



2014

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How Teachers Learn: The Roles of Formal, Informal, and Independent Learning

(The final publication is available at Springer via <http://dx.doi.org/10.1007/s11423-014-9337-6>)

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Abstract

A qualitative study of math and science teachers at two middle schools identifies how their system for learning to integrate technology into their teaching goes beyond what school leaders typically consider when planning for teachers' learning. In addition to (a) the district-initiated, or formal, system of professional development (PD) and professional learning communities (PLCs), it includes (b) teacher-initiated, or informal, learning with colleagues as well as (c) teachers' independent learning activities. Analysis of why and how they form their system highlights how by only supporting the formal PD activities and PLCs, the district not only loses the valuable collective knowledge of the districts' teachers derived from their informal and independent learning activities, but also diminishes the learning teachers derive from the formal PD activities since informal collaborations and independent work after formal PD activities often helps to bring the learning from the training room to the classroom. We present teachers' insights and then discuss implications for the design of a holistic approach to facilitate teachers' formal, informal, and independent learning that is tied together and supported by technology. While research on formal, informal and independent teacher learning exists, with technology frequently mentioned as a potential support for each of these three modes, these approaches have not been considered together as interdependent parts of the same holistic system for teacher learning nor has the way technology might knit these modes of teacher learning together been imagined as a part of that system.

Keywords: Technology related teacher professional development – Formal and informal teacher learning – Technology integration

How Teachers Learn: The Roles of Formal, Informal, and Independent Learning

It is widely recognized that K-12 teacher professional development (PD) is a critical component of improving the quality of education in the United States (Lawless & Pellegrino, 2007; Birman, Desimone, Porter & Garet, 2000). It is a component that is often utilized to help teachers remain current with changes in statewide student performance standards and new methods of teaching in the content area, as well as for disseminating new teaching strategies as school environments shift and student populations become more diverse (Lawless & Pellegrino, 2007). In addition, rapidly developing areas, such as digital technology, add additional pressure on teacher PD to assist teachers in preparing their students for a more technologically sophisticated society and workplace. To accomplish this, teachers need opportunities to learn to teach in ways that differ from how they were taught and provide a technology rich environment for today's technology savvy students.

Researchers have examined teacher PD from various perspectives. Lawless and Pellegrino (2007) articulated a systematic evaluation plan for teacher PD activities in integrating technology into teaching and learning designed to help improve the outcomes of these activities. Similarly, Garet, Porter, Desimone, Birman and Yoon (2001) compared effects of characteristics of PD on teachers' learning, and identified three core features that significantly improve teachers' self-reported increases in knowledge and skills in classroom practice: (a) focus on content knowledge; (b) opportunities for active learning; and (c) coherence with other learning activities. However, while PD has been shown to produce positive teacher and student outcomes when done effectively (Martin et al, 2010), it is still regarded as typically inadequate in meeting teachers' learning needs (Lawless & Pellegrino, 2007).

Easton (2008) suggests the paradigm of PD be reconsidered, and instead of teacher *development* being examined, the focus be applied to teacher *learning*. The movement in schools to establish professional learning communities (PLCs), where teacher learning can be facilitated through on-going discussion groups, represents one dimension of this trend (Hamos et al., 2009). This study extends this view of teacher learning by contextually examining the role of formal structures within a holistic view of the ways in which teachers learn, including (a) formal PD and PLCs, (b) informal learning with colleagues, and (c) independent learning, to consider how teachers utilize these specific approaches and how to leverage their specific affordances.

Background

Formal Professional Development

While some specific PD programs have been shown to improve teacher knowledge and student outcomes (Martin et al, 2010), these programs rarely reach teachers on a large scale. Most teachers engage in only the minimal professional learning required of them and report these experiences as only reinforcing their existing practices (Hill, 2009). Many formal PD activities utilize face-to-face instruction delivered at specific times and inherently possess temporal and geographic related difficulties (Tytler, Symington, Malcolm, & Kirkwood, 2009; Plair, 2008). In addition to these shortcomings, PD for technology integration has additional challenges. The unprecedented growth of digital technologies and the rate at which technology now evolves creates a need for greater flexibility in teacher PD. Districts struggle to identify and develop formal PD opportunities to respond to new technological innovations. Mobile technologies and the applications that run on these devices, which typically have quick development times, evolve at a faster rate than traditional software designed to work on personal computers. To remain current in these technologies and understand how to effectively utilize them in instruction,

teachers require learning opportunities that can evolve at a similar rate. In addition, people other than the teachers it is designed for often dictate the content and format of formal PD experiences. This process ignores teacher voice, as well as wastes an opportunity to capitalize on teacher experience or build capacity within an organization (Rodrigues, Marks, & Steel, 2003). Formal PD experiences are often constrained to a specific time period and lack the on-going support teachers require (Mackey & Evans, 2011). The timing of these experiences also may not align with when teachers need the instruction.

These inadequacies of traditional formal PD models have prompted consideration of alternative formal models and how emerging technologies can be utilized. The improvements in communication technologies, specifically, have increased interest in utilizing teacher learning communities. Largely based on the theory of communities of practice (Wenger, 1998), educational organizations began developing PLCs. Communities of practice are defined as informal communities that people form as they pursue shared enterprises (Wenger, 1998). While Wenger suggests these communities cannot be developed by an organization, he believes organizations can provide supports that facilitate the development of such communities.

Recent literature focusing on utilizing PLCs for teacher learning suggest that formal PLCs (i.e. organized by the school with expectations for participation) can facilitate improved communication among teachers, and between teachers and others, by providing structured time for sharing and collaboration (DuFour, 2004; Duran, Brunvard, & Fossum, 2009; Gerard, Bowyer, & Linn, 2010; Loving, Schroeder, Kang, Shimek, & Herbert, 2007). The benefits of this improvement include promoting a culture of collaboration and facilitating authentic and research based learning (DuFour, 2004; Lai, Pratt, Anderson, & Stigter, 2006), as well as providing access for teachers to peers, mentors, and university faculty (Loving et al., 2007).

However, while formal PLCs can offer these benefits, this model of PD still exhibits shortcomings (Marsick & Watkins, 1990). For example, content and learning processes are dictated by the organization which, while serving organizational goals, may not align with teacher learning goals or preferred learning processes (Rodrigues, Marks, & Steel, 2003). As well, while improvements in communication technologies allow for virtual asynchronous communications to help alleviate the time constraints for teachers to participate in PLCs, teachers require training in this method and the tools required for participation (Loving et al., 2007).

Informal Teacher Learning

In a 2004 study by Stevenson, teachers in grades three through six in two elementary schools reported valuing informal collaboration over organizationally planned activities for learning about technology integration. In this study, the goal of the collaborations was to improve technology use in teachers' classrooms; the technologies under examination were only identified as specifically as computer hardware and software, as well as the Internet. Teachers in the study identified immediate support, new idea generation and brainstorming opportunities as key components of informal collaboration. This is underscored by a 2008 survey of a representative sample of U.S. schools in which various roles (technology staff, administrators, teachers, library media specialists, etc.) were ranked by the amount of support they provide to teachers integrating technology, and fellow teachers were reported providing the highest percentage of "moderate" and "major" assistance (Gray, Thomas, & Lewis, 2010). The study by Stevenson also provided insight into the nature of informal collaborations between teachers regarding technology use. First, teachers in the study reported informal collaboration regarding technology being a pervasive part of their professional lives. The pervasive nature of these

informal collaborations provide several elements of effective professional development such as coherence with other learning activities, and collective participation from teachers in the same school grade or subject (Garet et al., 2001). Second, informal collaboration among teachers is influenced primarily by time and the perceived potential for receiving information specific to their needs. The influence of time was also echoed in a case study of the online *Continuing Professional Development for Teachers* (e-CPDeIT) project, in which teachers reported the lack of provided work-time as a primary barrier to their participation in the activities (Ming, Wah, Azman, Yean, & Sim, 2010). Informal learning activities, not being organizationally sponsored, seldom receive the organizationally provided learning time provided to formal learning activities. Lastly, teachers in the Stevenson study reported seeking out two different types of individuals depending upon the broad area with which they needed assistance; teaching colleagues for curriculum ideas and technology specialist for how-to information. This finding was echoed in a study by Tytler et al. (2009) in which teachers reported utilizing mentoring relationships outside of the formalized mentoring program in their schools.

Informal communities of practice (COPs) we define as a group of practitioners who choose to come together to share information and work together on a problem of practice; it is because of their choice to assemble, rather than that they are organized by their school or district leaders, we consider them informal learning activities. Informal COPs share many of the same affordances as formal PLCs such as improved communication among teachers, however informal COPs also provide a greater level of just-in-time support as well as consideration of teacher choice in content and process. Teacher support through informal COPs is not constrained by pre-set times or organizational assignments and boundaries like that which is experienced through workshop-style PD activities or through the use of an organizational technology

specialist. These informal communities are often formed between teachers who are in close contact with one another, either virtually or physically, thereby improving response time to needed support. These communities are self-sustaining and allow the learners to dictate both what is learned and how the learning occurs. However, while informal COPs may allow for improved teacher choice of content and process, these choices may not align with organizational learning goals. Peer learning in these environments can facilitate teacher collaboration, but the effectiveness of these environments is also largely dependent on the participants' knowledge and skills, as well as their interactions (Riverin & Stacey, 2008). The flexibility and choice inherent in informal learning in COPs may assist teachers in collaborating with peers on specific needs and at the most convenient times. However, because of the very nature of informal learning, teachers don't receive organizational support to participate in these types of activities and therefore must find their own time to do so outside of the work day and likely must learn to use any pertinent learning tools on their own (Ming et al, 2010). The abundance of resources available for informal learning such as teacher chat rooms, lesson portals, and web sites developed for teacher learning also introduces the problem of information overload (Riverin & Stacey, 2008), and without proper training on the use of informal learning tools, teachers may experience difficulty in effectively participating in this mode of learning. The affordances and constraints of utilizing informal COPs for teacher learning illustrate the difficulty in developing and supporting this mode of learning (Wenger, 1998), and organizations must balance the designed and emergent aspects of this type of community learning (Barab, Makinster & Scheckler, 2003).

Independent Teacher Learning

There is little research available on independent teacher learning, which we define as learning activities that teachers engage in on their own initiative and accord, and which possess no connection to their organization. However, with the emergence of social media in the last few years and the increased participation on social media sites like Twitter, FaceBook and YouTube, there is increased interest in personal learning networks (PLNs). PLNs are developed by teachers through their participation in professional learning sites, blogs, Twitter, wikis, podcasts, social bookmarking sites and online video sharing sites (Richardson & Mancabelli, 2011). This type of community learning differentiates itself from previously mentioned models such as informal COPs and formal PLCs in that the platforms used have no connection to a participant's organization, and not only is the participant's activity voluntary, it is often anonymous because of the use of alternate logins or user names. Participation in these networks is often described through the lens of connectivism (Siemens, 2005) more so than the communities of practice framework (Wenger, 1998). While the theory of communities of practice describes informal participation in a community, which is also appropriate for PLNs, connectivism considers the impact of modern technology on how communication is facilitated and how we learn.

Connectivism also reconciles the dual nature of independent learning and learning through communities. Siemens (2005) describes connectivism as such:

The starting point of connectivism is the individual. Personal knowledge is comprised of a network, which feeds into organizations and institutions, which in turn feed back into the network, and then continue to provide learning to individuals. This cycle of knowledge development (personal to network to organization) allows learners to remain current in their field through the connections they have formed (para. 25).

This theory of learning is also appropriate as we consider learning about the subject of technology integration in instruction, which is extremely dynamic, and presents additional challenges for members of organizations who are required to remain current in this field.

PLNs may provide quicker access to information on emerging technologies, as there is no wait time for learning activities to be developed. Teachers globally utilize social media to report, in real time, their successes and failures using new tools. PLNs possess many of the same affordances as PLCs and informal COPs, however generally utilize a larger network of resources, possess more current information on technology integration, and allow for anonymous participation (Alderton, Brunsell, & Bariexca, 2011; Hur & Brush, 2009; Siemens, 2005).

Anonymous participation in these networks has been reported by teachers as allowing them the ability to discuss issues they feel are inappropriate for organizationally sponsored platforms, and allows them to seek support without feeling intimidated (Hur & Brush, 2009). However, PLNs suffer some of the same constraints as informal learning communities such as lack of organizational support and misalignment of the teacher's and the organization's learning goals. In addition, PLNs also require teachers to possess somewhat advanced knowledge of technology in order to utilize and navigate among several different platforms (Flanigan, 2011).

Summary

Thus, we see that (a) district-initiated, or formal, systems of PD and PLCs, (b) teacher-initiated, or informal, learning with colleagues, and (c) teachers' independent learning activities each possess affordances and constraints. Each learning mode typically occurs through different configurations of uses of time and space, but all could be supported or enhanced by technological means. Although sparse, there is literature that examines how by combining modes of teacher learning their relative constraints can be overcome and new affordances can emerge.

Higgins and Spitulnik (2008), in reviewing empirical research and synthesizing the effective elements of professional development programs that support science teacher learning about technology integration, suggest that formal and informal interactions with colleagues and researchers can be effective in helping teachers integrate technology. As well, Mackey and Evans (2011) suggest that formal learning activities may be effectively supported in informal COPs through on-going and just-in-time support. Additionally, alignment of teacher and organizational learning goals may be improved through the use of informal and formal learning activities. This was illustrated in a study by Vavasseur and Macgregor (2008) in which school principals participated with their teachers in an informal COP designed to facilitate discourse around a formal learning activity. Teachers in the study reported the principals' participation as pivotal to their success in the program, and the researchers noted that utilizing teacher and principal voice was a key aspect to the success of the program as a whole.

This study extends this emergent literature of how different modes of learning might be employed for greater effect by providing teachers' insights into how to combine formal, informal, and independent modes of learning so they flow together and particularly when supported by technology create a more holistic approach for teacher learning.

Methods

Subjects

The school district in which these case studies are set is one of the 100 largest in the country, and serves almost 60,000 students. We selected this district because of its model for providing technology integration support. The district employs technology integrators, who are certified teachers that specialize in assisting classroom teachers with technology integration. While this type of resource teacher is not unique, this district organizes these teachers by subject

area. This provides, for each content area, a full-time resource teacher to assist all the teachers in that content area in the district. This model recognizes the unique relationship between content and technology and seeks to provide specialized technology support in various content areas. Technology integrators in this district have previous experience in the content area in which they work.

There are twelve middle schools in the district. Two middle schools, both serving sixth, seventh, and eighth grades were identified by district technology leaders as strong technology schools, and were recommended to us as our study locations. This purposeful sampling was used to ensure a sufficient level of data on technology integration. The schools differed significantly in student demographics, as is shown in Table 1, with one school having 18 percent minority compared with the other having 46.4 percent minority.

Table 1

Student Demographic Information for School Sites

School Name*	Level	Grades Served	Percent Minority^B
Thompson Middle School	Middle	6 – 8	18
Smith Middle School	Middle	6 - 8	46.4

Note. * School names are pseudonyms; ^B Black (not of Hispanic origin), American Indian/Alaskan Native, Asian, Hispanic, Native Hawaiian/ Pacific Island.

All math and science teachers participated in grade level focus groups; these data are the primary source of information for the study. Table 2 displays teacher demographic data for each school.

Table 2

Teacher Demographic Information for School Sites

School Name*	Number of Teachers Per Department	Years of Teaching Experience (number of teachers in each range)	Years At School (number of teachers in each range)	Gender (number of teachers)
Thompson Middle School	Science = 7 Math = 14 Both = 2	1 – 5 = 2 6 – 10 = 9 11 – 15 = 3 16 – 20 = 5 21 – 25 = 2 26+ = 2	1 – 5 = 23 6 – 10 = 0 11 – 15 = 0 16 – 20 = 0 21 – 25 = 0 26+ = 0	Female = 14 Male = 4
Smith Middle School	Science = 6 Math = 9 Both = 2	1 – 5 = 4 6 – 10 = 6 11 – 15 = 1 16 – 20 = 2 21 – 25 = 2 26+ = 3	1 – 5 = 11 6 – 10 = 3 11 – 15 = 0 16 – 20 = 0 21 – 25 = 1 26+ = 2	Female = 14 Male = 4

Note. * School names are pseudonyms.

Procedures

Six focus group interviews were conducted in total, one for each grade level in each school. Each focus group lasted approximately 60 minutes, and all were conducted during the same spring semester. The semi-structured interviews were designed to facilitate conversation among the participants through initial prompting questions. Primary questions concerned sources of information for learning about technology integration, supports required for learning about technology integration, processes for sharing technology integration ideas and knowledge, and elements which facilitate or constrain learning in this area. For each question, further probing questions were introduced to elicit additional information in areas such as in and out of

school activities, online and face-to-face learning activities, and recommendations for change in organizationally supported PD activities for technology integration. All focus group interviews were recorded, with the permission of the study participants, and transcribed.

Tools

The focus group transcripts were analyzed using a structured coding scheme made up of five primary coding areas and one supporting coding area. The coding areas were as follows:

1. Work and role of technology integrator
2. Technology use to support math and science teaching
3. Opportunities to learn, generate ideas, and sharing
4. District and school-level context
5. School and district leadership for technology
6. Analytic codes (these codes are used in conjunction with other codes to allow for another level of analysis. In this study the two analytic codes were “facilitators” and “inhibitors”, which allowed us to identify factors facilitating and inhibiting technology integration within other areas.)

Data Analysis

The findings presented in this paper are based on the focus groups that generated data we coded with area number three: opportunities to learn, generate ideas, and sharing. Within this coding area, we identified three sub-codes from a review of the literature reflecting (a) district-initiated, or formal, systems of PD and PLCs; (b) teacher-initiated, or informal, learning with colleagues; and (c) teachers' independent learning activities. We categorized the ways in which teachers learned how to integrate technology into their instruction using a sub-code for each mode: formal, informal, and independent.

We operationally define and coded as formal any activities provided by the district or school, such as professional development workshops or courses, conferences, scheduled meetings with technology integrators, faculty meetings and PLC meetings. Activities were coded as informal if they were not regulated by the school or division, including informal conversations or electronic correspondence with colleagues. These informal activities often occur during planning times or before and after classes, and frequently arise from teachers being in close proximity and witnessing new teaching activities. Activities were coded as independent if they were not regulated by the school or division or did not arise from collaboration with peers; for example Internet searching, and generation of ideas based on teachers' personal experiences are included in this category. These three sub-codes were derived from our review of the literature, in which we identified these three modes of learning as distinct in their affordances and constraints for teacher learning of technology integration, but also inter-related and utilized by teachers for different types of learning activities.

After an initial review of the sub-codes and agreement was reached between the authors in terms of operational definitions, the first author coded the focus group transcripts using the NVIVO software application that allows for various lengths of text to be "tagged" by one or more codes. A report consisting of all text segments coded by specific codes and sub-codes was generated and analyzed.

Findings

Formal Professional Development

Most teachers reported general satisfaction with the formal PD activities, and noted many of these activities to be beneficial in supporting their technology integration efforts, yet also identified several shortcomings. Next, we discuss their impressions of the three primary formal

PD activities that they described, which were training classes, one-on-one sessions with technology integrators, and PLC meetings, as well as the internal network for resources known as “the portal”.

Training classes. Several teachers recommended that training classes should be customized to content area and choice be provided as to which training classes they could attend. They felt they were required to attend classes that were not useful for them due to lack of resources or inappropriateness with their particular content area. One teacher, in discussing a summer training class, noted, “I learned a lot of different technologies, but then I came back to school and I don’t have (computer carts) in my room...I saw lots of things that I could use but I don’t have access to it.” Several teachers also agreed that shorter classes with better on-going support would be desirable.

The scheduling of the training sessions often did not align with teachers’ needs. One teacher suggested that virtual training could allow access on-demand, which would provide access to the information at the time needed. Several teachers agreed and reported scheduling conflicts as another barrier to attending training sessions. In addition to scheduling constraints, several teachers articulated that training sessions often did not provide clear alignment to their practice. One teacher indicated she would value training sessions offered by other teachers as this may allow her to see technologies authentically being used in a classroom: “I’d rather see someone else, a fellow teacher. I’d rather not have the expert come in and give me everything in three hours. I’d rather go in and watch a teacher do a lesson on it.”

Technology integrator sessions. Scheduled sessions with technology integrators were reported as valuable in assisting teachers with incorporating new technologies into their instruction. One teacher noted, “She’s just great. (The technology integrator) will take time and

work with you individually, or if it's a problem that she hears from several of us, then she will do a small group kind of training." These one-on-one activities allowed teachers to suggest the content to work with, and the technology integrator would provide expertise on possible technology use. One teacher explained this process; "I was going to bring ideas to the table, they were going to bring ideas to the table, and then we'd go from there. But I was counting on them to have the expertise to move the lesson forward." Often the technology integrator would model the designed activities for the teachers by teaching the lesson in their classroom. Teachers reported learning how to integrate iPod touches, GPS devices and interactive whiteboards through their work with the technology integrators. There had been significant budget cuts in the school division just prior to this study, and teachers noted there were fewer technology integrators available than in the past. This greatly reduced the amount of time teachers could work with them; "If I had more access to someone like him, not having to wait so long for him to come, if I had more access for, you know, someone to be able to come once a month." Teachers were forced to schedule time with integrators months in advance and reported difficulty aligning that meeting with the teaching of the content they wanted to work on. Technology integrators also scheduled larger training sessions to provide instruction on new technologies being adopted by the district, and several teachers agreed if the new technology was one they were required or chose to use, these sessions were beneficial.

PLC meetings. The PLC meetings provided teachers with a rare chance to sit and talk about technology integration. They expressed that these meetings were foundational in their development of effective communications with each other. One teacher noted, "I also think it facilitates rapport between teachers because you do take that time to sit down and talk to each other and that, in and of itself, can help build relationships." Several teachers reported this

activity as beneficial and noted it provided work-time for teachers to discuss technology ideas around curricular content they were currently working with, allowed them to brainstorm and share ideas with their peers about technology projects, and provided them on-going peer-support for technology issues. One teacher expressed the feeling that she was missing out on important dialogue and felt “in the dark” when her schedule changed and she was not able to continue participating in her PLC. However, another teacher reported that required paperwork required for these meetings inhibited the collaboration; “It’s time to do paperwork, I think. And then we share more, I think, on the fly, you know, come down and check on each other.”

School portal. The school division also provided resources to teachers on their “portal”, which is an internal network accessible to division personnel. Teachers reported that technology integrators assisted them in learning how to use the portal, and one teacher noted the value of this tool, “The portal for me is the best right now, just because it has the most information in one place.” Most teachers agreed that the resources on the portal were valuable, but believed more could be done with this tool. They expressed the need for technology integrated lesson plans, and indicated these would provide value in their effort to integrate technology into their classes. They noted that with the number of teachers in the division teaching the same material, this would provide a substantial benefit to a large number of teachers with minimal effort.

Overall, teachers indicated the formal PD program in the division was beneficial. Large training sessions provided by technology integrators to provide instruction for district adopted new technologies such as grading programs and interactive whiteboards, one-on-one sessions with technology integrators on the use of iPod touches and GPS devices, general discourse on technology integration during PLC meeting times, and resources provided on the internal district network were all viewed as efficient uses of resources. However, echoing findings from the

literature, teachers identified temporal constraints, little customization, and the lack of on-going support as limitations of these formal activities.

Informal Learning

To overcome some of the limitations these teachers described in their formal learning opportunities, teachers utilized various informal learning activities and indicated these played an especially large support role in their use of technology for instruction. One teacher noted: “I definitely rely on co-workers. Those are the strongest supports.” Another described this informal learning: “I think sometimes you just see what other people are doing. I mean you walk into their classroom and say ‘oh, that’s neat’, and you know, get things that way.” A third teacher commented, “There’s a lot of sharing that goes on that’s not in that meeting. I think that’s the part, that like I run to (another teacher’s) room and I say, ‘alright, I’m really struggling with...’.”

Informal learning happened primarily through email and face-to-face conversations among fellow teachers, and with teachers in others schools, administrators, principals, library staff, district leaders and friends. Despite the popularity of social networking tools, teachers did not report using these tools for informal PD, but instead indicated using these only in non-work related activities. Teachers reported face-to-face conversations as both beneficial and efficient. They explained how short conversations in the halls—perhaps just one to two minutes in length—allowed them to get information quickly and just when they needed it; “...in between classes, at the end of the day, I use this, here you go... I mean there is some formal aspect to it but its like [teacher 1] finding ideas from [teacher 2] over a 60 second conversation.”

Several teachers acknowledged formal PD activities were often the genesis of these informal learning activities. Formal and informal modes of learning appeared to be

complimentary as formal PD activities provided teachers with exposure and context, and the resultant informal activities filled the gaps of on-going and just-in-time support.

Teachers noted structural, socio-human and cultural elements that supported informal learning among colleagues. One teacher described the uniqueness of her school culture, and how it promoted informal collaboration.

We just like each other and respect each other. I have been in an environment before where you didn't ask, [which] was more because you were supposed to know everything. I mean, that's the way people made you feel. So you shouldn't come ask anything. But I think we're all very comfortable here, we respect each other, we know how each other are as professionals.

Teachers agreed that by aligning planning periods within content areas, informal interactions between teachers of the same content area were facilitated, which in turn promoted informal collaborations. One teacher described these informal collaborations: “We share lessons, we share tests, we share ideas, we share data on all of our tests, all of our quizzes. We collaborate on everything, I think probably better than any department.”

Teachers in this study reported informal learning as a key component of their learning of technology integration, and one they highly valued. They noted that efficient use of time and just-in-time support were two primary benefits of this type of learning activity. They acknowledged the synergistic relationship between formal and informal activities, but also noted the importance of a collaborative school culture as a critical basis for this informal mode of learning.

Independent Learning

Teachers reported participating in independent learning activities such as using Google, Brain Pop and other teacher specific web sites, such as Teacher Tube, to search for lessons and resources. Teachers frequently mentioned using the Google search engine to locate resources and lesson plans: “I think the biggest support is Google because you can Google everything and anything.” Another teacher echoed this sentiment: “Biggest support? well I guess just the Internet in general, or Google, that helps me a lot.” One teacher also reported utilizing professional organization web sites and private company sites as well: “Like the NSTA, Science Teachers Association, have an email list that you can join per subject area, so that’s another way that I get information. And Promethean has a Promethean Planet (web site).” Now that web site creation is simple enough for people other than professional developers, teachers often use other teachers’ web sites for resources and lesson plans. One teacher described this process.

I have favorite places that I go and a lot of times they are specific teacher’s (web sites). [An outside teacher] has an excellent work, she works much like I do, she has her own little website, I think it's for her students but at the bottom she says, you know, you're welcome...I never take what they do verbatim, I always have to tweak it but if they give me the skeleton, I'm not a reinvent the wheel kind of gal to be quite honest.

Video sharing sites also provide a great resource for teachers and by aggregating videos by content area and grade level assist teachers in efficiently locating resources. One teacher reported, “YouTube and Teacher Tube actually have some valuable resources, you just have to look at all of them first”, and then further articulated, “Some of them are just silly and pointless but there are a few out there that you can find that are really good.”

Several teachers indicated the importance of learning on their own and using their own creativity, and noted that with additional support they would be more inclined to implement lessons conceived in this way. One teacher commented, “I guess that does make us rely on our own creativity more and more, and I like that. The fact that we put so much time into thinking ‘what would the kids actually like and get out of it?’” This teacher then described this process further as “that's what real teaching is about.” Several teachers also report that there are times when adequate support is not provided and they are forced to employ independent learning: “I found that I’ve done a lot on my own to learn some of the tools that we need or that we use in science.” Another teacher noted that learning new technology tools often requires more than a single training session, and that she requires time to play with the tools on her own: “We have some sessions on it but you can't really learn until you get in and start to use it, I think. That's me as a learner; I have to do it in order to learn it.”

Several teachers communicated the desire for training in how to better utilize web resources for independent research as well as for time to be built into their schedule for this type of research. One teacher articulated the need for organizationally provided time to learn how to integrate new technologies in her classroom.

It comes back to the time thing... you will become more efficient with all the technologies when you have time to play with it, practice it on your own, individually. So if we're not given time during the school day I mean we will use some time at home but that's limited. We all have other things that we do at home, other people that need us and so forth. So the more time you spend with something, the more comfortable you become with it. Then yes, you're efficient and it becomes worthwhile and it becomes productive and exciting for the kids other than a piece of paper. But when

we don't have the time to do that, you know, don't bring more and more technology even though it may look great on paper it's not going to be if I don't have the time to put it together, it's not going to work; it's not going to be efficient for me either.

Teachers in this study reported independent learning as another primary activity crucial to their learning of technology integration. They expressed positive feelings about being able to utilize their own knowledge and creativity in this process. However, they reported a lack of organizationally provided time to engage in this type of activity, and a desire for instruction on how to better utilize independent learning tools and techniques.

Discussion

From the viewpoint of the teachers at these schools, their system for learning about technology integration is comprised of three parts: (1) the formal system of PD and PLCs provided for and arranged by their school; (2) informal learning from colleagues; and (3) independent learning. Teachers reported valuing their time in PLCs as a rare chance to discuss ideas and collaborate but indicated a desire for additional work time and the means for collaborative efforts. They also reported that informal learning, such as face-to-face and email conversations, addressed specific questions and was not constrained by pre-scheduled meeting times and places. Finally, the teachers reported their independent learning efforts made highly efficient use of their time and allowed them to bring their own new and creative ideas into the school as they researched specific areas of interest. Considered together, they expressed the need for content-specific, on-going, and just-in-time support, and, when access to outside expertise is needed, a means to overcome geographic and temporal limits.

From the teachers' perspectives, it was the shortcomings and constraints of the formal system provided by school leaders for learning about technology integration that spurred their

efforts to learn via independent and informal means. Teachers in this study reported that each mode of professional learning is important, useful for different learning situations, and supportive of the other modes. Spurred by need, they had crafted a system where each mode of learning supported the others in powerful ways. Considered altogether they illustrate the range of learning approaches teachers choose to use and consequently that schools may be well served to support.

It is likely that by only focusing on and providing support for formal PD activities this school district limited not only their teachers' learning as individuals, but likely lost an opportunity to leverage the diverse experiences and perspectives of these teachers. This not only diminishes the collective knowledge of their teacher population but also misses an opportunity to collect and leverage knowledge building for the good of the organization. It also suggests that the complete potential and benefit of formal PD activities was not realized, as informal and independent activities that built upon the formal activities were not nurtured.

Over a decade ago the seminal work *How People Learn* (Bransford, Brown & Cocking, 2000) summarized thirty-plus years of relevant cognitive science research to recommend four specific elements of effective environments that foster deep learning. An examination of these elements nearly predicts these teachers' responses to go beyond formal PD offerings and generate additional means for their learning ends given the shortcomings of their formal learning system, which were quite typical of those described in the literature. Thus, considering the characteristics of a desirable system for teacher learning, what is surprising isn't that these teachers augmented what their organization provided to them by reaching out to peers and making efforts independently, but rather that their organization doesn't better support teachers' informal and independent learning given the unique attributes and potential that these two

models offer. We next discuss the potential for addressing this in terms of organizational efforts led by the school leaders.

An effective learning environment (Bransford, Brown & Cocking, 2000) should be *learner-centered*, meaning that individual learner knowledge, interests, and prior experience be taken into account, while also being *knowledge-centered*, or directed toward developing deep understanding. To foster the development of deep understanding, they should also be *assessment-centered*, using feedback and other assessment mechanisms to guide the learner. Learners also gain guidance and feedback from a *community-centered* learning environment, which allows for the dispersal of common information and the development of norms and shared meanings.

In Table 3 we organize by each of these four elements the affordances (noted with a plus sign) and constraints (noted with a minus sign) that these teachers described for formal, informal and independent learning modes. We see that while much criticism is leveled at formal learning both in the research literature and here by these teachers, as shown in Table 3 informal and independent learning activities also possess constraints. Thus rather than suggesting either or both of these modes as a replacement to formal learning, it is only when we start to view all three working together as a holistic system that you see how all the conditions for effective learning environments can be better supported. For example, formal PD might typically be considered not very learner-centered as its schedule and topics are usually dictated by the organization and not the learners, whereas informal and independent modes of learning are driven by the learner's interests and shaped by their experiences and context-specific needs. But were schools to rely solely on teachers' meeting their learning needs via informal and independent means, they would forfeit the ability to advance an organization-wide agenda for all teachers on particular

knowledge and skills, and be unable to assure that all teachers received a fair chance to participate in the learning opportunities they required so that teachers might reach those goals.

(table 3 about here)

Organizing the constraints and affordances of these teachers' support system for learning in terms of elements of effective learning environments provides insights into the coherence of the system these teachers used to support their learning to integrate technology. In the following section we discuss the implications of leaders purposefully crafting such a holistic approach, arguing why and how school leaders should provide leadership and organizational supports for each mode as a complement to the others and thereby generate a means for learning that extends beyond the limits of the formal learning system.

Implications

One key implication for leaders is the opportunity this provides to model for teachers and give them first-hand experience with high quality learning environments. School leaders could explicitly model checking for gaps in the holistic teacher learning in terms of quality learning environments (c.f. Bransford, Brown & Cocking, 2000), and then systematically strengthening each component part as well as the connections among them. Utilizing emerging technologies for teacher learning also serves to provide hands-on experience with technology integration into pedagogy, modeling for teachers how they could use technology with their own students. Teachers are presently in a unique position where they are asked to teach utilizing these quickly evolving technologies, a style with which they are often unfamiliar. However, by experiencing these tools as learners they could gain valuable perspective and knowledge, and in teaching as they were taught, become prepared to utilize them for engaging, high quality instruction.

Another key implication is that district leaders should consider how altogether their leadership practices (and the tools, routines, and structures of which they are comprised), combine to facilitate a range of supports for formal, informal, and independent teacher learning activities. For example, they may find their mandates for, recognition of, and policies regarding teacher PD activities need to be amended to include informal and independent learning activities in the same light as formal learning activities. It would likely soon become apparent that in order for teachers to be able to use new tools effectively for informal and independent learning that they should first receive training on them, which could be most systematically addressed through tools and time provided by the organization as formal PD. Independent learning activities require time to allow teachers to discover new technologies relevant to their needs and draw upon both their experience and creativity, and informal collaboration opportunities require structures to be put in place so as to assist in subsequently disseminating teacher discoveries through the organization. These learning activities will also benefit from leadership participation as well as organizational facilitation when needed.

A third implication is that school leaders must formally recognize the presence of and contributions from each of the three learning modes. Balancing the affordances and constraints of each mode should be combined with considering how technologies might weave together the modes. For example, formal learning activities are hampered by lack of on-going and just-in-time support—two constraints that can be eased by informal learning tools such as virtual communication platforms. District leaders should specifically consider how emerging technologies could assist them in facilitating this new paradigm of teacher learning. Social media is well suited to support various aspects of formal, informal, and independent teacher learning as it powerfully connects people who are not geographically proximate. This might

mean school leaders promoting the use of social media, such as Facebook, Twitter, or other tools for informal teacher learning activities to overcome temporal and geographic constraints, as well as to create virtual communities and access crowd-sourced data—all important for just-in-time and on-going support.

Conclusion

While districts are investing significant time and money into formal teacher PD, they are missing opportunities to enhance the teacher and student outcomes by not supporting, recognizing, connecting to, and building upon teachers' informal and independent learning processes already in place. By considering each mode of learning, school divisions could develop activities for technology integration that support teacher learning in a more holistic way, utilizing the affordances of formal, informal and independent learning activities for areas best served by these types of activities: (a) Formal PD activities can bring teachers together and promote further collaboration to continue through informal learning; (b) Informal collaboration can provide the necessary on-going and just-in-time support for projects that originated in formal PD activities; (c) Independent activities can also spawn informal collaborations, or provide the needed background knowledge and skills to support collaborations that began in formal or informal activities. School leaders would be remiss to not improve and establish a more efficient holistic teacher learning system for technology integration and need only to look at current teacher practices in this area to envision what barriers to these types of learning activities to remove, what supports to provide for these activities, and how to continuously expand on the benefits associated with the new synergies created.

We conclude that the three modes should be considered altogether as a holistic system for teacher learning, and by doing so we believe that each investment made in teacher learning

would be better spent as it would close the gaps in the system that contribute to potential loss of learning and lack of follow-through.

Table 3

Affordances (+) and Limitations (-) of Learning Modes by Aspect of Effective Learning

Environment

Aspect	Formal PD	Informal PD	Independent
Learner-centered -build on knowledge, interests and prior experiences	- Topics and schedule dictated by organization, not by learners	+ Allows participant choice of both content and learning process + Considers teachers' experience, and unique situations, diverse talents and experiences + Flexibility in participation time	
	- Misalignment of scheduling with teacher need	+ Additional learning time through asynchronous activities and time outside of traditional workday	
	+ Alignment of schools' and teachers' learning goals + Assurance of exposure to mandated skills	- Lack of assurance of participation in mandated activities	
Knowledge-centered -work toward deep understanding	- Whole group approach lacks specificity to address content area specific skills + Support could be provided for securing outside experts	+ Allows for content-specific learning yet potentially a lack of expertise inside of school/district and acquisition and effectiveness dependent on participants	+ Greater potential to reach outside content-specific expertise but acquisition and effectiveness dependent on participants
	- Delivery platforms may not offer latest, richest options and features for knowledge building + Training provided for selected platform	+ Quicker access to emerging technologies - Burden on participating individual to develop and sustain self-selected learning platforms - No support on how to use self-selected learning tools	
	- Shorter in duration - Lack of on-going and just-in-time support - Support is out of context	+ Continuous learning + Provides on-going and just-in-time support + Learning is or can be situated in practice - Potential information overload from greater amount and variety of resources	
	+ Organization provides the time for formal learning	- Organization does not provide time for informal and independent learning	
Community-centered -disperse common information, develop shared meanings	+ Localized learning develops community within organization	+ Self-selection of community may accelerate collaboration and community development	+ Community development outside of school or district + Advantages of anonymity
	+ Increases communication within school/ district	+ Increases communication within school/ district, and potentially outside	+ Increases communication potentially with peers globally
Assessment-centered	This aspect was not evident in the data for any of the three parts, but formative feedback and or reflective activities could be a part of any of them.		

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