like to share this practice with? Why? How would you go about sharing it?</td>
<td>2.2b Have the practices being shared adopted by the teachers?</td>
</tr>
<tr>
<td>18. What kind of practices that you have shared been adopted by others? Or, what kind of practices that others have shared with you been adopted by you?</td>
<td>2.2b Have the practices being shared adopted by the teachers?</td>
</tr>
<tr>
<td>19. What kind of communication technology do you use for sharing practices with your peers? Describe what you do online w.r.t. sharing practices with other teachers.</td>
<td>2.2c What are teachers’ current practices if any regarding online sharing?</td>
</tr>
<tr>
<td>20. Suppose there was a place for you to stay in touch with your collaborators w.r.t. sharing the use of technology. What would you find there? (forums, wikis, blogs, chats, facebook, adobe connect, etc.)</td>
<td>Not coded</td>
</tr>
</tbody>
</table>
### Appendix C: Keys

#### AT Construct: Subject

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tags</th>
<th>Example snippets</th>
</tr>
</thead>
</table>
| **Level of Analysis** | organization (IT staff, IT admin, the school). Primary point is to comment on the person or persons in this activity, at the organizational level this would perhaps a department, admin, etc. | "Then there are some programs that we are required to use here - we have the grading program (Micro Grade), the attendance program, inventory where we keep track of our calculators."  
"The CFF teachers are required to take 2 (30 hr) online free crses mandated by PDE. Its delivered by a company called Embedded Learning which provides the online environment. It was written by another company on contract. One crse is called Teaching for the 21st century – the need for change. Another..." |
|                     | individual teacher: Primary point is to comment on the person in this activity, at the individual level. This would be a teacher engaged in the activity of learning and using and integrating technology in the curriculum. What are his personal characteristics, preferences, qualifications and so on. | "But I am forced to use Mac. At home I have a PC which makes life complicated"                                                                                                                                  |
|                     | group: the department, collaborations, dyads, triads where the school admin does not play the primary role and the teacher or coordinators take collective actions/decisions/initiatives as part of a group. Primary point is about the group setting, department-level policies, issues, constraints, and so on. | "And I learnt how to do the audio editing on papers from my mentor when I was an intern and I shared that also and I know of 2 other people who were in grad school with me who use it now to edit papers. And Google Docs - I told 2 teachers about how great it was and now they are using Google Docs." |
| Characteristics     | technology background, age, gender, length of service, other activities/responsibilities, self-efficacy, attitude, preferences | "I think my tech background is limited but gradually improving."                                                                                                                                                  |
| subject valence     | positive, negative, neutral                                         | For most of what we do it isn’t necessary to use the probes, for example, I think that sometimes the students get too caught up with the technology and don’t really understand what was occurring with the actual lab itself. |
### AT Construct: Tool

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tags</th>
<th>Example snippets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tool Name</td>
<td>Word, iMovies, Sympodium, Logger pro, Excel, etc.</td>
<td>I use Word, spreadsheet, Powerpoint, projector, symposium, schoolwire, Email, list serve, Google Docs, Moodle, Internet. I have used Sympodium, the laptop carts.</td>
</tr>
<tr>
<td>Tool type</td>
<td>Email, phone, blog, chat, online discussions, list serves, observation, edl tech tools, cms tools, online resource web sites, online forums, list serves, file server, collaborative tools (Email, I2f, phone, blog, chat, online discussions, Google Docs, list serves, observation, schoolwires, etc. - local resources provided by district or dept.)</td>
<td></td>
</tr>
<tr>
<td>Tool use/functions</td>
<td>productivity, communication, research, edl technology, cms, multimedia/learning enrichment, student collaboration, teaching, club advising, Administrative, Sharing, Course delivery, Meeting management, TPD, Subject tool, Listing homework, teacher meetings, teacher collaboration, submit assignments</td>
<td>&lt;this would be interpreted as an edl technology tool because it is specifically used for a subject&gt; I have used in the past, the LoggerPro before but not used for a few yrs now. They got it from Juniata, the probes - it was not the best quality. And then there were issues with Juniata not having enough funding. &lt;additionally, the snippet below can be interpreted as a teaching/course delivery tool&gt;</td>
</tr>
<tr>
<td>Tool Frequency of Use</td>
<td>depends on availability, not often, all the time, daily, weekly, throughout the year, etc.</td>
<td>&lt;the snippet above can be interpreted as 'depends on availability' and the one below as 'all the time'&gt; I use my laptop on a regular basis almost every single period with the projector - its very useful.</td>
</tr>
<tr>
<td>Tool Developmental Level</td>
<td>not used, entry, adoption, adaption, appropriation, innovation</td>
<td>&lt;the snippet above and the one below can be interpreted as 'entry'&gt; Its not that its difficult - for example to take time to learn iMovies. Its difficult enough to get thru the curriculum. To teach some of the students how to use iMovies and then to give them time to use it, requires huge chunks of time and we don't have enough of it. &lt;the snippet below can be interpreted as 'appropriation'&gt; I use my laptop on a regular basis almost every single period with the projector - its very useful.</td>
</tr>
<tr>
<td>Tool valence</td>
<td>positive, negative, neutral</td>
<td>&lt;this snippet can be interpreted as having a negative valence&gt; I use the symposium but not that often. Its difficult for the student to read when I write on the symposium. I don't like the stylus pen. Whereas if you type up the notes its a lot cleaner. The handwriting on the symposium is very sloppy.</td>
</tr>
</tbody>
</table>
## AT Construct: Rules/Norms

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tags</th>
<th>Example snippets</th>
</tr>
</thead>
</table>
| Organizational norms (IT admin norms) | shared values, state-dist relations, quid pro quo, IT training norms | <these snippets can be tagged as 'IT training norms'>
“The bulk of the training takes place during the summer when teachers are out of school – we do 80% of the training in those days. We also plan trainings a lot around in-service days which are kind of spread out throughout the year and then there are also times if we bring in a third-party trainer”
“I would rather have lots of teachers who know how to use computers rather than lots of computers and no one knowing how to use them” |
| Department norms                    | leadership for technology, curriculum assignments, not focused on IT | <can be interpreted as 'not focused on IT'> when questioned about how teachers generally use assigned time for professional development such as on in-service days the answer was: 'That can vary. Sometimes we went to PSU for tours at the forensic labs. Other times, special themes like Martin Luther King day. Sometimes its about the school safety. Its all over the place.' |
| Classroom norms                     | submit assignments thru Google Docs, thru email, thru Moodle, etc. | < can be tagged as 'submit assignments through Google Docs'>
Google Docs is when the kids are doing various projects they will submit it to me that way. I have used it throughout the year. |
| District Funding                    | no funding, insufficient funding, funding available | <can be interpreted as 'insufficient unding'>
See the problem is - we only have two laptop carts being shared by 6 teachers. |
| Department Funding                  | no funding, insufficient funding, funding available | <can be interpreted as 'insufficient unding'>
I have used in the past, the LoggerPro before but not used for a few yrs now. They got it from Juniata, the probes - it was not the best quality. And then there were issues with Juniata not having enough funding. |
| Meetings                            | inservice, building meetings, faculty meetings, dept meetings | We have faculty meetings, building meetings and CTC meetings. All of these meetings take place once a wk - so we pretty much have a mtg every wk. |
| Assigned duties                     | STEM initiative, bus duty, study hall, lunch duty, etc. |                                                                                                                                                                                                                                                                                                                                                  |
| Rules Valence                       | positive, negative, neutral               | <can be interpreted as having a negative valence due to funding related issues which fall under the Rules/Norms category>
I have used in the past, the LoggerPro before but not used for a few yrs now. They got it from Juniata, the probes - it was not the best quality. And then there were issues with Juniata not having enough funding. |
### AT Construct: Community

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tags</th>
<th>Example snippets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where did they share?</td>
<td>on-site (Hallway, in-service, online, dept meetings, IT training sessions, office, building, lunch, morning bus duty, afterschool bus duty, study hall, online community, conferences, workshops), off-site, on-line (list serves, forums, blogs, chats)</td>
<td>I collaborate a lot with Drew on our daily lessons. He teaches a class in the morning that I have in the afternoon and flip flop. So we give each other a run down - exchange what worked or not.</td>
</tr>
<tr>
<td>Sharing activities</td>
<td>Collaborative activities (mentor/mentee, observation, teamwork, reflection, assessment, formal sharing) Informal sharing</td>
<td>And I learnt how to do the audio editing on papers from my mentor when I was an intern and I shared that also and I know of 2 other people who were in grad school with me who is it now to edit papers. And Google Docs - I told 2 teachers about how great it was and now they are using Google Docs.</td>
</tr>
<tr>
<td>Who did they share with?</td>
<td>tech savvy teachers, tech savvy students Dept peers, other dept teachers, same subject teachers, students, teachers in other schools, teachers in other districts</td>
<td>Talking to colleagues. See what lessons worked out what did not. Even with regard to our daily lessons - I collaborate a lot with Drew on our daily lessons. He teaches a class in the morning that I have in the afternoon and flip flop. So we give each other a run down - exchange what worked or not.</td>
</tr>
<tr>
<td>What did they share?</td>
<td>day to day practices, conference lessons</td>
<td>&lt;the above snippet can be tagged as 'daily lesson using technology'&gt;</td>
</tr>
<tr>
<td>How did they share?</td>
<td>Email, f2f, phone, blog, chat, online discussions, Google Docs, list serves, observation, schoolwires, etc.</td>
<td>&lt;the above snippet can be tagged as 'f2f'&gt;</td>
</tr>
<tr>
<td>Community Valence</td>
<td>positive, negative, neutral</td>
<td>&lt;the above snippet can be tagged as 'positive'&gt;</td>
</tr>
</tbody>
</table>
### AT Construct: Division of Labor

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tags</th>
<th>Example snippets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who?</td>
<td>IT Staff, Teachers, External providers, dept coordinator, subject teacher groups</td>
<td>&lt;this snippet can be tagged as 'IT Staff'&gt; but mostly I am going to the IT training sessions with D and J.</td>
</tr>
<tr>
<td>What did they do?</td>
<td>On-site training, off-site training, self-directed, group-directed, online, in-class training, classroom teaching, coaching/advising, admin work, informing parents</td>
<td>&lt;this snippet can be tagged as 'in-class training'&gt; I have used in the past, the LoggerPro before but not used for a few yrs now. They got it from Juniata, the probes - it was not the best quality. And then there were issues with Juniata not having enough funding.</td>
</tr>
<tr>
<td>Type of training</td>
<td>formal, ad-hoc</td>
<td>&lt;the above snippet can be tagged as 'formal'&gt;</td>
</tr>
<tr>
<td>DOL Valence</td>
<td>positive, negative, neutral</td>
<td></td>
</tr>
</tbody>
</table>

### AT Construct: Object

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tags</th>
<th>Example snippets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object</td>
<td>TPD, student learning enrichment, student learning, problem solving, curriculum integration, technology integration, curriculum completion, sharing resources online</td>
<td>&lt;this snippet can be tagged as 'student learning enrichment'&gt; I use Biologycorner.com. I use some web resources regularly for an activity or a lab. Most of the time its just going on Google and lookup images. The vast majority of the time its just the general search. &lt;this snippet can be tagged as 'sharing resources'&gt; I use Moodle for putting notes and Powerpoints. I have done a survey on Moodle. For most part Moodle for me is a way to communicate with the students - here are the notes that you missed and imp info that you need for the class. &lt;this snippet can be tagged as 'curriculum integration', 'student learning'&gt; For most of what we do it isn't necessary to use the probes, for example, I think that sometimes the students get too caught up with the technology and don't really understand what was occurring with the actual lab itself.</td>
</tr>
<tr>
<td>Objective Valence</td>
<td>positive, negative, neutral</td>
<td>&lt;this snippet can be tagged as, 'negative'&gt; For most of what we do it isn't necessary to use the probes, for example, I think that sometimes the students get too caught up with the technology and don't really understand what was occurring with the actual lab itself.</td>
</tr>
</tbody>
</table>

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## AT Construct: Outcome

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tags</th>
<th>Example snippets</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPD</td>
<td>self, on-site, off-site, formal, informal, online, in-class</td>
<td>&lt;this snippet can be tagged as 'Informal TPD'&gt; Technology - mostly I talk to other teachers and see what they are doing in their classes</td>
</tr>
<tr>
<td>Technology Integration</td>
<td>satisfaction, frustration</td>
<td>&lt;this snippet can be tagged as 'satisfaction'&gt; I use Moodle for putting notes and Powerpoints. I have done a survey on Moodle. For most part Moodle for me is a way to communicate with the students - here are the notes that you missed and imp info that you need for the class.</td>
</tr>
<tr>
<td>Curriculum Integration</td>
<td>satisfaction, frustration</td>
<td>&lt;this snippet can be tagged simply as 'satisfaction'&gt; Google Docs is when the kids are doing various projects they will submit it to me that way. I have used it throughout the year.</td>
</tr>
<tr>
<td>Difficulties encountered</td>
<td>Tool learning difficulties learning curve, transfer of learning, lack of time, low self-efficacy Tool Using difficulties technical issues, version problem, usability, low chance of availability, home internet access, lack of in-class time</td>
<td>&lt;this snippet can be tagged as 'tool using-usability'&gt; I use the symposium but not that often. Its difficult for the student to read when I write on the symposium. I don't like the stylus pen. Whereas if you type up the notes its a lot cleaner. The handwriting on the symposium is very sloppy.</td>
</tr>
<tr>
<td>Contradictions</td>
<td>primary, secondary, tertiary, quarternary</td>
<td>&lt;the above snippet can be tagged as having 'primary' contradiction&gt;</td>
</tr>
<tr>
<td>Outcome Valence</td>
<td>positive, negative, neutral</td>
<td>&lt;the above snippet can be tagged as 'negative'&gt;</td>
</tr>
</tbody>
</table>
### Appendix D: ETap 2

<table>
<thead>
<tr>
<th>Entry</th>
<th>Adoption</th>
<th>Adaptation</th>
<th>Appropriation</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary</strong></td>
<td>I use basic computer and network tools when it is absolutely necessary to get my work done. I accept my students' work from computer sources, but I neither encourage nor assign such work on a regular basis. I am not convinced of the value of technology in learning, but I'll use it if I must.</td>
<td>I apply the basic technical tools - word processor, email, and the internet - to my teaching of the traditional subjects. Technology is here to stay, and important for my students to use. I'll use it when it works, and when it's under my control. Technology allows students to employ multiple forms of expression in my classes, and I assign many projects that call for them to employ different media to help them learn a variety of topics. I want my students to have the opportunity to learn with today's tools; it's essential to their development. I look forward to learning new technologies as they appear, and then quickly applying them to my teaching. Technology has enabled me to invent new ways of engaging my students with the content they need to learn.</td>
<td>Technology has helped me to transform the learning environment in my classroom. I want to try new technologies as they appear. Technology is central to all that we do in class; it's the way we do business.</td>
<td></td>
</tr>
</tbody>
</table>

| **Curriculum** | I stick to tried and true approaches in my teaching, using standard textbooks, whole-group instruction, and set schedules for the most part. If my students use technology at all, it's for acquiring basic knowledge and skills. I assign computer work occasionally in my class, requiring the use of basic computer productivity tools such as word processing. | Most of my curriculum materials are posted online, and student use them to develop key concepts and higher-level thinking skills. More and more of their assignments involve the application of cognitive and digital tools to skills to the solution of real-world problems. My students apply the skills they have learned to real-world problems, using the same technology tools that are used in business and research. All of my reference materials are online, and available in many media forms to support a variety of learning styles. Students work on their own in cooperative groups for most of the class time. | | |
| I often design new lessons that take advantage of the capabilities of the new technologies to develop key concepts in the standard subject areas. In fact, most of the activities in my class involve computers in one way or another, including a good deal of online learning. | | | | |

162
<table>
<thead>
<tr>
<th>Entry</th>
<th>Adoption</th>
<th>Adaptation</th>
<th>Appropriation</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching</strong></td>
<td>Most of my assignments involve paper and pencil tools, as do my tests and quizzes. I direct my lessons carefully, and ensure that all students proceed at a standard pace with the rest of the class. Any use of the computer or the network is incidental to the traditional teaching in my class.</td>
<td>Students work on traditional academic tasks with the technology, for the most part all working at the same assignment. The technology is under my careful supervision at all times, and sometimes includes a slide show that I deliver. Once in a while, I let small groups of students work at the computer, and I sometimes evaluate their projects with a simple rubric.</td>
<td>My students often initiate projects that use technology, and many of my assignments expect them to employ computers in their work. Though multimedia projects are not easy to assess, I have developed criteria to judge the academic value of this kind of work, some of which is accomplished by cooperative group activity.</td>
<td>I encourage my students to take the lead in finding new problems to solve and topics to explore. They often locate useful online learning resources of which I was unaware. The results of their investigations become part of an online digital portfolio that is assessed by peers and teachers.</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>Since most of the world seems to be using email, I use it as well when it's the only way to communicate, at home and for certain required tasks at school. But most of my communication employs the standard modes of telephone, face-to-face meetings, and written notes.</td>
<td>Many of my parents and a few students communicate with me by email, and I find this useful. I've even tried instant messaging with a few of them. Our class newsletter and some assignments are now published online.</td>
<td>Many of the assignments and materials for my classes are posted online, and I often find myself using email and instant messaging to communicate with my students and their parents. I have also found it valuable to use email, IM, and other online forums and chats to share ideas with other teachers and professionals.</td>
<td>My web site has become a comprehensive resource-bank for me and my students, with most assignments posted online. Students develop collaborative projects that are published on the web, and they often use instant messaging (including audio and video) to get this work done.</td>
</tr>
<tr>
<td>Media</td>
<td>Entry</td>
<td>Adoption</td>
<td>Adaptation</td>
<td>Appropriation</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>If students include digital images in their work I accept them, but do not expect such work as a matter of course. I use a digital camera at home for family photos, but seldom in school. I know how to make a simple slide show on the computer, but I don't do so very often.</td>
<td>Some of this year's assignments require students to develop simple projects on the computer that include images from the web, and get into what's called digital storytelling. My presentations to the class often include simple slide shows to illustrate key points.</td>
<td>My students are improving in their development of multimedia projects to explore key concepts in the standard subject areas. They have learned to use audio and video editing software, and can produce simple podcasts of their reports. The complexity of their digital storytelling is increasing.</td>
<td>Students in my classes produce original multimedia works in all of the standard subject areas, and publish these on the web, on DVD, and as enhanced podcasts.</td>
</tr>
</tbody>
</table>

<p>| Productivity | The projects my students produce are aimed at a broad audience, and contain mostly original material developed from primary sources, in whatever media is most appropriate to communication and understanding. | I prefer that students do their writing on a word-processor, and I welcome their questions over email. It's common for me and my students to use word processing, spreadsheets, and computer slide shows in our standard curriculum work. I know how to store these files on the school's server. | In class, we often analyze quantitative information with a spreadsheet or database to help us understand key concepts in science and social studies, and we use the equation editor in math. Students have learned to mark up each other's writing using their word processors, and so the amount of peer editing has increased. | We build simulations of natural and historical phenomena with a spreadsheet, and students are able to design and carry out their own analyses of complex data. They frequently use the school network for collaboration, and for organizing their research materials. | My students and I often devise new ways to use word processors, spreadsheets and databases to explore the information in the curriculum. We jump at the chance to learn a new software or hardware tool as soon as it appears. |</p>
<table>
<thead>
<tr>
<th>Information</th>
<th>Entry</th>
<th>Adoption</th>
<th>Adaptation</th>
<th>Appropriation</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most of the information in my class comes from print sources, but I allow internet research, and sometimes print out web pages for my lessons. I can find what I need on the internet some of the time, but would rather work in the library.</td>
<td>As a complement to their library research, students often find information on the Web, usually through sites that I identify for them. We have done Web scavenger hunts as part of certain curriculum units.</td>
<td>To help develop higher-order thinking skills, I construct webquests and other strategies that send students to a wide range of information resources. Online research has supplanted the books we used to use. We've begun to create an online archive of the most valuable sources.</td>
<td>My students are good at locating and evaluating new sources of academic information online, and use these sources to raise issues and solve new problems. Internet research has pretty much replaced book research in my class, and the web has become the chief method for students to publish their findings.</td>
<td>The students and I publish our work in a variety of formats, including web sites, podcasts, and video documentaries. These works are often consulted by other students, parents, and the community because of their educational value.</td>
<td></td>
</tr>
</tbody>
</table>
Subject Area:

Describe a “personal growth plan” aimed at moving you forward. What project or goals do you want to try?

What do you need to do to be prepared to do this project or meet these goals?

What additional resources do you need?

What support or training do you need from your Instructional Technology Specialist?
### Appendix E: Classrooms For The Future

<table>
<thead>
<tr>
<th>Professional Development</th>
<th>Description</th>
<th>Teachers</th>
<th>IT staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hands-on vendor provided professional development sessions</td>
<td>Teaching in the 21st Century: The Need for Change</td>
<td>half day to 2 days</td>
<td>8 days</td>
</tr>
<tr>
<td>On-line blended study group courses through Wilkes Univ.</td>
<td>Authentic Teaching and Learning in the (Math, English, Science, Social Studies) Classroom</td>
<td>30 hours per year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Differentiated Instruction in the (Math, English, Science, Social Studies) Classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inquiry-based Learning in the (Math, English, Science, Social Studies) Classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project-based Learning in the (Math, English, Science, Social Studies) Classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-site instructional technology coaches</td>
<td>School districts collaborate with the State Department of Education to recruit, select and hire Classrooms for the Future instructional technology coaches, who currently hold an Instructional I or II certificate or an Instructional Technology Specialist certificate and have a minimum of three years of classroom experience.</td>
<td>provide on-going and need based support to teachers</td>
<td></td>
</tr>
<tr>
<td>Instructional Technology Integration Coaches Boot Camp</td>
<td>Instructional technology coaches attend an intensive 3 ½ day “Boot Camp” each year to deeply engage them in discussions of coaching, instructional strategies, and curriculum integration.</td>
<td></td>
<td>3 ½ days per year</td>
</tr>
<tr>
<td>Leadership sessions for administrative staff and technology staff</td>
<td>Administrators are required to participate in a one-day pre-grant meeting, a one-day grant kick-off meeting and orientation and follow-up meetings for the on-line professional development component of the project. In addition, they are required to participate in the first course of the 21st Teaching and Learning Series, The Need for Change.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PD Components</td>
<td>Description</td>
<td>Teachers</td>
<td>IT staff</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Ongoing professional development opportunities</td>
<td>Throughout the year teachers, administrators, coaches and technology directors are invited to participate in free weekly webinars on topics of interest, preconference events specifically designed for coaches and administrators at the PETE&amp;C conference, the Penn State 1:1 conference or the Pennsylvania School Librarians Association conference. In addition, the CFF community has a robust virtual community which includes listservs for specific groups, a CFF coach moodle site, wikis and other web 2.0 social networking sites. These ongoing opportunities create opportunities for teachers and coaches to collaborate, share ideas and extend learning beyond their individual schools.</td>
<td>events for networking and sharing ideas</td>
<td>events for networking and sharing ideas</td>
</tr>
<tr>
<td>Virtual Camps (2009)</td>
<td>Four virtual camps are available for CFF teachers and coaches the summer of 2009. Participants have the opportunity to learn a web 2.0 technology thoroughly and develop instructional units and lessons over four to six weeks during the summer. Camps include Google, Taking it Global, Wikispaces and ePals.</td>
<td>4-6 weeks over the summer</td>
<td>4-6 weeks over the summer</td>
</tr>
<tr>
<td>Intermediate Unit Technology Integration Mentors (IU TIM)</td>
<td>The IU TIM develops a professional learning community for all CFF instructional technology coaches within their respective IU. The PA IU TIMs provides regional leadership activities for Classrooms for the Future schools by visiting schools, hosting local meetings and facilitating regional trainings. They are the first point of contact for CFF instructional technology coaches who may need assistance and work with the PDE mentors to support the program in their region.</td>
<td>PLC of coaches</td>
<td>PLC of coaches</td>
</tr>
<tr>
<td>Collaboration Days</td>
<td>Most IU TIMs have worked with regional coaches to create “Collaboration Days” for teachers to come together to share effective classroom strategies in depth in a particular subject area (English, math, social studies or science).</td>
<td>Collaboration Days for sharing effective practices</td>
<td>Facilitate Collab Days</td>
</tr>
<tr>
<td>PDE Mentors</td>
<td>A PDE Mentor is the first point-of-contact for the IU TIM when there is a question or concern related to CFF. A PDE Mentor collaborates with the IU TIM regularly to determine the best methodology to support the IU TIM efforts. A PDE Mentor communicates regularly with the CFF Project Manager, vendors, and IU TIM through face-to-face meetings, conference calls, webinars, telephone calls, and e-mail to ensure that schools successfully plan, implement and monitor their CFF programs.</td>
<td>PDE Mentors provide leadership for CFF coach professional development (PD) throughout Pennsylvania. They actively engage the coach community to determine PD needs. They design and implement CFF coach PD opportunities provided by PDE, including, but not limited to, face-to-face workshops, webinars, and written materials.</td>
<td>PDE Mentors provide leadership for CFF coach professional development (PD) throughout Pennsylvania. They actively engage the coach community to determine PD needs. They design and implement CFF coach PD opportunities provided by PDE, including, but not limited to, face-to-face workshops, webinars, and written materials.</td>
</tr>
</tbody>
</table>
Support Data: Nov 2008 - Nov 2009

Problem Types:
- Audio cable
- Bad hard drive
- Battery charger
- Cracked bezel
- Cracked case
- Database edit
- Email problem
- Entry/deletion permission right conflict
- Falcon gate access
- IE
- Keyboard
- Laptop cover
- Laptop reimage
- Laptop trackpad
- Missing equipment
- Monitor-LCD replacement
- Network connection
- Network connection - wire
- Network device request - keyboard
- Peripheral device request - speakers
- Peripheral device repair
- Projector alignment
- Projector bulb
- Projector cable
- Projector filter
- Projector repair
- Projector screen
- Reset PW
- Send mail problem
- Smartboard
- System administrator PW lost
- User ID lock
- Virus
- Voice mail pin reset
- Website update

Total
Appendix G: Training by IT Staff

IT Staff Provided Training Sessions for High School Teachers:
Fall 2005-Fall 2009

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2005</td>
<td></td>
</tr>
<tr>
<td>Fall 2007</td>
<td></td>
</tr>
<tr>
<td>Fall 2008</td>
<td>23</td>
</tr>
<tr>
<td>Fall 2009</td>
<td>16</td>
</tr>
<tr>
<td>Spring 2008</td>
<td>20</td>
</tr>
<tr>
<td>Spring 2009</td>
<td>22</td>
</tr>
<tr>
<td>(blank)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix H: Teacher Interactions

This question concerns how teachers interact with each other in your school. Please indicate the frequency with which YOU do each of the following. (Never, Seldom, A few times a year, Once or twice a month, Once or twice a week, Almost daily). Next, please indicate how much of these interactions included the discussion/use of technology (not at all, less than 20%, 20%-40%, 41-60%, 61-80%, more than 80%). So, for example, one interpretation is that I “seldom” have discussions with others, but that within that small number of discussions they are “less than 20%” about technology.

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Never</th>
<th>Seldom</th>
<th>A few times a year</th>
<th>Once or twice a month</th>
<th>Once or twice a week</th>
<th>Almost daily</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss what you/they learned at a workshop or conference.</td>
<td>0</td>
<td>7</td>
<td>28</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>48</td>
</tr>
<tr>
<td>Share and discuss student work.</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>12</td>
<td>13</td>
<td>48</td>
</tr>
<tr>
<td>Discuss particular lessons that were not very successful.</td>
<td>4</td>
<td>10</td>
<td>6</td>
<td>16</td>
<td>11</td>
<td>1</td>
<td>48</td>
</tr>
<tr>
<td>Discuss beliefs about teaching and learning.</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>48</td>
</tr>
<tr>
<td>Observe another teacher teaching.</td>
<td>4</td>
<td>20</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>48</td>
</tr>
<tr>
<td>Had conversations about what helps students learn best.</td>
<td>0</td>
<td>5</td>
<td>7</td>
<td>14</td>
<td>7</td>
<td>15</td>
<td>48</td>
</tr>
<tr>
<td>Be observed by another teacher.</td>
<td>8</td>
<td>15</td>
<td>14</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>48</td>
</tr>
<tr>
<td>Influenced the teaching practices of another teacher.</td>
<td>2</td>
<td>7</td>
<td>17</td>
<td>13</td>
<td>5</td>
<td>4</td>
<td>48</td>
</tr>
<tr>
<td>Tried something new in your classroom because of the influence of another teacher.</td>
<td>0</td>
<td>7</td>
<td>23</td>
<td>11</td>
<td>7</td>
<td>0</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How much of it was about technology in the given context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answer Options</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Discuss what you/they learned at a workshop or conference.</td>
</tr>
<tr>
<td>Share and discuss student work.</td>
</tr>
<tr>
<td>Discuss particular lessons that were not very successful.</td>
</tr>
<tr>
<td>Discuss beliefs about teaching and learning.</td>
</tr>
<tr>
<td>Observe another teacher teaching.</td>
</tr>
<tr>
<td>Had conversations about what helps students learn best.</td>
</tr>
<tr>
<td>Be observed by another teacher.</td>
</tr>
<tr>
<td>Influenced the teaching practices of another teacher.</td>
</tr>
<tr>
<td>Tried something new in your classroom because of the influence of another teacher.</td>
</tr>
</tbody>
</table>
Appendix I: Technology use for Classroom related practices

Total

- Word processing
- Wikis
- Web Development/Updates on Schoolwires
- Web Development/Updates on Google Sites
- Video editing software
- Symposium
- Survey
- Spreadsheet
- Social networking (Facebook, LinkedIn, etc.)
- Smartboard
- Scoodle for Course management
- School list serves
- Projector
- Presentation software (e.g. ppt, keynote)
- Photoshop
- Other list serves
- Lead server for file sharing
- Internet for research
- Google Docs for Course management
- Email
- Discussion Boards and Forums
- Collaboration Tools (e.g., Google Docs)
- Blogs
- Audio recording software

0 1 2 3 4 5 6 7
Appendix J: Survey Results

A survey was also conducted to probe the help preferences of teachers in the high school. About 56 teachers responded but only 48 completed the survey. The chart below shows the distribution of respondents by the departments they work in. In this only 42 respondents answered the question. The Science, Math and English teachers made up more than half of the respondents. The remaining respondents were from other departments.

Respondent Data

![Survey Respondents by Department]

Help Preferences

We asked the teachers to describe their strategies for seeking help if they needed to design a lesson with technology use. The chart below shows that teachers showed evidence of using all the strategies listed. Using the web, asking a tech-savvy teacher in their own subject and asking the IT coach were the most
popular strategies. Bringing this up at department meetings or asking a mentor or senior teacher was the least popular strategy for seeking help.

**Teacher Interactions**

We also wanted to probe how teachers interact with each other in their school and for what reasons. We asked them to indicate the frequency with which they do each of the following. (1=Never, 2=Seldom, 3=A few times a year, 4=Once or twice a month, 5=Once or twice a week, 6=Almost daily). Next they indicated how much of these interactions included the discussion/use of technology (1=not at all, 2=less than 20%, 3=20%-40%, 4=41-60%, 5=61-80%, 6=more than 80%). So, for example, one interpretation is that I “seldom” have discussions with others, but that within that small number of discussions they are “less than 20%” about technology. A rating average of 3.5 and below would be considered rare (never, seldom, few times a year). A rating average of 3.5 and above would be considered high (monthly, weekly, daily). The most popular reasons for frequent interactions were for sharing and discussing students’ work, what helps
them learn best, and beliefs about teaching and learning. At times, they also discussed lessons that didn’t work well. Teachers seemed to be highly influencing their colleagues in adopting their practices. However, it was relatively less likely that they were adopting practices that others had shared with them. Observation was not popular as a way of sharing practices.

Teacher Interactions about Technology Practices

Next we asked teachers to indicate how much of these interactions included the discussion/use of technology (1=not at all, 2=less than 20%, 3=20%-40%, 4=41-60%, 5=61-80%, 6=more than 80%). So, for example, one interpretation is that I “seldom” have discussions with others, but that within that small number of discussions they are “less than 20%” about technology. Here we
will consider a rating average of 3.5 and above to indicate high incidence of technology practices entering discussions and between 3.0-3.5 as being medium. The results indicate that teachers were not including technology practices in their interactions very frequently. However, in some cases, technology practices entered into discussions about 20-40% of the time. This happened when teachers shared what they had learnt about technologies in a conference or workshop or when wanted learn to try something new in their classroom from other teachers. They were also discussing technologies when they wanted to inquire what helps students would learn best. It also follows from this that they discussed how technologies were changing their beliefs about teaching and learning. Once again, observation was not popular as a way of sharing technology practices.
Technology Use to support classroom related practices

We also asked teachers to indicate the extent to which they were using technologies to support their teaching activities in the classroom teaching, preparation, evaluation, planning meetings, etc. (1=Never, 2=Seldom, 3=A few times a year, 4=Once or twice a month, 5=Once or twice a week, 6=Almost daily). A 3.5 or higher would indicate high usage, between 3.0 and 3.5 would be medium and less than 3 would indicate low usage of the listed technologies. For communication, sharing and collaboration the most popular tools were email, Google Docs, lead server, school list servs and even social networking tools. Projector and presentation software were high on the list for instruction and delivery. Word processor was the most popular productivity tool. Teachers also used spreadsheet a lot. Not surprisingly, the internet was used very highly for research. In the medium range, teachers reported using other list servs (that were not provided through the school), and also updating the school’s website with information about their curriculum. Sympodium was used mainly by Math teachers, and, as such, appeared to fall under the medium category. However, among the Math teachers it was highly used. Technologies that were less in popular use were Discussion Boards and Forums, Google Sites, Moodle for course management, Survey, Photoshop, Smartboard, Video editing software, Audio recording software, Blogs and Wikis. Please note that Moodle shows a low usage mainly because the English and Social Studies teachers were the first ones to receive the training and laptops to use it.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Not available</th>
<th>Rating Average</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>0</td>
<td>5.81</td>
<td>High</td>
</tr>
<tr>
<td>Internet for research</td>
<td>0</td>
<td>5.38</td>
<td></td>
</tr>
<tr>
<td>Projector</td>
<td>0</td>
<td>4.68</td>
<td></td>
</tr>
<tr>
<td>Collaboration Tools (e.g. Google Docs)</td>
<td>0</td>
<td>4.36</td>
<td></td>
</tr>
<tr>
<td>Lead server for file sharing</td>
<td>0</td>
<td>4.10</td>
<td></td>
</tr>
<tr>
<td>Email</td>
<td>0</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>Presentation software (e.g. Powerpoint, keynote)</td>
<td>1</td>
<td>3.80</td>
<td></td>
</tr>
<tr>
<td>Spreadsheet</td>
<td>0</td>
<td>3.79</td>
<td></td>
</tr>
<tr>
<td>Social networking (Facebook, LinkedIn, etc.)</td>
<td>1</td>
<td>3.51</td>
<td></td>
</tr>
<tr>
<td>Other list serves</td>
<td>3</td>
<td>3.32</td>
<td>Medium</td>
</tr>
<tr>
<td>Sympodium</td>
<td>9</td>
<td>3.27</td>
<td></td>
</tr>
<tr>
<td>Web Development/Updates on Schoolwires</td>
<td>0</td>
<td>3.27</td>
<td></td>
</tr>
<tr>
<td>Discussion Boards and Forums</td>
<td>2</td>
<td>2.93</td>
<td></td>
</tr>
<tr>
<td>Web Development/Updates on Google Sites</td>
<td>0</td>
<td>2.88</td>
<td></td>
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<tr>
<td>Google Docs for Course management</td>
<td>0</td>
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<td>Moodle for Course management</td>
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<tr>
<td>Survey</td>
<td>0</td>
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<td>Low</td>
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<td>Photoshop</td>
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<td>2.63</td>
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<td>Smartboard</td>
<td>27</td>
<td>2.60</td>
<td></td>
</tr>
<tr>
<td>Video editing software</td>
<td>2</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td>Audio recording software</td>
<td>3</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>Blogs</td>
<td>2</td>
<td>1.88</td>
<td></td>
</tr>
<tr>
<td>Wikis</td>
<td>3</td>
<td>1.53</td>
<td></td>
</tr>
</tbody>
</table>
We also asked teachers to recall any training sessions they attended online, again thinking back to the past 5 years. They listed the type of training and the quarter/year (if they remembered). They were also asked to state if these online training programs were requested by the school district or initiated by them through their department. From the responses it was clear that most teachers were taking online courses that were mandated through the CFF program. Of the 29 respondents to this question, only 9 reported having taken these classes. Only two teachers reported taking online courses other than the CFF online courses.
Appendix K: Grounded Theory Analysis

1. WHAT IS TECHNOLOGY INTEGRATION (TI)

When asked the question, “how do you integrate technology in your practice”? teachers were unsure of what it meant. They approached it in different ways as they built an answer. Based on interviews, it is clear that the on-site IT training provided to the teachers focuses on pedagogy. They expose teachers to different tools that can be used as different strategies for teaching. For curriculum integration, some of it takes place when teachers share their practices in the follow-up session during spring. Most of CI takes place within departments or collaborations between teachers.

- Technology Integration is the use of computers in general content areas in education in order to allow students to learn computer and technology skills. Generally speaking, the curriculum drives the use of technology and not vice versa. [1][2]

- The International Society for Technology in Education (ISTE) has established technology standards for students, teachers and administrators in K-12 classrooms. The ISTE, a leader in helping teachers become more effective users of technology, offers this definition of technology integration:

"Curriculum integration with the use of technology involves the infusion of technology as a tool to enhance the learning in a content area or multidisciplinary setting... Effective integration of technology is achieved when students are able to select technology tools to help them obtain information in a timely manner, analyze and synthesize the information, and present it professionally. The technology should become an integral part of how the classroom functions — as accessible as all other classroom tools. The focus in each lesson or unit is the curriculum outcome, not the technology." [3]

http://en.wikipedia.org/wiki/Technology_integration

In the English-speaking world the term pedagogy refers to the science or theory of educating; trainee teachers learn their subject and also the pedagogy appropriate for teaching that subject. The Introduction of information technology into schools has necessitated changes in pedagogy; teachers are adopting new methods of teaching facilitated by the new technology.

http://en.wikipedia.org/wiki/Pedagogy

Information and communication technologies in education deal with the use of Information and Communication Technologies (ICTs) within educational technology. ICT in education can be broadly categorized in the following ways:
i. ICT as a subject (i.e., computer studies)

ii. ICT as a tool to support traditional subjects (i.e., computer-based learning, presentation, research)

iii. ICT as an administrative tool (i.e., education management information systems/EMIS)

2. **DIFFERENT TYPES OF TECHNOLOGIES THAT ARE CURRENTLY USED BY SCHOOL TEACHERS**

Word processing, Spreadsheets, Keynote, iPhoto, iMovies, Pagemaker, Dreamweaver, Garageband, Schoolwires, Google Docs, Doodle, Moodle, Gmail, Sympodium software, File Sharing Server (LED Server), FM Pro databases, Online Grading System

3. **DIFFERENT TYPES OF TECHNOLOGY ONTOLOGIES**

Teachers and IT Staff that were interviewed described their way of viewing technology in different ways as described below:

i. **Categorization by Roles:**

- **For teaching side of the job:**
  - Lesson planning: Word Processsing, Sympodium Software, Keynote/Powerpt, Spreadsheet, email, network file server
  - Delivering instruction: subject specific tools + productivity + course enrichment tools +research tools + course management + course delivery + network server.

- **For coordinating side of the job (dept. head):**
  - Meeting management
  - Doodle for scheduling meetings (with potluck)
  - Google Docs for setting up a document that teams of teachers fill out collaboratively.
  - Google Docs for surveys and polls (deciding on who should get the Sympodiuims first)
  - For follow-up communication after meetings: Google Docs and email

ii. **Task Specific categories:**

- Lesson Plans: share/download from network server, power point, collaboration tools, word to make note packets
- Teaching: Powerpoint, symposium, edl technologies.
• Assignments submissions: Moodle submissions, gmail submissions, hand in box network server submissions.
• Tests/Exams: word (has equations)
• Meetings: Doodle, Google Docs

iii. Offline/Online categories:

• Offline tools: Microsoft office, iPhoto, iMovie, Keynote, etc.
• Online tools: Moodle, network server, Google Docs, attendance, grades, fm pro databases

iv. Categorization by Functions: these technologies can be classified according to the functions they provide.

• Public Outreach: Schoolwires – only teachers/staff can edit. Students can’t build websites on these.
• Collaboration: Google Docs, Gmail, network server
• Productivity: Word, Spreadsheets.
• Administrative: FilemakerPro databases (vacation, attendance, grades, keeping track of calculators)
• Communication: gmail, facebook, school website page.
• Sharing: network server for file sharing, email attachments.
• Course content development: Flash, iPhoto, iMovies, Word, Spreadsheet, Flash, Keynote, Powerpoint
• Course management: Moodle, Schoolwires
• Course delivery: Schoolwires, powerpoint, symposium
• Course Enrichment: Flash, iPhoto, iMovies, Podcast
• Research: Internet Resources
• Meetings management: Doodle, Google Docs (surveys,polls)
• Teacher professional development: List servs, online courses
• Subject specific: Texas Instrument, Graphing Calculator, Calculus in Motion (Math)
• Communicate with parents: email, schoolwires
• For listing homework: webpage (Schoolwires), Moodle
• Attendance: district online system

4. Levels of Integration

Technology integration means different things to different people. The most popular view as propagated by ISTE is about achieving curriculum integration. However, Curriculum Integration cannot take place in isolation. It requires the need to integrate technology in a variety of ways. Some are enunciated below:

i. Subject specific technologies can be integrated with other instructional technologies.
For example, during teaching, a teacher can integrate a graphing calculator with the computer. The computer itself is integrated with the projector.

“Personally, the most common used tech in classroom is the Graphing calculator but that I now use with an emulator that’s on my computer. I would use the TI84+calculator on the comp that project 3 diff representations at the same time.”

ii. **Course content development technologies can be integrated with course management technologies.**

For example, lessons can be developed using word, spreadsheets and other course enrichment tools such as iPhoto, iMovie, pageMaker etc. and then uploaded to the course management tools such as Moodle.

iii. **Course content development technologies can be integrated with collaboration technologies.**

For example, a lesson plan can be developed collaboratively by creating it in Google Docs, or by exchanging it through the file server with other teachers, or by exchanging it as email attachments.

iv. **Different technologies can be integrated through a common user interface.**

For example, collaboration technology (Google Docs), web development technology (Schoolwires) and course management technology (Moodle) have been integrated. Once a user has logged into Moodle, he does not have to log in again to access Google Docs. A teacher can develop a survey using a Google Doc form and display the form on her page on Schoolwires. Additionally, communication and collaboration technologies have also merged by migrating the old webmail to gmail for a natural integration with Google Docs.

5. **DIFFICULTIES**
i. Too many list servs available.
ii. Too many web resources available
iii. Low self efficacy
iv. Hardware/Software problems
v. Network problems (“If I walk my MAC from here to there I lose connection”)
vi. MAC vs PC at home. (“Online answer book does not work on every platform.”) Introduction of Google Docs solves this problem to a large extent.
vii. Technical issues with calculator
viii. Learning and transferring into the classroom context. (“most significant PD is getting in the classroom and teaching because then you find out that the high and mighty ideas don’t work when the rubber hits the road. Sometimes it’s interesting but not applicable”).

- Not sure if technology can be a diversion instead of being a help.
- Access to computers limited due to sharing laptop carts
- Lack of time required for learning and transferring teaching tools. (“We are just told that these technologies are available and then you just swim”).
- Timeliness: “Here they don’t necessarily teach us what we need to know. They don’t teach us at an appropriate time – like before we are going to use it.”

6. PROFESSIONAL DEVELOPMENT PRACTICES

i. Professional development in IT

- IT dept training resource
- Peers
- Self
- Friends
- Watch news
- Talk to spouse
- In-service days
- Off school
- After school

ii. Professional Development in Math (can include use of IT):
• On-site district wide
• On-site dept. based – peer 2 peer
• Off-site conferences
• NSF funded project with PSU – Computer Intensive Algebra – then part of a traveling team.
• Geometry has not changed in 2000 yrs. (intertwining thought ideas)

iii. Professional Development of IT Staff:

• Apple Distinguished Educators – selects 50 members each year.
• Apple Learning Interchange – is an online community
• Educational Technology Blog
• PSU has 1-on-1 conference every year by Kyle Peck (Penn Educational Computing Conference every Feb)

7. COLLABORATIONS

Several instances of collaborative classes are taking place. Each time, technology has played a role in initiating and facilitating the process. There is some form of division of labor occurring which would be interesting to follow. Tech savvy teachers are usually taking on the responsibility of the technology aspect. It is not clear if other less technology oriented teachers are learning these skills implicitly by just being there.

i. Affordances from the introduction of new educational technology.

For example, vernier sensors acquired by Science dept. made possible a collaboration among physics teachers where they had combined activities for 5 physics classes in analysis of real time sound, motion and light data. This will lead to collaboration with Engineering teacher next.

ii. Convenience offered by technologies that make it easier for integration of curriculum for teachers to collaborate on common topics.

For example, Feed the Pig campaign. With old fashioned teaching, it would be hard to manage such collaboration. Two teachers collaborated on teaching a Econ and Finance course together on the topic of Savings and Investment. Then they would collaborate with two more teachers next.
iii. **Ripple Effect:**

- Cross disciplinary: Physics teachers were planning to collaborate with Engineering teachers after collaborating with same subject teachers.
- Scaling: The Business Edn teacher was planning to expand and include more classrooms in his next venture. Teachers in his department heard about the collaboration and were interested in joining.

iv. **Difficulties in collaboration:**

- While working with other teachers:
  
  "Dogmatic teachers who don’t discuss, just tell....."
  
  "Collaboration is where we exchange ideas, materials and discuss the curriculum....."
  
  "Blogs, Facebook etc. are time sinks"

- While conducting a collaborative class:

8. **NORMS**

- Training is more important than equipment:

  Director – “I would rather have lots of teachers who know how to use computers rather than lots of computers and no one knowing how to use them. So, training funds have not been affected this year despite the low budget. We did not purchase any new computers, only replaced the 4 yr old computers.”

- Most training is done on release time:

  "We don’t do it on an in-service day because there are too many teachers and too few IT Staff."

  “On-site ad hoc brown bag training: not well attended. Mostly para-professionals show up for these and that too is rare.”

- No use of online systems:

  “On-line places do not work. We attempted some things on our own. We found that people like to go some places to get ideas, but to take some time to contribute is hard for teachers.”

- IT training is not mandated but....
“½ day and 1 day summer programs were optional. But then we started introducing laptops and other equipment. Then we required them to come to training. That’s where we introduced the Kiva Project. This required giving them one Fall day off and give them a homework to come and share at the end of spring. That’s our model and it works. When we first initiated this teachers were weary. They are used to teaching kids but not speaking in front of their peers. They are becoming more comfortable. We have been doing this for 5 years.”

• Cross disciplinary group of trainees – “it’s not the subject but the strategy that they use.”

• How are needs identified?

“We meet once every 2 weeks with the director of technology, Help Desk manager, etc. – a group of 10 people who meet called the Technology Management Team – we bring ideas. People who go to a conference talk about what they saw. For example we saw Google Docs in one of the conference. It solved the problem of versions. 97% of our kids have internet at home. So it works very well.”

“Kerry Pack has a 1-on-1 conference once a year at Penn State where we go. Sometimes one of us will go to a National Educational Computing Conference. We try to go mostly to the conferences on the east coast.”

“Building IT staff are communicating with teachers all the time. For example, some teachers suggest things that would like to learn in their on-site training programs. Asst. Principle once wished if disciplinary referral could be done electronically. So she took this request to the bi-monthly meeting and a programmer built this system.”

“Students are doing more and more video. But since the school bars You Tube, children have no way to publish. So IT Staff talked about the need in a meeting and identified a tool. We would like a tool that the whole world can’t see and parents can authenticate to it. So we have identified a tool. Teacher Tube is very slow.”
Vita
HANSA SINHA

Education
Hansa Sinha joined the Ph.D program at the College of Information Sciences and Technology, Penn State University (PSU) in 2006. She holds a Masters’ degree in Accounting & MIS from the Smeal School of Business Administration at PSU. She earned a Post Graduate Degree in Personnel Management and Industrial Relations (PGDIR) from XLRI (Xavier Labor Relations Institute), India. She has an undergraduate degree in Economics (with honors) and Secondary Education.

Experience
While pursuing her Ph.D, Hansa worked on several research projects in the areas of Human Computer Interaction (HCI), User Experience, Computer Supported Collaboration and Learning (CSCL), Computer Supported Cooperative Work and Communities of Practice. Her dissertation research focuses on teachers’ professional development with respect to technology enabled work practices. An important outcome of her study was the adaptation of Activity Theory as a framework for analysis for technology integration and dissemination. During this period Hansa was a course instructor for a senior level undergraduate course and a teaching assistant for several courses. Before joining the Ph.D program, Hansa had worked at PSU as a Database Administrator/Webmaster, Application Programmer/Analyst and a Software Implementation lead.

Awards
Best Paper Award, 2009 IST Graduate Symposium, 2009
Best Long Paper Award, VL/HCC Conference, 2007

Publications
Hansa’s research has been published in four peer-reviewed journals and nine academic conferences. Some of the selected publications are listed below:

Journal Paper

Conference Paper