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Innovative Teacher's Perceptions of Their Development When Creating Learner-Centered Classrooms with Ubiquitous Computing

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Abstract

Though many USA schools embrace ubiquitous computing, few teachers reach a pedagogical developmental stage that makes the most effective use of technology for learning. In order to better understand the advanced stage of pedagogical development, this research gathers the perceptions of seven innovative – advanced teachers, from four different schools in order to report on their change processes. All participants once taught in traditional classrooms and now create learner-centered classrooms with ubiquitous computing. The results are based on interviews in a comparative case study framework. Despite teaching in various contexts, results revealed that teachers had common experiences. Qualitative themes were based on combining three common developmental change theories. The "entry" stage was heavily influenced by dissatisfaction of societal needs and past ineffective teachers. In later stages, teachers developed strong beliefs coupled with student observations and project creation techniques, and they overcame obstacles of fear through collegial collaboration, furthering their continuous growth. As innovators, teachers' current concerns focused on how to deepen student learning with meaningful experiences so that technology was worth the cost of time and effort. Teachers' experiences suggest concepts for further exploration in research and professional development.

Keywords: change, innovation, innovative teaching, one-to-one computing, ubiquitous computing, professional development, teacher change, teacher development, teaching with technology, technology integration, stages of development, learner-centered teaching

Abbreviations: Technological Pedagogical Content Knowledge (TPACK), Substitution, Augmentation, Modification, and Redefinition (SAMR), Stages of Concern (SoC), Project Based Learning (PBL)

1. Introduction

1.1. Need to Study Innovative Teachers

With access to technology, teachers are integrating technology in their classrooms (Gray, Thomas, & Lewis, 2009) but unfortunately, teaching style may not evolve to encourage the most effective student use of technology (Lim, Zhao, Tondeur, Chai, & Tsai, 2013; Moreno & Ortegano-Layne, 2008; Zhao & Frank, 2003). According to the 40-year meta-analysis on technology integration, technology had a positive impact on learning, but effects were greater when technology was used to

support cognition rather than traditional presentation of information (Tamim, Bernard, Borokhovoski, Abrami, & Schmid, 2011). This meta-analysis signifies the need for a better understanding of technology integration pedagogy.

In order to describe the intricate pedagogy needed, frameworks for technology integration have been created. One framework is Technological Pedagogical Content Knowledge (TPACK) (Koehler, Mishra, Kereluik, Shin, & Graham, 2013; Mishra & Koehler, 2006) which draws attention to the interrelationship between the concepts of content discipline, pedagogy and technology in order to successfully integrate technology (Harris & Hofer, 2011; McGrath, Karabas, & Willis, 2011). Another framework, Substitution, Augmentation, Modification, and Redefinition (SAMR) (Puentedura, 2014) focuses on four levels of technology implementation in the classroom. Within this framework, substitution is the most basic form of integration when technology is used for traditional teaching methods. This contrasts with redefinition, which is considered the most advanced level of integration since technology is used in this case to learn and teach in ways that were not possible without it. In light of this, frameworks are useful but not sufficient; teachers need to change their roles (Kirkland, 2014; Romrell, Kidder, & Wood, 2014).

Researchers and practitioners of classroom pedagogy have endorsed the practice of teachers changing their teaching roles so that classrooms are learner-centered or student-centered rather than the traditional, teacher-centered. When a classroom is teacher-centered, technology is regarded to be largely irrelevant in in learning (Fernandez, Ritchie, & Barker, 2008; Gulek & Demirtas, 2005; National Education Technology Plan, 2010; Reigeluth & Karnopp, 2013; Silvernail *et al*., 2003). The American Psychological Association published the capstone document for learner-centered instruction in the *Framework for School Reform and Redesign* published in 1990 and 1997 (The Learner-Centered Principles Work Group of the APA's Board of Educational Affairs, 1997) which the APA identified psychological principles for learner-centeredness that take into account cognitive and metacognitive factors, motivational and affective factors, developmental and social factors, complex problem solving and individual student differences.

In practice, when learner-centered classrooms are implemented, the "teacher loses the position of external boss or dictator but takes on that of leader of group activities" (Dewey, 1938). This is not done by lecturing to students, but by teachers emphasizing student inquiry, student collaboration, discussion, and the treatment of students as experts (Chinn & Malhortra, 2002; Robinson, 2011). Learner-centered classrooms are strongly associated with constructivists' beliefs about learning. Teachers believe their students are "collaborators in a common enterprise" (Robinson, Molenda, & Rezabek, 2007, p. 20), and so that the teachers observe their students, how the students learn, and guide learning in a meaningful way. Often, teachers coach students to find answers to their own questions, use project-based learning and student customization, which have positive outcomes on learning (Carr & Bromely, 1996; Eisler, 2000; Inan, Lowther, Ross, & Strahl, 2010; Sandholtz, Ringstaff, & Dwyer, 1997; Strobel & van Barneveld, 2009; Zhao, 2012; Zhao & Frank, 2003). A recent research study examined the value of learner-centered instruction. A meta–analysis (Cornelius-White, 2007) examined 119 studies showing that learner-centered strategies do in fact positively correlate to student affective, behavioral, and cognitive outcomes by reducing drop-out rates, resistant behavior and increase student participation.

Two studies specifically examined teachers who practiced more advanced pedagogies for learner-centered classrooms. In one study, researchers explored the perception of six teachers that had effective pedagogies and had various technology such as Smart Boards, phones and computers (Tondeur, Kershaw, Vanderlinde, & van Braak, 2013). Researchers found that peer collaboration and an informal desire to learn technology, for personal use, aided their ability to create more learner-centered classrooms. Emo (2015) conducted another student of thirty self-selected teachers that felt they were innovative in the classroom. Of those thirty, only a mere two mentioned the influence of technology. Most teachers were self-motivated due to a desire to eschew boredom and drew inspiration from student engagement when trying new techniques.

General studies on technology integration find that most teachers do not become learner-centered but use computers or digital devices to support traditional "substitution" (SAMR) or teacher-centered practices (Clausen *et al*., 2011; Ertmer & Ottenbreit-Leftwich, 2010; Ritzhaupt, Dawson, & Cavanaugh, 2012; Sandholtz *et al*., 1997; Silvernail *et al*., 2003). For example, the Pew Foundation surveyed 2,462 middle school and high school teachers (Purcell, Heaps, Buchanan, & Friedrich, 2013) that taught advanced placement classes or completed extensive professional development in writing. Even among the teacher group that values quality pedagogy, less than half of the teachers used programs or technology that promoted collaboration and authentic publication that would foster learner-centered technology activities.

However, computing enthusiasts predicted that when every child in school had a computer, learner-centered classrooms would be produced (Ramig, 2014; Topper & Lancaster, 2013). The movement is called one-to-one computing also know as ubiquitous computing (Towndrow & Wan, 2012). In fact ubiquitous computing does seem to have some positive results: produces greater technology skill, greater satisfaction with school, more digital presentations with and research. Yet, despite those benefits, it does not necessarily create learner-centered classrooms (Cuban, 2002; Jing & Yong, 2008; Oliver & Corn, 2008). The more recent findings are echoes of the first longitudinal study on ubiquitous computing (Sandholtz *et al*., 1997).

Sandholtz *et al*. (1997) supported and studied one-to-one computing from 1985-1995. The group reported that most teachers did not develop "extended knowledge construction" or learner-centered classrooms. Since then, most research studies have focused on the range of teachers employing technology, rather than specific teachers who had created learner-centered classrooms (Clausen *et al*., 2011; Ertmer & Ottenbreit-Leftwich, 2010; Ritzhaupt *et al*., 2012; Sandholtz *et al*., 1997; Silvernail *et al*., 2003).

Unlike the extant research, this study sought to solely focus on the development of a few innovative teachers that did, in fact, display advanced pedagogical development. I interviewed seven teachers from four different schools who described their incremental role changes from traditional teacher-centered instruction, to becoming learner-centered facilitators with one-to-one computing.

1.2. Developmental Stages

In order to understand teachers' development, stages have been identified to explicate personal development or an individual's innovation acceptance (Rogers & Wallace, 2011)**.** Developmental stages are controversial since an individual's growth is rarely completely linear, whereas stages are implicitly linear. Despite the controversy, developmental stages are accepted since they provide signposts for the change process, which allows educational leaders to support teachers' professional development (Blanchard, Southerland, & Granger, 2009; Hennessy, Ruthven, & Brindley, 2005; Honey & Graham, 2012; Smyth, 2005; Straub, 2009; Toledo, 2005). Three stage theories are explained here: Innovation-decision process based on Rogers theory *of Diffusions of Innovations* (1995); the Stages of Instructional Evolution (Sandholtz *et al*., 1997); and the Stages of Concern (Hall & Hord, 2014).

1.2.1. Rogers' Innovation-Decision Process

Rogers' (1995) innovation-decision process is considered the most general of the change theories and is often used in disciplines other than education. The innovation-decision process consists of five stages: Knowledge, Persuasion, Decision, Implementation and Confirmation. The Knowledge Stage is parsed into awareness-knowledge and how-to knowledge in which the individual plays a passive role by observing changes. The Persuasion Stage is mainly affective, in that the person is dominated by the feelings associated with the innovation and actively seeks information about the innovation so it can be evaluated. If the person is persuaded, they will adopt the innovation; if not

persuaded, they will reject of the innovation. If favorable, persuasion leads to the Decision Stage followed by Implementation. Implementation of the innovation requires full action where the person actually changes as a result of the innovation, even though a degree of uncertainty may still remain. In the last stage, Confirmation, the person engages in re-invention. In summary, invention is the process of idea discovery; adoption is implementing the innovation that was invented by someone else; reinvention is when the invention becomes the user's and takes on the nuances of the particular context.

1.2.2. Stages of Instructional Evolution

During a longitudinal study of ubiquitous computing, Sandholtz *et al*. (1997) identified stages of teacher style development with technology integration: entry, adoption, adaptation, appropriation, and invention. These stages align closely with the participants' experience of this study since the change theory was created specifically for ubiquitous computing in the classroom. Below, these stages are summarized with an explanation of the teacher characteristics explained at each stage and more recent studies to demonstrate current relevancy.

Stage 1-Entry. Teachers incorporate technology into traditional lesson plans. Some teachers feel frustration with student misbehavior and changing classroom dynamics, often feeling unprepared for the changes, as the students are often perceived to have "too much control" (Sandholtz *et al*., 1997, p.57). These characterizations are now expected at the beginning stage of technology integration (Day, 2012; McDonald, 2009; Ng, 2011).

Stage 2-Adoption. Teachers gain a positive disposition toward technology through skill development. They make sense of the changes, anticipate problems, begin concerning themselves with "larger goals" (Sandholtz *et al*., 1997, p.66), and want to include technology in their daily traditional lesson plans (Hakverdi-Can & Dana, 2012; McGrath *et al*., 2011; Yildirim, 2000).

Stage 3-Adaptation. Teachers are comfortable incorporating daily computer activities into lesson plans. They increase individualized instruction accompanied by a rise in students' productivity, while seat work and lecture – a form of direct instruction – dominate interaction, with a limited amount of computing work (Sandholtz *et al*., 1997). In additional studies, technology integration was limited to word processing and digital presentations. Currently, most teaching development remains at this stage (Davis, Preston, & Sahin, 2009; Harris & Hofer, 2011; Lemke & Martin, 2004a, 2004b, 2004c; Pierson & Cozart, 2004).

Stage 4-Appropriation. According to Sandholtz *et al*. (1997), appropriation is more a milestone than a stage. The crucial element in this stage: the teacher's belief changes, regarding how students learning, to align with the practices of learner-centered classrooms. The Appropriation stage does not seem natural for most teachers since the role of the teacher fluctuates. Rather than teacher mainly teacher direct instruction, students engage most of the class time on project-based learning that including higher level thinking activities (Bransford, Brown, & Cocking, 2003; Sandholtz *et al*., 1997). Under these circumstances, constructivists' beliefs and practices begin to align (An & Reigeluth, 2011; Judson, 2006; Orrill, 2001; Sockman & Sharma, 2008; VanSledright, 2002).

Stage 5- Invention. The inventive teacher aligns constructivist belief and practice, holding strong while engaging in experimentation with different types of learning. When this stage is reached, the whole classroom "buzzes" (Sandholtz *et al*., 1997, p.44) because students are active, as opposed to passive, learners who are also learning from one another as well as the teacher (Brookfield & Preskill, 1999; Brooks & Brooks, 1993; Wood, Bruner, & Ross, 1976). There is not much detail regarding this stage because so few teachers reach the invention stage of development.

1.2.3. Stages of Concern ("SEDL")

The Stages of Concern (SoC) are based on Concern Based Theory (Hall & Hord, 2014) which can be applied to any innovation within education. The SoC theory assumes that individual concerns

must be addressed before an innovation can be properly implemented. Research that uses the SoC often works in conjunction with professional development so that administrators and professional developers can adequately deliver the appropriate professional development instruction (Towndrow & Wan, 2012).

The Stages of Concern theory has identified seven stages based on individual development (Hall & Hord, 2014) : Stage 0 Unconcern – people do not have knowledge, so due to ignorance are not concerned; Stage 1 Information – people want more information about the innovation; Stage 2 Personal – people are concerned how they will be affected by the innovation; Stage 3 Management – people have management concerns; Stage 4 Consequences – teachers are concerned about the way the students are affected; Stage 5 Collaboration- teachers are concerned about how their colleagues are using the innovation; and, Stage 6 Refocusing - teachers are concerned with how the innovation could be improved. As teachers become more comfortable with an innovation, their concern profile changes, which moves concerns to a higher stage level.

1.2.4. Stages Synthesized

Other articles have referenced the stages as a means to refine change theories for the given innovation (Honey & Graham, 2012; Straub, 2009; Toledo, 2005). In this research study, the three developmental theories are used in order to determine the significance of the stages for the innovative teachers. (*See Table 1*)

Table 1. Three developmental change theories

Innovations – Decision process (Rogers, 1995)	**Stages of Technology Integration** (Sandholtz *et al*., 1997)	**Stages of Concern** (**http://www.sedl.org/about/**)
Knowledge Stage	*Entry*	Unconcern & Information
Persuasion Stage	*Adoption*	Personal
Decision Stage	*Adaptation*	Management
Implementation Stage	*Appropriation*	Consequence & Collaboration
Confirmation Stage with reinvention	*Invention*	Refocusing

Description: The table shows how three developmental change theories have been compared. The Results section uses the stages as per the synthesis.

1.2.5. Purpose of the Study-Innovative Teachers

Throughout the studies of technology integration stages and ubiquitous computing, there is a general consensus that most teachers do not develop learner-centered classrooms, nor have there been empirical studies focusing on the teachers who indeed have reached an advanced stage of pedagogical development in ubiquitous computing environments. As per the research need stated, I seek to understand the development of innovative teachers.

For this study, the teachers' innovation combines pedagogy and technology. Rogers (1995) defines innovation as "a broad category, relative to the current knowledge of the analyzed unit. Any idea, practice, or object that is perceived as new by an individual or other unit of adoption could be considered an innovation available for study" (p.11). An innovation can be a thing, practice or both (Straub, 2009). Through discussions and observations with innovative teachers, the research answers the following questions regarding their development to embrace this innovation:

- How do the characteristics of the developmental change theories apply to the innovative teachers?
- What do the innovative teachers accentuate as salient in their change process?

In the section 4, Results, teachers' perceptions were grouped into stages with aligning characteristics. In section 5, Discussion, the salient findings were used to emphasize considerations for researchers and professional development based on the issues that the innovative teachers generated within interviews.

2. Research Design

I sought to understand seven innovation teachers' development in their contextual conditions. To this end, the exploration used a case study framework where teachers were treated as individual participants within four cases. These cases were four different schools. Each teacher within the school was a participant for the purpose of answering extrinsic investor questions and to increase the validity of the answers that were found. Stake notes, "it is believed that understanding them (*the cases)* will lead to a better understanding, possibly theorizing about perhaps a larger collection of cases" (Stake, 2000, p.437). Qualitative methods were used giving credence to teachers' perspectives (Van Manen, 1997). Approximately 35 hours were spent with the four schools. Since the study sought participant perception of development, interviews served as the primary data collection strategy with additional data collection strategies for triangulation (Yin, 1993).

2.1. Case and Teacher Participant Selection

The four school cases ranged in socio-economic background, with the study targeting grades 5-12. Most research conducted on computer integration has focused on the differences of socio-economic background and age group with technology (Gray *et al*., 2009; Purcell *et al*., 2013). In contrast, this study sought to find the similarities among the innovative teachers regardless of the content taught or the socio-economic background of the students (*See Table 2*).

Although the four selected cases do not represent the entirety of school diversity, the cases have substantial differences. For instance, the poverty level of each school is indicated by the percentage of students that received free or reduced lunch, which ranged from as low as 15% to as high as 100%. Furthermore, the types of schools suggest the school philosophy and demographic variances: City, Rural, Charter and Boarding school. Three schools are public schools, City, Rural and Charter; the Boarding school is private, but 100% of the population lives with low income. Despite these differences, each school offered ubiquitous computing to their students.

The administrators of the four schools chose teacher participants, which is selection method similar to that of studies conducted by Judson (2006) and Tondeur *et al*. (2013), who asked the administrators to select the participants so that the context was honored and researcher bias was limited. The administrators selected the teachers that had traditionally taught before utilizing ubiquitous computing, and evolved to create learner-centered classrooms. Participant teachers were all certified and educated through teacher education programs provided within the United States of America.

2.2. Case Profiles

Pseudonyms are used for all people and schools participating in the study to protect their identity. Profiles were based on interviews with administrators, observation, and document analysis of the school.

Table 2. School cases

School Cases	Participant	Participant Age	Grade Taught & Subject	Total Years Experience	Years with one-to-one	Standardized test performance of students	Student Demographics
Boarding (*Private School*)	Zoe	**37**	Grade 9 Earth Science	9	3	Not Available	• 50% Caucasian 50% Minority • 100% Low income
City (*Public School*)	Wyatt	**28**	Grade 8 Reading	4	3	Reading 55% Proficient Math 70% Proficient	• 570 Pupils • 80% Free/reduced lunch • Latino 65%; Caucasian 25% African 10%
Rural (*Public School*)	Anne	**46**	Grade 12 Grade 10 English	13	4	Reading 80% Proficient Math 78% Proficient	• 1015 Pupils • 20% Free/reduced lunch • Caucasian 98%; African 4%; Latino 5%
	Taylor	**35**	Grade 12 Grade 10 History	9	4		
Charter (*Public School*)	Jessica	**25**	Grade 5 & 6 All major content areas	5	2	Reading 60% Proficient Math 60% Proficient	• 100 Pupils • 18% Free/ reduced lunch • Latino 6%; Caucasian 87%; African 3%; Asian 3%
	Samantha	**45**	Grade 5 & 6 All major content areas	13	4		
	Inga	**33**	Grade 7 & 8 All major content areas	5	4		

Rural. The assistant principal and the technology supervisor selected two teachers who co-taught a European History class as well as their disciplines in traditional structures. The administrators felt that Anne, an English teacher, and Taylor, a history teacher, were doing something "beyond" what others did—"They're very forward, innovative, forward thinking…I mean they (Anne and Taylor), are the epitome of completely transforming what having a one-to-one scenario can do for you…"

City. The experienced principal of 23 years recommended Wyatt because he had undergone significant change. "Wyatt has embraced technology, and went forward with it at a very rapid pace, so his style of teaching is different than in the recent past… he had changed the way he teaches and it's, without question, because of the technology."

Charter. The principal felt that *any teacher* could be selected since teachers were hired based on their philosophy of teaching and learning. With that in mind, the school hired those that had a "different state of mind [and] who had been looking for alternative ways to do things," and was not necessarily preoccupied with project-based experience. Samantha, Jessica and Inga were asked to participate since they had taught in traditional schools prior to the charter school.

Boarding. The principal selected Zoe due to her understanding of the content and enthusiasm that affected her students. He described his observations of Zoe in the following manner: "Her classes move along at a pace that is best suited for them. So some kids are more advanced, and they're further ahead; some kids are further behind, and that's okay. It is differentiated instruction to its best."

2.3. Data Collection and Analysis

Semi-structured interviews served as the key data collection technique. Each administrator was interviewed for 1.5 hours, during which time teacher selection was discussed. Then, each teacher was interviewed for 1.5 hours with a follow-up interview of 30 minutes. The classrooms and schools were observed for a minimum 2 hours each; the researcher took field notes while detailing teacher-student interactions and the physical environment. Document analysis included examination of the school websites, national reports, newspaper articles and the teachers' lesson plans.

2.3.1. Sample Interview Questions

Questions:

- Could you go back in time for me? Do you remember when you and the students made the move to one-to-one computers? What was the story behind this for you?

  Rationale: Unearth the attitude and emotions in the transition to ubiquitous computing (Fullan, 1993; Sandholtz & Reilly, 2004; Saunders, 2013).

- Now that you have had ubiquitous computing, can you tell me what your classroom looks like now? How did you get there? Please describe your transition – what was it like for you?

  Rationale: Understand the current teacher role and then, uncover how he/she developed (Brookfield, 1990; Fullan & Stiegelbauer, 1992).

2.3.2. Qualitative Analysis

Multiple levels of analysis were used in order to examine, categorize and test findings to condense data into meaningful themes (Yin, 2003). Each interview was first audio recorded, then transcribed and open codes were created using the interviewees' words. After the first interview, additional research questions were created to verify the information. Interviews were again transcribed and analyzed for open codes, with approximately 250 being present. Field notes and lesson plans were treated as evidence to support the areas about which the teachers spoke. The third level of analysis began after the second interview. The codes used across cases determined the themes (Yin, 2003) by mapping like codes in order to determine similarities and differences, while also remaining cognizant to the divergent voice. The software HyperResearch© was used to organize the groups' codes in cross case synthesis. After, themes were developed, staying close to the participants' words. The themes then naturally oriented to the stages: Instructional Evolution (Sandholtz *et al*., 1997), the Innovation – Decision process (Rogers, 1995), and Stages of Concern (Hall & Hord, 2014).

2.4. Trustworthiness of Data

The trustworthiness of the data is contingent on the techniques and the limitations. There are three techniques that point to the trustworthiness of the data: participant selection, member checks, and data validity (Lincoln & Guba, 1985). Participant selection was based on administrator interviews for over an hour, during which time he/she described the school's culture and rationale for teacher selection.

Member checks were conducted by email; each participant was sent an email of his/her interview that was parsed into themes of identity growth, beliefs about teaching and learning development,

teaching and learning skills shaped with technology, joys experienced, and fears acknowledged. Half of the participants responded beyond basic approval, which included feedback such as, "Wow this is me! How did you know?" Some participants provided minor corrections such as degrees earned or dates, and others did not write back at all.

I completed the all parts of analysis and later, engaged independent coders. During initial steps, I kept a journal so that I could be aware of my pre-conceived notions. It was not until after coding and theme coding that that the connections to stages were made. Additionally, two independent coders read the transcripts of all teachers' interviews to identify block quotes that aligned to characteristics of developmental stages. There was 92% agreement among the independent coders. I, the author, was a former public middle school teacher and now college professor who has struggled with my own professional development (Sockman & Sharma, 2008). Personally, I wanted to learn from these teachers.

3. Results: Innovative Teachers Perceptions of Their Developmental Growth

These findings are interwoven with extant literature so that first and second research questions are answered with the innovative teachers' perceptions: how do the characteristics of the developmental change theories apply and what characteristics are salient in their progress?

It was discovered that the teachers' developmental process did follow developmental stages when the stages were combined as in Table 1, but the salient characteristics in the stages differed than those previous found in literature. The five stages are a merger of Instructional Evolution (Sandholtz *et al*., 1997), the Innovation-Decision process (Rogers, 1995), and the Stages of Concern (Hall & Hord, 2014). In order to identify the similarities and distinguish differences with the literature, there are themes within each stage that were significant in the teacher's context and across school cases. The first four stages have one theme each. In stage five, the final stage, there are three themes. Paragraphs comparing the findings to previous studies are located at the end of each stage.

3.1. Stage One Entry – Awareness Knowledge - Information

3.1.1. Theme 1: Dissatisfaction with the Status Quo Influenced Teachers' Perception of Classroom Needs to Include Using Technology

Every teacher, in each case, spoke about his or her "awareness-knowledge" (Rogers, 1995). Each teacher's awareness took two different forms: societal technology that predominated the workplace and awareness of their own dissatisfaction with traditional schools' ability to reflect societal changes.

Societal technology needs. Interviewed teachers mentioned an awareness of societal needs. For example, Inga, from the Charter School, explained why she decided to become involved with a ubiquitous computing school:

> I was kind of turned on by the fact that the school was a lot of work on the computer. I know how much computers are a part of society today, and how important it is for everybody to learn those skills, because it's used so much in everybody's job. I think it's important for kids to learn as soon as possible, and become comfortable with the computer.

Inga felt that computers were important to student learning because they potentially allowed for a combination of creativity and professional looking products. This sentiment was also reflected in the teacher from the City group and another from the Rural group.

Negative personal experience influenced need. For other teachers (Taylor, Zoe, Jessica), the decision making process was instigated by dissatisfaction drawn from personal experience. Over time, these teachers became disillusioned with education because of the way in which they believed learning occurred. Taylor stated bluntly:

> My stereotype of a teacher and the job just did not seem to interest me at all. I felt you'd be cookie-cuttered into a certain way, and I had some teachers, unfortunately, who would just bore you.

Negative past experience and the desire not to replicate the experience encouraged Taylor and others to think creatively, so that a class would be less boring. The computer gave him a tool that was "less like a textbook," and could be more engaging for the students.

Teacher awareness focused on dissatisfaction. Since I, the researcher, did not ask questions about dissatisfaction, but rather the participants initiated dissatisfaction, the finding here is valid. Dissatisfaction is more completely described with awareness knowledge based on Innovation-Decision Process (Rogers, 1995) than with Sandholtz's stage of Entry alone (Sandholtz *et al*., 1997).

3.2. Stage Two Adoption – Persuasion - Personal

3.2.1. Theme 2: Change Evoked Strong Emotions That Evolved Over Time with Awareness of the Technology Needed

Computer integration was not sterile but emotional; the teacher's emotional gamut ranged from joy to fear, similar to other studies (Sandholtz *et al*., 1997). Taylor, at Rural, provided an optimistic example when he first received the laptops, saying, "There was no resistance from me at all to adapt this…it's phenomenal to be able to go out and get the resources." Others, were resistant—four teachers identified resistance or fear.

When Jessica first applied for the job at the Charter, she was nervous about the technology, however, in her interview she was appeased, and her fear was somewhat alleviated. "My fear of technology…putting everything in files, on the web, sort of went down when I saw the quick reaction of their confidence. When I saw their confidence, I had confidence in me." Colleague confidence in Jessica built on her confidence. In all school cases teachers were easily persuaded to use the technology despite the emotional range among them.

With fear or resistance, teachers needed to be personally persuaded to move forward. Throughout the stages teachers were greatly influenced by a collaborative culture, especially at Charter and Rural. At the Charter, collaboration was mandatory since teachers team-taught and collaborated to determine in-services. At Rural, collaboration was encouraged through department meetings and an intra-net shared folder. Every school encouraged teacher experimentation and support through colleague-sharing and administrative encouragement through risk-taking, which has been shown to be effective in other studies (Anthony, 2012; Glazer, Hannafin, Polly, & Rich, 2009; Inan *et al*., 2010).

3.3. Stage Three Adaption - Decision - Management

3.3.1. Theme 3: Small Trials with Computers Opened Doors to Create Options for Pedagogical Change

Teachers engaged in small trials or experiments that led them to believe their instructional style needed to evolve. Similar to other studies, teachers were comfortable incorporating computer activities into daily lesson plans. Sometimes, students willingly extended classroom requirements and initiated learning which teachers met with mixed feelings.

Wyatt shared an anecdote illustrating these mixed feelings: "One of the kids just flipped up his laptop, went on to Google and typed it in (*the teacher's question)* and he raised his hand." The

student yelled out, "I know the answer!" Wyatt was bewildered by the student's responses and declared, "You know you cheated," since the student used the Internet to find the answer. But, the student retorted, "I didn't cheat!" Wyatt then realized that searching the Internet for an answer emulated what he did. He reflected, "I think that's what we do now." His pedagogy was evolving.

Similar to other studies, teachers observed students spontaneous learning through the availability of web resources and increase in productivity, such as writing with word processors. Some teachers first perceived this as challenging, but then saw a positive opportunity to enhance learning moving toward project-based approaches (Sandholtz *et al*., 1997). These findings are confirmed with previous studies focused on teacher change that is motivated when they observe student learning (Black & Wiliam, 2010; Peery, 2004).

3.4. Stage Four: Appropriation - Implementation – Consequence & Collaboration

3.4.1. Theme 4: Technology Influenced a Disposition toward Collaborative Growth

All teachers developed their belief and disposition with continual input from others. Without prompting from the researcher, all teachers admitted their inability to know-it-all and actively sought feedback from colleagues, students, parents and support from administrators while implementing project-based learning.

At Rural, Taylor and Anne worked through their role change together. Taylor, from Rural, noted, "I can be creative when I'm working with Anne." Anne is his colleague who believed that the computer made "education more accessible, and they *(students)* don't have to rely on just me." Student independence was one consequence for ubiquitous computing with project-based learning, but all teachers did not welcome independence.

According to Taylor, student independence from the teacher can be frightening and contentious to many. Taylor described his reasoning:

> I think that most of my colleagues want to be content experts, and I'm talking probably throughout the nation, in the world and in the profession of teaching. The more you are the master of the content, the more the kids will respect you, the more your colleagues will respect you. The easier it is for you: as the people struggle, you stand there and laugh saying "I know all of this."

Taylor believed teachers were more comfortable and less threatened when lecturing and as a result most teachers would not continue to develop their teaching pedagogy. All of the teachers in this study felt that students' independence meant that his or her role had changed so that they were more of a guide to the students.

Collaboration varied, but was valued for personal growth. At Charter, the culture mandated collaboration from the start: Teachers formally present their projects to one another during teacher in-service so that they can question and help one another create stronger projects for the students. At City and Boarding, the teachers stated that they needed support from colleagues to verbally refine their courses, share ideas, problem solve or cooperate on a project.

According to Instructional Evolution stages (Sandholtz *et al*., 1997), most teachers do not reach the Appropriation milestone, but in this study, all had managed to. The SoC theory (Hall & Hord, 2014) elucidates a rationale for teacher growth by focusing on the stages of Consequence and Collaboration. In this study, all teachers observed the consequences and subsequently, problem solved with one another, though they may have experienced uneasiness in the change. These findings are supported by the research done by Glazer and Hannafin (2008) in which nine teachers were studied were mentored by teacher leaders. The three teachers that actively collaborated with mentors reached a more advanced stage in their development when compared with teachers who were well intentioned but integrated technology in isolation.

3.5. Stage Five: Invention – Confirmation with Reinvention - Refocusing

Three themes characterize stage five. Themes five and six detail the way the teachers re-invented and refocused traditional work with ubiquitous computing to create more meaningful learning experiences. Theme seven identifies teachers' new concerns once they saw the benefits and challenges with technology.

3.5.1. Theme 5: Technology Aided in Project-Based Learning (PBL) While Illuminating New Challenges and Finding Solutions for Planning

Planning projects was more complex than traditional lesson planning. The change meant harnessing complex projects that utilized web resources and developing individual student accountability within the ubiquitous computing environment so that students would experience complex – meaningful learning. In order to effectively plan, six of the seven teachers found that they needed to plan ahead, at least a month ahead, which starkly contrasted with the traditional planning in which teachers would plan a week or two in-advance.

Some teachers were overwhelmed with the complexity and breadth of resources for making projects. For example, Samantha viewed teachers' on-line projects, and said, "I could see the logic" of projects, but they were "more a spider web, intertwining and connecting in so many ways." Samantha said that this caused personal anxiety since she was "more linear." To resolve the problem, she developed a project-making process that was more linear, while not "losing the big picture and getting lost in the details."

In contrast, Inga used the web to help herself organize a project. She detailed the workflow on a website with a "website calendar" listing all of the "knowledge and skills that would be required for specific times." She then listed all of the "websites students could use," and finally, listed the "standards the projects met." Alternatively, Zoe started projects with her dream projects, by "building the Taj Mahal," and then retracted to realistic expectations. Regardless of process, all teachers found workflows for project creation that personally worked for them.

There are a number of articles and books on the value of PBL (Land & Greene, 2000; Reigeluth, 1999), implementation of PBL (Inan *et al*., 2010; Levin & Nevo, 2009; Vega & Brown, 2013) and a meta-analysis detailing when PBL was valuable (Strobel & van Barneveld, 2009), but I could not find empirical literature that discussed the different ways that teachers plan specifically for PBL according to learning style or planning style. Research does not problematize the teacher creation process.

3.5.2. Theme 6: Observations of Engaged Students Led Teachers to Acknowledge a Need for Various Instructional Methods

Teachers observed students and adapted themselves to meet the greater student demands. For instance, teachers valued student interest—six of the seven teachers looked specifically for student "disinterest" as a sign for an instructional change. The only teacher that did *not* identify student disinterest, specifically, was Wyatt at City, yet he still discussed student engagement.

All teachers varied instructional styles based on their students' needs. Although projects composed much of the class time, not all classes or students were taught in the same manner. For example, Wyatt, from City, said, "With my lower level classes I do have to give less independent work." Teachers from all the schools concurred with Wyatt on this point. The teachers at the Charter School focused on individual needs of students rather than the aggregated needs of classes. In another example, Samantha noted: "you need to be able to match the right approach to the kids at the right time," and that may mean "direct instruction." Also, Zoe focused on particular content knowledge conducive to direct instruction and other content knowledge conducive to project based learning. Using different instructional methods for different content and students' learning needs coincides with literature on the five stages of the Instructional Evolution (Sandholtz *et al*., 1997).

3.5.3. Theme 7: Experience with Technology-Integrated Learning Raised Concerns That Benefits Needed to Outweigh the Cost

The three schools that had traditional structures felt the pressure of time with particular classes. The City and Boarding teachers taught four or five classes for 45 minutes per each class. The Rural school taught one class for 90 minutes and four other classes that were 45 minutes each. The Charter school taught the same students all day, and thus, they did not feel the time pressure. In light of this reality, teachers noted that project based teaching methods demanded more time for student processing which concurs with other studies (Inan *et al*., 2010; Ravitz, 2010; Vega & Brown, 2013). As a result, the City, Boarding and Rural teachers were frustrated when students did not achieve the learning goals in 45 minutes.

Zoe summarized what all the innovative teachers felt. She asks herself particular questions to determine one-to-one's value:

> How is that better than using your textbook? How is that better than the library? Help me! … If it doesn't make it more meaningful, if it doesn't allow a deeper level of understanding in a method that you couldn't achieve without it, you shouldn't be using it.

Technology can help deepen student understanding in a meaningful way, but the benefit should outweigh the cost. When working with technology, Zoe felt that the student activities and products needed to be examined through the student-learning lens, continually developing student understanding, which served as her justification for technology use. Project-based learning justified technologies use, yet, in 45 minutes, PBL could be an uphill struggle.

At Rural, Taylor struggled to balance time and creativity in project work. Students had struggled differentiating between the "essential" and "really auxiliary" information. Taylor added, "The difficult thing is, if a student doesn't do a good job or doesn't do a job at all, then you've completely skipped an important piece of information which you were responsible for." Taylor explained that he did not have the time in just 45 minutes, but could complete what was necessary with the block of 90 minutes.

The current research of ubiquitous computing discusses time as a potential obstacle to technology integration, but for reasons other than the teacher's concern. Usually, time is addressed in relation to the teacher's professional learning time or time needed to teach the students technical skills (Topper & Lancaster, 2013; Towndrow & Wan, 2012). Time is not in addressed in terms of student learning for project-based learning in ubiquitous computer environments.

4. Discussion: Perceived Characteristics That should to be Considered for Teachers' Professional Development and Further Research

Prior to the study, teacher pedagogical stages of development were described by characteristics in each stage. After interviews of innovative teachers' perceptions, I found that teachers did pass through the developmental stages, but some of characteristics in the stages differed from what was previously identified in the literature. The most prominent findings were found in stage one, four and five. In the paragraphs below, the implications of these findings will be addressed with considerations for professional development and further research.

4.1. Dissatisfaction with the Status Quo

In this study, the beginning developmental stage was motivated by individual dissatisfaction which is more completely described with the term "awareness knowledge" based in the Innovation-Decision Process (Rogers, 1995). All teachers voiced dissatisfaction based on societal need or negative experiences with poor teachers.

Dissatisfaction is a particularly interesting motivational factor since it is not typically addressed in *teacher* developmental change models (Sandholtz *et al*., 1997; Smyth, 2005; Straub, 2009), or in literature on technology change based on teachers' characteristics (Ertmer & Ottenbreit-Leftwich, 2010; McDonald, 2009; Rogers & Wallace, 2011). However, the heavily cited article "Conditions that Facilitate the Implementation of Educational Technology Innovations," by Ely (1990) states that dissatisfaction of the status quo is the first condition for change. Similarly, in a study of self-selected innovative teachers without technology, Emo (2015) found that most teachers were motivated because of their dissatisfaction with textbooks, which was similar to the findings here. Specifically, Taylor also wanted to avoid textbooks, and all participants disdained student boredom.

In light of these revelations, researchers and professional developers may want to encourage teachers into thoughtful reflection on their dissatisfaction, as a robust motivation to change. Reflection on dissatisfaction may seem odd since there is a desire to keep teachers positive about an innovation for fear of additional resistance or rejection. However, dissatisfaction is considered a necessary ingredient to change. As passive awareness-knowledge, it is a cognitive process that is valuable for the decision as cognitive activity provides the foundation for further inquiry and acceptance of an innovation (Rogers, 1995).

It is clearly known that reflection can induce significant change when supported with thoughtful guidance (Peery, 2004). Though not expressly seen in the body of literature, professional development could help teachers reflect on positive and negative experiences. First, educational leaders could guide teachers to articulate their personal experiences in their younger school years, and then, could use personal anecdotes as a way to address the innovation changes that are needed in schools. Second, professional developers and researchers may want investigate awareness knowledge of societal changes with teachers. For example, teachers could read articles or watch videos on societal changes from the past industrial age to the current knowledge age (Duffy, 2010; Reigeluth & Karnopp, 2013; Robinson, 2011; Watson, Watson, & Reigeluth, 2012; Zhao, 2012). In reflection, teachers could examine the roles of the school and the roles of the teacher, and then, the way teachers' roles should change in response to impending needs.

4.2. Working through Belief and Changing the Teacher Role

Working on appropriation, belief and teacher role transformation is critical for learner-centered classroom which has shown to be problematic for teachers (Sandholtz *et al*., 1997). As Taylor said, "Most teachers don't like it." They may feel students' independence as a threat to their identity and may not value their new role as a facilitator (Robinson *et al*., 2007). Moving to this stage does not seem like a natural process for most teachers, and thus they are apprehensive in approaching it (Carr-Chellman & Dyer, 2000).

Johansson and Kroksmark (2004) note that teachers relied on the past and when role change occurs, they are left with uncertainty. "When the teaching situation no longer stays within the teacher's frame, a pedagogical breakdown of the teacher's preparation happens" (Johansson & Kroksmark, 2004, p.370). Most times, teachers revert to habits that reflect the entrenched beliefs of the status quo so that they feel that they are doing their job.

To support the teacher role change, professional developers and administrators want to establish collaboration through teacher apprenticeship (Glazer, Hannafin, & Song, 2005; Glazer *et al*., 2009) or create professional learning communities where teachers interact in personal learning networks that focus on their critical questions (Aubusson, Steele, Dinham, & Brady, 2007; Sakamoto, 2011). Eventually, when questioning, people discard their old assumptions and become paralyzed by the uncertainty of ways to act, a pedagogical void exists with the emotion of the loss and grieving (Aubusson *et al*., 2007; Brookfield, 1995; Nolan & Meister, 2000). When teachers are part of collaborative communities, they receive encouragement through this tough process and continue to

inspire one another becoming student-centered teachers (Anthony, 2012; Glazer *et al*., 2009; Inan *et al*., 2010).

4.3. Invention, Reinvention and Refocusing – Differences with School Cases

Sandholtz *et al*. (1997) warned that few teachers reach Invention; so it is that there is little research available. The change theory stages of Refocusing from SoC (Hall & Hord, 2014) and Confirmation with Reinvention (Rogers, 1995) provided harbingers that even advanced teachers have concerns. According to the SoC, teachers at the last stage figure out "something that would work even better," and so it follows that the teachers did determine techniques that were beneficial for their environments.

As mentioned in the 3.5.1 Results, there is a dearth of research on project based learning development from the perspective of the teachers who, in this study, felt that it was essential to establish a process for creating PBLs. While each had a process, it took time to develop and each found a different process that was unique for themselves. There is significant research on project-based learning (Strobel & van Barneveld, 2009; Tamim & Grant, 2013; Vega & Brown, 2013), and literature on the way to create projects (Boss & Krauss, 2007). There is little research on the process of creating projects, and even less research taking into account instructors' learning style with project design or the lesson planning process.

If PBL is essential to ideal implementation of ubiquitous computing (Boss & Krauss, 2007; Ertmer & Ottenbreit-Leftwich, 2010), then researchers may want to explore the teacher creation process in order to determine the way in which they create, obstacles experienced and how successful teachers overcome those obstacles. Researchers may want to partner with professional developers to test the many books and theories on the creation of project-based learning.

The second concern was in the section 3.5.2 Results; teachers' observations of students helped them to continuously evolve different teaching styles based on the students' needs and engagement. When teachers were engaged in invention and reinvention, they used various instructional methods ranging from direct instruction to project-based learning as per the needs of the student and content involved. Sandholtz *et al*. (1997), found similarly that the most advanced teachers had "balanced and strategic use of direct teaching and project-based teaching" (p.53). However, reaching the teaching balance takes learning experience.

Nolan and Meister (2000) observed teachers that were implementing PBL in one school. They found that when teachers were learning the new method, they tended to use PBL for teaching most things in the curriculum. The teachers felt that they overcompensated, overusing PBL for knowledge areas that would have been better suited with another teaching strategy (Nolan & Meister, 2000). Teachers in this study shared similar experiences.

To aid teachers with the appropriate instructional method for a given learning goal, more research needs to explore the instructional methods for goals within disciplines (Harris & Hofer, 2011; McGrath *et al*., 2011). Currently the work of learning objects, advanced matrices such as the technology integration matrix (see http://fcit.usf.edu/matrix/matrix.php), and identification of TPACK activity types (see http://activitytypes.wmwikis.net/) is helping to align technology integration and curricular goals. Researchers and professional development communities will want to continue progress toward a comprehensive list of concepts that aligns with teaching approaches to meet the learning goals.

The last concern was in the section 3.5.3 Results; teachers felt that technology needed to be worth the cost especially with classroom time constraints. In traditional schools, teachers questioned the validity of the traditional 40-minute model of instruction, as 40 minutes was inadequate to engage student in their projects. In Charter, where the teachers had the same students all day, this was not a concern.

For classes where project-based learning is conducive, block scheduling or 90 minute classes seems advantageous. Studies show that students reap the long-term benefits of block scheduling when they reach college with learning increases when benefits are measured by grades (Huelskamp, 2014; Trenta & Newman, 2002). Regardless of technology, studies find that teachers need more professional development on block scheduling that include instruction on learning techniques (Trenta & Newman 2002).

4.4. Limitations and Ethical Considerations

Though this study has been helpful to understand the specific innovator characteristics in different stages, there are shortcomings to the application of findings. The nature of qualitative research inhibits generalization to a broad population. Both the context and nature of the sample provide additional delimitations. The study was completed in the USA with a nominal number of participants.

There are ethical considerations as well. As a researcher, the participants may have told the researcher what they perceived to be the "right" thing to say. Since the main data collection was done via interview, teachers shared their perceptions face-to-face. Like all perception, interviews are based on the experience that is embedded in the person's memory and interpretation of a context (Van Manen, 1997). Despite these limitations, all teachers shared similarities that were found in the themes. The purpose of qualitative research is like history; humans learn from others' stories (Stake, 1995; Yin, 2003) and so we can learn from the innovators to advise further research and professional development.

4.5. Conclusion

The aim of this research was to begin filling the gap in teacher's developmental change research by learning from those few teachers who have managed to become innovative in ubiquitous computing environments. This study focused on seven teachers who once taught traditionally, but now, were in an advanced stage of pedagogical development. Examining this small group of teachers assisted understanding, just as studying any expert group (Covey, 1993; Csikszentmihalyi, 1990). They articulated their developmental path so others could learn from their experience, and could discover additional concepts for meaningful exploration.

In order to gain their personal perspective, teachers were interviewed from four different schools. Three developmental stage theories were used to classify their experiences: Innovation-decision process based on Rogers theory *of Diffusions of Innovations* (1995); the Stages of Instructional Evolution (Sandholtz *et al*., 1997); and the Stages of Concern (Hall & Hord, 2014). By using the characteristics at each stage, results determined that innovative teachers supported the developmental change theories when theories were combined, but some of their salient experiences were not clearly identified in previous literature.

First, in the Entry stage, dissatisfaction and negative experiences became positive motivations for change. Listening to the innovate teachers, indicates that dissatisfaction seems underutilized as a motivation for teacher change, providing an area that educational researchers should explore. Later in development, at a point where most teachers stop developing, these teachers continued. The teachers passed through the Appropriation stage, which is considered a milestone where the belief and student-centered practices align so that he/she was less of a lecturer and more of a facilitator. Teachers valued the observations of students and colleague collaboration in order to address uncertainty when trying something new and treading upon unvisited educational terrain. Peery (2004) notes, "It is hard to correct one's ineffective patterns if there is no true dialogue, collaboration, or re-awakening of the student like mind" (p.37). Similarly, participant teachers improved teaching with support from colleagues.

In the final stage, even advanced teachers refocused and reinvented practices to continuously improve themselves, while understanding new limitations. Teachers learned how to create projects for PBL based on their own personal preferences. They varied their instructional style for students based on the students' particular learning needs. Instructional style was not only constrained by students needs, but also on the school schedule. Teachers from traditional schools critiqued the 45-minute traditional time period for implementing PBL in ubiquitous computing environments. These new concerns and the developmental process shed light on the needs for future professional development and research. They remind us that there is more work to be done with continuous learning and building professional collaborations so that teachers have the support needed to grow (Emo, 2015; Topper & Lancaster, 2013).

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References

[1] An, Y. J., & Reigeluth, C. (2011). Creating technology-enhanced, learner-centered classrooms: K-12 teachers' beliefs, perceptions, barriers, and support needs. *Journal of Digital Learning in Teacher Education, 28*(2), 54-62.

[2] Anthony, A. B. (2012). Activity theory as a framework for investigating district-classroom system interactions and their influences on technology integration. *Journal of Research on Technology in Education, 44*(4), 335-356.

[3] Aubusson, P., Steele, F., Dinham, S., & Brady, L. (2007). Action learning in teacher learning community formation: Informative or transformative? *Teacher Development, 11*(2), 133-148.

[4] Black, P., & Wiliam, D. (2010). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan, 92*(1), 81-90.

[5] Blanchard, M. R., Southerland, S. A., & Granger, E. M. (2009). No silver bullet for inquiry: Making sense of teacher change following an inquiry-based research experience for teachers. *Science Education, 93*(2), 322-360.

[6] Boss, S., & Krauss, J. (2007). *Reinventing project-based learning: Your field guide to real-world projects in the Digital Age*. Eugene, OR: International Society for Technology in Education.

[7] Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2003). *How people learn: Brain, mind, experience, and school* (Expanded ed., 8th print). Washington D.C.: National Academy Press.

[8] Brookfield, S. D. (1990). *The skillful teacher: On technique, trust, and responsiveness in the classroom*. San Francisco, CA: Jossey-Bass.

[9] Brookfield, S. D. (1995). *Becoming a critically reflective teacher*. San Francisco, CA: Jossey-Bass.

[10] Brookfield, S. D., & Preskill, S. (1999). *Discussion as a way of teaching: Tools and techniques for university teachers*. San Francisco, CA: Jossey-Bass.

[11] Brooks, J. G., & Brooks, M. G. (1993). *In search of understanding: The case for constructivist classrooms*. Alexandria, VA: Association for Supervision and Curriculum Development.

[12] Carr, A. A., & Bromely, H. (1996). Technology and change: Preservice perceptions on agency. *Teaching Education, 8*(2), 15-22.

[13] Carr-Chellman, A. A., & Dyer, D. (2000). The pain and ecstasy: Pre-service teacher perceptions on changing teacher roles and technology. *Educational Technology and Society, 3*(2), 96-105.

[14] Chinn, C. A., & Malhortra, B. A. (2002). Epistemological authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education, 86*(2), 175-218.

[15] Clausen, R., Vilberg, J., Murray, O., Meidl, C., Sockman, B. R., Sonak, B., & Peck, K. (2011). *21st Century teaching and learning with technology (21st CTL) year 4 evaluation*. State College, PA: The Pennsylvania State University.

[16] Cornelius-White, J. (2007). Learner-centered teacher-centered relationships are effective: A meta-analysis. *Review of Educational Research, 77*(1), 113-143.

[17] Covey, S. R. V. (1993). The 7 habits of highly effective people: Powerful lessons in personal change. [Cassette Recording]: Covey Leadership Center, Inc.

[18] Csikszentmihalyi, M. (1990). *Flow-The psycholollgy of optimal experience: Steps toward enhancing the quality of life*. New York: Harper Perennial.

[19] Cuban, L. (2002). *Oversold and underused: Computers in the Classroom*. Cambridge, MA: Havard University Press.

[20] Davis, N., Preston, C., & Sahin, I. (2009). Training teachers to use new technologies impacts multiple ecologies: Evidence from a national initiative. *British Journal of Educational Technology, 40*(5), 861-878.

[21] Day, C. (2012). New lives of teachers. *Teacher Education Quarterly*, *39*(1).

[22] Dewey, J. (1938). *Experience and education*. New York: Macmillan Publishing Company.

[23] Duffy, F. M. (2010). *Dream! Create! Sustain! Mastering the art and science of transforming school systems*. Lanham, MD: Rowman & Littlefield Education.

[24] Eisler, R. (2000). *Tomorrow's children: A blueprint for partnership education in the 21st century*. Boulder, Co: Westview Press.

[25] Ely, D. P. (1990). Conditions that facilitate the implementation of educational technology innovations. *Journal of Research on Computing in Education, 23*(2), 298-305.

[26] Emo, W. (2015). Teacher's motivation for initiating innovations. *Journal of Educational Change, 16*(2), 171-195.

[27] Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255-284.

[28] Fernandez, T., Ritchie, G., & Barker, M. (2008). A sociocultural analysis of mandated curriculum change: the implementation of a new senior physics curriculum in New Zealand schools. *Journal of Curriculum Studies, 40*(2), 187-213.

[29] Fullan, M. G. (1993). *Change forces: Probing the depth of educational reform*. London: Falmer Press.

[30] Fullan, M. G., & Stiegelbauer, S. (1992). *The new meaning of educational change* (2nd ed.). New York: Teachers College Press.

[31] Glazer, E., & Hannafin, M. (2008). Factors that influence mentor and teacher interactions during technology integration collaborative apprenticeships. *Journal of Technology and Teacher Education, 16*(1), 35-61.

[32] Glazer, E. M., Hannafin, M. J., Polly, D., & Rich, P. (2009). Factors and interactions influencing technology integration during situated professional development in an elementary school. *Computers in the Schools, 26*(1), 21-39.

[33] Glazer, E., Hannafin, M. J., & Song, L. (2005). Promoting technology integration through collaborative apprenticeship. *Educational Technology Research & Development, 53*(4), 57-67.

[34] Gray, L., Thomas, N., & Lewis, L. (2009). *Teachers' use of educational technology in U.S. public schools: 2009— First look*. P. Tice (Ed.). Washington, DC: National Center for Education Statistics, Institute of Education Science.

[35] Gulek, J. C., & Demirtas, H. (2005). Learning with technology: The impact of laptop use on student achievement. *The Journal of Technology, Learning and Assessment, 3*(2), 5-38.

[36] Hakverdi-Can, M., & Dana, T. M. (2012). Exemplary science teacher's use of technology. *Turkish Online Journal of Educational Technology, 11*(1), 94-112.

[37] Hall, G. E., & Hord, S. M. (2014). *Implementing change: Patterns, principles and potholes* (4th ed.). Upper Saddle River, NJ: Pearson.

[38] Harris, J. B., & Hofer, M. J. (2011). Technological Pedagogical Content Knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43*(3), 211-229.

[39] Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: commitment, constraints, caution, and change. *Journal of Curriculum Studies, 37*(2), 155-192.

[40] Honey, S., & Graham, E. (2012). A model of teacher change and development. *International Journal for Technology in Mathematics Education, 19*(2), 59-71.

[41] Huelskamp, D. (2014). Block scheduling and its effects on long-term student achievement: A review of the research. *Global Education Journal, 2014*(3), 122-126.

[42] Inan, F. A., Lowther, D. L., Ross, S. M., & Strahl, D. (2010). Pattern of classroom activities during students' use of computers: Relations between instructional strategies and computer applications. *Teaching and Teacher Education, 26*(3), 540-546.

[43] Jing, L., & Yong, Z. (2008). One-to-one computing: What does it bring to schools? *Journal of Educational Computing Research, 39*(2), 97-122.

[44] Johansson, T., & Kroksmark, T. (2004). Teacher's intuition-in-action: How teachers experience action. *Reflective Practice, 5*(3), 357-381.

[45] Judson, E. (2006). How teachers integrate technology and their beliefs about learning: Is there a connection? *Journal of Technology & Teacher Education, 14*(3), 581-597.

[46] Kirkland, A. B. (2014). Models for technology integration in the learning commons. *School Libraries in Canada*, *32*(1), 14-18.

[47] Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2013). The technological pedagogical content knowledge framework. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (4th ed., p.101-112). New York: Springer.

[48] Land, S. M., & Greene, B. A. (2000). Project-based learning with the world wide web: a qualitative study of resource integration. *Educational technology research and development, 48*(1), 45-66.

[49] Lemke, C., & Martin, C. (2004a). One-to-one computing in Indiana: A state profile. *Ubiquitous Computing Policy Study.* Retrieved May 30, 2005, from http://wms.westside66.org/modules/groups/homepagefiles/cms/701787/File/laptopresearch/INProfile.pdf.

[50] Lemke, C., & Martin, C. (2004b). One-to-one computing in Maine: A state profile. *Ubiquitous Computing Policy Study.* Retrieved May 30, 2005, from http://wms.westside66.org/modules/groups/homepagefiles/cms/701787/File/laptopresearch/ME-Profile.pdf.

[51] Lemke, C., & Martin, C. (2004c). One-to-one computing in Virginia: A state profile. *Ubiquitous Computing Policy Study.* Retrieved May 30, 2005, from http://wms.westside66.org/modules/groups/homepagefiles/cms/701787/File/laptopresearch/VAProfile.pdf.

[52] Levin, T., & Nevo, Y. (2009). Exploring teachers' views on learning and teaching in the context of a trans-disciplinary curriculum. *Journal of Curriculum Studies, 41*(4), 439-465.

[53] Lim, C. P., Zhao, Y., Tondeur, J., Chai, C. S., & Tsai, C. C. (2013). Bridging the gap: Technology trends and use of technology in schools. *Educational Technology & Society, 16*(2), 59-68.

[54] Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills: Sage.

[55] McDonald, L. (2009). Teacher change: A dynamic interactive approach. *International Journal of Learning, 16*(10), 623-636.

[56] McGrath, J., Karabas, G., & Willis, J. (2011). From TPACK concept to TPACK practice: An analysis of the suitability and usefulness of the concept as a guide in the real world of teacher development. *International Journal of Technology in Teaching & Learning, 7*(1), 1-23.

[57] Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

[58] Moreno, R., & Ortegano-Layne, L. (2008). Do classroom exemplars promote the application of principles in teacher education? A comparison of videos, animations and narratives *Educational Technology Research and Development, 56*(4), 449-465.

[59] National Education Technology Plan. (2010). Transforming American Education Learning Powered by Technology. Washington, D.C.: U.S. Department of Education, Office of Educational Technology. Retrieved April 23, 2012, from http://www.ed.gov/technology/netp-2010.

[60] Ng, W. L. (2011). Reliability and validity of an information and communications technology attitude scale for teachers. *Asia-Pacific Education Researcher, 20*(1), 162-170.

[61] Nolan, J. F., & Meister, D. G. (2000). *Teachers and Educational Change: The Lived Experience of Secondary School Restructuring*. Albany, NY: State University of New York Press.

[62] Oliver, K. M., & Corn, J. O. (2008). Student-reported differences in technology use and skills after the implementation of one-to-one computing. *Educational Media International, 45*(3), 215-229.

[63] Orrill, C. H. (2001). Building technology-based, learner-centered classrooms: The evolution of a professional developmental framework. *Educational Technology Research and Development, 49*(1), 15-34.

[64] Peery, A. B. (2004). *Deep change: Professional development from the inside out*. Lanham, MD: Scarecrow Education.

[65] Pierson, M. E., & Cozart, A. (2004). Case studies of future teachers: Learning to teach with technology. *Journal of Computing in Teacher Education, 21*(2), 59-63.

[66] Puentedura, R. R. (2014, December 12). Technology in education: An integrated approach. Retrieved June, 23, 2015, from http://www.hippasus.com/rrpweblog/.

[67] Purcell, K., Heaps, A., Buchanan, J., & Friedrich, L. (2013, February 28). *How teachers are using technology at home and in their classrooms*. Washington, D.C.: Pew Foundation. Retrieved from http://www.pewinternet.org/2013/02/28/how-teachers-are-using-technology-at-home-and-in-their-classrooms/.

[68] Ramig, R. (2014). One-to-one computing and learning has it lived up to its expectations? *Internet@Schools, 21*(2), 6-8.

[69] Ravitz, J. (2010). Beyond changing culture in small high schools: Reform models and changing instruction with project-based learning. *Peabody Journal of Education, 85*(3), 290-312.

[70] Reigeluth, C. M. (1999). *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. 2). Mahwah, NJ: Lawrence Erlbaum Associates.

[71] Reigeluth, C. M., & Karnopp, J. R. (2013). *Reinventing schools: It's time to break the mold*. Lanham, MD: Rowman & Littlefield Education.

[72] Ritzhaupt, A. D., Dawson, K., & Cavanaugh, C. (2012). An investigation of factors influencing student use of technology in K-12 classrooms using path analysis. *Journal of educational computing research, 46*(3), 229-254.

[73] Robinson, K. (2011). *Out of our minds: Learning to be creative* (2nd ed.). West Sussex, United Kingdom: Capstone.

[74] Robinson, R., Molenda, M., & Rezabek, L. (2007). Facilitating learning. In A. Januszewski, & M. Molenda (Eds.), *Educational technology: A definition with commentary* (2nd ed., p.15-48). NY: Lawrence Erlbaum.

[75] Rogers, E. M. (1995). *Diffusions of innovations* (4th ed.). NY: Free Press.

[76] Rogers, R. K., & Wallace, J. D. (2011). Predictors of technology integration in education: A study of anxiety and innovativeness in teacher preparation. *Journal of Literacy & Technology, 12*(2), 28-61.

[77] Romrell, D., Kidder, L. C., & Wood, E. (2014). The SAMR model as a framework for evaluating mLearning. *Online Learning, 18*(2), 1-15.

[78] Sakamoto, N. (2011). Professional development through kizuki - cognitive, emotional, and collegial awareness. *Teacher Development, 15*(2), 187-203.

[79] Sandholtz, J. H., & Reilly, B. (2004). Teachers, not technicians: Rethinking technical expectations for teachers. *Teachers College Record, 106*(3), 487-512.

[80] Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms*. NY: Teachers College Press.

[81] Saunders, R. (2013). The role of teacher emotions in change: Experiences, patterns and implications for professional development. *Journal of Educational Change, 14*(3), 303-333.

[82] SEDL. (n.d.). Retrieved April 23, 2015, from http://www.sedl.org/about/.

[83] Silvernail, D. L., Harris, W. J., Lane, D., Fairman, J., Gravelle, P., Smith, L., . . . McIntire, W. (2003). The Maine learning technology initiative: Teacher, student, and school perspectives—Mid-year evaluation report. ME: Maine Education Policy Research Institute.

[84] Smyth, J. (2005). Three rival version and a critique of teacher staff development. In D. Hopkins (Ed.), *The practice and theory of school improvement* (p.208-222). Netherlands: Springer.

[85] Sockman, B. R., & Sharma, P. (2008). Struggling toward a transformative model of instruction: It's not so easy! *Teaching and Teacher Education, 24*(4), 1070-1082.

[86] Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, London, New Dehli: Sage Publications.

[87] Stake, R. E. (2000). Case studies. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed.,pp.435-454). Thousand Oaks: Sage Publications Inc.

[88] Straub, E. T. (2009). Understanding technology adoption: Theory and future directions for informal learning. *Review of Educational Research, 79*(2), 625-649.

[89] Strobel, J., & van Barneveld, A. (2009). When is PBL more Effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-based Learning, 3*(1), 44-58.

[90] Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. *Review of Educational Research, 81*(1), 4-28.

[91] Tamim, S. R., & Grant, M. M. (2013). Definitions and uses: Case study of teachers implementing project-based learning. *Interdisciplinary Journal of Problem-based Learning, 7*(2), 72-101. doi: 10.7771/1541-5015.1323

[92] The Learner-Centered Principles Work Group of the APA's Board of Educational Affairs. (1997, November). Learner-centered psychological principles: A framework for school reform and redesign. Washington, D.C.: American Psychological Association. Retrieved from http://www.apa.org/ed/governance/bea/learner-centered.pdf.

[93] Toledo, C. (2005). A five-stage model of computer technology integration into teacher education curriculum. *Contemporary Issues in Technology and Teacher Education, 5*(2), 177-191.

[94] Tondeur, J., Kershaw, L. H., Vanderlinde, R. R., & van Braak, J. (2013). Getting inside the black box of technology integration in education: Teachers' stimulated recall of classroom observations. *Australasian Journal of Educational Technology, 29*(3), 434-449.

[95] Topper, A., & Lancaster, S. (2013). Common challenges and experiences of school districts that are implementing one-to-one computing initiatives. *Computers in the Schools, 30*(4), 346-358. doi: 10.1080/07380569.2013.844640

[96] Towndrow, P. A., & Wan, F. (2012). Professional learning during a one-to-one laptop innovation. *Journal of Technology and Teacher Education, 20*(3), 331-355.

[97] Trenta, L., & Newman, I. (2002). Effects of a high school block scheduling program on students: A four-year longitudinal study of the effects of block scheduling on student outcome variables. *American Secondary Education, 31*(1), 54-71.

[98] Van Manen, M. (1997). *Researching lived experience: Human science for an action sensitive pedagogy* (2 ed.). London: Althouse Press.

[99] VanSledright, B. (2002). Confronting history's interpretative paradox while teaching fifth grade to investigat the past. *American Education Research Journal, 39*(4), 1089-1115.

[100] Vega, A., & Brown, C. G. (2013). The implementation of project-based learning. *National Forum of Educational Administration and Supervision Journal, 30*(2), 4-29.

[101] Watson, W. R., Watson, S. L., & Reigeluth, C. M. (2012). A systemic integration of technology for new-paradigm education. *Educational Technology, 52*(5), 25-29.

[102] Wood, D., Bruner, J., S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89-100.

[103] Yildirim, S. (2000). Effects of an educational computing course on preservice and inservice teachers: A discussion and analysis of attitudes and use. *Journal of Research on Computing in Education, 32*(4), 479-495.

[104] Yin, R. K. (1993). *Applications of case study research* (Vol. 34 of Applied Social Research Methods). Newbury Park, CA: Sage.

[105] Yin, R. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, London, New Delhi: Sage Publications.

[106] Zhao, Y. (2012). *World classs learners: Educating creative and entrepreneurial students*. Thousand Oaks, CA: Corwin.

[107] Zhao, Y., & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal, 40*(4), 807-840.

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