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Closing the Gap Between Technological and Best Practice Innovations: TPACK and DI

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Abstract

Implementing differentiated instruction with the fast changing landscape of technology is a complex process (Fullan, 2014; Tomlinson; 2014) and requires widespread diffusion of multiple innovations by educators (Meyer, 2004). However, most U.S. classrooms remain stagnant in their attempts to successfully incorporate innovative pedagogies (Darling-Hammond, 2010; November, 2014; Prensky, 2010; Robinson, 2011). Thus Fullan (2014) reported, “The time is right to bring together knowledge of systems change, new pedagogies and technologies that allow change to scale through diffusion” (p. 13).

To understand this problem, this pragmatic, mixed-methods study (Creswell, 2009) collected data through the following condensed research questions: What are the relationships between educators’ TPACK and DI self-efficacy and the following demographics: grade level, years of teaching, adopter category, device-student ratio, professional development hours in technology or DI, class size, certification(s), and educational background? How do teachers describe their use of technology to differentiate instruction?

A questionnaire with open-ended questions provided quantitative and qualitative data (*N*=72). Of the respondents, 22% were categorized as innovators and 32% as early adopters-considered teacher leaders. Even though both groups demonstrated more confidence with DI-T than later adopter categories, neither showed significantly stronger TPACK. However, Grade 8-12 teachers demonstrated significantly higher TPACK and self-efficacy to DI than pre-kindergarten to grade 4 teachers.

Qualitative themes confirmed the problem. Educators demonstrated misconceptions of TPACK and self-efficacy to DI, and these innovative practices were not successfully being diffused. Thus, recommendations identified specific professional development needs, and for educational systems to create communication channels to more rapidly diffuse innovational pedagogies.

Introduction

The research on the diffusion of innovations was christened in 1943 with Ryan and Gross' agricultural study on the diffusion of seeds (Meyer, 2004). Meyer (2004) and Rogers (2003) pointed out that this study became the framework for all future studies. The characteristics of these studies primarily involved, "a) quantitative data, b) concerning a single innovation, c) collected from adopters, d) at a single point in time, and e) after widespread diffusion had already taken place" (Meyer, 2004, p. 59). However, this methodology had benefits and limitations (Meyer, 2004), and since innovational, quick-start change is needed in education (Fullan, 1982), more educational research is needed on the diffusion of "interrelated innovations" (Meyer, 2004, p. 2). Elmore (1996) theorized even with as much change as education continually experiences, systemic change would not occur until adaptations in teaching practices were reached. Thus in education, research is needed on both innovative best practices such as differentiated instruction and technological pedagogical content knowledge (Harris, Mishra, & Koehler, 2009; Meyer, 2004).

Problem Statement

Most educational change research, to this point, has focused on the diffusion of a single innovation rather than on a "technology cluster." The latter defined as "a set of interrelated innovations that complement each other in a way that adoption of one innovation might naturally lead to adoption of one or more of the other innovations" (Meyer, 2004, p. 60).

> Effective technology implementation in schools is a complex puzzle. Hundreds of interrelated factors play a role. The presence of computers in a school does not guarantee improved student achievement…Ultimately, the implementation of best practices is as important as the technology itself; and the value of technology in terms of student achievement depends on the quality of its implementation. (Greaves et al., 2010, p. 10)

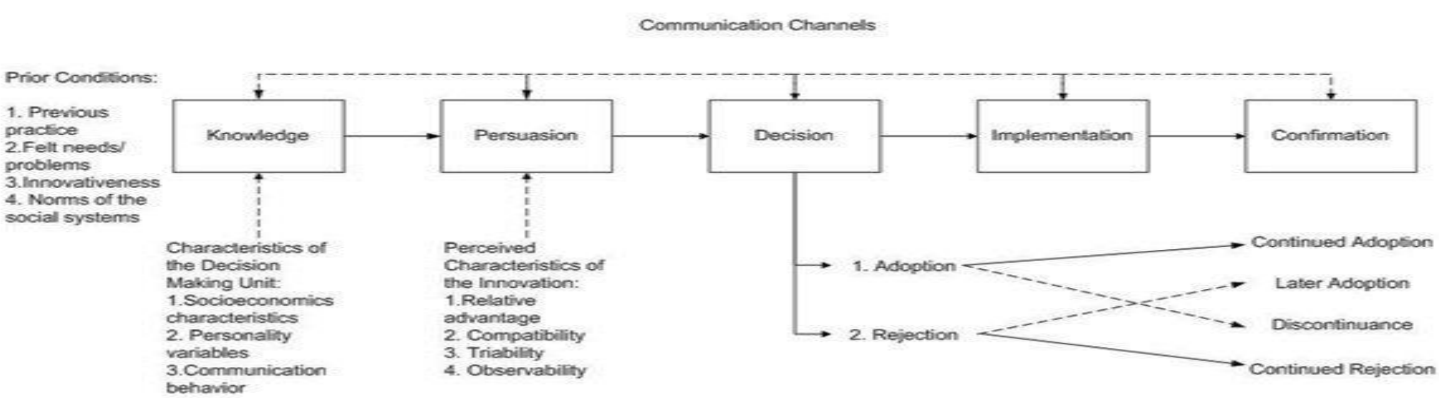
Thus, Fullan (2014) declared, "the time Is right to bring together knowledge of systems change, new pedagogies and technologies that allow change to scale through diffusion" (p. 13). To increase the rapidity of diffusion of these innovational practices, more stakeholders need to readily communicate and accept innovation throughout school organization. In order to make this happen, teachers, first, need to develop awareness of the technological infrastructure available (Dede & Richards, 2012; Jacobs, 2010; Jukes, McCain, & Crockett, 2010). Secondly, teachers' attitudes must accept the changing dynamics of learning in the 21st century (Harris, Mishra, & McCain, 2009; Jukes, McCain, & Crockett, 2010). Thirdly, teachers must build their technological pedagogical content knowledge (TPACK) to employ effective best practices, and these practices clearly go hand in hand with differentiated instructional practices. Fourth, a significant shift in how professional development is developed, implemented and assessed must happen to build these capacities (Hofer, Grandgenett, Harris, & Swan, 2011; Jacobs, 2010; West, 2010). Lastly, teachers must not focus on the technology itself, but rather on the learning outcome that is supported by technology (Greenstein, 2012; Harris, Mishra, & McCain, 2009; Jacobs, 2010; Jukes, McCain, & Crockett, 2010).

Technological innovations, in practices, ideas, and technology, require wide-spread, second-order change (Fullan, 2014; Houle & Cobb, 2011; November, 2014; Pink, 2005; Robinson, 2010, 2011; Wagner, 2008, 2012). Without educators working to find solutions to instill second-order changes in best practices, ones that will optimize teaching and learning in ways not fully understood, then today's students will be ill-prepared to compete in the global society (Collins & Halverson, 2009; Cunningham, 2009; Friedman, 2005; Houle & Cobb, 2011; Littky & Allen, 1999; Prensky, 2010; Trilling & Fadel, 2009; West, 2011, 2012).

Background of Study

Diffusion of an Innovation

Rogers (2003) distinguished that "an innovation is an idea, practice, or object perceived as new by an individual or other unit of adoption" (p. 35). Rogers (2003) also specified the "process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 34). There are five steps in this communication process: knowledge gathering influenced by the characteristics of the organization; persuasion based on advantage, compatibility, complexity, trial opportunities, and observations; the decision to adopt or reject the innovation; the implementation if innovation is adopted; and the confirmation from the members (Rogers, 2003).

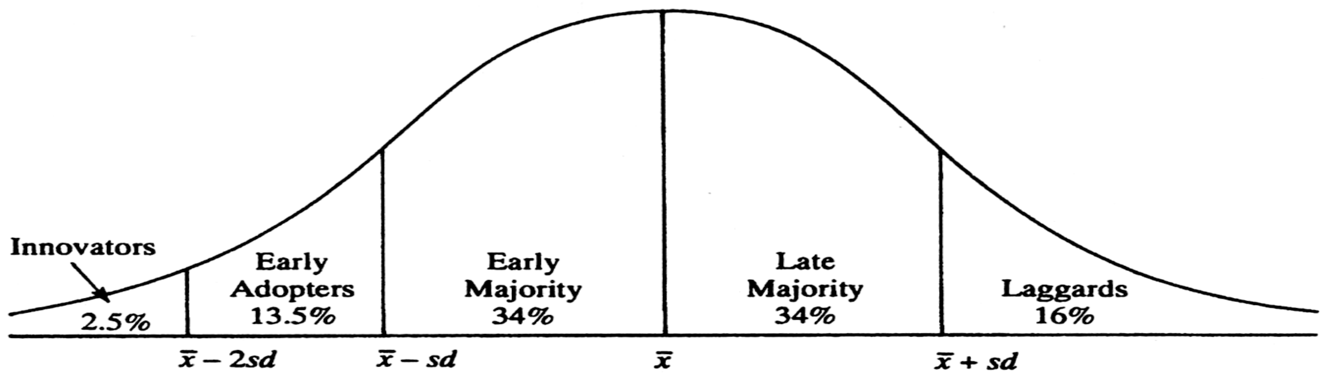


(Rogers, 2003, p. 170)

Figure 1. Model of Five Stages in the Innovation-Decision Process

Early in the communication, a small percentage of an organization's members accept and confirm the positive or negative value of an innovation. These innovators, in turn, affect another percentage of members by communicating their perceived value of the innovation. This communication thus increases or decreases the chances of an innovation being accepted by the remaining members (Rogers, 2003). Rogers (2003) termed the members of the community involved in this process of diffusing an innovation as *innovators (2.5%)*, *early adopters (13.5%)*, *early majority (34%)*, *late majority (34%)*, and *laggards (16%) (*further defined in Appendix A). Elmore (1996) surmised that change happens in organizations as more and more members communicate to accept or reject an innovation over time.

According to Rogers (2003), a bell-curve graphically represents this adoption curve.



(Rogers, 2003, p. 281)

Figure 2. Adopter Categorization on the Basis of Innovativeness

History of Innovation Diffusion in Education

The diffusion of innovation attempts in education has been both prolific and problematic throughout history (Fullan, 1982). Fullan cited that diffusion was problematic due to the perceived or real value of these innovations and also due to the persuasive bias educators possess towards innovation. Fullan also pointed out that “innovations are not neutral in their benefits, and that there are many reasons other than educational merit which influence decisions to change” (p. 22).

Elmore (1996) theorized that the segregation between innovators, those that accept the innovation early on, and laggards, those that accept the innovation last or sometimes not at all, limited the ability of an innovation to have substantial impact on learning and teaching. “Innovations that require large changes in the core of educational practice seldom penetrate more than a small fraction of U.S. schools and classrooms, and seldom last for very long when they do” (Elmore, 1996, p. 1). Therefore, large-scale replication of successful, innovational reform has been elusive (Darling-Hammond & Bransford, 2005; Elmore, 1996; Fullan, 2006; Houle & Cobb, 2011).

Each attempt to diffuse an innovation signals possible change in organizational behavior, philosophies, and beliefs (Fullan, 1982), and these attempts have also been historically pervasive in public education (Elmore, 1996; Fullan, 1982; Hargreaves & Fullan, 2009). From the progressive movement that “represented an astonishing range of pedagogical forms and institutional forms” (Elmore, 1996, p. 7) to the curriculum reform movements of the more recent decades (Darling-Hammond, 2010; Elmore, 1996), innovative best practices have been researched, debated, and applied throughout educational history. However, successful diffusion and change has been elusive, and as a result, public education has remained stagnant in its attempts to innovate and change behaviors, philosophies, and beliefs since the early 1900s (Fullan, 1982).

Hargreaves and Fullan (2009) posited many reasons for a lack of successful change in American public education: a) exemplars only existing in isolated pockets, b) innovations not being accepted systemically; c) a lack of motivated stakeholders; and d) a minimal belief that change will achieve better results. The researchers pointed out that this lack of successful change had benefits and deficits. On the one hand, the difficulty of diffusion meant that substandard innovations, those that had no value, did not harm the system. However, on the other hand, this lack of diffusion also meant that valuable innovations, those that would have catalyzed profitable educational change, met the same fate. Elmore's (1996) argument was a bit different and should cause researchers and decision-makers to pause:

> The closer an innovation gets to the core of schooling, the less likely it is that it will influence teaching and learning on a large scale. The corollary of this proposition, of course, is that innovations that are distant from the core will be more readily adopted on a large scale. (Elmore, p. 4)

Elmore warned that organizations should avoid the pitfalls identified by Hargreaves and Fullan (2009) to affect large-scale change by "changing fundamental conditions affecting the relationship of student, teacher, and knowledge" (p. 6).

The dimensions of change are essential to identify because "ignorance of these dimensions explains a number of interesting phenomena in the field of education change: for example, why some people accept an innovation they do not understand" (Fullan, 1982, p. 29). In later research, Fullan's (2006) theory of action observed:

> There are seven core premises that underpin our use of change knowledge. (True to the theory of action itself, it should be noted that the seven premises have been 'discovered' via reflective action especially, over the past decade). The seven premises are a) a focus on motivation; b) capacity building, with a focus on results; c) learning in context; d) changing context; e) a bias for reflective action; d) tri-level engagement; and f) persistence and flexibility in staying the course. (p. 8)

In similar research outside of education, Heath and Heath (2010) corroborated that there are three individual components to successful change: addressing the mind, the emotions, and the direction. They also warned organizations, "What looks like resistance is often a lack of clarity" (p. 17), and Fullan (1982) summarized the factors that affect implementation of innovational change at the school level:

- The history of innovative attempts
- The adoption process
- Central administrative support and involvement
- Staff development (in-service) and participation
- Time-line and information system (evaluation)
- Board and community characteristics (p. 56).

In the end, the process of attempting to diffuse innovations evokes change (Fullan, 1982), and therefore, the acceptance or rejection of innovations within the organization-such as innovative best practices in education-results in an acceptance or rejection of change (Rogers, 2003). However, the problem with the research on educational change is not the amount of research that exists on diffusion of innovations or the change process, but rather “the primary problem of scale is understanding the conditions under which people working in schools seek new knowledge and actively use it to change the fundamental processes of schooling” (Elmore, 1996, p. 4). In addition, schools as organizations “must view change as a highly personal process in which people assess with their minds and hearts whether the proposed change is aligned with their own values and beliefs” (Brown & Moffett, 1999, p.135).

Innovation and Educational Change

Futurists like Dede (2007) as well as organizational theorists like Zuboff (1984), Senge (2000, 2006), and Fullan (2014) revealed the importance of researching the complexities of innovations because this research enables organizations, like school systems, to strategically plan for the future. Dede (2001), in his testimony to the U.S. Senate and House of Representatives, reported:

> ...learning technologies are worth the time, effort, and resources required for widespread implementation only when they are used appropriately. Technology is not a ‘vitamin’ whose mere presence in schools and teacher preparation programs catalyzes better educational outcomes. (p. 4)

Warschauser and Matuchniak commented (2010) on this testimony. They stated that Dede “wisely pointed out the problems with what he termed the “fire” metaphor of information technology. Just as a fire radiates heat, many people expect a computer to radiate learning” (p. 201).

Trilling and Fadel (2009) also announced that the top “21st century challenge” (p. 40) in the United States continued to be the ability to create a system of education that supported a personalized, digital learning environment where students will become literate in the necessary skills for the future. Warschauer and Matuchniak (2010) argued, “the most important technology discrepancies in U.S. schools are not in whether computers and the Internet are used, but for what purpose” (p. 198).

The benefits of combining academic technology and academic best practices has been historically difficult to define and even more difficult to measure. A historical review of research about adequate technology use in a classroom produced similarities of results. Two similar studies conducted 20 years apart, Apple Classrooms of Tomorrow (1990) and Collins and Halverson (2009), found, according to teachers, the primary reason technology was not being implemented in public schools classrooms was lack of knowledge of how to incorporate the technological innovations available with best practices.

Greaves, Hayes, Wilson, Gleniak, and Peterson (2012) in an International Society for Technology in Education study titled Project Tomorrow (2013) found:

> The presence of computers in a school does not guarantee improved student achievement. Indeed, providing every student a computer is the beginning, not the end, of improving student performance. In fact, schools with a 1-to-1 student–computer ratio that address only a few of these key factors perform only marginally better than non–1-to-1 schools. Ultimately, the implementation of best practices is as important as the technology itself; and the value of technology in terms of student achievement depends on the quality of its implementation. (p. 10)

Students also contributed to the debate. Project Tomorrow (2013) found student "dissatisfaction with using technology at their school is not about the quantity or quality of the equipment or resources; it is about the unsophisticated use of those tools by their teachers, which they believe is holding back their learning potential" (p.7). Hudson (2011) summarized this change in the digital divide definition:

> While we've traditionally used the term digital divide to refer to the technology gap between financially secure suburban districts and their poorer urban counterparts, another divide has emerged, and it's cause for concern: the disparity between how educators view their use of technology and how students themselves perceive it. To put it simply, we're falling short of kids' expectations about technology can and should be used in the classroom. And its not just high schoolers and middle schoolers-many first graders can easily find the Arctic on Google Earth or videos of the American black bear without any assistance at all. (p. 48)

Within U.S. public schools, evidence is everywhere that "in most cases, the technology is implemented for traditional practices, while paradigmatic change in teaching, learning, and assessment in technology-rich environments is rare" (Rosen & Beck-Hill, 2012, p. 226).

As access to technology increased in public school classrooms, researchers, teacher leaders, and policy makers thought that the digital divide would disappear. However, the first-order diffusion on technological innovations did not raise student achievement; it merely diffused the innovation of computers into the landscape (Greaves, Hayes, Wilson, Gielniak, & Peterson, 2012; Fullan, 2014). This only sparked the realization that technological innovations must combine with innovational practice and idea change in education.

Diffusion of Innovational Best Practices

Diffusion of technological devices happened relatively easily in public school systems (Houle & Cobb, 2011; Kahn, 2012); however, there are now more complex questions involving the diffusion of innovational best practices: How does a system integrate innovational technologies with innovational best practices to prepare students in 21st century skills (Becker, 2000; Jackson, Zhao, Kolenic, Fitzgerald, Harold, Von Eye, 2008; Harris & Hofer, 2009; Koehler & Mishra, 2008; Warschauser & Matuchniak, 2010)? How were school systems going to increase understanding about how to use both technological and best practice innovations in order to close the gap between first-order, technical changes and large-scale, second-order adaptive changes to enhance student learning (Becker, 2000; Jackson, Zhao, Kolenic, Fitzgerald, Harold, Von Eye, 2008; Harris & Hofer, 2009; Koehler & Mishra, 2008; Warschauser & Matuchniak, 2010)?

Traditionally in order to incorporate best practices into the classroom, educators integrated what they knew about their content and pedagogy (Shulman, 1987). Shulman (1987) categorizes this knowledge:

> Content knowledge; general pedagogical knowledge, with special reference to those broad principals and strategies of classroom management and organization that appear to transcend subject matter; curriculum knowledge, with

> particular grasp of the materials and programs that serve as "tools of the trade" for teachers; pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special of professional understanding, knowledge of learners and their characteristics; knowledge of educational contexts, ranging from the workings of groups in the classroom, the governance and financing of school districts, to the character of communities and cultures, and knowledge of educational ends, purposes, and values, and the philosophical and historical grounds. (p. 8)

His conceptual framework and his argument that "comprehension alone is not sufficient" (p. 14) provided a theoretical basis for the new literacies (Harris, Mishra, & Koehler, 2009). Unlike the pen and paper technologies of the past, new technologies are "qualitatively different in that its functioning is more opaque to teachers and offers fundamentally less stability" (Koehler & Mishra, 2009, p. 61). Therefore, research began on the innovational technological knowledge teachers must possess and its relationship to their pedagogical content knowledge (Harris, Mishra, & Koehler, 2009).

Koehler and Mishra (2008) termed this new theoretical framework as "technological pedagogical content knowledge" (TPCK or TPACK). This framework integrates technology as a "pedagogical tool" (Hu & Fyfe, 2010, p. 184).

Similar to Shulman (1986, 1987), Koehler and Mishra define the sub-dimensions as well as the relationships between and among the sub-dimensions. According to Harris, Mishra and Koehler (2009), the definitions of content and pedagogical knowledge as well as the interrelationship between the two are the same as Shulman (1987) defined:

- Content knowledge (CK) is knowledge about the subject matter that is to be learned or taught (p. 397);
- Pedagogical knowledge (PK) is deep knowledge about the processes and practices of teaching and learning, encompassing educational purposes, goals, values, strategies, and more (p. 397);
- Pedagogical content knowledge (PCK) is teaching knowledge applicable to a specific content area (p. 398).

However, these researchers expanded on the construct to include:

- Technological knowledge (TK) is always in a state of flux...and requires a deeper, more essential understanding and mastery of technology for information processing, communication, and problem solving than does the traditional definition of computer literacy. Also, this conceptualization of TK does not posit an "end state," but rather assumes TK to be developmental, evolving over a lifetime of generative interactions with multiple technologies (p. 398);
- Technological pedagogical knowledge (TPK) is an understanding of how teaching and learning change when particular technologies are used (p. 398);
- Technological content knowledge (TCK) includes an understanding of the manner in which technology and content influence and constrain one another (p. 399).

And finally, technological pedagogical content knowledge (TPACK):

> Encompasses understanding and communicating representations of concepts using technologies; pedagogical techniques that apply technologies appropriately to teach content in differentiated ways according to students' learning needs; knowledge of what makes concepts difficult or easy to learn and how technology can help redress conceptual challenges; knowledge of students' prior content-related understanding and epistemological assumptions, along with related technological expertise or lack of thereof; and knowledge of how technologies can be used to build on existing understanding to help students develop new epistemologies or strengthen old ones. (p. 401)

Harris, Mishra, and Koehler (2009) continued, "TPACK is a form of professional knowledge that technologically and pedagogically adept, curriculum-oriented teachers use when they teach" (p. 401). To use this framework is to enter into a relatively new pedagogical era and one where more research is needed, "activity type taxonomies…should be tested and refined according to what teachers and teacher educators discover and recommend when using them" (Harris, Mishra, & Koehler, 2009, p. 412).

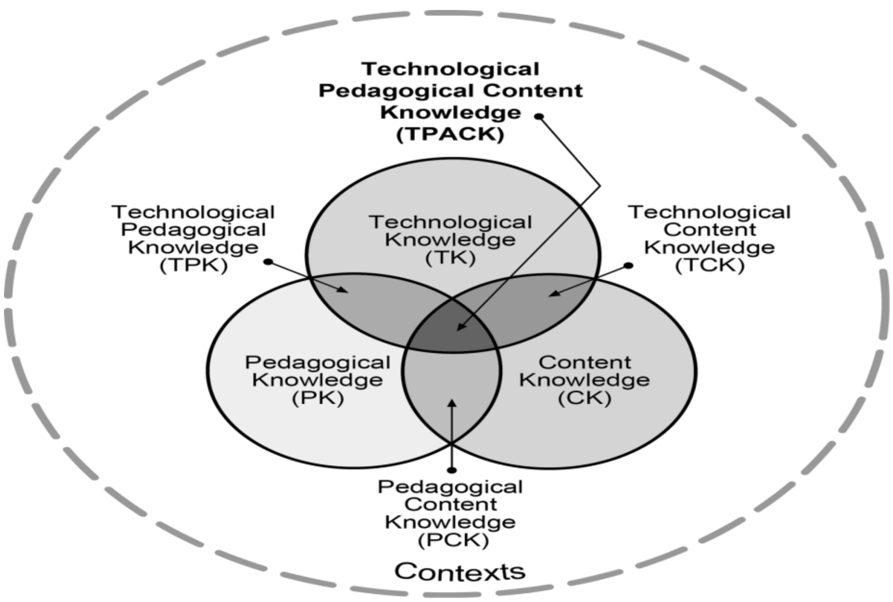


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Figure 3. TPACK Construct

Fullan (2014) reported, "The time is right to bring together knowledge of systems change, new pedagogies and technologies that allow change to scale through diffusion" (p. 13). Today, Fullan (2014), November (2014), Tomlinson (2014) and other leaders in innovational best practice research would agree with Schulman (1986) when he declared, "Needed change cannot occur without risk, however. The current and trivial definitions of teaching held by the policy community comprise far greater danger to good education than does a more serious attempt to formulate the knowledge base" (p. 20).

Educational Change and Capacity Building

Currently in education, second-order change, change that would have a more profound effect on learning, is still in the early adoption stage and faces resistance (Collins & Halverson, 2009;

Cunningham, 2009; Houle & Cobb, 2011; Littky & Allen, 1999; Prensky, 2010; Trilling & Fadel, 2009; West, 2011, 2012). This second-order change requires all stakeholders to face challenges that are adaptive, not technical (Heifetz & Laurie, 2001). The difference between the two is that technical changes involve obvious problems, solutions that are already known, and the focal point of the work is top-down. Adaptive changes have problems and solutions that require the acquisition of new knowledge, and all stakeholders share the main core of the work (Heifetz, Grashow, & Linksy, 2009).

Zuboff (1984) remarked, “Now a new kind of learning must begin. It is slow and scary, and many workers are timid, not wanting to appear foolish and incompetent” (p. 72). In fact, Dede (2007) warned, “Educators, business executives, politicians, and the general public have much to unlearn if 21st century understandings are to assume a central place in schooling” (p. 19). To address these adaptive challenges, Bandura (1997) stated that all stakeholders must be “given appropriate skills and adequate incentives...” and continued on to stress that “efficacy expectations are a major determinant of people's choice of activities, how much effort they will expend, and of how long they will sustain effort in dealing with stressful situations” (p. 194).

According to Zuboff (1984), employers in the private sector understand that there was “stark difference in the forms of knowledge” workers must now employ (p. 74), and in order to make a marked change “a reskilling process is required” (p. 76). In public education, Fullan (2005) agreed, “capacity building involves developing the collective ability-dispositions, skills, knowledge, motivation, and resources-to act together to bring about positive change” (p. 4).

Fullan also argued:

> There is no chance that large-scale reform will happen, let alone stick, unless capacity building is a central component of the strategy for improvement. Related to this, we now know that capacity building *throughout the system* at all levels must be developed in concert, and to do this will require powerful new system forces. (p. 11)

The National Education Technology Plan (2010), and it also recognizes a lack of implementation:

> This gap in technology understanding influences program and curriculum development, funding and purchasing decisions about educational and information technology in schools, and preservice and in-service professional learning. This gap prevents technology from being used in ways that would improve instructional practices and learning outcomes. Still, we must introduce connected teaching into our education system rapidly, and therefore we need innovation in the organizations that support educators in their profession—schools and districts, colleges of education, professional learning providers, and professional organizations. (xii-xiii)

To pragmatically find ways to bridge this gap, Archambault and Barnett (2010) suggested that future research include specific examples within teacher practice to avoid the confusion and to avoid the limitations of this research only being “effective in the hallways of academia” (p. 1661), and to find the root of the problem in order to make recommendations more useful to those stakeholder that work each day in the hallways of United States public school systems” (p. 1661). Chai, Koh, and Tsai (2013) agreed that more work on the instruments used to assess TPACK are needed and also recommend that “cross-fertilizing” frameworks such as the adoption with the TPACK model may allow researchers the ability to “envision the acceptance of certain emerging technology by analyzing it TPACK properties as well as the stages of concern that would follow when the technology is implemented” (p. 46).

Research Questions

The research questions guiding this study were:

1. What is the relationship between the overall dimension of TPACK and the sub-dimensions of TPACK (TK, PK, CK, TCK, PCK, TPK) and the following demographics: grade level assignment, total years of teaching experience, self-described adopter category: innovator, early adopter, early majority, late majority, laggard, digital device-student ratio, number of hours of professional development in technology-related topics over past two years, number of students in class, certification(s), and educational background.
2. What is the relationship between self-efficacy to differentiate instruction and the following demographic variables: grade level assignment, total years of teaching experience, self-described adopter category: innovator, early adopter, early majority, late majority, laggard, number of hours of professional development in differentiation over past two years, number of students in class, certification(s), digital device-student ratio, and educational background.
3. How do teachers describe their use of technology to differentiate instruction?

Research Design

The purpose of this study was to collect data on the theories of technological pedagogical content knowledge (TPACK), differentiate instruction (DI) as well as demographic data in order to find solutions to the problem statement in a pragmatic manner. This transformative, sequential, mixed-methods study was therefore justified in its selection and allowed for the inclusion of the theoretical lenses, differentiated instruction (DI), technological pedagogical and content knowledge (TPACK) as well as diffusion of innovation and change theories. Additional support was given through a literature review, and all data collection, data analysis, instrument development, participant, limitation, delimitation information was provided (Millen, 2015).Quantitative collection was completed first because “survey research provides a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population” (Creswell, 2009, p. 12).

Quantitative data were analyzed first using item-level within dimension frequencies, percents, ranked means, and standard deviations. Questions 1 and 2 were analyzed using a one-way ANVOAs that assessed whether there were significant differences between TPACK along with its sub-domains and the extent of differentiation. Questions 3, 4 and 5 were analyzed using simple correlation, as well as *t*-tests and one-way ANOVAs.

All research designs have pros and cons, so mixed methods research is used (Morse as cited by

Beck, 2014):

- To make the research richer and more useful, or
- To obtain another perspective, using a different data type (such as observational data to conduct a core project that uses interviews), or
- To obtain data from a different level of analysis.

There was also a gap in this type of research with respect to TPACK. An empirical study (Wu, 2013) revealed the following trends of TPACK research: a) between 2002-2006: *N* = 2 (100%) qualitative; *N* = 0 quantitative and mixed methods; b) between 2007-2011: *N* = 8 (36.4) qualitative; *N* = 11 (50%) quantitative; *N = 3* (13.6%) mixed methods. These data combined with recommendation of experts identified a need for more mixed method studies on this topic:

> To build a more nuanced and complete understanding of enacted TPACK, however, researchers should consider using multiple data types and sources...We suspect that analyzing a triangulated combination of planning documents, observations, and teacher interviews (optimally, conducted both before and after observed teaching) would provide a more complete and accurate assessment of a teacher's TPACK. (Harris, Grandgenett, Hofer, & Swan, 2011, p. 4357)

Similarly, researchers of differentiated instruction found:

> Although we have witnessed curriculum changes that promote the implementation of differentiation, literature lacks of substantial research evidence supporting differentiation theory...Only a small number of studies investigate the effectiveness of differentiation on the whole and under certain conditions. (Stavroula, Leonidas, & Mary, 2011, p. 4)

Therefore sequentially, after analysis of the quantitative data, the two-open ended questions at the conclusion of the survey were scored and coded using pre-defined rubrics associated with TPACK and DI. These responses were coded and analyzed using what Beck (2014) termed pre-defined themes. Again, these themes are inherent in the theories in this study: technological pedagogical content knowledge (TPACK) and differentiated instruction (DI).

This mixed-method design addressed "the challenges inherent in assessing teachers' knowledge accurately via self-reports" (Harris, Grandgenett, Hofer & Swan, 2011, p. 4352), thus the additional open-ended questions provided additional, pragmatic, data on how to solve the problem and its inherent consequences (Creswell, 2009).

Participants

Participants were purposely-selected teachers (*N* = 180) from a suburban district in New England. Certified teachers (grades pre-k-12) were targeted and the selected district had recently launched a 1-1 technology program in grades 8-12. This system was selected based on representative demographics for the possibility of generalizability of the results (Cavanagh & Keohler, 2013).

For the second phase, participants were randomly selected from those that provided additional qualitative data (*N* = 42*).* This purposely small sample was also chosen because of the time limitations of this study. Patton notes, "the validity, meaningfulness, and insights generated from qualitative inquiry have more to do with the information rightness of the cases selected and the observational/analytical capabilities of the researcher than with sample size" (p. 245).

Instrumentation

Quantitative Instruments. Data were collected via modifications of three surveys in order to address the limitations of previous surveys and better evaluate the constructs found in this study: *Survey of Pre-service Teachers' Knowledge of Teaching and Technology* (Schmidt, Baran, Thompson, Koehler, Mishra, & Shin, 2009), *Meaningful Learning Survey* (Koh, & Chai, 2011), and *Survey of Beginning Teachers' Perceived Preparedness and Efficacy for Differentiating Instruction* (Casey, 2011).

To decide on modifications, a thorough literature review was conducted including reviews of previous research that explored both the TPACK construct and DI construct. Once surveys were modified, pilot surveys (*N* = 8) were administered since changes to original surveys were made. Demographic questions began the survey and were reworded to address current study demographics: pre-service to in-service teachers. Other changes were made due to the evolution of the constructs involved in this study (Harris, Mishra, & Koehler, 2009, p. 413). The instrument was sent to a panel of experts (*N* = 3) for review.

The final quantitative modified instrument, *DI-TPACK Survey* (Millen, 2015) was therefore a combination of the above instruments and was developed with a thorough review of literature by experts in both topics (TPACK: Harris, Grandgenett, & Hofer, 2010; Mishra, Koehler, & Schmidt, 2009; DI-Tomlinson, 2008; Renzulli & Reis, 2013; Hall, Strangman, & Meyer, 2011; Self-efficacy: Bandura, 1997). In addition to ensure "the extent to which the items in an instrument actually measures the content they were intended to measure" (Gall, Gall, & Borg, 2007, p.123); this survey was combined with the survey modified to collect data on questions 2 and 3.

Upon completion of this construction and modification process, the surveys were piloted (*N* = 8) for formal readability analysis. The instrument was also sent to a panel of experts (*N* = 3) to examine content validity. The final survey, *DI-TPACK Survey*, consisted of 10 demographic questions, 40 self-reporting, 5-point Likert scale items. Likert style questions related to the TPACK construct, with an additional 10 related to the DI construct and six related to the DI-T construct. The overall internal consistency of the data for each dimension was measured by Cronbach alpha ($\alpha \geq .80$) (Appendix B).

Qualitative Instruments. After analysis of quantitative data, a decision was made to code the two open-ended questions at the end of the survey. Upon completion of this coding, the choices in previous research studies were considered such as document reviews, semi-structured interviews, structured interviews, and observational data. However, additional data collection was deemed unnecessary.

Data Collection

Participants (*N* = 180*)* were first invited to participate in the first of the two-phase study via email.

A introduction letter from the superintendent of schools was followed by an email from the researcher that provided the explanation of the study, the statement of purpose, the details of an incentive, and also the human subjects “rights and permission” statement.

Data Analysis

“The quality of correlational studies is determined not by the complexity of the design or the sophistication of analytical techniques, but by the depth of the rationale and theoretical constructs that guide the research design” (Gall, Gall, & Borg, 2007, p. 335). Thus this pragmatic, mixed-methods study collected both quantitative data, in the form of descriptive data from the survey and document review, and qualitative data from the open-ended questions and the interview.

Quantitative Analysis

Quantitative data were analyzed through the use of SPSS-22.0. Research questions 1 and 2 were analyzed using item-level within dimension frequencies, percents, ranked means, and standard deviations. These data exhibited the self-reported levels of TPACK and the self-efficacy levels of differentiated instruction. One-way ANOVAs then measured whether there were significant differences between TPACK levels and extent of differentiation. Follow-up Scheffé tests were completed, where necessary.

Qualitative Analysis

To protect against threats to validity when analyzing results, Creswell and Plano-Clark (2011) recommend researchers “weigh the options for follow-up, and choose the results to follow-up that need further explanation” (p. 242). Thus, two open-ended responses followed the quantitative questionnaire (Millen, 2015). This follow-up qualitative data for the two questions were analyzed through thematic coding of the “predefined themes” (Beck, 2014) within in the constructs of the two theories inherent in this study: technology, pedagogy, and content knowledge (TPACK) and differentiated instruction (DI). Prior research finds “the challenges inherent in assessing teachers’ knowledge accurately via self-reports” (Harris, Grandgenett, Hofer, & Swan, 2011, p. 4352), thus this analysis began with Krippendorff’s techniques of clustering and the construction of a dendrogram (as cited in Beck, 2014). Next, in order to make inferences and conclusions about the clusters, the following strategies were employed:

- “Eyeball” the results to see “what jumps out”
- Check initial inferences against field-notes and initial data
- Revise any initial conclusions that do not match field-notes
- Check primary conclusions through “confirmation, checking, and verification tactics”
- Clarify individual case and within-case level understanding before cross-case inferences
- Tie the inferences with theory; “go beyond descriptive summation toward explanation”. (Miles, Huberman, & Saldana, 2013, p. 117)

Data Collection Results

Permission to conduct this study was granted by the Superintendent of Schools after a review of the proposal and questionnaire. In return, the researcher agreed to provide the district with an executive summary of results and recommendations to the Superintendent and the Curriculum Director to inform the district's professional development program. Each teacher was then invited to participate in the study by the researcher via email.

Survey Questionnaire Demographics

At the closing of the survey, 91 participants (50%) had returned either fully completed surveys or partially completed surveys. Of those returned, the researcher reviewed patterns in the partially completed surveys, and found that 72 (40%) were viable responses (having completed the majority or all of the questions).

Instructional Level. The composition of the number of participants (*N* = 72*)* was 17 (24%) early elementary teachers (grades preK-2), 16 (22%) intermediate elementary teachers (grades 3-4), 19 (26%) middle school teachers (grades 5-7), and 20 (28%) high school teachers (grades 8-12) (Appendix C).

Innovator Demographics. Due to the pragmatic nature of this study, other demographic data were collected as well (Millen, 2015). The specific data for innovator categories (Appendix A) determined that 16 (22%) of the participants described themselves as innovators. In the next category, 23 participants were in the early adopters category. In addition, 20 (28%) respondents considered themselves to be in the early majority category, 11 participants as late majority and finally, two represented as laggards (3%) (Appendix D).

Quantitative Findings

In the original study (Millen, 2015), participants were asked to evaluate the self-perceived knowledge in the seven dimensions areas content knowledge (CK), technological knowledge (TK), and pedagogical knowledge (PK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and pedagogical content knowledge (PCK). Finally, participants evaluated their overall knowledge relating the combination of all the dimensions: technological pedagogical content knowledge (TPACK) (Appendix E). The overall rank order means on a 5-point (SD – SA) Likert scale, pre-kindergarten to grade 12 teachers self-perceived TPACK ranged from 3.46 to 4.00 (for more details see original study, Millen, 2015).

In the second part of the questionnaire, participants (*N* = 72) were asked to evaluate their self-efficacy levels in two dimensions beginning with self-efficacy to differentiate instruction (DI) and then self-efficacy to differentiate instruction with technology (DI-T). The overall mean for this dimension was 4.01 for DI and (Appendix F) and 3.16 for DI-T (Appendix G). Seven out of nine individual items between the categories of *confident* and *very confident* with item means ranging from 4.00 to 4.17 (for more details see original study, Millen, 2015).

In addition, all of stated demographics in the research questions were evaluated. Appendix H and I display the results for the statistically significant and non-significant findings. When results were statistically significant, Scheffé tests were examined. Significant findings were found for certain demographic groups with respect to TPACK and self-efficacy to differentiate with technology (DI-T) (Appendix H). To start, Grade 8-12 teachers (*M* = 4.42*)* have a significantly higher mean compared to grade 3-4 teachers (*M* = 3.74) and preK-2 teachers (*M* = 3.74*)* with respect to their technological pedagogical content knowledge (TPACK). A large effect size ($\eta^2 = .21$) was determined. In addition, Grade 8-12 teachers have a significantly higher mean (*M* = 3.73*)* to grade 3-4 (*M* = 2.53*)* and preK-2 (*M* = 2.78*)* teachers in their self-efficacy to differentiate instruction with technology (DI-T). A large effect size was determined ($\eta^2 = .23$). Lastly, there was a significant difference in Grade 3-4 teachers' self-efficacy to differentiate with technology (DI-T) (*M* = 2.53) and Grade 5-7 teachers' self-efficacy (*M* = 3.44*).* A large effect size ($\eta^2 = .23$) was determined.

There were also significant results for the demographic of Roger's Adopter Category with Respect to Technological Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Self-efficacy to Differentiate with Technology (DI-T) (Appendix I). First, a significant difference exists among technology knowledge (TK) of those that described themselves as early adopters (*M* = 3.49*)*, early majority (*M* = 3.47*)*, late majority (*M* = 2.24*)*, and those that describe themselves as innovators (*M* = 4.50*)*. A large effect size was determined ($\eta^2 = .59$). Secondly, a significant difference exists between technology knowledge (TK) of late majority (*M* = 2.24*)* as compared to early adopters (*M = 3.49)*, early majority (*M* = 3.47), and innovators (*M* = 4.50*)*. A large effect ($\eta^2 = .59$) size was determined.

A significant difference appears also in the technology content knowledge (TCK) of innovators (*M* = 4.40*)* and early adopters (*M* = 4.20*)* as compared to those that self-categorize themselves as late majority (*M* = 3.36) (Appendix I). A large effect size ($\eta^2 = .28$) was determined. Fourth, a significant difference is displayed among all four innovator categories and technological pedagogical knowledge (TPK). Specifically, those in the late majority self-reported technological pedagogical knowledge (TPK) *(M*= 2.65*)* statistically different from the other three categories: early majority *(M* = 3.30), early adopters *(M* = 3.47*),* and innovator *(M* = 4.11*).* A large effect size ($\eta^2 = .38$) was determined.

Lastly, a significant difference between late majority and other categories is displayed with respect to participants' self-efficacy to use technology to differentiate instruction (DI-T) (Appendix I). The late majority category (*M* = 2.21*)* has a significant difference between early adopters (*M* = 3.31*);* and innovators (*M* = 3.98*)* have a significant difference among early majority (*M* = 3.05*)* and late majority *(M* = 2.21*).* A large effect size ($\eta^2 = .32$) was determined.

Qualitative Findings

Limited examples existed in the qualitative data *(N* = 47) of effective models of both TPACK and DI practices, and this analysis both confirmed the literature on the constructs. Quantitative data collected from the survey demonstrated that there were significant differences in participants that fall into specific innovator categories and the several of the dimensions in this study; the qualitative data confirmed this finding. Also according the quantitative data, there is also a significant difference with respect to technological pedagogical content knowledge (TPACK) and a teacher's efficacy to differentiate with technology between upper level educators and lower level educators, and this again was confirmed by the qualitative data.

Review of the themes that emerged (Millen, 2015):

- The qualitative responses indicated differentiation occurred most often in content areas-the "what to teach" (Tomlinson, 2014).
- Qualitative findings support the premise that those demonstrating stronger pedagogical content knowledge also feel more confident in their ability to differentiate instruction.
- The theme of differentiating the process was somewhat evident. Again, supporting the quantitative findings that educators with stronger pedagogical content knowledge also feel more confident in their ability to differentiate, and most of the respondents that communicated specific areas of differentiating the process were teaching at the high school level.
- Five out of the 47 responses (11%) to the first open-ended response, "Describe a specific episode where you effectively demonstrated or modeled differentiated instruction (DI)..." noted that there had not been an opportunity to teach a lesson in this manner.
- Most of the respondents that communicated specific areas of differentiating the process were teaching at the high school level, these respondents also communicated the highest level of technological pedagogical content knowledge (TPACK).
- When describing TPACK to support differentiation, respondents typically described websites or programs not pedagogical practices.
- From the descriptions of differentiated practices, many would be classified as not being effective models of differentiation in one or more of the following areas: content, process, product, and environment.

The initial inferences were then checked against field notes and initial data, and the results began the confirmation process of the quantitative findings. In particular, the findings clearly confirmed the quantitative data that participants had strong content knowledge and in turn, content was the most popular way to differentiate instruction. In addition, upper level (Grade 8-12) educators were more confident in their pedagogical content knowledge than lower grade educators as evidenced by the clarity of their responses. Thirdly, strong technological pedagogical content knowledge (TPACK) was evident in responses that also demonstrated strong teacher self-efficacy to differentiate with technology.

However, during the final qualitative analysis step which asks the researcher to “tie the inferences with theory; go beyond descriptive summation toward explanation” (Miles, Huberman, & Saldana, 2013, p. 117), the qualitative data supported the literature and confirmed the problem that these innovative practices were not being thoroughly diffused throughout this social system.

Pragmatic Analysis and Discussion

Pragmatic Discussion of Research Questions

Knowledge levels and modeling percentage were important findings due to the pragmatic nature of the study and are both consistent and inconsistent with the literature in the following ways:

1. The quantitative data results in this study suggested that the majority of the participants considered themselves *innovators* (22%) or categorize themselves as *early adopters* (32%). This right-skewed data in the study contradicted the literature’s theoretical left-skewed data (Appendix J) (Rogers, 2003).

2. The data in this study suggests that the participants have sufficient knowledge to begin the process of integrating technology as a “pedagogical tool” (Hu & Fyfe, 2010, p. 184).

3. Consistent with the literature, the social system investigated in the study appears to have collected sufficient knowledge for the first stage. Unfortunately, the low percentage of modeling by leadership groups appears to stymie the diffusion of these innovational practices in these next phases.

4. In the study, the data in the study are inconsistent with this literature because 22% of the sample identified themselves as *innovators*. When connecting this inconsistency with analysis of the first stage of the diffusion process, knowledge, and the second diffusion stage, persuasion, this large percentage of persons may identify why there is a discrepancy between knowledge and actual application of this knowledge within the classrooms.

5. Further discussion on the findings focuses on the *early adopter*s. This group typically consists of 13.5% of the membership group according to literature (Rogers, 2003). However, the quantitative data in this study are again inconsistent with the literature. In the study, this group was more than double the theoretical membership percent and consisted of 32% of the social system.

6. Other studies also found that the communication of members in an organization increases or decreases the chances of an innovation being accepted by the remaining members (Rogers, 2003). Ely (1999) included eight conditions that must exist in an organization for members to consider implementation of an innovation:

a) members must be dissatisfied with the status quo; b) members must have sufficient knowledge and skills; c)

> members must have access to available resources; d) members must have time available; e) reward or incentives are perceived; f) participation is encouraged by other members; g) there is a general sense of commitment; and f) leadership is present in the membership. (p. 5-6)

Compared to this research, there is not clarity as to whether or not the teachers are dissatisfied with the current environment and will be a recommendation for further study. It is also unclear whether enough time is available for implementation, or if there are incentives in the system for risk tasking, there is a clear mission and goals reveal the importance of TPACK priorities. Those interpreting the generalizability of these results should take these internal factors into account when determining next steps. However, it is clear that in most of the overall dimensions, the self-perceived knowledge is sufficient for change even though diffusion has not occurred. This confirms the literature that innovational practices that enhance achievement and engagement of 21st century students are not happening, and according to the literature, unless something significant occurs in the persuasion and decision stage, the practices that students themselves are requesting most likely will not happen.

7. The early majority grouping and the following group late majority are represented by 68% of the sample population, and again demonstrated TPACK. Together, they perceived themselves as modeling effective TPACK practices the most, at just over 50% (M = 2.20). This is consistent with diffusion literature that explains early majority and late majority will closely follow the lead of early adopter members. However, the fact that this group self-perceives their modeling a bit higher than other groups indicates that, while it could be a good sign, caution should also be noted. Results show that earlier adoption groups were not accepting TPACK quickly or in its entirety. The slightly higher modeling of latter groups, if consistent with the literature, may suggest that there is a possibility that this group may not be choosing outright rejection, but the possibility of discontinuance, with later adoption in the next stages-decision and confirmation. As further research is completed on TPACK, data related specifically to this group should continue to track this progress.

8. The lack of wide-spread effective modeling of DI in the classroom by all members may indicate a lack of sustained the effort and or social acceptance needed for wide-spread diffusion of this innovative practice (Bandura, 1997; Rogers, 2003). This was also confirmed by the qualitative data collected for research question #5.

9. The findings described administrative modeling of DI occurs only about 50% of the time (M = 2.08). The literature suggests that it is possible teachers perceive this as a limitation which then affects their confidence in employing wide-spread innovational practices that are “changing fundamental conditions affecting the relationship of student, teacher, and knowledge” (Hargreaves & Fullan, 2009, p. 6) like differentiated instruction and the even more progressive, multiple innovations of DI and technology.

10. Literature on diffusion processes also suggests that this lack of modeling by leadership members, teacher leaders and administrators may indicate to teachers that DI and ultimately DI-T is not advantageous or worth the risk. Consistent with the findings of TPACK, those in the other membership-the early majority and the late majority-also may not readily accept the innovation as profitable (Rogers, 2003). Teachers' self-perceived self-efficacy of DI is confident (*M* = 4.01), but according to quantitative data, the modeling is rated as 50% of the time (*M* = 2.32). These results may indicate, as with TPACK, that this innovation has the potential to be outright rejected or to be discontinued with a latter possibility of adoption.

11. Since literature describes differentiated instruction as the process of adjusting the content, process, product, and environment to meet individual needs (Tomlinson, 2014), this quantitative data combined with the qualitative data from question #5, would arguably suggest that teachers feel comfortable differentiating instruction in areas relating to content-topic, standards, problem-solving, and applicability, but do not feel as confident in differentiating in multiple areas such as content with process, product, and/or environment. This may indicate some acceptance of the innovation by the social system members, rather than outright rejection.

12. Grade 8-12 teachers have a significantly higher mean (*M* = 3.73) to grade 3-4 (*M* = 2.53) and preK-2 (*M* = 2.78) teachers in their self-efficacy to differentiate instruction with technology (DI-T). A large effect size was determined ($\eta^2 = .23$). Again, content specific courses and ability leveled courses may be heightening the educator efficacy to apply content knowledge, as well as differentiate the process, product, and environment (Tomlinson, 2014). However, these findings combined with the higher TPACK knowledge and the significant differences in TPACK and self-efficacy to use technology to differentiate instruction between Grades 8-12 and grades prek-4, should indicate to educational leadership, including administration and teacher leaders, to focus support and capacity building should be directed toward the lower grade demographics, at least initially (Jacobs, 2010; Slepkov, 2008).

13. This study is consistent with the literature due to the low percentage of effective TPACK modeling among the participants, and the qualitative findings that identified a low percentage of exemplar TPACK related practice and a higher-rate of techno-centric practices (Rosen & Beck-Hill, 2012). As a result, the quantitative data and qualitative data supports the literature that there is difficulty for leaders to make connections to exemplars (Hargreaves & Fullan, 2009; Prensky, 2010; West, 2010, 2011) especially if administrators do not possess the knowledge to identify the exemplars themselves.

Recommendations

Based on the analysis, this organizational group demonstrated evidence of currently rejecting the diffusion of DI-T. If the leaders of this system seek to avoid continued rejection and move toward later adoption (Rogers, 2005), the literature suggests that social systems studied need to breakdown the segregation between innovators, those that accept the innovation early on, and laggards, those that accept the innovation last or sometimes not at all (Elmore, 1996). This requires both a process of engagement throughout the system and capacity building. Then leadership and stakeholders must determine the need to change visions, beliefs, and philosophies (Fullan, 2005). Researchers also emphasized that effective change leaders help connect members to exemplars (Ely,1999; Fullan, 2014; Hargreaves 2009; Elmore, 1996; Heath and Heath, 2010). However, research is trying to currently define Di and TPACK exemplars (Fullan, 2014; Marzano & Magaña, 2014; November, 2014, 2015), and posited exemplars may only exist only in isolated pockets (Hargreaves & Fullan, 2009; Prensky, 2010; West, 2010, 2011). Thus this process should be done carefully and purposefully (Fullan, 2014).

In addition, in order to pursue this acceptance and find a solution to the problem of implementation, the fourth stage in diffusion (Rogers, 2005), the literature denotes that second order change-a shift from the status quo and a shift in philosophy, methodology, routines, and structure of organizations (Greaves et al., 2012)-is necessary. Cuban (1988, as cited in Greaves et al., 2012) stated, “Second-order changes, on the other hand, aim at altering the fundamental ways of achieving organizational goals because of major dissatisfaction with the current arrangements” (p. 7). If teacher leaders, administrators, and teachers themselves have the confidence to implement DI and DI-T, then again, the problem may not be knowledge or efficacy, but rather the lack of the perceived need to change the existing structure.

Therefore, based on the findings and the theories involved in pragmatic discussions, a list of recommendations is as follows:

#1: In an effort to increase the use of technology to support more effective differentiated instructional practices in the classrooms, identify the early adopters and provide targeted professional development on related topics of technological pedagogical content knowledge (TPACK) and differentiated instruction (DI).

#2: In an effort to increase the use of technology to support more effective differentiated instructional practices in the classrooms, increase the communication with and connection to exemplars.

#3: In an effort to increase the use of technology to support more effective differentiated instructional practices in classrooms, provide targeted professional development on related topics of technological pedagogical content knowledge (TPACK) and differentiated instruction (DI) to other groups-early majority, late majority and laggards specifically targeting lower grade levels initially.

Additional Recommendations:

#4: Create a strategic growth plan with clear mission and goals relating directly to these two constructs.

#5: Include "early adopter" leadership questions when interviewing for new staff.

Recommendations for Further Study

The original study suggested that leadership categories, administrators and teacher leaders, have a low-percentage of modeling TPACK knowledge (Millen, 2015). However, even though the teacher leaders were evident in this study, empirical studies using administration as the primary participants are lacking. Thus, it is recommended that future research study the self-reported knowledge levels of administration with respect to the constructs studied in this research (DI-T)-technological pedagogical content knowledge (TPACK) and differentiated instruction (DI).

It is also evident that even though the problem with the research on educational change is not the amount of research that exists on diffusion of innovations or the change process, but rather "the primary problem of scale is understanding the conditions under which people working in schools seek new knowledge and actively use it to change the fundamental processes of schooling" (Elmore, 1996, p. 4). Further educational research targeting those responsible for shaping the processes is necessary to understand the conditions that must exist in order to fully combat this problem of scale. Thus, an additional recommendation for further study includes clarification on whether or not teachers are dissatisfied with the current environment. Dissatisfaction is a necessary component to large-scale, second order change (Fullan, 2005). If further research does not find dissatisfaction between member groups, continued rejection will occur and diffusion of DI-T practices will not occur (Fullan, 2014; Rogers, 2005).

Summary

Greenstein (2012) made a call to action:

> At the same time that dramatic technological and social changes are occurring, research continues to illuminate what good teaching looks like...These techniques for effective teaching can and should be coordinated with new technologies so that each supports the other. (p. 128)

Innovative schools are creating strategic professional growth plans that integrate personalized learning goals and objectives intertwined with teachers as facilitators within a substantive technological infrastructure. With technology being rooted within the system and the view that students should be directly at the center of the learning, this research and resulting recommendations expanded on the elements that are necessary to build teacher self-efficacy in the effective navigation of transformational learning and teaching of the 21st century (Enydey, 2014; Fullan, 2014; Littky & Allen, 1999; November, 2014; Tomlinson, 2014; West, 2012).

Weston and Bain (2010) concluded systems that systems should:

> Consider a school where teachers and students have cognitive tools. In that school, we should reasonably expect to

> see educational practices that have been transformed by technology that accelerates (Collins, 2001), differentiates (Tomlinson & McTighe, 2006), deepens (Herrington & Kervin, 2007), and most importantly maximizes the learning experience of all students (Darling-Hammond, 2008; Slavin et al., 2001). We should also expect that teachers reflect the transformation through their highly valued and complete knowledge and skill of specific research-based practices. (p. 11)

Thus, the results of this study along with the research collected, determine the recommendations to contribute to the limited research available on how to overcome the adaptive challenges of this second-order change. The goal was to provide data on the conditions needed to successfully diffuse the multiple innovations of differentiated instruction supported by technology (Collins & Halverson, 2009; Cunningham, 2009; Houle & Cobb, 2011; Littky & Allen, 1999; Prensky, 2010; Trilling & Fadel, 2009; West, 2011, 2012) and to follow Hargreaves (2009) recommendations to affect large-scale change by “changing fundamental conditions affecting the relationship of student, teacher, and knowledge” (p. 6).

Appendix A

Innovator Categories of Organization Members (Rogers, 2003)

Innovators: persons in an organization (social system) that have the willingness to accept a new innovation and to take the risk that the innovation may not be successful. These persons are often not accepted by others in the organization due to their risk-taking attitude and because of their relationship with other innovators outside of the organization.

Early Adopters: persons in an organization (social system) that are leaders in the system and act as information seekers and distributors in regards to a new innovation. More socially accepted in the organization as compared to innovators, early adopter's acceptance or rejection of an innovation is important and is effectually communicated throughout the organization.

Early Majority: similar to early adopters, early majority are well-accepted persons in an organization (social system). However, unlike early adopters, these persons lack the leadership qualities to have a major impact in the diffusion of an innovation.

Late majority: late majority, only accept an innovation after most others in the organization have already done so, and often only accept due to pressure from others or because of economic reasons. The members of this group are not considered leaders; therefore, leaders must ensure that late majority persons are included within a learning community.

Laggards: laggards prefer the status quo and are traditionalists by nature. These persons view innovations in a negative light, and those they perceive as agents of change. Laggards do not carry a leadership role in the organization as a whole; however, groups of laggards often isolate themselves and have a cohesive connection amongst those that are also laggards.

Appendix B

Alpha Reliabilities for DI-TPACK Survey Data

Domain	Number of Items	Alpha Reliability
Technological Knowledge (TK)	*6*	*.90*
Pedagogical Knowledge (PK)	*8*	*.87*
Content Knowledge (CK)	*3*	*.86*
Technological Content Knowledge (TCK)	*3*	*.80*
Pedagogical Content Knowledge (PCK)	*4*	*.80*
Technological Pedagogical Knowledge (TPK)	*7*	*.90*
Technological Pedagogical Content Knowledge	*8*	*.89*
Self-efficacy to Differentiate Instruction (DI)	*9*	*.92*
Self-efficacy to Differentiate Instructions (DI-T)	*7*	*.93*

Appendix C

Frequencies of Instructional Level Categories (N = 72)

Instructional Level	*frequency*	percent
Pre-K-2	17	24
Grade 3-4	16	22
Grade 5-7	19	26
Grade 8-12	20	28

Appendix D

Frequencies and Percents for Innovator Categories (N = 72)

Innovator Category	*frequency*	percent
Innovator	16	22
Early Adopter	23	32
Early Majority	20	28
Late Majority	11	15
Laggard	2	3

Appendix E

Technological Pedagogical Content Knowledge (TPACK) (N = 72)

Item		Rating: Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly agree	*M*	*SD*
Technological Pedagogical Content Knowledge (TPACK)							**4.00**	**.64**
Develop at least one of the 21st century skills (17g)	*f* %	- -	3 4	5 7	32 45	31 44	**4.28**	.78
Promote critical thinking (17a)	*f* %	- -	2 3	7 10	38 54	24 34	**4.18**	.72
Foster a learning partnership between my students and myself (17h)	*f* %	- -	3 4	8 11	35 49	25 35	**4.15**	.77
Provide opportunities for authentic conversations (17c)	*f* %	- -	3 4	12 17	37 51	20 28	**4.02**	.79
Include new lines of inquiry (17b)	*f* %	- -	4 6	16 22	28 39	25 33	**4.00**	.89
Include opportunities to find solution(s) to real-world problems (17e)	*f* %	1 1	4 6	14 19	34 46	19 26	**3.92**	.90
Provide opportunities for students to express knowledge of concepts, procedures, relationships, and to receive feedback from multiple sources (17d)	*f* %	- -	7 10	15 21	32 44	18 25	**3.85**	.91
Include exemplars and connections to experts in the area of study (17f)	*f* %	1 1	8 11	22 31	27 38	13 18	**3.61**	.96

Note. Item responses were: 1 = *Strongly Disagree,* 2 = *Disagree,* 3 = *Neither Disagree or Agree,* 4 = *Agree*, 5 = *Strongly Agree*

Appendix F

Self-efficacy to Differentiate Instruction (DI) (N = 72)

Item		Rating						
		Not Confident	Somewhat Confident	Undecided	Confident	Very Confident	*M*	*SD*
Self-efficacy to Differentiate Instruction (DI)							**4.01**	**.65**
Pre-assess students to determine their levels of understanding (18a)	*f* %	- -	5 7	1 1	43 60	23 31	**4.17**	.77
Assess student interests (18b)	*f* %	- -	4 6	3 4	47 65	18 25	**4.09**	.72
Demonstrate escalating expectations (18g)	*f* %	- -	5 7	9 13	36 51	20 29	**4.01**	.84
Develop a student centered classroom (18d)	*f* %	- -	3 4	13 18	37 51	19 26	**4.00**	.79
Grade students as a reflection of individual growth and progress (18h)	*f* %	- -	5 7	10 14	38 53	19 26	**4.00**	.83
Utilize active learning (18f)	*f* %	1 1	5 7	11 15	31 43	24 33	**4.00**	.95
Identify student learning profiles (18c)	*f* %	1 1	4 6	7 10	41 58	18 25	**4.00**	.85
Use broad-based concepts, not focused on minute details or unlimited facts, but adjusting the degree of complexity to suit diverse learners (18i)	*f* %	- -	5 7	11 15	40 56	16 22	**3.93**	.81
Ensure respectful assignments for all learners (18e)	*f* %	1 1	5 7	10 14	39 54	17 24	**3.92**	.88

Note. Item responses were: 1 = *Not Confident,* 2 = *Somewhat Confident,* 3 = *Undecided,* 4 = *Confident*, 5 = *Very Confident.*

Appendix G

Self-efficacy to Differentiate Instruction with Technology (DI-T) (N = 72)

Item		Rating						
		Not Confident	Somewhat Confident	Undecided	Confident	Very Confident	*M*	*SD*
Self-efficacy to Differentiate Instruction with Technology (DI-T)							**3.16**	**1.02**
Offer a variety of assessments that balance structure and choice (19d)	*f* %	6 8	11 15	12 17	36 50	7 10	**3.38**	1.12
Differ student assignments and culminating projects based on individual or group readiness, learner needs, and interests (19c)	*f* %	5 7	11 16	13 19	33 48	7 10	**3.38**	1.10
Vary tasks according to depth of knowledge (19b)	*f* %	7 10	11 16	14 20	28 39	11 16	**3.35**	1.21
Support and provide higher level tasks for all learners (19a)	*f* %	7 10	12 17	18 25	27 38	8 11	**3.24**	1.15
Assign and assess digitally based formative assessments (19e)	*f* %	14 19	13 18	22 31	15 21	8 11	**2.86**	1.27
Assign and assess digitally based summative assessments (19f)	*f* %	14 19	14 19	19 26	20 28	5 7	**2.83**	1.23

Note. Item responses were: 1 = *Not Confident,* 2 = *Somewhat Confident,* 3 = *Undecided,* 4 = *Confident*, 5 = *Very Confident*

Appendix H

ANOVA Significant Results for Instructional Level with Respect to Technological Pedagogical Content Knowledge (TPACK) and Self-efficacy to Differentiate with Technology (DI-T)

Dimension	Instructional Level: pre-K -2 early elementary *(n = 17)*		grades 3-4 *intermediate* *(n = 16)*		grades 5-7 *(n = 19)*		grades 8-12 *(n = 20)*					Summary of Significant Differences
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	η^2	
Technological Knowledge (TK)	3.42	.83	3.26	1.12	3.52	.88	3.61	1.01	.42	.737	.02	NSD
Pedagogical Knowledge (PK)	4.35	.51	4.24	.44	4.39	.45	4.64	.37	2.70	.050	.11	NSD
Content Knowledge (CK)	4.43	.40	4.56	.43	4.56	.42	4.57	.89	.22	.884	.01	NSD
Technological Content Knowledge (TCK)	3.88	.64	3.81	.23	4.02	.39	4.23	.74	1.32	.276	.05	NSD
Technological Pedagogical Knowledge (TPK)	3.09	.71	3.06	.84	3.64	.57	3.71	.82	3.87	.013	.15	NSD
Pedagogical Content Knowledge (PCK)	3.94	.58	3.86	.81	3.89	.64	4.32	.56	2.05	.116	.08	NSD
Technological Pedagogical Content Knowledge (TPACK)	**3.71**	.37	**3.74**	.72	4.03	.55	**4.42**	.62	6.08	**.001**	**.21**	**PreK-2, 3-4 < 8-12**
Self-efficacy to Differentiate Instruction (DI)	3.94	.63	3.85	.67	4.05	.52	4.01	.65	.75	.528	.03	NSD
Self-efficacy to Differentiate Instruction with Technology (DI-T)	**2.77**	1.03	**2.53**	.99	**3.44**	.68	**3.73**	.93	6.72	**.001**	**.23**	**PreK-2, 3-4 < 8-12; 3-4 < 5-7**

Note. NSD = No Significant Difference. Post-hoc Scheffé mean difference is significant at the *p* = 0.05 level. Using the Bonferroni adjustment for dimension level required significance at the p < .006 level. Note. Effect size guidelines indicate .01 = small; .06 = medium; .14 = large. The response format for TPACK was as follows: 1 = *Strongly Disagree, 2 = Disagree, 3 = Neither Disagree or Agree, 4 = Agree, 5 = Strongly Agree.* The response format for DI and DI-T was as follows: *1 = Not confident, 2 = Somewhat Confident, 3 = Undecided, 4 = Confident, 5 = Very Confident.*

Appendix I

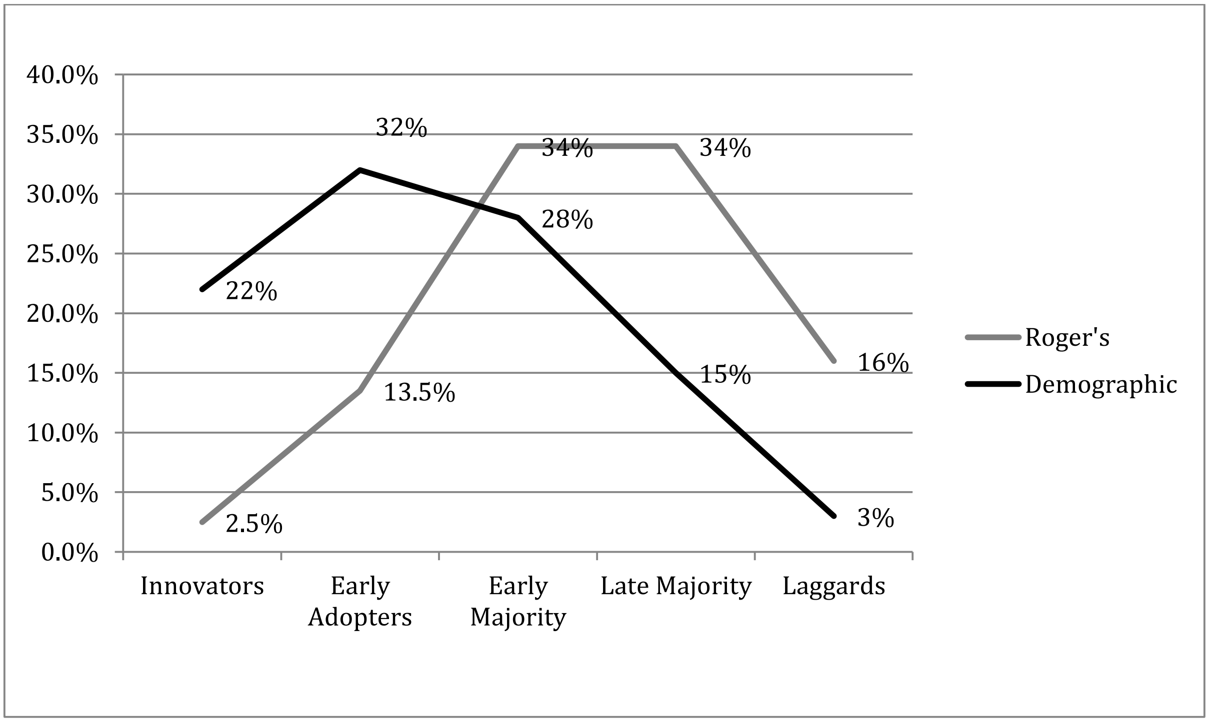
ANOVA Results for Roger's Adopter Category with Respect to Technological Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Self-efficacy to Differentiate with Technology (DI-T)

Dimension	Adopter Category											Summary of Significant Differences
	Innovator (I) *(n = 16)*		Early Adopter (EA) *(n = 23)*		Early Majority (EM) *(n = 20)*		Late Majority (LM) *(n = 11)*					
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	η^2	
Technological Knowledge (TK)	**4.50**	.51	**3.49**	.61	**3.47**	.70	**2.24**	.42	31.38	**.001**	**.59**	**LM, EM, EA < I; LM < EM, EA, I**
Pedagogical Knowledge (PK)	4.53	.48	4.43	.45	4.39	.50	4.28	.35	.67	.575	.03	NSD
Content Knowledge (CK)	4.42	.97	4.67	.40	4.47	.45	4.55	.34	.70	.558	.03	NSD
Technological Content Knowledge (TCK)	**4.40**	.49	**4.20**	.49	3.95	64	**3.36**	.62	8.36	**.001**	**.28**	**LM < EA, I**
Technological Pedagogical Knowledge (TPK)	**4.11**	.53	**3.47**	.58	**3.30**	.73	**2.65**	.47	13.38	**.001**	**.38**	**LM < EM, EA, I**
Pedagogical Content Knowledge (PCK)	3.91	.72	4.00	.75	4.13	.59	3.95	.52	.67	.787	.02	NSD
Technological Pedagogical Content Knowledge (TPACK)	4.26	.66	3.97	.58	4.10	.46	3.57	.66	3.28	.026	.13	NSD
Self-efficacy to Differentiate Instruction (DI)	4.09	.50	4.03	.49	3.89	.85	4.15	.48	.55	.649	.02	NSD
Self-efficacy to Differentiate Instruction with Technology (DI-T)	**3.98**	.82	**3.31**	.77	**3.05**	.88	**2.21**	.85	10.39	**.001**	**.32**	**LM < EA; LM, EM < I**

Note. NSD = No Significant Difference. Post-hoc Scheffé mean difference is significant at the $p = 0.05$ level. Using the Bonferroni adjustment for dimension level required significance at the $p < .006$ level. Note. Effect size guidelines indicate .01 = small; .06 = medium; .14 = large. The response format for the TPACK dimensions were as follows: 1 = *Strongly Disagree, 2 = Disagree, 3 = Neither Disagree or Agree, 4 = Agree, 5 = Strongly Agree.* The response format for DI and DI-T was as follows: *1 = Not confident, 2 = Somewhat Confident, 3 = Undecided, 4 = Confident, 5 = Very Confident.*

Appendix J

Comparison of Roger's Theoretical Adopter Categorization and Participant's Self-Perception Categorization on the Basis of Innovativeness



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