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Comparative Study of School and Science Teacher Technology Leaderships in High and Middle Schools in the United States and China

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Comparative Study of School and Science Teacher Technology Leaderships in High and Middle Schools in the United States and China

by

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Dedication

To my father Tang Zuyin, mother Zhang Zhenglan, sister Tang Yuehua, wife Xiaoling Tang, daughter Tina Tang, and son Jeffrey Tang for your love and support.

I hope you all know that I have aimed high, worked hard, and lived joyfully.

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Table of Contents

List of Tables

List of Figures

Abstract

Researchers found that various schools took different technology leadership approaches and that school leadership practices were empirically associated with outcomes for teacher performance and student learning. To date, few studies systematically examined the salient aspects of school technology leadership (STL) and science teacher technology leadership (STTL), and the effects of country and grade-level on school and science teacher technology leaderships. A comprehensive technology leadership model was lacking for secondary school science education. Therefore, this research study focused on the status of school technology leadership, science teacher technology leadership, and their relationships and differences across country and grade. In this study, the specific school technology leadership practices and artifacts were investigated in eight schools in the U.S. and China and at both high and middle school levels. This study was completed using both quantitative and descriptive data from surveys, interviews, observations and artifact review. Meanwhile, in the study, school technology and science teachers' technology leaderships were examined on the bases of their information and communication technology (ICT)-supported learning environment, ICT competence, ICT-enriched curriculum, and ICT-integrated instruction. Additionally, how school and science teacher technology leadership style differed across county and grade-level contexts was examined in this study. As a result, this study increased understanding of the nature and scope of school and science teacher technology leaderships and their differences across country and grade. This study provided school leaders, science teachers, and policy makers with important implications for the development of ICT-integrated education in the digital age.

Chapter 1: Introduction

Background

Educational researchers and educators have noted the impacts of educational technology or information and communication technology on twenty-first century teaching and learning (Dexter, 2011a; Garrison & Anderson, 2011; Suarez, 2012; Tapscott, 1999, 2010, 2011). For example, they realized that traditional leadership perspectives such as *Great Man* theory (Carlyle, 1840/2008) can hardly be applied to fast-moving and changing educational practice with high technology in the new century; one dominant leader cannot handle technology-integrated education single handedly (Militello & Janson, 2007; Spillane, Halverson, & Diamond, 2001; Uhl-bien, Marion, & McKelvey, 2007). Thus, new perspectives about leadership have emerged that better addressed these new instructional realities. As examples, distributed leadership (Spillane, Halverson, & Diamond, 2004), collective leadership (Leithwood & Mascall, 2008), and school technology leadership (STL) (Anderson & Dexter, 2005; Dexter, 2011b) were among the theoretical frameworks emerging in the educational reform movement in schooling and school systems in the United States.

School technology leadership (STL) was about goals, competencies, and responsibilities of school principals, technology coordinators, and teachers in use of information & communication technology (ICT) in school and instructional improvement (Flanagan & Jacobson, 2003), strategic approaches of integrating technology with school education (Hsu & Sharma, 2006), and impacts of school leader and teacher technology leadership practice on students learning and achievement (Anderson & Dexter, 2005). Critical technology leadership practices in school included sharing a technology vision, providing technology instructional support, integrating technology resources in the curriculum, and ensuring opportunities for teachers to learn, share, and exercise a leader's role (Dexter, 2011a). Educational practitioners (Bybee, 1997, 2000, 2009) recognized that the impact of technology leadership was not only on technology itself, but also on education of science, technology, engineering, and mathematics (STEM). Although the scope and content of school technology leadership is still expanding and developing (Vanderlinde, van Braak, & Dexter, 2012), its importance has already caught the attention of the government at the federal, state, and local levels. When talking about the impact of science, technology, engineering, and mathematics (STEM) education on the competence of the U.S. in the world, President Barack Obama stated:

> Maintaining our leadership in research and technology is crucial to America's success. But if we want to win the future, then we also have to win the race to educate our kids. Leadership tomorrow depends on how we educate our students today-especially in science, technology, engineering and math. (Obama, 2013)

Given another example, in 1989, President George H. W. Bush and the 50 state governors announced a set of national goals for education; ranking first in the world in mathematics and science by the year 2000 was among these ambitious goals (Darling-Hammond, 2014).

In 1983, the Republican administration of President Ronald Reagan issued *A Nation at Risk*, a report that sparked the American people's concern about "a rising tide of mediocrity" of education in the United States. In light of the report, some politicians charged that public schools were failing and decried that America was losing ground in the global economic competition (Spring, 2011). From the 1980s to the present, commissions, studies and reports have been published, which came to be called the standards movement (Finn & Ravitch, 2004).

Since President George H. W. Bush and the governors of the fifty U.S. states (1989) set up ambitious goals to improve the ranking of American students' performance in mathematics and science (Clark, 2014) at the education summit in Charlottesville, VA, some sweeping reforms such as No Child left Behind (NCLB, 2001) and The Common Core (2010) were implemented, affecting education on levels ranging from local to federal government. However, the outcome has not been effectual as hoped: the most recent international assessment conducted by the Program for International Student Assessment (PISA) indicated that the achievement gap between students in the U.S. and students in other countries had increased (Darling-Hammond, 2010, 2014; Weisenthal, 2013) rather than diminished over the years.

The review of the literature in this dissertation indicated that building school technology leadership may need more detailed information in five areas: technology, pedagogy, content, organization, and leadership. Because school administrators, technology leaders, and teachers were all involved in the processes of planning and implementing technology initiatives in schools in the digital age, each group's knowledge and expertise in technology, pedagogy, content, organization and leadership were critical to the effective practice of STL to implement technology-integrated education (Anderson & Dexter, 2005; Angeli & Valanides, 2005; Guerrero, 2005; Keating & Evans, 2001; Margerum-Leys & Mark, 2002; Yurdakul et al., 2012).

The philosophical and epistemological stance used in this dissertation about STL was primarily based on postmodernism (Scheirer, 2013; Cornett, 2013), which comprised the following key points assumed in the study: 1) the contemporary world and education had many uncertainties; 2) educational tasks were complex and problematic; 3) many "voices" were critical, as power was held by multiple stakeholders; and 4) decision making was contextuallybased. Based on this orientation, I understood that integration of technology with education was needed to face a challenging and changing world, technology-integrated education was complex with variety of tasks, school technology leadership may be distributive rather than center-controlled (Vanderlinde, van Braak, & Dexter, 2012), and STL was performed in the text of school; it was situational. This epistemological and philosophical stance guided my research study on the topic.

In my literature review, I found a dearth of research examining science teacher technology leadership (STTL) in the context of the school setting. To further investigate this, I conducted studies in eight schools. In order to identify how STL and STTL differed and related across grade levels and cultures, two high and two middle schools were used in the U.S. while two high and two middle schools were used in China. These schools were samples convenient to me; no random selections were conducted. I used quantitative methods to assess each school's use of education technology, its ICT capacity or e-capacity, and its technology leadership under which science education was conducted. I intended to clarify how science teachers' attitude, perspective, and competence in educational technology affected their technology leadership (STTL) in secondary science education. I wanted to investigate the interactive effects of educational technology (ET), STL, and STTL on school science education. In addition, I hoped to find differences in school technology leadership and science teacher technology leadership between the schools in the U.S, and between the schools in the U.S. and those in China, which was one of the most rapidly-improving nations in science and mathematics education in the world (Johnson, 2013).

My three research questions were 1) What do teachers and administrators perceive as salient aspects of school technology leadership (STL)? 2) What do teachers perceive as salient aspects of science teacher technology leadership (STTL)? and 3) How does STL and STTL differ across country and grade-level contexts?

Based on my research questions, the appropriate methodology for my investigation area was a quantitative approach, primarily focusing on quantitative statistical analysis with descriptive data examination serving as support to the study. Identifying factors that affected school technology leadership (STL), science teacher technology leadership (STTL), and interaction of STL and STTL render quantitative research a necessary method in the research study. In the complex context of K-12 education, the study of technology leadership may need applications of the multivariate statistical procedures (Daniel, 2013; Dinsmore, 2013). For example, factor analysis was used for reducing sizable numbers of variables into a few meaningful clusters. Bivariate correlation was used to study relationships between STL and STTL. ANOVA and MANOVA were applied to examine the main effects of culture and grade conditions and their interaction on STL and STTL.

Although quantitative research methodology was critical to address my research questions, descriptive artifacts were used in this research study. For example, a teacher's integration of information and communication technology into his or her instruction may be influenced by his or her personal practical theories (PPTs) (Cornett, Yeotis, Terwilliger, 2006). Science teachers' knowledge in technology, pedagogy, and science content may affect their efficacy in technology-integrated instruction, technology-enriched curriculum, and technology-supported learning environment. Interviews, observations, and surveys were used to support the quantitative data analysis. Data collected through these methods provided deep understanding of school technology leadership and science teacher technology leadership. In addition, the descriptive data were used to provide the quantitative data with context. Thus, the research questions of the study were better addressed with a combination of quantitative and descriptive means.

In light of the above described ideas, this study highlighted the quantitative and descriptive approach. Many researchers viewed the use of multiple perspectives, theories, and research methods as beneficial to educational research because they may provide results with greater breadth and depth (Creswell, & Plano Clark, 2011; Vanderlinde, van Braak, & Dexter, 2012; Yin, 1989). They maintained that descriptive and quantitative research methods were complementary (Johnson and Christensen, 2012): numerical data may be incorporated in descriptive research, and narrative data may exist in a quantitative study (Roberts, 2010). According to a fundamental principle of quantitative and descriptive research (Brewer & Hunter, 1989; Johnson & Turner, 2003), “it is wise to collect multiple sets of data using different research methods and approaches in such a way that the resulting mixture or combination has complementary strengths and nonoverlapping weaknesses” (Johnson & Christensen, 2012, p.51). In order to address the research questions of this study, a quantitative study of technology leadership was more narrative using the support of descriptive data. The descriptive data relating to the effects of technology leadership on teaching across grades and cultures were based on strong numerical data. Thus, a quantitative approach with a descriptive support was appropriate for the study.

Problem Statement

Educational technology was considered to be one of the most effective tools to improve teaching and learning—and, hence, student academic achievement—in the digital age (Chubb, 2012; West, 2011a). However, this claim has not been strongly supported by research study results (Scott, McMurrer, & McIntosh, 2012). Moreover, there was a dearth of school/teacher technology leadership research (Schrum, Galizio, & Ledesma, 2011) in the U.S. In their survey of current school administrators, Schrum and colleagues (2011) found that most of the administrators believed that their preparation programs were not adequate for them to lead technology utilization and implementation efforts. And none of the fifty state Departments of Education currently required course work in technology leadership for preparation of principals. McLeod and Richardson (2011) found that from 1997 to 2009, only 2.02% of American Educational Research Association presentations had a technology leadership focus. All these examples indicated that STL and STTL have been an underrepresented area in educational research and lacked the attentions of the U.S. educational policy makers (Dexter, 2010a; Schrum et al., 2011).

Purpose of Study

The purpose of the research study was to investigate school technology leadership and science teacher technology leadership and their interactive effect on science education in both high and middle schools of the United States of America and of China. This research study may 1) advise educational practitioners how to use educational technology (ET) and exercise technology leadership (STL and STTL) in order to improve science instructional practice and maximize student learning, 2) help educational researchers clarify educational technology leadership at levels of whole-school and science-departments and the interactive effect of STL and STTL on student learning, and 3) inform policy makers about appropriate investment and policy on ETs. In addition, the study would shed light on students' appropriate use of technology resources for enhancing learning and productivity.

Research Questions

According to the purpose of the research, the research study needed to address the following two research questions:

1) What do teachers and administrators perceive as salient aspects of school technology leadership (STL)?
2) What do teachers perceive as salient aspects of science teacher technology leadership (STTL)?
3) How does STL and STTL differ across country and grade-level contexts?

Significance of the Study

The results of the research study were of particular importance to science teachers and scholars in the field of STEM education in general. The results were also critical for school leaders, technology coordinators, and ICT professional development trainers. The study will provide educational policymakers with implications that may inform strategic investment and effective educational technology policies. In addition, students may benefit from the study using ICT strategically for their science learning or STEM learning in general.

From this research study, my findings would add to the understanding of how e-capacity and school technology leadership were evaluated, how teachers' beliefs and perspectives affected their technology leadership, and how STL and STTL interacted to influence science education.

The improved understanding of the STL and STTL, the relationships of STL and STTL with science teachers' philosophies of education, and the effect of STL and STTL on the outcomes of science education may improve science teachers' technology leadership and the quality of their instruction. Using these findings, science teachers would be able to optimize the structure of their knowledge and skill in the domains of technology, pedagogy, and science content (TPACK) (Koehler & Mishra, 2008; Yurdakul et al., 2012). This study would enable educators and educational researchers to identify leadership practice and instructional support that may lead to higher levels of student learning and achievement in education in the new century.

For technology leaders or technology coordinators in the schools or districts, this research study may allow them to identify the impact of school technology leadership on schooling and school systems. They may better understand how to perform ICT policy planning in a context of instruction improvement and curriculum reform. Their vision and understanding of team-based technology leadership would enable them to plan and implement improvement efforts efficiently and effectively using technology to enhance teaching and learning. Successful improvement in schooling and the entire school system may not only include quality curriculum and instruction, but also include knowledge of constantly changing technology and its appropriate integration with teaching and learning for both teachers and students. For education in a digital age, a technology leader or coordinator should serve not only as a technology master, but also as an instructional expert by providing advice on when and how to incorporate the best educational technology into a lesson as part of the curriculum.

Principals in schools and district administrators may also benefit from this research study. They may understand that the solution to using technology in support of teaching and learning lied not only on monetary investment but also on strategic planning at both school and district levels. Good planning required positive interactions between the district and school classrooms (Anika Ball, 2012). This study may inform the administrators that STL was both distributive and situational. Thus, each principal needed to know as much as possible about the school's technology system and the specific technical needs of the faculty. For example, they may set up acceptable use policies such as "bring your own devices" for digital learning. They may also adopt new learning models such as introduction of student-centered learning, inquiry-based or problem-based learning, just-in-time-learning, and technology-mediated learning to their schooling in response to educational reforms and changes in educational technology. Factors that may better support the use of educational technology may include the matching of the technology with instructional needs, involving teacher leaders in technology projects, coordination of various expertise of the ICT planning team, and professional development of the faculty. For example, administrators' understanding of the relationship between teachers' attitude and technology leadership may help improve a school's technology training programs for enhancing teachers' technology skills and empower teachers in the new century's teaching and learning (Ouyang & Liu, 2011). Thus, with better implementation of educational technology, the chances of improved student academic performance and achievement may be increased.

For policymakers in K-12 education, this research study may help them clarify the role of STL in the improvement of students' academic performance in science or more generally in STEM (Bybee, 1997, 2000, 2009). The results of this comparative research study may help policymakers identify shared goals for ICT policy planning and ICT-related policy domains so that ICT planning and implementation can be more practical and effective in K-12 education (Chubb, 2012). Thus, the policymakers in different levels of the government may design more effective initiatives to support schools in technology planning and implementation (TPS). In addition, this research study may shed light on the question of what makes science and math instruction in China more rapidly-improving in international assessment compared with the U.S. (Johnson, 2013). This may have implications for improving the science and math achievement of U.S. students, especially under the new educational reform movements such as Race to the Top (RTTT) program and the Common Core State Standards in the country.

Delimitation of the Study

My research focused on a comparative study of school technology leadership and science teacher technology leadership in secondary schools in the U.S. and China. A quantitative study was conducted in eight schools in order to address the three research questions. Data was collected from four schools—two high schools and two middle schools—in one district in the southeast of the United States, as well as from one high school in middle south of China and another high school together with two middle schools in southern coast of China.

Using descriptive methods, school administrators that included principals, assistant principals, and technology coordinators were surveyed by using the survey of STL (see Appendix C) for measurement of the school's use of educational technologies, e-capacity, and technology leadership. Science teachers in the school were also surveyed using STL survey to evaluate schools' technology leadership from these teachers' point of view. Additionally, science teachers were surveyed using the survey of STTL (see Appendix D) to examine science teacher technology leadership attributes. Two science teachers in each school were asked to be volunteers for interviews to measure in-depth their technology leadership in science education in the schools. Additionally, observation of the school's ICT infrastructure (e.g., laptop, media cart, i-Pad cart) and review of relevant documents (e.g., school educational technology policies, school newspapers) were conducted as complementary methods for data collection and analysis in the descriptive research part of the research study.

In addition to descriptive research, quantitative research methods were used in the study. The data was analyzed through multivariate statistical analysis procedures such as descriptive statistical analysis, multiple regressions, and factor analysis (Sincar, 2010; Tang, 2014). Comparative analysis was conducted within each school and between schools. For example, comparisons between different schools in the same nation and between schools in different countries were carried out in the study for comparative analysis. Additionally, cross-sectional data may be collected from middle and high schools for longitudinal effect analysis.

Both quantitative and descriptive data from the eight schools were collected, examined and interpreted to investigate the scopes of school technology and science teacher technology leaderships and how country and school level contexts influenced the leaderships. In this study, the quantitative and descriptive data were gathered in parallel from the schools, and converged in the interpretation stage (Cresswell & Plano Clark, 2001; Vanderlinde, van Braak, & Dexter, 2012).

Definition of Terms

AUP: *acceptable use policy*; school/district acceptable use policies for internet, mobile devices, and other digital learning devices in school education. In this study, schools' AUPs were revealed through observation, interview, and document review.

BYOD: *Bring your own devices* to the technology-supported learning environment was one of AUPs. BYOD and other AUPs were studied in this study.

E-capacity: it referred to the schools' ability to create and optimize sustainable school-level and teacher-level conditions to bring about effective ICT change for school education. This framework was created by Vanderlinde and Braak (2010). In light of the framework, I developed survey of STL to measure STL and survey of STTL to measure STTL. Each school's e-capacity was measured in the study by using surveys, interview, observation, and artifacts review.

ET: *Educational technology* was the study and ethical practice of facilitating e-learning, which was the act of learning and improving performance by creating, using and managing appropriate technological processes and resources. The status of the use of ETs was evaluated in the study through surveys, interview, observation, and artifacts review.

IBL: *Inquiry-based learning* began with posing questions, problems or scenarios—rather than simply presenting established facts or portraying a smooth path to knowledge. IBL may be adopted by science teachers when they integrated educational technology in instruction. Thus, this model was observed in science teachers' instruction.

ICT: *information and communication technology*; because most current educational technology was based on ICTs in the digital age, this term was interchangeable with educational technology (ET) in the dissertation.

JITL: *Just-in-time-learning* provided learning when it was actually needed rather than learning on a deferred base. It helped students stay on top of today's fast-paced, changing life experience. Because of the advancing nature of STEM, science teachers may adopt a JITL model for instruction: they made content immediately and readily available so that students can learn from it under their own direction and motivation. Technological advancements such as simulation, virtual reality, and multi-agent systems empowered the teacher to do so. Thus, the use JITL was examined in the study.

NETS: The *National Educational Technology Standards* developed by the International Society for Technology in Education (ISTE, 2002, 2007) included 1) standards for administrators (NETS-A), which underpins survey of STL and the observation protocol for evaluation of schools' STL; 2) ISTE standards for teachers (NETS-T) based on which I developed survey of STTL and the interview protocol for evaluation of science teacher technology leadership; and 3) ISTE standards for students (NETS-S), which helped create an artifact review protocol and other measures in order to relate the evaluated STL and STTL with students' learning gains. The research study used these standards individually for measuring technology leadership in various individual domains: administrators, technology coordinators, and teachers. However, the relationship between the sets of standards was emphasized in the study because successful integration of technology in education relied on interaction of school, teacher, and students in a whole educational system.

PBL**:** *Problem-based learning* was a student-centered pedagogy in which students learned about a subject through the experience of problem solving. Through PBL, students learned not only domain knowledge, but also, more importantly, critical thinking strategies. Whether PBL was used in science teachers' tech leadership practice was checked by the study.

PISA: the *Program for International Student Assessment* (PISA) was an international assessment that measured secondary students' reading, mathematics, and science literacy. This assessment measured students' cross-curricular competencies, such as problem solving. PISA emphasized functional skills that students had acquired as they neared the end of compulsory schooling. Thus, it was regarded as an evaluation of students' academic achievement (Johnson, 2013).

PPT: In this study, *personal practical theory* meant educational practitioners' personal theories and beliefs and their practical knowledge derived from experience (Cornett, 2013; Levin, & He, 2008) with the integration of ICT technology in school education. Whether held implicitly or stated explicitly, a school leader's personal practical theories (PPTs) may affect his or her school technology leadership (STL) practice, which, together with teachers' PPTs, may influence teachers' classroom practices (STTL). Therefore, STL and STTL—as well as their interaction—may influence the opportunities that students had for learning. This sequence was examined in the study.

SCL: *Student-centered learning*, in contrast to traditional teacher-centered or subject-centered learning, provided students with a new teaching environment that replaced lectures with active learning, integrates self-paced learning programs with cooperative group learning, and held the student finally responsible for his or her own advances in education (Nanney, 2004). Educational technology enabled, enriched, and enhanced student-centered learning. The interactive effect of ETs on SCL may be studied in the research of school and science teacher technology leadership practice.

STEM: *science, technology, engineering, and mathematics* were highly related domains. Effective use of ETs and optimal technology leadership practice in science education may work for STEM as a whole system (Bybee, 1997, 2000, 2009). Therefore, the research study was aimed at conceiving of STEM as an integrative system. However, the researcher was cautious not to generalize the results of the study because science, technology, engineering and mathematics had individual characteristics that may limit the application of the study findings in the separate fields.

STL: *school technology leadership*; According to the National Educational Technology Standards for Administrators (ISTE, 2002), school technology leadership should include six aspects: The first aspect is leadership and vision. Educational leaders should foster a shared vision of ICT-integrated education in school and develop a learning environment to realize the vision. The second section is learning and teaching. In order to maximize teaching and learning, educational leaders should focus on curriculum, pedagogy, content, and appropriate educational technologies. The third area is productivity and professional practice. Educational leaders need to use ICTs as a level to increase their professional practice and productivity. The fourth is support, management, and operations. Educational leaders should provide teachers, students, and staff with support to enhance teaching, learning and administration. The fifth is assessment and evaluation. Educational leaders need to develop effective evaluation ways and criteria for assessment of digital teaching and learning. The sixth aspect is social, legal, and ethical issues. Educational leaders understood these issues were related to successful technology integration and application. These aspects of school technology leadership were discussed by Anderson and Dexter (2005) in their research studies (Dexter, 2011b). Based on this set of standards (NETS-A), e-capacity framework (Vanderlinde & van Braak, 2010), and inventories from other research studies (Sincar, 2010), a survey of STL was built to measure STL (see in Appendix C) in this study. Additionally, observations (Appendix E) and artifacts review (Appendix F) were used to examine STL descriptively.

STTL: *Science teacher technology leadership*; According to ISTE standards for teachers (NETS-T), the National Research Council's (2000, 2013) framework for K-12 science education and national science education standards, and American Association for the Advancement of Science benchmarks for science (AAAS, 1993), survey of STTL was created for measurement of science teacher technology leadership. Two science teachers in each of the eight schools were asked to be volunteers for interviews by the researcher using the interview protocol (see Appendix G) for in-depth understanding and description of their STTL in science education.

TML: *technology mediated learning* was a collection of the relationships among technology capabilities, instructional strategy, psychological processes, and contextual factors that were involved in learning (Alavi & Leidner, 2001; Neset, Eileen, & Christopher, 2008). This study examined relationships among STL, STTL, and TML.

TPACK: *Technological pedagogical and content knowledge* was basically defined as a framework that integrated ICT into the teacher's traditional pedagogical content knowledge framework (Yurdakul et al., 2012). TPACK was used as a part of the theoretical framework in this study to explore science teachers' technology leadership. Based on TPACK together with other literature review, this study was to develop a more comprehensive model with more dimensions that included teacher leadership, ICT, pedagogy, content, and their integration.

Organization of the Study

The dissertation was organized into five chapters: introduction; literature review; methodology; data analysis and results; and summary, conclusions, and recommendations

(Roberts, 2010; Godwyll, 2014). Chapter One set the stage for the dissertation and provided an overview of the research study. It encompassed the background to the study, the problem statement, research questions, significance of the study, and the scope of study. Chapter Two provided the literature review, the theoretical framework, and the conceptual framework. The methodology of the research was presented in Chapter Three. This chapter gave a detailed description of the research design including quantitative and descriptive parts, selection of participants, sources of data, data collection and data analysis instruments, and procedure of the study. Chapter Four covered data analysis and results, data preparation, and presentation of the results organized according to the research questions. Finally, Chapter Five encompassed a summary of findings and interpretations of results; limitations and reflections from the study; and implications and recommendation for educators, educational researchers, and educational policymakers. References, appendices, and vita of the researcher were also included.

Chapter 2: Literature Review

Introduction

Facing the impact of information technology and economic globalization, U.S. schools are challenged by changes in 21st-century teaching and learning. Traditional leadership approaches such as *Great Man* leadership were antiquated in dealing with these challenges (Anderson & Dexter, 2005; Lambert, 2002; Tapscott, 1999, 2010, 2011). Educators needed to think beyond traditional models of leadership and utilize new perspectives to adapt to the impact of informational and communication technology on education. They needed to integrate technology and digital resources into teaching and learning to address the needs of a new generation of learners and prepare them to succeed in a world rich in information technology. Anderson and Dexter (2005) defined the leadership of integrating technology into instruction in support of student-centered learning as school technology leadership (STL). Leadership was vital to innovation in schools (Spillane, Halverson, & Diamond, 2001, 2004). STL's theoretical foundations, systems of practices, and integration of technology in instruction had raised the interests of educators and educational researchers (Dexter, 2011a, 2011b; Burnard, 2011; Flanagan & Jacobson, 2003; Marshall, 2010; Overbay, Mollette, & Vasu, 2011; Owen & Demb, 2004; Rutkowski, Rutkowski, & Spark, 2011; Sincar, 2010, Sugar & Holloman, 2009; Tapscott, 1999, 2010). Some researchers and theorists had emphasized the importance of technology and technology leadership to organizations to enable them to respond to different missions and external challenges (Burk, 2010; Burk & Litwin, 1992; Davidson, 2002; Mintzberg, 1979). Determining requirements during information systems delivery was a complex organizational endeavor in which political, sense-making, and communicative processes were involved

(Davidson, 2002). Specifically, researchers contended that reframing organizations and organizational changes was central to educational leadership (Barber, 2011, Bolman & Deal, 1991, 2008; Grace, Korach, Riordan, & Storm, 2006; Levi, 2007; Vanderlinde, van Braak, & Dexter, 2012; West, 2010b). Thus, when observing a school's technology leadership, I needed to examine how school's ICT infrastructure, their use of ICT, and their technology leadership practices were organized in the context of school education.

The purpose of this chapter was to review the literature regarding school technology leadership (STL), science teacher technology leadership (STTL), and their interactions within science education. Specifically, the literature review centered on science teachers' technology leadership: relationships between their knowledge in educational technology, instructional pedagogy, science content, and technology leadership. The literature review focused on technology-integrated teaching, technology-enriched curricula, and technology-supported learning environments. The review was also to present research studies that were relevant to comparative research between the U.S. school education and international counterparts around the world in the field of educational technology and school technology leadership. Specifically, my guiding research questions focused on: 1) What do teachers and administrators perceive as salient aspects of school technology leadership (STL)? 2) What do teachers perceive as salient aspects of science teachers' technology leadership (STTL)? and 3) How do STL and STTL differ across country and grade-level contexts?

Theoretical Framework

Framework part I: e-capacity model. The e-capacity model was presented by Vanderlinde and van Braak (2010) in order to develop a conceptual model and scale construction from a perspective of school improvement. As defined by Vanderlinde and van Braak (2010), “E-capacity refers to the schools’ ability to create and optimize sustainable school level and teacher level conditions that can bring about effective ICT change” (p. 543). They put “ICT curriculum implementation” and “ICT as a lever for instructional change” at the center of the model that checked four conditions in a school: 1) teachers’ actual use of ICT, which included three levels—basic ICT skills, information tools, and learning tools; 2) ICT-related teacher conditions, which addressed teachers’ ICT competences and professional development; 3) ICT-related school conditions, which contained ICT coordination, support, vision, policy planning, and ICT infrastructure; and 4) school improvement conditions, which encompassed professional relationships, participation in decision making, and leadership. Additionally, there were four pillars for the e-capacity model: 1) international ICT policies; 2) national ICT policies and curriculum standards; 3) social systems and cultural norms; and 4) economic system and economic forces. In light of the literature review in this study, I decided to use the e-capacity model as a part of the theoretical framework for my dissertation research study.

However, Vanderlinder & van Braak’s model (2010) was created and applied in primary or elementary schools’ technology leadership studies (Vanderlinde, van Braak, & Dexter, 2012). Several questions remained unaddressed: First, could the model be well used in contemporary secondary schools? In other words, was school grade level a factor that influenced school technology leadership? Second, could the model be well used in schools of various countries? In other words, was country or culture a factor that influenced school technology leadership? Third, can the e-capacity model examine teachers’ technology leadership in depth? The e-capacity model described by Vanderlinder & van Braak (2010) only contained “ICT-related teachers' conditions" as a log in the framework rather than examining their leadership in depth. It can be argued that at the secondary school level, especially in high schools, higher cognitive level and more sophisticated educational technologies were needed than were needed in primary schools; thus, these teachers' technology leadership needed to be explored. Therefore, in this study, I developed a scale or instrument to measure school technology leadership in the context of secondary schools across two countries—the U.S. versus China—and two grades—high verses middle schools. Moreover, I developed a scale or measure to evaluate science teacher technology leadership in the same context.

Framework part II: TPACK model. Vanderlinde & van Braak's e-capacity model indicated that teachers' ICT competences were critical for good teaching conditions, but the model didn't describe the scope of teachers' competences. For example, the model did not clarify whether the competence was limited to teachers' skills in ICTs or included additional skills such as integrating ICT, pedagogy, and content. Thus, another more inclusive framework was needed. Literature review revealed that technological pedagogical and content knowledge (TPACK) model (Angeli & Valanides, 2009; Keating & Evans, 2001) can assist in defining and clarifying teachers' competences in detail. According to Yurdakul et al.'s description (2012), the TPACK model was a framework of teachers' knowledge for integration of educational technology into the teachers' traditional knowledge framework of pedagogy and content knowledge. The framework consisted of three individual components: technology knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). The model contained three double overlapped areas: TPK, TCK, and PCK. Additionally, the central part of the model was a triple overlapped area-TPACK (Koehler & Mishra, 2009). Thus, the TPACK model can be used as the other part of a theoretical framework in this study to explore teachers' competence as a key part of science teacher technology leadership. However, the TPACK framework did not encompass STTL fully. In the literature review, I identified other factors that may be salient to STTL. These factors included science teachers' ICT competence, ICT learning environment, ICT-enriched curriculum, and ICT-integrated instruction. Therefore, the TPACK model only helped clarify one component of STTL. Substantially more work needed to be done in this study in order to clarify other salient factors, relationships between these factors, and their integration into a measure for evaluation of science teacher technology leadership.

Analyses and Syntheses of Relevant Empirical Studies

Centered on the purpose of the study and three research questions for this study, relevant empirical studies were identified and reviewed. The major topics of the relevant studies included 1) impact of educational technology on science education, 2) emerging paradigms in ICT-integrated education, 3) school technology leadership, 4) science teacher technology leadership, 4) effects of ICTs on students' learning, and 5) comparative studies between U.S. schools and other nations' schools.

Impact of educational technology on education. Educational technology was the field of study related to ethical, instructional practice of facilitating e-learning, which was the learning and improving performance through creating, using and managing appropriate technological processes and resources (Richey, 2008).

Educational technology. Educational technology was often associated with two major areas within the educational research field: instructional and learning domains. Thus, educational technology may be extended to include instructional techniques of the educator

(Gerard, Varman, Corliss, and Linn, 2011) and models of student learning (Kablan & Kaya, 2013). In general, educational technology included all systems that were used in the process of developing human capability (Garrison & Anderson, 2003). Because educational technology is developing quickly and widely in the digital world, its definition is elusive (Lowenthal & Wilson, 2010). For the purpose of this study, educational technology included computers, software, hardware, media, and internet applications and activities (Moore, Dickson-Deane, Galyen, 2011).

Information and communication technology. Technology in education can be defined as an array of tools that might prove helpful in advancing student learning and may be measured in how and why individuals behave when they encounter this technology. Some experts predicted that information and communication technology (ICT) would transform schooling (Chubb, 2012). However, other researchers contended that technology itself cannot remake education (West, 2011a). Meaningful changes in education and educational technology required school and teacher technology leadership that encompassed organizational structure, technology adaptation, instructional approach, and educational assessment (West, 2011b).

Educational technology has been changing not only declarative knowledge, schematic knowledge, and procedural knowledge of our kids, but also their attitude and behavior toward their education and their society (Gover, 2014; Eugenia, 2012). Gover and Eugenia called the teenagers in the new generation “digital natives” or “iGeneration”. The teenagers were heavily immersed in a digital learning and entertainment environment. Under the influence of technologies, they became tech savvy, collaborative, concerned about global issues, supportive of differences, and high-achieving. However, educators have also noticed a negative side of the educational technology and associated changes. While educational technology was used by the teenagers to address their interests and needs, some unfortunate side effects were that teenagers' attention spans were shortened, their persistence was decreased, and their communication with parents and grandparents became more and more difficult (Gover, 2014). Understanding these effects was important to educators and policymakers because the effects may change the quality of school education, kids' careers, and our society.

Song and Owens (2011) investigated technology disparities and instructional practices within urban schools. 7322 teachers responded to a survey administered by National Center for Educational Statistics to evaluate the overall status of technology in the U.S. Analysis of the results revealed that socioeconomic status of students in the school affected how well teachers were trained and their ability to integrate technology in the classroom. They concluded that "in order for technology to have its greatest impact on our educational system, teachers and students must not only have access to technology, but access to technology in a contextual matter that is culturally relevant, responsive and meaningful to their educational practice" (p.23). This conclusion was critical and informative. It inspired me to conduct this study to clarify school and science teacher technology leaderships and how they differed cross culture and grades.

Integrating technology, pedagogy, and science content. Researchers found that the lack of teacher knowledge, skills and ability in use of technology in the educational process was the major barrier to integration of technology in education (Beland, 2009; Bingimlas, 2009). Some research studies revealed that teachers' personal practical theories influenced their classroom practice (Cornett, Yeotis, & Terwilliger, 2006; Levin & He, 2008). Specifically, in a case study of a secondary science teacher, Cornett et al. (2006) found that teachers' personal practical theories had a strong influence on their curricular and instructional actions. Although Cornett et al.'s work was not directly about technology, their clarification of relationships between teachers' attitude, curriculum, and instruction informed me that in a digital word, teacher's ICT attitude, ICT-enriched curriculum, and technology-integrated instruction may also be associated. I may need to investigate their relationships. To better address challenges in current classrooms, Keating and Evans (2001) provided a conceptual model of technological pedagogical content knowledge (TPCK). It was also defined as a framework of teacher knowledge (TPACK) in the contemporary world (Koehler & Mishra, 2005, 2009; Yurdakul et al., 2012). This teacher knowledge framework was developed by incorporating information and communication technology (Angeli & Vanlanides, 2005) into the teacher's traditional knowledge framework of pedagogical content knowledge (PCK) (Shuman, 1986). Yurdakul et al. (2012) continued to develop the framework into a scale for measurement of preservice teachers' knowledge base and studied the scale's validity and reliability. They found that the TPACK scale included 33 items and had four factors. The whole scale's Cronbach's alpha coefficient was found to be .95, and the alpha coefficients for individual factors ranged from .85 to .92. Thus, they maintained that the scale was a valid and reliable instrument for measurement of TPACK.

In light of the framework, 21st century science education required an integration of technological knowledge (TK), pedagogical knowledge (PK), and science content knowledge (SCK). In other words, a competent science educator in the digital era must have mastery of a complex interaction and intersection of the three bodies of knowledge: technology integrated with pedagogy (TPK); technology with science content (TSCK); and pedagogy with science content (PSCK). Furthermore, these three interactions created the higher level of interaction and intersection TPASCK (technology, pedagogy, and science content knowledge) at the center of the model. This model was consistent with Bybee's integration of science literacy, technology literacy, and pedagogy (1997, 2000 and 2002).

According to Bybee (2002), digital technology cannot replace the roles of pedagogy and science content. A great science education consists of technology, pedagogy, and the content; it is dangerous for educators and policymakers to replace pedagogy and science content with ICT in science education. For example, student-centered learning is one paradigm favored by practitioners for digital learning. However, in the processes of inquiry-based learning within a computer simulation, if students lack sufficient support from the instructor, the learners will "have difficulties in generating and adapting hypotheses, designing experiments, interpreting data and regulating learning" (de Jong & van Joolingen, 1998). In fact, removing a teacher's guidance and assistance may seriously undermine a student's discovery learning. Wu (2010) revealed that an expert-designed, technology-enhanced learning environment supported students to demonstrate expert-like modeling practices.

Emerging paradigms in ICT-integrated education. In the digital age, learning processes, supporting pedagogies, and technology applications are evolving at a fast pace. This evolution has affected academia and professional practice in many ways (IADIS, 2012). For example, advances in both cognitive psychology and computing technology have directly affected science education. Some educational paradigms have emerged and are being supported by technological advancements. Just-in-time learning (JITL), student-centered learning (SCL), and technology-mediated learning (TML) were among these paradigms (IADIS, 2012).

Technological advancements such as simulations, virtual reality, and multi-agent systems enabled science educators to use JITL, SCL, TML, and other models in science teaching and learning.

Understanding how to use these paradigms in learning processes in the digital age is critical for improvement of science education or STEM education in general. Today's students heavily rely on ICT for entertainment, socialization, and many other aspects of their lives (Gover, 2014). This may have caused the student productivity paradox (Neset, Eileen, & Christopher, 2008); contrary to our expectation that ICT would make work more efficient, students actually worked less efficiently because they enjoyed using the technology so much that they became distracted. Thus, school leaders needed to exercise STL, science teachers needed to practice STTL, and policymakers needed to make informed decisions about school investment in ICT. For educational researchers, we needed to explore these paradigms that included relationships among technology capacities, instructional strategy, psychological processes, and contextual factors that were involved in teaching and learning (Alavi & Leiderner, 2001). Therefore, educational research called for study on STL, STTL, and their interactive effects on student science learning.

School technology leadership. What is school technology leadership? What is the impact of STL on 21^{st} century teaching and learning? These questions have garnered interest from educators, researchers and educational policymakers around the world. Substantial research studies about STL have emerged beginning in the 1990s. Different definitions of STL were found in a variety of research studies. For example, Vanderlinde and van Braak (2010) provided the concept of e-capacity. They defined e-capacity as "the school's ability to create and optimize sustainable school level and teacher level conditions to bring about effective ICT change" (p. 541). On the basis of e-capacity framework, they constructed scales to evaluate school technology leadership.

Standards for evaluation of STL. Technology leadership roles in schools involved many responsibilities such as setting up appropriate facilities in classrooms to facilitate learning and using technology in ways that supported democratic principles and protected the equal access to technology (Flanagan & Jacobson, 2003). All of these facets of educational technology leadership should be evaluated by comprehensive, well-defined standards because in a digital world, international and national ICT policies and curriculum standards were critical pillars for school technology leadership (Anderson & Dexter, 2005, Banoglu, 2011; Sincar, 2010; Vanderlinde & Braak, 2010). The International Society for Technology in Education (ISTE) developed technology leadership standards called the National Educational Technology Standards (NETS). The ISTE Standards are standards for learning, teaching and leading in the digital age and are recognized and adopted worldwide (ISTE, 2007). The family of ISTE standards include standards for students' learning (NETS-S), teachers' teaching (NETS-T), and administrators' leadership (NETS-A). These standards worked together and were intended to improve and transform education through technology.

STL as distributed leadership. Embedded in the context of education, STL was a distributed leadership (Dexter, 2011a, 2011b; Spillane, 2005) because STL consisted of integrative roles of school leader, technology coordinator, and teachers in a technology leadership team. From a distributed leadership perspective (Spillane, 2005), implementing STL initiatives needed to spread leadership over leaders, followers, and situations. Lopez, Ahumada, Sergio, & Madrid (2012) used portable technology to perform research on educational leadership from a distributed leadership perspective, and they found that STL came from interaction of principals, technology experts, and teachers. Given a school setting, school technology leadership practice involved interactions of school leaders, teachers, technology coordinators, students, and educational situations. Thus, school technology leadership practice was socially based and situationally driven (Militello & Janson, 2007). Stakeholders can be motivated in Siegwart & Nicolai's model (2011): under joint motivational conditions, "individuals can see themselves as part of a joint endeavor, each with his or her own roles and responsibilities; generate shared representations of action and tasks; cognitively coordinate cooperation" (Siegwart & Nicolai, 2011, p. 500).

STL as team-based leadership. Put in the context of the organization, STL was a team-based leadership; a team may be necessary for successful STL initiatives (Kotter & Cohen, 2002). Dexter stressed the necessity of team-based leadership in STL initiative implementation:

> Successfully implementing a complex improvement effort warrants a team-based leadership approach, especially for an improvement concerned with using technology to support teaching and learning. A group of people working together on a technological leadership effort makes it more likely that the necessary amount of expertise is available and that the team can keep up to date and address all technology leadership needs. (Dexter, 2011b, p.166)

Thus, maintaining positive group dynamics and promoting teamwork (Gilley, Gilley, & McMillian, 2009) was the key to successfully implementing STL initiatives in K-12 schools. For instance, as the major participants in using technology for the 21st-century teaching, educators should not be an aggregate or a simple collection of people. Rather, they should work as a group. More accurately, they needed to be a team (Banoglu, 2011; Overbay, Mollette, & Vasu, 2011). For example, to implement STL initiatives in science teaching and learning, science teachers may form a team in which they were a specialized group of people who worked interdependently to accomplish a common goal in response to demands or opportunities placed on them (Roth, 1998; Wu, 2010). For example, Wu (2010) formed a team with other science teachers in her school who cooperated on students' learning in a technology-supported learning environment. They found that the technology environment boosted students' inquiry-based learning.

Integrating STL with other approaches of leadership. Up to this point, I summarized leadership relevant to leading teachers as they implement educational technology. However, in the context of school, technology cannot be isolated in school leaders or in teachers. Instead, it relates to other stakeholders, such as students and the environment around the school. Thus, some different but related notions of leadership were also be discussed.

Great man leadership. Understandably, "the earliest conceptions of leadership focused on individual differences" (Judge, Piccolo, & Kosalka, 2009). Thomas Carlyle's "Great man" theory (Carlyle, 1840/2008) represented one perspective of leadership. This theory emphasized leaders' attributes and their contribution to human history. However, most educators and educational researchers (Banoglu, 2011; Overbay, Mollette, & Vasue, 2011; Sugar and Holloman, 2009) recognized that this Great man leadership did not fit educational challenges in a digital age. For example, Overbay et al. noted that in a high school, the principal led an ICT project as "the real driving force" (p.59) without faculty members' leadership. As a result, 50%

of the staff left the school in two consecutive years, the principal was transferred to another school, and the project failed. Thus, researchers have been critical of Great man leadership (Leithwood & Mascall, 2008).

Bureaucratic leadership. Bureaucratic leadership relied on rules and regulations and clearly defined structures or positions within organizations (St. Thomas University, 2014). People in bureaucratic leadership were likely to report only to their immediate supervisor, such as the principal of a school or the president of a company. For people in the bureaucratic structure of an organization, it was hard to step out of the organizational role they played. They were always followers because they were evaluated and promoted based on their ability to conform to the rules in bureaucracies. Commonly, bureaucratic leadership was founded on strict hierarchies and written job descriptions that explained the hierarchy and their relationships. Thus, some researchers associated bureaucratic with Great man leadership (Pearce & Conger, 2003). They believed that neither Great man nor bureaucratic leaderships fit in the digital age.

Transformational leadership. Transformational/transactional leadership was attractive and effective for teachers to develop their leadership in education. This theory not only covered students' immediate self-interest but also uplifted their maturity, ideals, and concerns for the wellbeing of others (Bass, 1985, 1999; Zhu, Avolio, Riggio, & Sosik, 2011). As transformational leaders, teachers needed to use idealized influence to build students' vision and confidence to achieve educational goals. They should provide students with inspirational motivation that encouraged them to overcome resistance and difficulties to grow. They ought to give students intellectual stimulation that empowered them to create new ideas. And they need to offer individualized consideration that motivated and encouraged students to achieve. In other words, STL should relate to effects of technology on students' learning, their growth, and their future.

Complexity leadership theory. Most leadership models in the last century employed closed-systems thinking and bureaucratic control paradigms (Marion, 2002). These models did not fit the new century paradigms (Uhl-Bien, Marion, and McKelvey, 2007). The complexity of science and technology called for a different paradigm for leadership. According to Uhl-Bien et al., this new paradigm may need to frame leadership as a complex interactive dynamic that consisted of rapidly-changing environmental demands with a mechanism of information flow and pattern formation. Adaptive outcomes such as learning, innovation, and adaptability emerged from the dynamic system. The theory of Uhl-Bien et al. may provide a framework for technology leadership research because it informed how to use technology in an educational setting and develop school technology leadership. More importantly, this framework may need to be embraced because educators are facing a world that has such an interactive dynamic as described by the complexity theory. Meanwhile, learning, creativity, and adaptability are exactly what we are seeking out in education. Therefore, relating STL to complexity leadership theory is a worthwhile endeavor.

Science teacher's technology leadership. As a host of institutional factors, STL influenced teachers' technology leadership. For example, a school's ICT infrastructure affected science teachers' integration of technology into their instruction in the school. However, teachers' beliefs or personal practical theories and competence can also influence their technology integration in instruction (Ageel, 2012; Anika Ball, 2012). Thus, although STL and science teacher technology leadership (STTL) were related to each other, they were not equivalent concepts. They may have interactive effects on science education. The synthesis of the literature review indicated that science teachers' technology leadership consisted of technology competence, technology-integrated instruction, technology-enriched curriculum, and technology-supported learning environment.

Fundamental scope of STTL. According to ISTE's National Educational Technology Standards for Teachers (NETS-T), STTL may include the following dimensions: 1) technology operations and concepts; 2) planning and designing learning experiences; 3) teaching, learning, and the curriculum; 4) assessment and evaluation; 5) productivity and professional practice; and 6) social, ethical, legal, and human issues (ISTE, 2002, 2007). According to this list of dimensions, STTL should measure the degree to which science teachers demonstrated the following practices: First, teachers demonstrated technology competence that included knowledge, skills, and understanding of technology operations and concepts. Second, teachers designed effective learning environments supported by technology. Third, teachers implemented curriculum plans with strategies for applying technology to maximize student learning. Fourth, teachers applied technology for effective assessment and evaluation of digital learning. Fifth, teachers used technology to enhance their productivity and facilitate their professional practice. Sixth, teachers understood the issues—ethical and legal—associated with the use of technology (ISTE, 2002, 2007). These leadership practices were recommended by ISTE for teachers in general, but this study focused on their implementation by science teachers.

Technology-integrated science instruction. Current science teaching reforms and standard documents call for teachers to engage students in scientific inquiry (American Association for the Advancement of Science, 1993; National Research Council, 1996, 2000, 2013). Inquiry-oriented instruction has resulted in more robust student science understanding than other instructional approaches (Duschl, Schweingruber, & Shouse, 2007; Haug & Odegaard, 2014). Researchers discovered that new technologies can support classroom inquiry by providing opportunities for students to experiment with dynamic simulation of scientific phenomena (Pallant & Tinker, 2004; Wilensky & Reisman, 2006), engage in scientific modeling (Chang, Quintana, & Krajcik, 2010), and participate in scientific experimentation activities (McDonald & Songer, 2008). When using these technology-enhanced innovations, students experienced scientific inquiry in collecting data and conducting analyses using probe-ware and scientific databases; their learning gains on scientific principles were significantly higher than students using traditional textbook-based materials only (Chang et al., 2010; Geirer et al. 2008; Lee, Linn, Verma, & Liu, 2009; Quintana et al., 2004).

Technology-enriched curriculum. In 2010, the federal government called for educators to transform learning and teaching with digital resources and tools (The U.S. DOE, National Educational Technology Plan, 2010). Additionally, researchers (Bybee, 2000, 2002) advocated that educators used technologies to enrich their curricula. To serve these reforms, Rosemary (2011) encouraged individuals who had worked with technology in the standard curriculum to look at how technology can transform the curriculum. She also advocated that educators who had been using technology for education move toward a more student-focused use of technologies within the existing curriculum. Janson & Janson (2009) advised principals and teachers to integrate digital learning objectives (DLO) in the classroom. They asserted that establishing digital learning objectives impacted educational practice, and installing DLOs was needed for educational leadership.

Subramaniam (2012) developed technology-enriched puzzles in the form of images for teachers to add to the curriculum and link concepts at the primary and secondary school level. The customized technology-enriched puzzles for authentic curriculum development and implementation were intended to ensure the sustainability of meaningful science teaching. The implications of the study revealed that science teaching and learning should not operate on a mere "acceptance" and "conformist" approach but rather with a "constructionist" thinking.

Marino et al. (2014) examined Universal Design for Learning (UDL) in the middle school science classroom. They offered 57 students with learning disabilities (LD) traditional curricular materials for some units of study and materials that were supplemented with video games and alternative printed-based text to align with UDL guidelines during other units. Their findings included 1) video games and supplemental text effectively provided students with multiple means of representation and expression, 2) the UDL-aligned units increased students' engagement, 3) there were no significant differences on posttest scores of the students with and without LD, and 4) students' performance did not show significant differences between UDL-aligned and traditional curricular materials.

Technology-supported learning environment. Roth (1998) used the constructivist learning environment survey (CLES) to measure the extent to which students perceived their learning environments as consistent with a constructivist epistemology (Taylor & Fraser, 1991; Taylor, Fraser, & Fisher, 1997) in two Grade 8 science classrooms. The instrument consisted of four subscales: autonomy, prior knowledge, negotiation, and student-centeredness. The study revealed that students' perceptions of their learning environment were related to their science achievement. He found that the higher students evaluated their learning environment, the more their science achievement. Wu (2010) designed a technology-enhanced learning environment and discussed how students develop their modeling capability in the learning environment. In order to build a technology-supported learning environment, Wu and his colleagues used scientists' modeling practices as students' learning objectives. Taking experts and students' knowledge levels into account, they designed an interactive modeling tool and provided students with dynamic simulations. These experiences helped students visualize complex processes. The learning activities they designed encouraged students to perform model–based reasoning. The results indicated that students' understandings about air pollution were substantially increased after they were engaged in the modeling activities and immersed in the ICT-supported learning environment.

Liu, Wivagg, Geutz, Lee, and Chang (2012) examined how middle school science teachers implemented a multimedia-enriched problem-based learning (PBL) environment. They identified four factors that motivated teachers to consider the adoption of technology-based PBL instruction. First, the PBL program addressed the teacher's curricular needs, implementing the program that received school leaders' and technical support. Second, the method was aligned with teachers' pedagogical beliefs. Third, the PBL program offered a new way of teaching and promoted the development of higher-order thinking skills. Fourth, the PBL program challenged all students in an attractive way and supported their leaning needs. Additionally, the program allowed science teachers to provide individualized instruction for meeting different students' needs.

STL's effect on teacher's ICT-integrated instruction. School leaders' technology leadership influenced teachers' technology leadership. Chang (2012) conducted a survey with

1,000 teachers who were randomly selected from Taiwanese elementary schools. The teachers were asked to evaluate their principals' technology leadership, teachers' technology literacy, and their instructional effectiveness. Chang found that strong technology leadership from principals encouraged teachers to integrate ICT into their instructions and helped improve teachers' technology competence. The results of Chang's study revealed that principals' technology leadership mediated by teachers' technology competence could affect teachers' effectiveness.

Effects of information and communication technology on students' learning. ICTs were found to have substantial effects on students' learning. Both positive and negative effects were identified by educational practitioners.

ICT enhances traditional instruction. Rutten, van Joolingen, and van der Veen (2012) conducted a meta-analysis to review the quasi experimental research of the past decade on the learning effects of computer simulations in science education in order to answer their two research questions: 1) Can computer simulations enhance traditional education?; and 2) How are computer simulations best used for improvement of learning processes and outcomes? The reviewed literature offered strong evidence that computer simulations can enhance traditional instruction, particularly when science inquiry was concerned. Trundle and Bell (2010) studied how pre-service teachers changed their conceptions of moon phase when inquiry-based instruction was offered. They used three different venues to collect data: 1) observation from nature alone, 2) the computer simulation alone, and 3) observation from both the computer simulation and from nature. Analysis of the results indicated that there were no significant differences among the three instructional events. In other words, the three methods of instruction resulted in equally effective outcomes for desired conceptual change. Thus, they concluded that educational technologies promoted learners' conceptual changes as much as other modes of inquiry, with the added benefit of saving instructional time.

Educational technology changes teachers' attitude toward ICT. As described by researchers (Ageel, 2012; Chubb, 2012; Regina, 2013), although ICT was obviously beneficial for education, the adoption of ICT in current schools had been hindered because of teachers' ignorance, misunderstanding, and negative attitude. Regina (2013) conducted an investigation on the impact of ICT on teacher education programs and professional development in Nigeria. Her research revealed that ICT enriched teachers' research and facilitated lesson presentation by providing access to more informational materials for teaching and professional development. Ageel (2012) found that immersing teachers in virtual learning environments (VLE) changed their attitude from negative to positive toward educational technology. Florence and Michele (2014) explained why synchronous virtual classroom, an equivalent of VLE, could positively shape teachers' attitudes about ICT. They contended that instructors used virtual classrooms to promote interactivity, develop community, and reach students at different places. These activities helped the teachers change their personal practical theories. Meral and Thomas (2012) examined exemplary science teachers' expertise and level of computer use in using specific computer applications for science instruction. They discovered that the more frequently science teachers use computer applications and tools, the more their students use technology in their science classrooms.

Digital technology positively affects social cognition of teenagers. Eugenia (2012) examined the social cognitive effects of ICT on teenagers' brains and their socialization processes. She found both pros and cons of digital technology's effects on teenagers, whom

Eugenia called “iGeneration.” For Eugenia, the advantages of digital technology included 1) helping teenagers in education and their ability to create content; 2) potentially bridging the educational gap between social economical populations, which was consistent with Smith’s research (2012) in Gizmos simulated labs; and 3) constructing teenagers’ new digital literacy and relating them to content-based online information and media.

Assessment of the effects of ICTs on student learning. Effects of ET, STL and STTL on students’ science learning, performance, and achievement have been assessed in various ways as reported by researchers. Teachers used a wide variety of educational assessment tools to measure students’ learning outcomes in the digital era. Hussain, Azeem, Nawaz, and Mehmood (2011) maintained that teacher-made tools were used for specific classes while standardized tests were used for larger groups because of their generalizability. They contended that a valid and reliable ICT assessment tool should be unbiased and meet the demands of curriculum.

Assessing students’ science learning when using ICTs. In the digital age, educational technologies have changed the scenario of developing assessment tools (Hussain et al., 2011). Under today’s educational reforms, multiple forces converged to determine science testing. Recent national science education frameworks and standards advocated a significant shift in focus to fewer, more integrated core ideas, deeper understanding of dynamic science systems, and greater use of science inquiry practices (Quellmalz et al., 2013). The National Assessment Educational Progress (NAEP) specified the science practices and their cognitive demands: identifying scientific principles represented declarative knowledge, using the principles illustrated schematic knowledge, and conducting inquiry required procedural-strategic knowledge (The U.S. DOE, 2009; Quellmalz et al., 2013). They summarized the principles for assessment design to ensure that assessments achieve the goals of identifying scientifically appropriate context, aligning tasks with learning objectives, and minimizing extraneous cognitive processing. The research study revealed that static assessments were not as effective as interactive assessments for differentiating between factual knowledge and the ability to apply the knowledge in meaningful contexts or inquiry practices. They advocated using active and interactive assessment tasks for assessment of science inquiry skills. Educational technology may facilitate these active and interactive assessments in science education.

Assessing students' science achievement when using ICTs. Students' science performance on Trends in International Mathematics and Science Study (TIMSS) may be used for assessment of students' science achievement (Johnson, 2013). In a study of correlation between students' learning styles and science achievement, Kablan and Kaya (2013) developed a science test from the released TIMSS items to measure 8^{th} grade students' science achievement. There are three cognitive domains on TIMSS assessment: knowing, applying, and reasoning. These domains create a hierarchy in the division of cognitive behaviors, as there is a range of difficulty for items in each of the cognitive domains. Thus, these domains are similar to Bloom's taxonomy. They found that students with some specific learning styles showed better performance on TIMSS items compared with those with other learning styles and the difference between abstract conceptualization and concrete experience became more influential when the complexity of the test questions was increased. Again, this research study indicated that educational technology may help make a more sophisticated test, analyze its complicated results, and interpret the meaning of the tests promptly (Kablan and Kaya, 2013).

Like TIMSS, SAT, ACT, and SAT subject tests (SATII) have been used to assess student achievement in specific academic areas (Moses, et al. 2011; Wilcox, 2007). Moses et al. (2011) measured students' aptitude by SAT scores, high school GPA, and an assessment of calculus readiness. A binary logistic regression analysis was used for predictability analysis. Wilcox investigated the relationship of technology preparation (Tech Prep) and non-technology preparation (non-Tech Prep) to high school exit examination scores and college readiness scores. She used ANOVA and discriminant function analysis to compare the ACT, FCAT math scores of Tech Prep and non-Tech Prep graduates and found that there was a statistically significant difference between the two groups. This indicated the effects of technology on student learning. Additionally, Wilcox's results informed that technology preparation was meaningful for improvement of students' college readiness.

Using ICT tools to assess students' science learning. Smith (2012) conducted a quantitative research study to explore the effects of using online, computer simulations on students' science performance. Gizmo Exploration Activities and Assessments developed by the simulated lab manufacturer ExploreLearning.com were used as both intervening events and assessments. The results revealed that Gizmos helped 50 fifth grade students from a variety of socio-economic backgrounds and ability levels engage in science. This indicated that ICT-integrated instruction may be influenced by socio-economic and grade conditions. According to Smith's studies, web-based simulations in conjunction with other instructional venues decreased achievement gaps among various populations.

Comparative studies. School and teacher technology leaderships were found to be influenced by social systems and cultural norms (Vanderlinde & van Braak, 2010). Dexter conducted research studies (Dexter, 2010b; Vanderlinde, van Braak, & Dexter, 2012) to compare technology leaderships, ICT policies and other relevant issues between schools in various countries.

Comparative study on school leadership. Flessa (2014) conducted comparative research on school leadership in Chile in contrast to school leadership in North America. She contended that a comparison across countries can help gain insight into how policymakers used investments in school leadership to achieve certain policy goals because different jurisdictions structure the principalship in different ways. She focused on Chile in her investigation. First, she described the particular structure of school leadership in Chile in the form of co-principalship. Second, she analyzed the co-principalship model in light of North American styles to understand and balance leadership and management in schools. She concluded that comparative research focusing on school leadership could assist both policymakers and practitioners to make wise decisions about using scarce resources to promote school improvement. Banoglu (2011) invited a scholar to translate and adapt an assessment of STL written in English by American researchers into Turkish, and the Turkish survey was found to be in line with original survey. Rutkowski, Rutkowski, & Sparks (2011) used data from a survey of ICT in education to investigate the availability of school-level support for 21st-century skill teaching activities among 18 national education systems. They also studied the relationship between the support and the increased use of ICT in teaching practices in the classroom. Among the 18 national education systems, they found that only South Africa, the Russian Federation, and Thailand had school-based support for ICT use in 21st-century teaching activities. These research studies informed me that comparative study of school and teacher technology leadership was needed.

Comparative study of education in specific educational field. Huang and Wang (2013) performed a comparative study of sustainability management education in China and the U.S. They selected top-ranked Chinese and U.S. business schools as the bases for their analysis. They compared the number of sustainability-related courses provided in each school, design and arrangement of the course curricula, content of the courses, and teaching methods in the courses across differing schools. They discovered that the two countries have different curriculum designs of the course. The differences cross culture were considered to rest on various locations of the institutes and different interpretations of sustainability between the two countries.

Comparative research of students' academic achievement. Johnson (2013) reported that some U.S. and Chinese researchers formed a team to identify instructional supports that lead to higher levels of mathematics achievement. Professors at Vanderbilt's Peabody College of Education and Human Development worked in partnership with researchers in Beijing Normal University and Virginia Polytechnic Institute and State University in order to address the question of what made math instruction in China more effective than instruction in the U.S. International comparisons of students in mathematics such as PISA and TIMSS have displayed higher performance by some nations than by U.S. students. However, neither PISA nor TIMSS was designed to identify the specific supports such as teacher professional development, collaboration, and school leadership for instructional improvement that may account for this imbalance in performance. Thus, the research team hoped to find fundamental differences underpinning the achievement gap between the two nations. Their research plan informed me that schools in U.S. and China have different cultures and different levels of educational technology. Thus, schools' educational technology and technology leaderships may differ cross culture and grades. Comparative study between schools at different grade levels and in different countries may help clarify effects of grade and culture and their interaction on STL and STTL.

Conceptual Framework

Based on the literature review, specifically on the original theoretical frameworks of e-capacity (Vanderlinde & Braak, 2010) and TPACK (Keating & Evans, 2001; Yurdakul et al., 2012), a conceptual framework was created for this study. The conceptual framework consisted of two parts: Part 1 was for STL measurement presented in Figure 1; Part 2 was for STTL measurement presented in Figure 2.

Figure 1 represented the model for measurement of STL. It focused on the center with three key items of STL: ICT vision, policy, and professional support. It measured STL using four lenses: use of ICT; ICT-related teacher conditions; ICT-related school conditions; and technology leadership and school improvement. Additionally, Figure 2 represented the model for measurement of STTL. It focused on the center with three key items of STTL: ICTs, pedagogy, and science content. It measured STTL using four lenses: ICT-integrated instruction; ICT-enriched curriculum; science teachers' ICT competence; and ICT-supported learning environment. For both measurement models, four corners represented the influences of environment on STL and STTL: international education policy and trend; national education policy and trend; social and cultural conditions; and grade-level or student developmental conditions. The conceptual framework with two parts depicted the ways the research problems were explored. Thus, it guided me in the investigation.

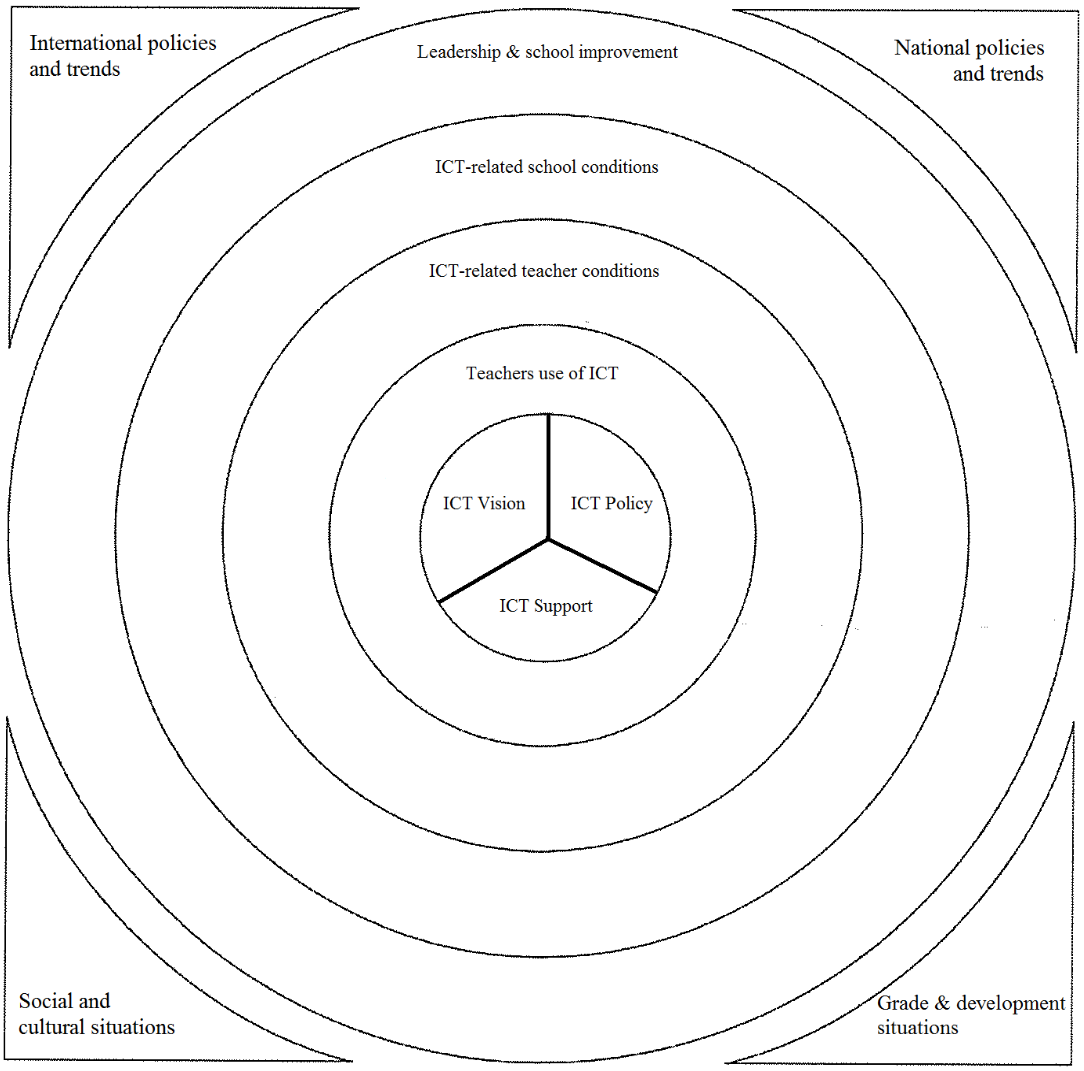

Figure 1. The conceptual framework (I) for school technology leadership

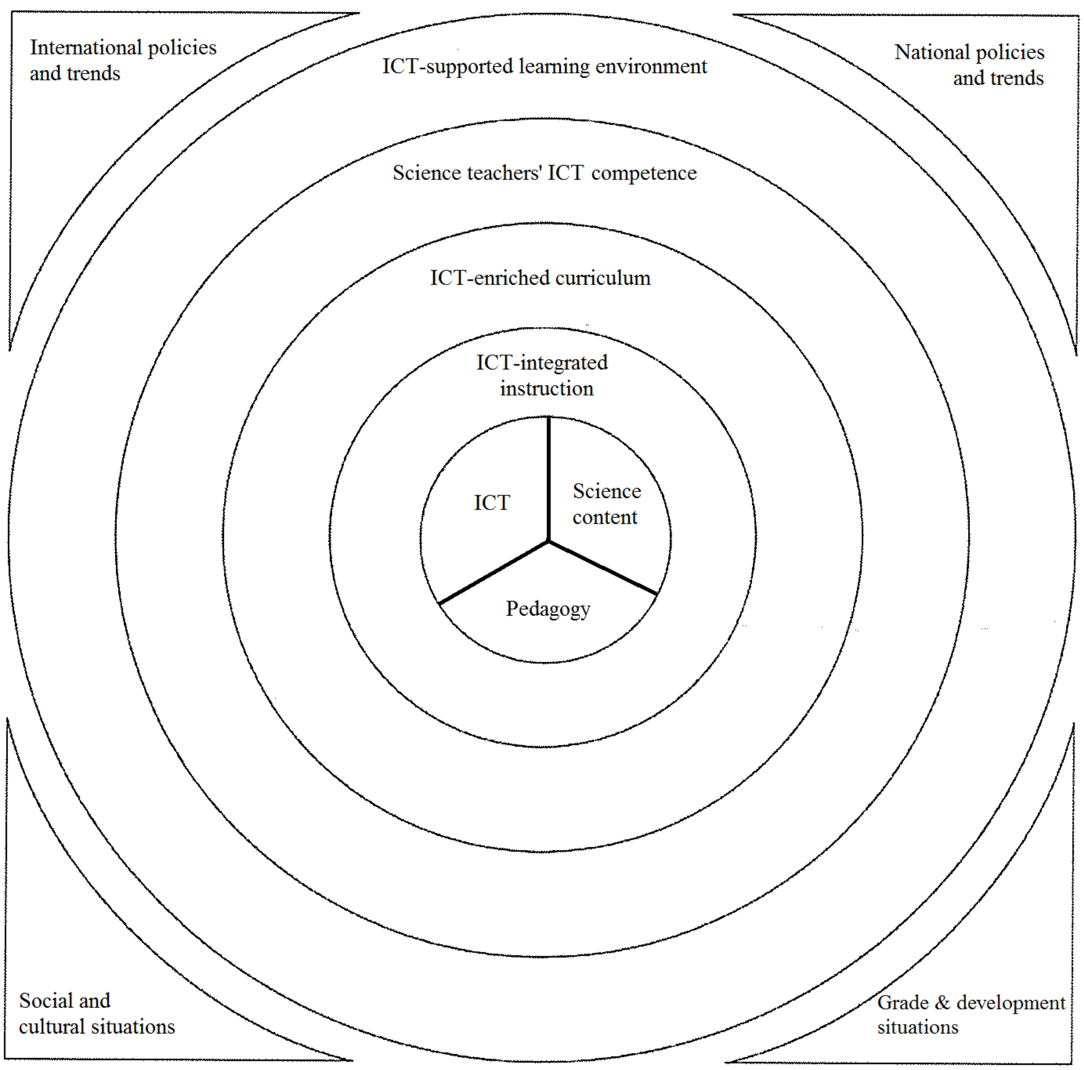

Figure 2. The conceptual framework (II) for science teacher technology leadership

Chapter Summary

This chapter provided an overview of the literature relevant to this study. Particularly, the literature review was pertinent to school technology leadership; science teacher technology leadership; the effects of some independent variables such as culture, grade, and demographic conditions on STL and STTL; and the effects of STL and STTL on students' science learning and achievement.

Vanderlinde and van Braak's e-capacity model provided this study with a primary part of the theoretical framework. It indicated that the status of school technology leadership may include the elements of leadership approach, school improvement, school conditions, and teacher conditions. However, the e-capacity model only provided a broad scale of resolution. A few important elements were not covered by this model. For example, it did not clarify whether the scale can be applied to measurement of secondary school technology leadership. In other words, the factors of grade or students' stage of physical and psychological development were not taken into account. Additionally, although the model generally indicated that STL may be affected by social systems and cultural norms, it did not describe how the sociocultural effect influenced school technology leadership. Thus, when taking e-capacity as the theoretical framework for STL, the present study may need to attend to grade and cultural effects on STL. In addition, the literature reviews indicated that ICT vision (Banoglu, 2011; Sincar, 2010), ICT policy (Vanderlinde, van Braak, & Dexter, 2012) and ICT professional development and support (Kopcha, 2012; Overbay, Mollette, Vasu, 2011) were important factors that may influence STL. Thus, as shown by Figure 1, the conceptual framework part 1 integrated technology leadership approach with school improvement, and school's ICT vision, policy and support was placed at the center of the model for STL measurement.

On the basis of the literature review, I found that the TPACK model may be used as the other part of the theoretical framework for measurement of STTL in this study. The model displayed some advantages: 1) it listed the fundamental elements of a good education in the digital age, 2) it placed educational technology as top one among the elements, and 3) it emphasized the integration of the three in an effective ICT-integrated education. However, it also showed some disadvantages pertinent to this study. First, it did not directly relate to teachers' technology leadership. Second, it is too general to fit specific subjects, such as science education. Third, it stressed only mixing the three elements, rather than quantitative relationships among the three. Therefore, TPACK model cannot be directly or individually used as a theoretical framework for STTL measurement. Fortunately, the above literature review suggested that science teacher technology leadership should have four elements: ICT learning environment, ICT competence, ICT curriculum, and ICT-integrated instruction. Thus, TPACK can be modified for measurement of STTL because STTL must be accomplished in the context of school education. Thus, by incorporating TPACK with the four elements or lenses, a conceptual framework for STTL was created. As displayed by Figure 2, the conceptual framework for STTL had TPACK at the center of the model and four subscales for measurement of STTL. The conceptual model was positioned within four major influences as a context of school education in the digital world.

The first conceptual framework (Figure 1) provided a measurement of school technology leadership in the investigation of the study. Likewise, the second conceptual framework (Figure 2) offered the other measurement of science teacher technology leadership in the research study. In combination, the two parts of the conceptual frameworks directed the investigation.

Chapter 3: Methodology

This chapter encompassed the methodology used in the research study. The themes in this chapter incorporated restatement of the study's purpose and research questions; research study design; sources of data that include sample, population, and sampling; instruments that cover measures and protocols for STL and STTL; procedures for quantitative and descriptive data collection; and the plan of data analyses for the three research questions. In addition, ethical aspects of the research were also discussed.

Restatement of the Study's Purpose, Research Problem, and Research Questions

The purpose of the research study was to investigate school and science teacher technology leadership and their interactive effect on science education in the schools in the U.S. in comparison with the schools in China—crossing culture and school grade levels. The schools included two high schools and two middle schools of a district in southeast of the USA, and two high schools and two middle schools with one high school in middle south and the rest in southern coast of China.

Although the U.S. had invested heavily in educational technology (SETDA, 2011, 2012), some K-12 schools in the country were still short of investments in educational technology and information and communication technology (McLeod and Richardson, 2011). In addition, there was a dearth of research studies in school and science teacher technology leaderships in the United States (Schrum, Galizio, & Ledesma, 2011).

Facing these challenges in the digital age, educational practitioners in science education may need to address the following research questions: 1) What do teachers and administrators perceive as salient aspects of school technology leadership (STL)? 2) What do teachers perceive as salient aspects of science teacher technology leadership (STTL)? and 3) How does STL and STTL differ across country and grade-level contexts?

Research Study Design

This study used a quantitative methods design that combined quantitative and descriptive studies (Brewer & Hunter, 1989). The investigation focused on the quantitative approach, with the descriptive artifacts serving as support of factors. In the eight study schools, quantitative and descriptive data were collected, analyzed and interpreted to investigate school technology and science teacher technology leaderships. The quantitative and descriptive data were gathered in parallel from the field and integrated only in the interpretation stage (Creswell & Plano Clark, 2011; Vanderlinde, van Braak, & Dexter, 2012). Based on the purpose and nature of the study, both quantitative and descriptive research methods were needed. Descriptive artifacts were used for deep, rich, and detailed research of the factors of school and teacher technology leadership and their effects on school education in order to address exploratory, descriptive and explanatory research questions (Yin, 1989; Stake, 1994). The three research questions of the study needed to be addressed by analysis of both quantitative and descriptive data.

Participants, Sites, and Data Sources

Participating schools-site selection. Eight schools in the U.S. and in China participated in this study. All eight schools were convenient samples and agreed to participate in the study. They were all located in urban areas in large cities. Four schools in the U.S. were from a district located in the southeast of the United States. One of the two American high schools from the district had a comprehensive science, technology, engineering, math program (STEM). The other American high school had limited technology and limited science classes. One of the two

American middle schools from the district was a school of the arts that included dance, vocal, cinematic, and other art programs. The other American middle school had academic programs normal to other American middles schools in the district. In contrast, one of the two Chinese high schools had comprehensive academic programs and located in the middle south of China. The other Chinese high school had a variety of educational technology programs. Two Chinese middle schools were located in the same city as one of the Chinese high school. These three schools were all located in southern coast of China and under the same name—HG School—but had their own administrations and campuses. One of the middle schools was a private school while the other two were public schools.

Participants for survey of school technology leadership. The participants for the survey on STL included school administrative leaders, technological coordinators, and science teachers in the eight schools in both the U.S. and China. In the schools, the principals and/or assistant principals, technology coordinators, and science teachers were invited to participate in the first survey about school technology leadership. Finally, 87 participants completed the survey. Among them, 38 were from U.S. schools; 49 were from Chinese schools. Among the 38 participants who competed the survey in the U.S. schools, three were principals, seven assistant principals, five technology coordinators, and 23 science teachers. Among the 49 participants who completed the survey in the Chinese schools, three were principals, eight assistant principals, nine technology coordinators, and 29 science teachers.

Participants for the survey on science teacher technology leadership. The second survey in this study was designated for measurement of science teacher technology leadership. Science teachers in each of the eight study schools were asked to complete the survey on science teacher technology leadership. Eventually, 76 participants completed the survey. Among these respondents, 26 were from U.S. schools and 50 were from Chinese schools.

Measures for this Research Study

This research focused on finding the salient aspects of school technology leadership (STL) and science teacher's technology leadership (STTL), and how STL and STTL differed across country and grade-level. Five measures were developed for this research study: a survey on school technology leadership, a survey on science teacher technology leadership, and protocols for interview, for observation, and for artifacts review. The measures were presented in the appendices.

Survey on STL. According to the conceptual framework part 1 (Figure 1), school technology leadership scale was formed (See Appendix C). There were four fundamental subscales: leadership and school improvement, ICT-related school conditions (ICT vision, policy, infrastructure, and school support and coordination), ICT-related teacher conditions (teachers' ICT vision and interaction with other stakeholders), and teachers' use of ICTs. Referring to Sincar's (2010) inventory of technology leadership roles, educational technology's characteristics—human centeredness, communication and cooperation—were taken into account. In addition, under the guidance of the standards for administrators of the International Society for Technology in Education (ISTE for administrators, 2007), the scale was related to school leadership and improvement. Thus, another subscale—leadership and school improvement—was added to the inventory. This revision was consistent with Song and Owens's (2011) statement: only when teachers and students have access to technology in ways that are relevant, responsive, and meaningful to their educational practice can technology have its greatest impact and reach its highest capacity on our educational system.

Survey on STTL. According to the conceptual framework part 2, my literature review, ISTE standards for teachers, the TPACK model (Angeli & Valanides, 2009; Keating & Evans, 2001; Yurdakul et al., 2012), and my experience in technology-integrated science instruction, science teacher technology leadership scale was formed (See Appendix D). There were four fundamental subscales—ICT learning environment, ICT competence, ICT curriculum, and ICT-integrated instruction. Concretely, the scope and arrangement of the scale was based on the National Research Council's (2013) framework for K-12 science education and national science education standards, the standards for teachers of International Society for Technology in Education (ISTE for teachers, 2007), and the U.S. Department of Education's (2010) national educational technology plan. Additionally, the TPACK model was referred to and used as key constructs at the center of the conceptual framework part 2. Moreover, ICT-related teacher conditions in Vanderlinde & van Braak's (2010) e-capacity scale were also referred to as a technology leadership evaluation of teachers in general.

Protocols. Three protocols were prepared for other descriptive data collection. Among them, an interview protocol was used for interviews of science teachers; an observation protocol was applied to observations of schools' ICT infrastructure and e-capacity; and an artifacts protocol was used for review of schools' artifacts about ICT policies, practices, and achievement of ICT-integrated education.

Interview protocol. According to NETS-A, NETS-T, and NET-S (ISET, 2007), the National Research Council's (2000, 2013) framework for K-12 science education and national science education standards, and DCPS Teacher Technology Integration Survey (DCPS, 2014), an interview protocol was produced. Two science teachers in each of the eight schools were invited for interview by the researcher using the interview protocol (see Appendix E). In addition to the surveys, the interviews focusing on in-depth understanding of science teachers' STTL, their evaluation of STL, and their perspective of the interactive effect of STL and STTL on students' learning were conducted to two or three science teachers in each of the schools.

Observation protocol. Based on ISET's standards (2007)—NETS-A—and the e-capacity framework (Vanderlinde, & van Braak, 2010), an observation protocol was formed for observation of the schools' use of ET and e-capacity (see Appendix F). It was a standardized observation in order to obtain reliable research data. This structured observation was used as a complementary measurement of school technology leadership-the schools' applications of ICT in education and the schools' e-capacity in addition to the survey of STL.

Artifacts review protocol. Based on NETS-A and NETS-T (ISET, 2007), an artifact review protocol was formed for school background, context and document review. The artifact review was used to gain comprehensive understanding of the school's practice and achievement in using ICTs, applying STL and STTL for school improvement, and effects of STL and STTL on school education and student learning. The protocol is provided in Appendix G.

Reliability and validity of the measures. The quantitative measures' structural reliability and validity were examined in order to warrant the research study. The reliability range of the measure of school technology leadership was from .89 to .97. Additionally, the reliability range of the measure of science teacher technology leadership was from .84 to .95.

Quantitative measures. The original STL survey used for this study consisted of 35 questions, which were written around the four conditions provided by Vanderlinde and van Braak (2010) in their framework. In contrast, there were 40 questions in the original science teacher technology leadership survey that was created on the four pillars synthesized from my literature review (science teachers' ICT competence, ICT-supported learning environment, ICT-enriched curriculum, and ICT-integrated science instruction). Both surveys used a Likert scale, a commonly used summated rating scale. Three types of survey tools were prepared: Qualtrics on–line survey, line-on-paper survey, and five-scale-on-paper survey. The surveys were provided depending on availability of the on-line form of survey as well as on the preference of the participants in the sites for this study. I translated the two surveys from English to Chinese. And the reverse translations were performed by Dr. Ouyang in the College of Education and Human Services at UNF. The reliability and validity of the reverse translation was double checked by Mr. Huang, a visiting scholar from China at UNF, Ms. Lu, an instructor for Chinese at UNF, and by English teachers and science teachers in Chinese schools. Additionally, the structural validity of the two surveys was examined by principal component factor analysis (PCA). The reliability coefficients of the two measures were tested by the Cronbach's alpha analysis (Daniel, Blount, & Ferrell, 1991; Sincar, 2010).

Descriptive measures. Interviews, observations, artifacts review were carried out in the U.S. schools using the protocols provided in the Appendices. I translated these three protocols from English into Chinese formats. The Chinese formats of the protocols were translated from Chinese back into English by Dr. Ouyang in the College of Education and Human Services at UNF. The reliability and validity of the reverse translation were also double checked by Mr.

Huang, Ms. Lu, and English teachers and science teachers in the Chinese schools. Additionally, triangulations were used to check and assure reliability and validity of the three descriptive measures.

Methodology for Data Analysis

Quantitative data analysis. For the data collected from quantitative studies, descriptive statistics, Pearson correlation, exploratory factor analysis, MANOVA and ANOVA were used in data analysis.

Statistical significance tests (SST) & null hypothesis significance tests (NHSTs). Statistical significance tests may offer opportunities to test the hypotheses. Since the formulation of NHST, it has become one of the most widely used quantitative methodologies. Its applications have expanded into nearly all areas of human endeavor (Lehmann, 1993; Roger, 2010), and there is no exception for the field of education. However, some researchers (Daniel, 1998) contended that NHST or SST has been abused. For example, some researchers confused significance with importance, others misinterpreted the meaning of statistically significant, and still others mistook SSTs as means for assessing result replicability (Thompson, 1993). Thus, MANOVA and 2x2 between-subjects ANOVA were used to check the main effects of grade and culture and interaction of the two factors. MANOVA and ANOVA tests were used after checking for fundamental assumptions so that the analysis was reliable and valid.

Correlations between variables. Correlation is needed for this research design. Miles, Pajares, and Herron (2006) studied self-efficacy, anxiety, and their relation to reading and listening proficiency by using Pearson correlations. In their research studies, correlation coefficients were computed among the self-efficacy, anxiety, and proficiency scales. They found that three of the five correlations with reading self-efficacy were statistically significant and the coefficients ranged from -.38 to .78. Analysis of the correlation results reveals that a stronger sense of reading self-efficacy is associated with a stronger sense of listen self-efficacy and is negatively associated with reading anxiety and listening anxiety. In addition, they discovered that a stronger sense of listening self-efficacy was associated with a stronger sense of reading self-efficacy and was negatively associated with reading anxiety and listening anxiety. These results were meaningful: the higher a person's confidence about his or her ability to read (or listen), the higher the person's self-efficacy about his or her ability to listen (or read), and hence the lower his or her anxieties about reading and listening (Miles et al., 2006). In light of their findings, Pearson correlations were used to clarify if school technology leadership was correlated with science teacher technology leadership in this study.

Exploratory factor analysis. EFA was a useful tool for this research design. The instruments that are used for measurement of teacher's technology leadership and student interest and attitude in educational technology and technology-integrated instruction contained multiple items. Factor analysis was used as a means for decreasing the number of variables and form several meaningful clusters (Sincar, 2010; Tang, 2014). That is, factor analysis was used to provide construct validity of the instruments. For example, Daniel, Blount, & Ferrell (1991) conducted research about students' academic misconduct by employing factor analysis. They reduced 22 variables into four meaningful clusters. In addition, they subjected the item subscale scores that resulted from their analysis to alpha reliability analysis. They found that the subscales were highly internally consistent. Given another example, Thompson & Daniel (1996) studied factor analytic evidence for construct validity of scores. They noted that factor analysis and construct validity have been associated with each other.

ANOVA and MANOVA. In this study, we assumed that the dependent variable STL and STTL and their factors were normally distributed; the groups or schools were independent in their responses on the dependent variables; and variance was supposed to be equal for all groups or schools. Thus, ANOVA with F test can be used as a robust tool (Hair, Black, Babin, & Anderson, 2010) to examine the effects of culture and grade on STL or STTL individually. Because in this study culture and grade were categorical variables, and STL, STTL, and their factors were interval variables, MANOVA may be used to test the main effects of culture and grade and their interaction effect on the multiple dependent variables STL and STTL if the assumptions on MANOVA are satisfied. Compared with ANOVA, MANOVA uses several criterion measures simultaneously and fewer statistical significance tests, so it can help provide this study with a more complete and detailed description of the phenomenon in STL and STTL and detect combined differences not found in separate ANOVA. Additionally, some researchers followed up statistically significant MANOVAs' effects with univariate ANOVAs (two-way ANOVA) for individual dependent variables (Daniel, 2013). In this study, a procedure of MANOVA multivariate tests & ANOVA univariate tests was applied to data analysis: MANOVA multivariate tests were used to examine the main effects and interaction effect of country and grade, and univariate ANOVAs were used with Bonferroni correction (Goldman, 2008) to check the effects of independent variables on each dependent variable in detail.

Descriptive data examination. The responses obtained from the two surveys were used as sources of quantitative data. The results of observation, document review, and interviews were used for descriptive data examination. The results from the survey on STL together with observation and artifacts review were assessed as school technology leadership in the eight participating schools. The results from the survey on STTL and interviews were assessed as science teacher technology leadership. The results obtained from different sources—survey, observation, interview, and document review—were compared for comprehensive and in-depth data examination. The descriptive data collected from multiple schools helped contextualize quantitative findings of the research study.

Combined research data analysis. This research study was considered as a quantitative method design (Leech & Onwuegbuzie, 2009). In multiple schools, both quantitative and descriptive data were collected, analyzed and interpreted to investigate STL, STTL, and the effects of country and grade-level on STL and STTL. Using my conceptual framework which was underpinned by the theoretical framework of Vanderlinde & Braak's e-capacity model and Yurdakul et al.'s TPACK model, quantitative data were analyzed by exploratory factor analysis, Pearson correlation analysis, and MANOVA and ANOVA tests. Descriptive data was collected via interviews, observations, and artifact review. The descriptive data were examined for commonalities that reflected categories or themes. The results through descriptive data examination were used to support and contextualize the quantitative study. According to Creswell & Plano Clark (2011), this research study had a parallel design: the quantitative and descriptive data were gathered at the same time and integrated in the interpretation stage. That is, quantitative and descriptive data examination informed each other; synergy of the two was sought out to address research questions.

Data Collection Procedure

Data collection began as soon as the IRB application was approved. The research study included the following procedures: First, each school's principals, assistant principals, technology coordinators, and science teachers were invited to participate in the survey about school technology leadership. Second, each school's science teachers were asked to participate in the survey of science teacher technology leadership. Third, two or three science teachers from each of the eight schools were asked for an interview using the interview protocol about their STTL, their school's STL, and the interactive influence of STL and STTL on student science learning. Fourth, each school's use of educational technology (e.g., desktops, laptops) and technology infrastructure (e.g., ICT labs or centers and classrooms with ICT equipment) were visited and observed using the observation protocol about the schools' use of ET, e-capacity, and STL. Fifth, each school's artifacts (e.g., ET policies, and ICT-related achievements) were collected based on the artifacts review protocol on schools' use of ET, e-capacity, and STL.

Quantitative data collection. In the four American schools, online surveys were available to the participants. Thus, Qualtrics form of survey associated with the on-line consent form were provided. However, for some participants who did not want to use an online survey, they were provided with alternative paper form of surveys together with the paper consent form. Because Qualtrics surveys were not available in the Chinese schools, online survey cannot be conducted in the schools; participants used a paper form, Likert- scale of surveys. Thus, data from the two surveys were collected either from computer Qualtrics program or from paper form of surveys on STL and STTL.

Descriptive data collection. Interview data were collected using transcripts and verbatim recording. Observation data were collected by taking field notes of observation on each site observed by the researcher. Schools' artifacts and documents were collected according to artifact review protocol from each of the eight schools. All data was saved in the researcher's computer or locked in cabinet for later document review and data analysis.

Plan of Data Analysis

Because quantitative and descriptive methods were combined in this study, data analysis was conducted using a quantitative approach. There were three steps in this approach: First, quantitative analysis was conducted with the surveys on STL and STTL using exploratory factor analysis, Pearson correlations, and MANOVA with ANOVA to get primary findings for school and science teacher technology leaderships. Second, descriptive data examination was conducted using interviews, observations, and artifacts in order to obtain themes emerged from descriptive studies. Third, descriptive data were used to contextualize, illustrate, and clarify quantitatively derived findings.

Research question one. Analysis of the survey on STL was used as a major source of information for addressing research question one. However, analysis of other data—the survey on STTL, interviews, observation, and artifacts—were also used to help address this question.

Rationale and assumption. Although quantitative and descriptive research studies sit in different paradigms, quantitative methods with descriptive examination data analysis is a viable approach (Creswell, 2002; Johnson & Christenson, 2012; Yin, 1989). Factor analysis is a useful tool for reducing sizable numbers of variables in STL measurement into several meaningful components and for studies of construct validity (Hair et al, 2010). Additionally, factor analysis can help clearly define STL variables and ensure that these variables are being accurately measured.

Plan of analysis. First, the data collected from the survey on STL measurement were analyzed by exploratory factor analysis to identify the number of factors and label the factors of STL. The scale and subscales of STL are tested for internal consistency by using Cronbach's alpha analysis (Pett, Lacky, & Sullivan, 2003). Secondly, the data collected from interview, observation, and artifacts were analyzed to find themes and details about school technology leadership. Thirdly, relationships between descriptive and quantitative findings were examined to support quantitative findings. Fourthly, STL and STTL and their factors were correlated in order to analyze effects of STTL on STL to enrich understanding of the role of teachers on school technology leadership.

Research question two. Analysis of the survey on STTL was used as a major source of information for addressing research question two. However, analysis of other data—the survey on STL, interviews, observation, and artifacts—were also used to help address this question.

Rationale and assumption. Although quantitative and descriptive research studies sit in different paradigms, a quantitative method with a descriptive examination of data analysis is a viable methodology. Like data analysis for research question one, factor analysis is a useful tool for reducing sizable numbers of variables in STTL measurement into several meaningful clusters and for studies of construct validity. Additionally, factor analysis can help clearly define STTL variables and ensure that these variables are being accurately measured.

Plan of analysis. First, the data collected from the survey on STTL measurement were analyzed by exploratory factor analysis to identify the number of factors of STTL and label them. The scale and subscales of STTL were tested for reliability coefficients of the scale by using Cronbach's alpha technique. Second, the data collected from interviews were analyzed in order to contextualize and support quantitative analysis of STTL. Third, observations, and artifacts data were analyzed to find categories and themes to support quantitative data about science teachers' technology leaderships. Fourth, relationships between descriptive data and quantitative data were analyzed in order to support quantitative findings with descriptive findings. STL and STTL and their factors were correlated in order to analyze effects of STL on STTL to enrich understanding of the effect of school context on science teacher technology leadership.

Research question three. Descriptive statistical analysis, Pearson correlation, and ANOVA and MANOVA of the survey on STL and the survey on STTL were used as major sources of information for addressing research question three. However, analysis of other data—interviews, observation, and artifacts—was also used to help address this question.

Statistical assumption. Basically, four statistical assumptions or null hypotheses underpinned this research question. First, there is no difference between the U.S. and Chinese schools' school technology leadership. That is, culture is not a main effect on variance of school and science teacher technology leaderships. Second, there is no difference between high and middle schools' school and science teacher technology leaderships. That is, school grade level is not a main effect on school and science teacher technology leaderships. Third, there is no interaction effect of culture and grade on school and science teacher technology leaderships. Fourth, school technology leadership has no correlation with science teacher technology leadership.

Plan of analysis. First, the factor scores received by participants on STL were analyzed using two-way MANOVA with three dependent variables (DVs) and subsequent two-way ANOVAs in order to find main effects of country (or culture) and grade and their interaction on the three factors or subscales of STL. Secondly, the scores received by participants on STTL were analyzed using two-way MANOVA with three DVs and subsequent two-way ANOVAs in order to find main effects of country (or culture) and grade and their interaction on the three factors or subscales of STTL. Thirdly, the data collected from interview, observation, and artifacts were analyzed against differences in STL and STTL across country and grade levels. Fourthly, relationships between descriptively- and quantitatively-derived findings were analyzed in order to support quantitative findings in the research question three. Fifthly, quantitative and descriptive measures were integrated in order to interpret and understand effects of STL, STTL, and interaction of STL and STTL on school's ICT-integrated education.

Ethical Aspect of the Research Study

About the investigator. I was aware of the role and responsibility of the researcher's part of the research study process. I needed to attend to research ethics and keep an impartial standpoint in the research study. For example, before the process, I needed to identify the influences of people, events, experiences, beliefs, and life commitments on the research study (Scheirer, 2013). Thus, my subjectivities were minimized or avoided in the research process. The attention to ethics was critical for the success of the study.

Research ethics. In the entire process of this research study, I committed to protecting the privacy of the participants and their rights as participants. I completed the IRB training and received the certificate. Additionally, I have applied for IRB approval for the research study with all required documents and received approvals from UNF IRB, DCPS IRB, and Chinese schools. My research activities started after the IRB approvals were formally granted. In addition, I followed all IRB rules and requirements from the documents to protect the rights of all participants and the confidentiality of all research data.

Chapter Summary

In order to fulfil the goal of this study, a quantitative methods approach (Creswell, 2002) that focused on quantitative study and used descriptive data as support was used as a primary design for this study. This study design addressed the three exploratory, descriptive, and explanatory research questions by integrating quantitative and descriptive studies in a single study that complemented each other and provided results with more breadth and depth (Roberts, 2010). This complement increased the reliability and validity of the research study.

Exploratory factor analysis (EFA) together with Cronbach alpha technique was applied to quantitative data analysis using SPSS in order to reduce sizable numbers of variables into several meaningful factors that result in variance in school technology leadership and science teacher technology leadership. Additionally, EFA was used to assure the structural validity of the surveys and Cronbach alpha technique for examination of the reliability coefficients of the surveys. In addition, Pearson correlation analysis was conducted between STL and STTL and their factors in order to analyze the relationships between the dependent variables. Furthermore, ANOVA and MANOVA were used for the analyses of the data collected from the two surveys. Concretely, a MANOVA with two-way ANOVAs procedure was used for examination of the main effects and interaction effect of the independent variables (IVs) of country and grade-level on the dependent variables (DVs) of STL and STTL and their factors. By using this procedure, MANOVA multivariate tests examined the main effects and interaction effect of the IVs on the DVs; and two-way ANOVAs equipped with a stricter testwise alpha (Goldman, 2008) were used for a refined, accurate verification of the effects.

Chapter 4: Analysis and Results

The purpose of the research study was to investigate overall school technology leadership and science teacher technology leadership and their interactive effect on science education in high and middle schools in the United States and in China. Three research questions were created to fulfil the goal of the research study: 1) What do teachers and administrators perceive as the salient aspects of school technology leadership (STL)? 2) What do teachers perceive as the salient aspects of science teacher technology leadership (STTL)? and 3) How does STL and STTL differ across country and grade-level contexts?

Descriptive Statistics

Descriptive statistics were used to summarize the large amount of information from respondents on a given variable using summary data collected from the eight schools in this study. Based on the exploratory nature of this study and the hierarchical nature of these data with teachers and administrators nested in particular schools, the comparison of grade- and country-level data was initially undertaken descriptively then using inferential statistics and descriptive data analysis. Table 1 presents descriptive statistics of the respondents' responses to the two surveys on school technology leadership (STL) and science teacher technology leaderships (STTL), respectively.

Descriptive statistics reflected in STL survey. Analysis of Table 1 revealed some trends. First, in the U.S. schools, middle schools' mean scores of school technology leadership were higher than those of high schools'. Similarly, in the Chinese schools, middle schools' mean scores of STL were also higher than those of high schools'. This indicated that middle schools scored higher in STL measurement than high schools regardless of countries in this study.

Second, at the high school level, the Chinese schools' mean scores were higher than those of the U.S. schools. Similarly, at the middle school level, the Chinese schools' mean scores were also higher than those of the U.S. schools. This indicated that Chinese schools scored higher on average than the U.S. schools in STL measurement, regardless of grades.

Table 1

Descriptive Statistics of Schools' Average Scores on Surveys

Country	Grade	STL			STTL		
		Mean	SD	n	Mean	SD	n
USA	High School	1910	538	12	2267	700	12
	Middle School	2102	525	12	2051	516	12
	Total	2006	529	24	2158	563	24
China	High School	1988	286	12	2495	287	12
	Middle School	2393	298	12	2391	293	12
	Total	2191	353	24	2443	288	24
Total	High School	1949	423	24	2380	481	24
	Middle School	2247	443	24	2221	446	24
	Total	2099	454	48	2301	465	48

Note. STL= school technology leadership; this survey contained 32 items; the score for each item was 100 points. STTL= science teacher technology leadership; this survey contained 39 items; each item's score was 100 points.

Descriptive statistics reflected in STTL survey. Some trends were found in STTL through analysis of Table 1. First, in the U.S. schools, high school science teachers' mean scores were higher than those of middle school teachers. Likewise, in the Chinese schools, high school science teachers' mean scores were higher than those of middle school teachers. This indicated that high school science teachers scored higher in STTL measurement than middle school science teachers did, regardless of countries in this study. Second, at both the high school and middle school levels, the Chinese school science teachers' mean scores were higher than those of U.S. school teachers. This indicated that Chinese schools scored higher on average than the U.S. schools in STTL measurement regardless of grades.

Contextualizing descriptive statistics results with descriptive data. Analysis of descriptive studies (interview, observation, and artifacts reviewed) in this study helped contextualize quantitative findings. This descriptive data assisted in the understanding of school and science teacher technology leadership, and their differences across country and grade.

I noted the differences in the contexts between the U.S. and China. Examining these differences may help understand descriptive data in this research study. First, the U.S. and China have different cultures and participants from different countries had different personalities. The American participants were found to express their opinions and evaluations of STL and STTL directly and openly while Chinese participants were reluctant to complain or criticize. This may help tease out the effect of culture limiting self-reporting, which was used in measures of this study. Second, the two countries have different curricula in their school education. In China, the curricula were more centralized at provincial or national level, whereas there was a more localized approach in the U.S. This may impact integration of ICT in school education.

Interview. In the interviews conducted in the Chinese schools, most teachers praised their school's technology leadership. They cited examples of their efforts in developing ICT-enriched curriculum for ICT-integrated instruction. In contrast, in the U.S. schools, some science teachers complained about ICT infrastructure and devices in their schools. They contended that their technology talents remained unused or limitedly used in schools' ICT-related decision making. Culture limiting self-reporting may need to be teased out. As the effect of grade was concerned, the interviews demonstrated that high school teachers' software and ICT learning environments were more sophisticated and comprehensive compared with middle school teachers. Thus, their evaluations of STL were found to be generally lower while their self-reporting STTL were higher compared with middle school teachers. In contrast, middle school teachers and leaders were found generally younger and showed to be more enthusiastic about using ICTs in their classrooms. This may partially clarified why middle schools' STL mean scores were higher compared with high schools'.

Observation and artifacts. Some findings were identified in observation and artifacts review. First, the U.S. schools were found to have stronger ICT infrastructure with more and better quality ICT tools and devices compared with Chinese schools. For example, as the quantity of computers was concerned, the U.S. schools had higher computer-to-student ratios than the Chinese schools did: the U.S. schools' ratios ranged from 0.3:1 to 0.7:1, which was about 6 times higher than the Chinese schools' ratios. Additionally, in terms of the quality of ICT devices, U.S. students used laptops and media carts, whereas Chinese students did not. Second, the U.S. schools' acceptable use policies (AUPs) for ICT systems such as BYOD created conditions and environment where ICT use was more flexible and accommodating to students. For example, students in the four schools in the U.S. were allowed to use their cellphones, laptops on the campuses where ICT blended learning platform were supplied by the district. In contrast, in the Chinese schools, students' own ICT devices were not allowed to be used on campuses in weekdays, and the school and district had not provided students with ICT platforms. However, analysis of observation and artifacts data revealed that Chinese schools had their strong points as well. Generally, they had solid ICT vision, curriculum, and professional development programs. For example, there were information technology departments in both high and middle Chinese schools. Teachers in the departments were experts who provided school teachers and administrators with both technological and pedagogical support for ICT-integrated instruction. Meanwhile, they provided school students with ICT courses as mandatorily required by the curriculum. Thus, Chinese teachers used existing ICTs in their schools to high capacity. However, Chinese schools' curricula were more centralized compared with the U.S. schools' more localized approach. This may impact their integration of ICT. As the effect of grade was concerned, observation and artifact data revealed that high schools had some specific centers for ICT applications. For example, the U.S. high schools had ICT centers for information medium, engineering, and logistics; the Chinese schools had ICT centers for psychological clinic where students' psychological problems can be treated with ICT tools. In contrast, both the U.S. and Chinese middle schools focused on investing more on ICT facilities in their computer and regular classrooms.

What Do Teachers and Administrators Perceive as Salient Aspects of STL?

Exploratory factor analysis for STL. In order to address the research questions, exploratory factor analysis (EFA) was conducted in reducing sizable numbers of variables into several meaningful factors that resulted in variance in school and science teacher technology leaderships. Scores of the overall scales were analyzed using principal components factor analysis (PCA) in order to check the structural validity of the instrument. The whole scale and subscales were examined using Cronbach's alpha reliability analysis in order to assure reliability coefficients of the instrument (Pett, Lackey, & Sullivan, 2003; Sinca, 2010). Through EFA of the STL survey using SPSS 22.0, principal component analysis and orthogonal rotation were applied to the study. Eigenvalues, extraction sums, and rotation sums are presented in Table 2. Using these data and associated scree plots as guides, three factors were extracted and rotated.

Table 2

Eigenvalue, Extraction Sum, and Rotation Sum for STL Factor Analysis

Component	Eigenvalues Total	Eigenvalues % of Variance	Extraction Sums % of Variance	Rotation Sums % of Variance
Leadership and improvement	17.95	51.29	51.29	25.71
ICT school condition	2.92	8.35	8.35	22.72
ICT teacher condition	1.80	5.14	5.14	13.62

After communality analysis and the alpha reliability analysis, three items-Item 23, 27, and 34 were removed from the original scale. As a result, 32 items remained in the STL instrument. The Cronbach's alpha reliability analysis was conducted with the whole scale and its subscales or factors. The final Cronbach's alpha values are presented in Table 3. The Cronbach's alpha coefficient for the whole scale was .97; Cronbach's alpha coefficients for the individual factors of the scale ranged between .89 and .96.

Table 3

Final Factor Solution for STL with Cronbach's Alpha Reliabilities

Scale (Subscale)	Cronbach's Alpha	Items (Variables)
Whole Scale	.97	32
Leadership and School Improvement	.96	14
ICT-Related School Conditions	.94	11
ICT-Related Teacher Conditions	.89	7

Through synthesizing the items with the themes that emerged from the items in each factor of the final factor solution, the three factors were labeled in the following list:

1) Factor 1: Technology leadership and school improvement (technology leadership approach, professional relationships, ICT decision making)
2) Factor 2: ICT-related school conditions (ICT vision and policy, ICT infrastructure, schools' professional development and support in both technology and pedagogy)
3) Factor 3: ICT-related teacher conditions (teachers' interaction with school leaders and other stakeholders in ICT-integrated instruction, their ICT visions and use of ICT).

The final factor solution for STL scale is summarized in Table 4. The table presents the matrix of statistical weights applied to the variable z-scores for each factor. As revealed by Table 4, Item 1 was a "doublet" item. That is, it is salient with both ICT-related school conditions and ICT-related teacher conditions. In the light of Cronbach alpha analysis, Item 1 was placed in ICT-related teacher conditions, which increased the factor's reliability. Analysis of Table 4 indicated that measurement of school technology leadership contained three subscales. Based on communality analysis and Cronbach alpha analysis, the final factor solution of STL consisted of three factors: Factor 1—leadership and school improvement—consisted of 14 items, Factor 2—ICT-related school conditions—contained 11 items, and Factor 3—ICT-related teacher conditions—comprised seven items.

Table 4

Factor Pattern Matrix for Exploratory Factor Analysis with Varimax Rotation of STL Measure

Subscale	Leadership & Improvement	ICT School Conditions	ICT Teacher Conditions
Our school leaders seek input from teachers and staff (e.g., surveys) to assess the educational technology needs in school.	**.805**	.229	.264
School leaders gather opinions from various members of the school about how to effectively integrate technology advancement into teaching and learning process.	**.794**	.343	.302
School leaders and teachers are informed about the role and tasks assigned to the technology coordinator.	**.786**	.252	.205
The schools' technology coordinator has a clear overview of the information and communication technology-related activities performed at my school.	**.780**	.337	.092
School leaders and teachers evaluate the influence of educational technology on the students' academic achievement.	**.749**	.391	.241
Our school leaders ask the teachers for their views on the effective use of educational technology in their classrooms.	**.733**	.443	.136
Administrators in our school share their vision for the efficient use of educational technology in school with the faculty.	**.729**	.270	.296
Our school leaders encourage the teachers to learn (through activities like professional development and conferences) about the use of educational technology.	**.705**	.444	.179
Our school leaders and teachers effectively identify the appropriate educational technology to facilitate teaching activities to best meet the learning goals of the school.	**.685**	.490	.239
The information and communication policy plan of my school begins with a shared vision about "effective" education.	**.681**	.130	.270
Our school has long-term plans for the advancement of technology when applied to the classroom.	**.665**	.352	.274
In my school, teachers participate in the decision making in school improvement.	**.651**	.007	.205
Administrators in our school have a strong and clear vision for the efficient use of educational technology in school.	**.620**	.213	.510
In my school, teachers communicate and cooperate well with each other when making educational decisions.	**.551**	.125	.514
The school's hardware (e.g., computers, laptops, e-readers) is sufficient to incorporate information and communication technology into classroom practice.	.122	**.856**	.234
In our school, classrooms are equipped with a sufficient amount of computers for information and communication technology–related educational activities.	.283	**.813**	.234
My school's information and communication technology infrastructure is appropriate for support of technologically based educational activities.	.394	**.764**	.165
I am satisfied with the school's software (e.g., e-reader, i-Pad applications, and computer programs) that is available for me to use with my students.	.335	**.706**	.192
The school's vision about the role of information and communication technology in education is accepted by all colleagues.	.147	**.696**	.446

In our school, teachers and staff receive adequate technical support while working with information and communication technology.	.283	**.676**	.371
School leaders have created a technology team that represents all members of the school to incorporate educational technology into the teaching and learning process.	.470	**.671**	.027
In our school, classrooms are equipped with smartboards for ICT-related educational activities.	.186	**.667**	.018
In my school, we have a shared vision of purposeful change that maximizes the use of digital-age resources to meet and exceed learning goals.	.397	**.641**	.237
In our school, classrooms are equipped with iPads for ICT-related educational activities.	.115	**.634**	-.177
In our school, teachers can receive support from pedagogical coach or expert to improve their information and communication technology-based instruction.	.243	**.574**	.461
My school has a clear vision on the role of information and communication technology in education.	.220	**.551**	.539
Teachers at my school know the school’s information and communication technology policy plan.	.283	**.538**	.296
Our school leaders communicate school priorities & goals clearly to teachers.	.200	.253	**.767**
School leaders and teachers use information and communication technology in communicating and cooperating with the community.	.455	-.018	**.682**
When my school teachers and leaders commit to a program or priority, they follow through.	.391	.482	**.649**
School teachers and leaders use the school’s ICTs in communicating and building collaborative working relationships with parents.	.441	.157	**.556**
School leaders in our school have communicated clear expectations and performance standards to teachers for the use of technology in classroom practice.	.274	.488	**.540**
In our school, colleagues help each other when facing problems with information and communication technology equipment.	.296	.268	**.521**
In our school, classrooms are equipped with digital projectors for ICT-related educational activities. [a]	.053	.133	.216
In our school, classrooms are equipped with digital documental cameras for ICT-related educational activities. [a]	.207	.181	.083

[a] The items that were removed from the original scale, based on communality analysis and Cronbach alpha analysis.

What Do Teachers Perceive as Salient Aspects of Science Teacher Technology Leadership?

Exploratory factor analysis for STTL. In order to address research question two, exploratory factor analysis was conducted in reducing sizable numbers of variables into several meaningful factors that resulted in variance in science teacher technology leadership. The whole scale and subscales were also subjected to Cronbach's alpha reliability analysis in order to assure reliability coefficients of the instrument.

Similar to factor analysis of STL, STTL measure's Eigenvalues, extraction sums, and rotation sums were presented in Table 5. Based on both the table and associated scree plot, three factors were extracted and rotated. Thus, a three-component factor solution was created using the procedure similar to factor analysis of STL.

Table 5

Eigenvalue, Extraction Sum, and Rotation Sum for STTL Factor Analysis

Component	Eigenvalues Total	Eigenvalues % of Variance	Extraction Sums % of Variance	Rotation Sums % of Variance
Learning environment	14.31	35.78	35.78	22.06
ICT competence	5.23	13.08	13.08	19.16
ICT curriculum	2.49	6.22	6.22	11.51

Through communality analysis and the item-whole scale correlation coefficient analysis, Item 35 was removed from the STTL measure. As a result, there were 39 items remaining in the STTL instrument. The Cronbach's alpha reliability analysis was conducted with the whole scale and the subscales. The final Cronbach's alpha values were presented in Table 6. As revealed by the data in Table 6, the Cronbach's alpha coefficient for the whole scale of STTL was .95; the Cronbach's alpha coefficient for the individual factors of STTL ranged from .84 to .94.

Table 6

Final Factor Solution for STTL with Cronbach's Alpha Reliabilities

Scale (Subscale)	Cronbach's Alpha	Items (Variables)
Whole Scale	.95	39
ICT Learning Environment	.94	18
Teachers' ICT Competence	.91	14
ICT-Enriched Curriculum	.84	7

By synthesizing the themes that emerged from the factor analysis and examining the items in each factor of the final factor solution, three factors were labeled in the following list:

1) Factor 1: ICT learning environment (academic standards, curriculum, ICT tools, training and communication) and science teachers' ICT-integrated instruction
2) Factor 2: Science teachers' competence (in each aspect of technology, pedagogy, science content and their integration) and their ICT-integrated instruction
3) Factor 3: Science teacher's ICT-enriched curriculum and their ICT-integrated instruction

The final factor solution for STTL scale is presented in Table 7. The table provides the matrix of statistical weights applied to the variable z-scores for each factor.

As revealed by Table 7, Item 35 was removed from the STTL scale because of its low communality value and low item-to-total correlation coefficient. According to Cronbach alpha analysis, Items 1 and 6 were kept in ICT learning environment factor because they increased the factor's reliability. Analysis of the data shown in Table 8 indicated that measurement of science teacher technology leadership contained three subscales. Based on communality analysis and

Cronbach alpha analysis, the final factor solution of STTL consisted of three factors: Factor 1—ICT learning environment—consisted of 18 items, Factor 2—teachers' ICT competence—had 14 items, and Factor 3—ICT-enriched curriculum—held seven items.

Table 7

Factor Pattern Matrix for Exploratory Factor Analysis with Varimax Rotation of STTL Measure

Subscale	Learning Environment	ICT Competence	ICT Curriculum
I have used the National Educational Technology Standards or International Society for Technology in Education as guides for my teaching practice.	**.814**	.217	.016
In my science classroom, I establish a technology-supported learning environment that encourages students to explore the relation among science, technology, and society.	**.780**	.104	.303
I provide my students with technology-integrated activity (e.g., experimental design using technology) to help them identify conceptual and practical relations between science, technology, engineering, and mathematics.	**.730**	.377	.252
I use educational technologies to promote student engagement, reflection and collaboration through inquiry-based learning environment in my science classroom.	**.718**	.209	.350
I look at how educational technologies can transform the science curriculum rather just working with technology in the existing curriculum.	**.680**	.188	.335
I incorporate digital tool such as video instructional games to customize learning activities in science education to address differences in student background knowledge and interest.	**.674**	.075	.153
I strengthen my curriculum for science teaching by utilizing educational technologies and social media to enhance student engagement.	**.660**	.394	.293
I use information and communication technology methods, activities, and materials that I learn from my colleagues and professional development staff to enrich my curriculum.	**.636**	.391	.059
I talk with experts to learn about things that have to do with educational technology.	**.628**	-.195	.262
I read about things that have to do with educational technology.	**.569**	-.051	-.002
I go to conferences to learn about things to do with the use of communication and informational technology for science education.	**.562**	-.150	.395
I attend in-service teacher training in educational technologies courses.	**.556**	-.227	.141
I seek help from my school leader, technology coordinator, and teacher coach to make appropriate changes in my technology-enriched curriculum and practice.	**.548**	.437	.267
I select e-reading, e-lab and other digital learning materials to enrich the science curriculum provided by the district or state.	**.538**	.329	.309
I discuss with my colleagues about how to use technology to support inquiry-based learning environment to promote students' higher–order thinking skills.	**.508**	.333	.358

I model my students using current educational technologies (e.g., digital demonstration) to enrich their understanding of scientific concepts.	**.458**	.412	.434
I attend in-service teacher training about the use of information and communication technology for instructional purposes.	**.341**	-.139	.144
I engage in professional learning community opportunities about educational technology at school or district levels.	**.308**	.102	.231
I have sufficient pedagogical skills to integrate technology into my science curriculum.	-.153	**.836**	.119
I have sufficient technical knowledge and skills to use information and communication technology in classroom.	.102	**.762**	-.074
I provide and facilitate productive technological experiences in my science instruction that advances student learning, creativity, and innovation.	.284	**.719**	.166
I have sufficient prior knowledge to use the Internet for pedagogy.	-.267	**.707**	.269
I use computer-based data system at school or district level to analyze my students' progress such as their scores in Curriculum Guide Assessment tests to customize my teaching/learning.	-.055	**.692**	.051
I provide my students with varied and multiple formative and summative assessment to assess their learning using educational technology tools.	.453	**.676**	.056
I use a technology-enriched curriculum (e.g., contemporary science curriculum with "Technology Connections") as the guidelines and resources for your instruction.	.466	**.656**	.099
I can use a computer skillfully to prepare multimedia presentations in my instruction.	-.418	**.645**	.346
I advocate legal and ethical responsibility and respect in a digital world.	.226	**.613**	.198
I design and develop learning experiences and assessments that incorporate contemporary educational technology tools (e.g., video instructional games) and resources (e.g., Internet) to maximize the learning of science concepts.	.458	**.594**	.142
I can easily fix technical problems related to information and communication technology.	.064	**.592**	-.123
I have training to use variety of software in my classroom for instructional purposes.	.300	**.570**	.027
I collaborate with my colleagues using current educational technologies (e.g., e-mail and interactive blogs) to communicate and share information.	.388	**.532**	.205
I use computer-simulated labs (e.g., Gizmo) in my science instruction.	.234	**.482**	.118
I am effective in structuring my science curriculum when integrating technologies into my lesson and class activities.	.019	.224	**.835**
I encourage students to incorporate educational technology for data collection and analysis in inquiry-based science project.	.235	.055	**.784**
In my science classroom, the teacher and students understand that social, ethical and legal issues and responsibilities are important in a digital world; we need to follow relevant rules.	.424	-.029	**.692**
The procedures in my classroom with technology-enriched curriculum maximize the time students spend on learning.	.508	.140	**.667**
I incorporate digital textbooks (e.g., e-Text, e-Readers) in my instruction to enrich students' learning experience.	.234	.402	**.510**
I encourage my students to take advantages of the school's electronic resources such as digital technology center, computer lab, and wireless internet for their learning in science.	.402	.100	**.458**

I apply the state or national standards (such as the Common Core) to my technology-enriched curriculum materials in order to align my instruction with their expectations.	.270	.139	**.436**
I allow students to bring their own digital devices such as lap-tops, iPads, and smart phones to the classroom and use them for instructional purposes. [a]	-.060	.102	.025

[a] The item was removed from the scale based on communality analysis and Cronbach alpha analysis.

How Does STL and STTL Differ Across Country and Grade-Level Contexts?

Multivariate data analysis. MANOVA was used in this study to test the main and interaction effects of categorical independent variables—country and grade—on multiple dependent interval variables—STL, STTL, and their factors. Because STL, STTL, and their factors are interval variables, American versus Chinese culture and high versus middle school grades are categorical variables; they fit requirements of MANOVA for variables (Hair et al., 2010). Meanwhile, assumptions underlying MANOVA were checked to be fundamentally met in this study. As a result, two-way MANOVA (multivariate analysis) and subsequent two-way ANOVAs were used in order to address Research Question 3.

The respondents' factor scores provided by SPSS factor score calculations were used for MANOVA and ANOVA analysis. This was practiced because a factor score for an individual can be calculated by a linear combination of the items that load on the factor of interest. Additionally, the PCA was used in the factor analysis of the study, which enabled the researcher to obtain exact factor scores on a particular factor (Pett, Lackey, Sullivan, 2003).

Two-way MANOVA of STL. MANOVA and subsequent ANOVA were used for analysis of STL measurement data. The effects of country, grade, and their interaction on school technology leadership were evaluated.

Descriptive statistics. Based on two-way MANOVA with two levels in country and grade as independent variables, and the three factors of STL as dependent variables, descriptive statistics were obtained. Table 8 presents the mean, standard deviation, sample size, and marginal means for each condition in the study. As shown by the data in Table 8, middle schools' factor scores were higher compared with high schools in all three factors of STL measurement.

Table 8

Descriptive Statistics for Respondents' STL Factor Scores Using MANOVA

Scale	Country	Grade	Mean	SD	n
Leadership & Improvement	USA	High School	-.007	1.09	20
		Middle School	.276	1.52	18
		Total	.127	1.30	38
	China	High School	-.459	0.78	22
		Middle School	.195	0.40	27
		Total	-.099	0.68	49
	Total	High School	-.244	0.96	42
		Middle School	.227	0.99	45
		Total	.000	1.00	87
ICT School Conditions	USA	High School	-.498	0.90	20
		Middle School	-.685	1.49	18
		Total	-.587	1.20	38
	China	High School	.373	0.43	22
		Middle School	.521	0.46	27
		Total	.455	0.45	49
	Total	High School	-.042	0.81	42
		Middle School	.038	1.16	45
		Total	.000	1.00	87
ICT Teacher Conditions	USA	High School	.083	1.22	20
		Middle School	.276	1.36	18
		Total	.175	1.27	38
	China	High School	-.463	0.72	22
		Middle School	.131	0.58	27
		Total	-.135	0.71	49
	Total	High School	-.203	1.02	42
		Middle School	.189	0.96	45
		Total	.000	1.00	87

Multivariate tests. Table 9 presents MANOVA results for STL across country and grade. Pillai's trace statistic, Wilk's lambda, F test score, and p values of main effects of culture, grade, and their interaction on STL factors are provided in Table 9.

Table 9

MANOVA Multivariate Tests for STL across Country and Grade

Effect		Value	F	Sig.	η^2
Country	Pillai's Trace	.317	12.51	<.01	.317
	Wilks' Lambda	.683	12.51	<.01	.317
Grade	Pillai's Trace	.101	3.03	.03	.101
	Wilks' Lambda	.899	3.03	.03	.101
Country*Grade	Pillai's Trace	.028	0.78	.51	.028
	Wilks' Lambda	.972	0.78	.51	.028

Analysis of the data in Table 9 revealed that the main effect of country had Wilk's λ .683, Pillai's Trace 0.317, $F(1, 44) = 12.51$, $p < .01$, $\eta^2 = .317$. This indicated that country affected school's STL. In other words, the U.S. and China group means were probably different. The multivariate $\eta^2 = .317$ indicated that approximately 32% multivariate variance of the dependent variables was associated with the country group membership in this study. Additionally, the main effect of grade on STL was also significant. In contrast, the MANOVA failed to reveal the interaction effect of country and grade on STL.

Univariate tests. The results of two-way ANOVA subsequent to MANONA are presented in Table 10. Analysis of Table 10 specified that the main effect of country on STL only focused on ICT-related school conditions (F = 30.65; p < .01), while other effects were not significant based on a more rigid alpha testing (α = .017 = .05/the number of dependent variables). The alpha used by the univariate ANOVA tests was generated by Bonferroni correction (Goldman, 2008). Analysis of Table 8 indicated that the Chinese schools' ICT-related school conditions were higher than the conditions in the U.S. schools (see Table 8).

Table 10

Univariate ANOVA Tests of Between-Subjects Effects for STL Factors

Source	Dependent Variable	F	Sig.	η^2
Country	Leadership & school improvement	1.59	.21	.019
	ICT school conditions	30.65	<.01	.270
	ICT teacher conditions	2.66	.11	.031
Grade	Leadership & school improvement	4.90	.03	.056
	ICT school conditions	0.01	.92	.000
	ICT teacher conditions	3.44	.07	.040
Country*Grade	Leadership & school improvement	0.77	.38	.009
	ICT school conditions	0.80	.37	.010
	ICT teacher conditions	0.90	.35	.011

Note: Country*Grade = interaction of country and grade.

Two-way MANOVA of STTL. For the same reasoning provided on STL MANOVA, the sample respondents' factor scores produced by SPSS were used for MANOVA of STTL.

Descriptive statistics. Based on two-way MANOVA with two levels in country and grade-level as independent variables (IVs), and the three factors of STTL as dependent variables (DVs), descriptive statistics were computed by SPSS and displayed in Table 11.

Table 11

Descriptive Statistics for Respondents' STTL Factor Scores Using MANOVA

Scale	Country	Grade	Mean	SD	n
ICT Learning Environment	USA	High School	-.035	1.11	14
		Middle School	-.849	1.39	12
		Total	-.411	1.29	26
	China	High School	.353	0.51	16
		Middle School	.314	0.48	16
		Total	.334	0.49	32
	Total	High School	.172	0.85	30
		Middle School	-.184	1.12	28
		Total	.000	1.00	58
ICT Competence	USA	High School	.201	1.37	14
		Middle School	.724	0.58	12
		Total	.442	1.09	26
	China	High School	-.365	0.77	16
		Middle School	-.353	0.77	16
		Total	-.359	0.76	32
	Total	High School	-.101	1.11	30
		Middle School	.108	0.87	28
		Total	.000	1.00	58
ICT Curriculum	USA	High School	.156	1.16	14
		Middle School	-.782	1.39	12
		Total	-.277	1.33	26
	China	High School	.055	0.57	16
		Middle School	.396	0.45	16
		Total	.225	0.53	32
	Total	High School	.102	0.88	30
		Middle School	-.109	1.12	28
		Total	.000	1.00	58

Multivariate tests. The results of two-way MANOVA are summarized in Table 12. Pillai's Trace statistic, Wilk's lambda, F test score, and p values of the main effects of culture, grade, and their interaction on STTL factors are provided in the table.

Table 12

MANOVA Multivariate Tests for STTL across Country and Grade

Effect		Value	F	Sig.	η^2
Country	Pillai's Trace	.466	15.11	<.01	.466
	Wilks' Lambda	.534	15.11	<.01	.466
Grade	Pillai's Trace	.159	3.29	.03	.159
	Wilks' Lambda	.841	3.29	.03	.159
Country*Grade	Pillai's Trace	.244	5.59	<.01	.244
	Wilks' Lambda	.756	5.59	<.01	.244

Note: Country*Grade = interaction of country and grade.

According to Table 12, the main effects of country, grade, and their interaction were all statistically significant. This indicated that country, grade, and their interaction may all influence science teachers' technology leadership.

Univariate tests. The results of two-way ANOVA subsequent to MANONA are presents in Table 13. Analysis of Table 13 specified that the main effect of country on STTL focused on ICT learning environment and science teachers' ICT competence. Additionally, the interaction effect of country and grade on STTL was also identified while other effects were not significant. This indicated that science teachers' ICT learning environment and ICT competence in the U.S. schools were different from their Chinese counterparts. Particularly, according to the factor scores analysis in Table 13, Chinese school science teachers' ICT learning environment was stronger compared with the U.S. teachers', whereas the U.S. school science teachers' ICT competences were higher compared with the Chinese teachers. Additionally, the significant interaction effect of country and grade on science teacher's ICT-enriched curriculum indicated that the differences in ICT-enriched curriculum between the U.S. and Chinese science teachers depended on their grade levels.

Table 13

Univariate ANOVA Tests of Between-Subjects Effects for STTL Factors

Source	Dependent Variable	F	Sig.	η^2
Country	ICT learning environment	10.38	<.01	.161
	ICT competence	11.33	<.01	.173
	ICT curriculum	4.79	.03	.081
Grade	ICT learning environment	3.14	.08	.055
	ICT competence	1.20	.28	.022
	ICT curriculum	1.47	.23	.027
Country*Grade	ICT learning environment	2.58	.11	.046
	ICT competence	1.10	.30	.020
	ICT curriculum	6.75	.01	.111

Pearson correlation between STL and STTL and their factors. As displayed by quantitative and descriptive data analysis, STL and STTL were found to be related. Thus, Pearson correlations were conducted between STL and STTL and their factors in order to provide quantitative relationships. The correlation results were presented in Table 14.

Table 14

Pearson Correlations between STL and STTL and Their Factors

	ICT learning environment	ICT competence	ICT curriculum	Total STTL
Leadership & improvement	.611** p < .01	.530* p = .02	.830*** p < .001	.783*** p < .001
ICT school conditions	.583* p = .01	.490* p = .04	.615** p < .01	.690** p < .01
ICT teacher conditions	.459 p = .06	.566* p = .01	.505* p = .03	.627** p < .01
Total STL	.647** p < .01	.591* p = .01	.781*** p < .001	.813*** p < .001

*p < .05. **p < .01. ***p < .001.

Analysis of the data Table 14 revealed that correlations between STL and STTL ranged from .46 to .83. The correlation results helped prove that assumptions underlying MANOVA were met and assisted interpretation of quantitative results with descriptive data analysis.

According to Table 14, STL and STTL are correlated. Analysis of Table 16 indicated that STTL influenced schools' leadership and improvement, ICT-related school conditions, and ICT-related teacher (general) conditions. Meanwhile, Table 14 indicated that STL influenced science teachers' ICT-enriched curriculum, ICT learning environment, and ICT competences.

Chapter 4 Summary

Chapter 4 consisted of three layers of data analyses. First, layer one provided the results of the quantitative investigation of the research questions in the present study. The findings were identified and organized based on analysis of the surveys on school technology leadership (STL) and on science teacher technology leadership (STTL). Additionally, quantitative observations conducted in the U.S. and the Chinese schools assisted quantitative data analysis and interpretation. The STL measure was constructed on the basis of the e-capacity model created by Vanderlinde and Braak (2010) while the STTL instrument was created based on the literature review. The exploratory factor analysis, bivariate correlation, ANOVA and MANVOA were applied to quantitative analysis using SPSS 22.0. Secondly, layer two provided results of descriptive investigation of the research questions. The themes were filtered out and the findings were summarized based on analysis of the descriptive data collected by interview, observation, and artifacts review in the eight schools involved in this study. Thirdly, layer three combined quantitative and descriptive analyses to address the three research questions. The quantitative analysis results were presented first and then contextualized by descriptive data examination.

Chapter 5: Summary, Conclusions, and Recommendations

A review of the literature found little empirical research had been conducted to clarify the scope of school technology leadership (Dexter, 2011a; McLeod & Richardson, 2011), the evaluation of science teachers' technology leadership (Smith, 2012), and the correlations between the two leaderships in the context of secondary schools (Kopcha, 2012; Song & Owens, 2011). Specifically, few studies were conducted to investigate school and science teacher technology leaderships across various school grade levels and cultural conditions by use of a quantitative method design (Gay and Airasian, 2003) that focused on quantitative data analysis with descriptive data being used to support quantitatively derived findings about technology leadership. This lack of research was identified as the research problem for this study. Three research questions were formed in order to find solutions to the problem.

Summary and Discussion of the Three Research Questions

This present study investigated school technology leadership, science teacher technology leadership, and their differences across two countries (cultures)—the U.S. versus China—and two school levels—high versus middle schools. This study was about the perceptions of leadership rather than actual leadership measures. A quantitative methods research design was used for this investigation. In the quantitative approach, two surveys were conducted along with the exploratory factor analysis, Pearson correlations, two-way MANOVA and subsequent two-way ANOVA were performed on the two surveys. In the descriptive approach, interview, observation, and artifacts review were carried out in eight secondary schools in order to contextualize the quantitative findings about the school and science teacher technology leaderships. Findings about the three research questions were summarized and discussed.

What do teachers and administrators perceive as salient aspects of STL?

Connecting analyses of quantitative and descriptive data for Research Question 1. Analysis of descriptive studies (interview, observation, and artifacts review) in this study helped contextualize quantitative findings and assisted in addressing Research Question 1. For example, in the study, the participants' raw scores on the factors were found to correlate to descriptive studies in each school. This co-analysis would make it easier to see how the two were connected to each other and help the reader make sense of both sets of data.

Interviews. Two out of the three interviewees at one of the American high schools described the school's technology leadership team as consisting of the principal, tech coordinators, and teachers. Enjoying sufficient and quality ICT devices such as I-Max computers and i-Pads in instruction, the teachers appreciated that their school had a clear ICT vision and policy and a solid ICT infrastructure as shown in their computer-equipped STEM program. Additionally, they believed that ICT-integrated education improved their students' science learning. For example, teachers in the engineering department used both i-pads and desktops to teach bridge design, which increased student interests and participation. In contrast, two interviewees from the other American high school were not sure who the ICT-related decision maker was. They were disappointed with the school's ICT infrastructure and they maintained they had not seen the positive effects of ICTs on students' learning thus far. Middle school responses paralleled high school responses. Two interviewees at one of the American middle schools confirmed that the school's technology leadership was strong. Their ICT infrastructure was sufficient and they believed that educational technologies such as Gizmos improved both teaching and learning in the school. In contrast, two interviewees from the other

American middle school complained about their insufficient ICT facilities, outdated ICT devices, and lacking resources for upgrading ICT-integrated teaching and learning.

In the Chinese schools, science teacher interviewees from one of the high schools believed that technology leadership was distributed among school leaders, technology coordinators, and teachers, whereas teachers at the other Chinese high school claimed that their school's technology leadership was performed by several bureaucratic offices in the school. This school's two interviewees contended that ICT was used only as an information tool rather than a learning tool that directly improved students' science learning and achievement. Teachers in one of the Chinese middle schools stated their school had strong technology leadership; their needs were met by the leadership team. In contrast, their colleagues in the other middle school maintained that their school's technology leadership was limited; city educational bureau and school leaders focused only on academics rather than integration of ICT with education, which rendered that teachers had no laptops and had to share desktops. Additionally, their classroom ICT facilities were installed seven years ago; they were already outdated.

Observation and artifacts. The observations and artifacts review conducted in the U.S. high schools demonstrated that the school where teachers praised their school's tech leadership had better ICT infrastructure: they had four ICT centers with I-Max computers, i-Pads, and 3-D printers just for their STEM program. In contrast, the other American high school had only one ICT center for the whole school. In the U.S. middle schools, the school where teachers praised their school's ICT infrastructure had the school's technology leadership distributed among school leaders, tech coordinator, and teacher representatives. The other middle school, where teachers complained about their school's ICT infrastructure was found to have a leadership performed mainly by the principal in the school.

In the Chinese schools, the high school where teachers praised their school's distributed tech leadership had a broad ICT applications such as an ICT-integrated psychological clinic and e-reading center. Their ICT-related decisions were made among the principal, tech coordinators, and teachers, which was a distributed leadership. By contrast, in the other high school, technology leadership was conducted by a bureaucratic organization of curriculum office, educational research office, and lab office, which was considered as a bureaucratic leadership. In the middle schools, the school where teachers praised their school's tech leadership had their ICT-related decisions made by a leadership team of principal, tech coordinators, and ICT teachers. In contrast, ICT decisions in the other middle school were made by the city bureau of education, school curriculum office and logistic department. This bureaucratic leadership was conducted by officers rather than the integration of school leaders, technology experts, and teachers. Thus, teachers' needs were not addressed in timely manners, which led to outdated ICT facilities and teachers lacking laptops.

Summary of quantitatively-derived findings. Exploratory factor analysis was conducted to reduce sizable numbers of variables into several meaningful clusters that resulted in variance in school technology leadership and science teacher technology leadership. The survey on STL was administered to 87 participants including school principals or assistant principals, technology coordinators, and science teachers who were working with four high and four middle schools in the U.S. and in China. Through the factor analysis of the survey on STL, three factors were salient with STL: 1) technology leadership and school improvement, 2) ICT-related school conditions, and 3) ICT-related teacher conditions. Specifically, the first factor encompassed school leaders' technology leadership approach, their professional relationships with teachers and other stakeholders of ICT-integrated education, and school ICT-related decision making. The second factor contained each school's ICT vision and policy planning; its ICT coordination, professional development, and other technological and pedagogical support for teachers in ICT-integrated instruction; and its ICT infrastructure. The third factor included teachers' interactions with school leaders and other stakeholders in ICT-integrated education, teachers' visions on educational technologies, and their ICT-integrated instruction.

Findings with respect to other data. Descriptive data analysis in this study supported the quantitative study's findings about the scope of STL and content of each factor. For example, interviews, observations, and artifact reviews revealed the types of schools' technology leadership and their influences on school educational changes. The descriptive studies in this study found three types of technology leaderships among the eight schools: 1) distributed leadership, 2) Great-man leadership, and 3) bureaucratic leadership. According to analysis of interviews, observations, and artifacts review, some schools in both the U.S. and China exercised distributed leadership: they considered leadership tasks, aligned the tasks to technology leadership, and distributed technology leadership practice over leaders, followers, and context (Spillane, Halverson, & Diamond; 2004). Descriptive data analysis also revealed that other schools, such as a couple of American schools, exercised Great-man leadership (Carlyle, 1840/2008): the principal or technology coordinator made ICT-related decisions primarily by themselves. Still other schools, such as a couple of Chinese schools, practiced technology leadership by bureaucratic organizational structure—bureaucratic leadership (Pearce & Conger, 2003; St. Thomas University, 2014). In the interviews, some teacher interviewees in the two American schools criticized their schools' technology leadership practices. They remarked that in their schools teachers were out of the decision making process, schools' ICT infrastructure was poor, and their ICT talents were unused in school instruction. Additionally, some teachers in one of the Chinese middle school denounced that their system's bureaucratic technology leadership may have caused them to respond slowly to fast changes in the ICT environment, leading to their outdated ICT-facilities and limited use of ICTs.

Findings with regard to prior research. Some findings sprang from comparing this study with prior research studies in the field. According to the theoretical framework for STL measurement, Vanderlinde and van Braak (2010) theorized four subscales for measurement of school technology leadership that included teachers' actual use of ICT in school as one subscale, which evaluated teachers ICT use in three levels: basic skills, informational tools, and learning tools. The findings of this study indicated that there was alignment between technology leadership approach and school educational changes or school improvement. There were some key constructs that were consistent with Vanderlinde and van Braak's model: 1) ICT coordination and support; 2) ICT vision and policy planning; and 3) ICT infrastructure, as supported by analysis of the findings in this study. However, this present study did not find teachers' basic ICT skills as a factor in the factor solution for STL. This indicated that teachers and administrators in this study stressed teachers' use of ICT as information and learning tools rather than basic computer skills. Moreover, PCA was used to examine the structure validity and the Cronbach alpha analysis was used to determine the reliability coefficients of the STL scale and subscales, which was consistent with Sincar's (2010) study of the inventory of primary school administrators' technology leadership. In Sincar's studies, four factors were identified: human centeredness, vision, communication and cooperation, and support. These factors were quite different from the factors in the factor solution for STL in this study. For example, Sincar's first factor—"human centeredness"—was not shown in the factor solution of this study. This indicated that teachers and administrators in this study did not see leaders' human centeredness as a salient aspect for STL. However, this study reflected importance of ICT vision, professional communication, school coordination and support, which were consistent with Sincar's factors. Because Vanderlinde & van Braak's model and Sincar's inventory were both originated for evaluation of primary school technology leadership, the differences between these models and this study indicated that secondary school teachers and administrators may have different perspectives of STL compared with primary school respondents. For example, they did not see leaders' human centeredness and teachers' actual use of ICT as salient aspects of school technology leadership.

What do teachers perceive as salient aspects of STTL?

Contextualizing quantitative results with descriptive data for Research Question 2. Analysis of descriptive studies (interview, observation, and artifacts review) helped contextualize quantitative findings and assisted in addressing Research Question 2.

Interviews in the U.S. schools. Interviews conducted in the U.S. high schools revealed that the two U.S. schools' science teachers had substantial differences in their ICT learning environment, competence, and curriculum. In the school that received higher raw scores in STL, technology coordinators had advanced degrees with specific training in ICT, so they could provide teachers with on-site training and support for new software and other ICT applications.

Additionally, the school had faculty members in the fields of science, technology, engineering, and math. Taking advantage of their strong expertise in ICTs, these STEM teachers integrated computers with school education at a high level. For example, they had four ICT centers with more than 200 computers in the areas of information medium, engineering, and logistics besides natural science. In contrast, the other American high school had only six science teachers teaching five natural science subjects. According to two interviewees from this school, science teachers in the school only used basic ICT skills—computers and internet. Additionally, in contrast, this U.S. high school had to invite software vendors to offer teachers training on campus. These vendors know ICT equipment well, but they may lack the skills necessary to integrate technology, pedagogy, and academic content.

Interviews in the Chinese schools. Interviews conducted in two Chinese middle schools helped clarify some confusions that were involved in quantitative studies. Although one of the two schools' scores on technology leadership, ICT-related school conditions, and ICT-related teacher conditions were all lower compared with the other school in STL measurement, this school science teachers' scores in ICT learning environment, competence, and curriculum were still higher than those of the teachers in the other Chinese middle school. This school science teachers' strong competence in integration of ICT with pedagogy and content as well as their great effort in integrating ICT with curriculum may help explain the remarkable difference in their STL and STTL measurements. This school's science teachers must pass their school's strict evaluation of their academic competence; moreover, schools' science curriculum must pass the city educational bureau's evaluation. Additionally, the teachers in this school worked hard in order to enrich their existing curriculum with new and innovative ICT resources. One of the interviewees in the school recalled that he and his colleagues worked as a team to create curriculum plans with ICT links. A couple of years ago, they used computers and the internet to search ICT resources. Each teacher located some ICT sources for the curriculum plans allotted to her or him. They finally created collections of videos, audios, and pictures for each part of the curriculum. Since then, they had shared and kept updating the tech-enriched curriculum and associated materials for science instruction. This may explain why this school's STL scores were lower compared with the other Chinese middle schools, but its STTL scores were still higher compared with the teachers in the other school.

Summary of quantitatively-derived findings. Like factor analysis of STL measurement, an exploratory factor analysis was conducted with STTL survey data. The survey of STTL was conducted with 76 science teachers who were working within the eight schools in the U.S. and China. The final factor solution of STTL consisted of three factors: 1) ICT learning environment that encompassed academic standards, curriculum, ICT tools, training and communication, and science teachers' ICT-integrated instruction; 2) science teachers' competence in ICT and its integration with pedagogy and science content; and 3) science teachers' ICT-enriched curriculum and their ICT-integrated instruction. The internal consistency coefficients of the STTL subscales ranged from .84 to .94; the Cronbach alpha reliability of the whole scale of STTL was .95. Descriptive data analysis in this study was found to support quantitative study's findings about the scope of STTL and content of its three factors.

Findings with respect to other data. Interviews were conducted with two science teachers in each of the eight schools in the U.S. and China. Analysis of the interview data helped identify some findings with STTL. First, science teachers emphasized that ICT learning environments influenced teachers' technology leadership. They believed that a great ICT learning environment such as online learning with simulated labs would allow teachers to use educational technologies to increase their productivities and boost their integration of ICT with science instruction and students' learning. They also maintained that school leaders' technology leadership and schools' ICT infrastructure influenced construction of teachers' ICT learning environments. Second, science teachers confirmed the importance of ICT competence of teachers in their technology leadership. They maintained that a science teacher's ICT competence in a digital world depended on how well they integrated ICT, pedagogy, and science content in their instructions. They attributed their ICT skills not only to their college educations but also to their schools' professional development and their self-practice. Third, science teachers stressed the critical role of an ICT-integrated curriculum in their technology leadership. They contended that an ICT-integrated curriculum guided them to integrate ICTs with their instruction and facilitated students' science learning. For example, in one of the Chinese middle schools, science teachers worked in teams to enrich curriculum with ICTs. Their videos and pictures collected from online increased students' understanding of science content.

Findings with regard to prior research. Some findings were developed by comparison of this study with prior research studies. Leithwood and Mascall (2008) studied collective leadership effects on student achievement. They found that teachers' educational performance was affected by their setting, motivation, capacity, and shared leadership. Most of these constructs such as setting, capacity, and shared leadership were consistent with this present study. First, teachers' ICT learning environment was found to be salient with STTL in this study. Its alpha coefficient was .94, which ranked as the first factor of STTL and was consistent with Leithwood and Mascall's findings about teachers' settings. This indicated that the ICT learning environment was actually a teacher's setting to perform their technology leadership. Second, this study showed that the second factor was science teachers' ICT competence and was consistent with teachers' capacity as described by Leithwood and Mascall. Additionally, Vanderlinde and van Braak did not study STTL specifically, but they stressed the effect of teachers' ICT competence on STL (2010). They suggested that teachers' ICT competence was a key factor in school technology leadership. Third, the third factor salient with STTL was ICT-enriched curriculum, which was not reflected in Leithwood and Mascall's results. However, it was emphasized by Vanderlinde and van Braak (2010), who put ICT curriculum implementation at the center of their e-capacity model. Additionally, this study's assignment of teachers' ICT competence as a critical factor for their technology leadership was consistent with the TPACK model (Yurdarkul et al, 2012). Based on the interviews in this study, science teachers believed that ICT and its integration with pedagogy and content was the core of teachers' educational competence.

How does STL and STTL differ across country and grade-level contexts?

Analysis method for addressing this question. MANOVA and ANOVA were used in this study to test the main and interaction effects of country and grade on STL and STTL. This application fit requirements of MANOVA for variables (Hair et al., 2010) because country and grade were categorical independent variables (IVs) while STL, STTL, and their factors were multiple dependent interval variables (DVs). Additionally, assumptions underlying MANOVA and ANOVA were checked to be fundamentally met in this study. Two-way MANOVA (multivariate analysis) and subsequent two-way ANOVAs (univariate tests) were found to be powerful tools for analysis of quantitative data. MANOVA respects the data's multivariate nature by taking advantage of the correlation among DVs and honors the reality that one IV (either country or grade in this study) often affect the subjects in more than one way, hence needing several criterion measures. Additionally, based on the Bonferroni correction (Goldman, 2008), a more rigid alpha testing—α is equal to .05 divided by the number of DVs—was used in the subsequent two-way ANOVAs univariate tests. This integrative procedure helped address Research Question 3.

The respondents' factor scores provided by SPSS factor score calculations were used for MANOVA and ANOVA analysis. Factor scores, rather than raw scores, were applied to MANOVA and ANOVA because a factor score for an individual respondent can be computed using a linear combination of the items that load on the factor of interest (Pett, Lackey, Sullivan, 2003). According to Pett et al., because the principal component analysis was used in the factor analysis of the study, it enabled the researcher to obtain exact factor scores on a particular factor. Moreover, a respondent's factor scores were generated by standardizing all of that individual's raw scores on the measures, weighting by factor score coefficient, and then summing across all items. Therefore, using factor scores decreased errors that were involved in the process of MANOVA. As a matter of fact, MANOVA with factor scores provided this study with a more elegant evaluation of the main effects and interaction effect on STL and STTL.

Quantitative findings with STL across country and grade. Two-way MANOVA multivariate tests and continual univariate ANOVAs or two-way ANOVAs were conducted with the individuals' factor scores to clarify the main effects of culture, grade, and the interaction of the two on school technology leadership. For analysis of STL and its factors, MANOVA multivariate tests revealed the main effects of country and grade on STL. In contrast, no interaction effect of country and grade was found in the results of STL MANOVA. Additionally, subsequent two-way ANOVAs revealed that only the main effect of country on ICT-related school conditions was significant. Under the scrutiny using Bonferroni procedure (Goldman, 2008), other effects were not supported by the data. This analysis indicated that the Chinese schools' ICT-related school conditions—ICT vision and policy, ICT infrastructure, professional development and other support in technology and pedagogy—were stronger than the ones in the U.S. schools (see Table 8).

MANOVA and ANOVAs displayed an interesting differentiation of schools' STL across grade levels. In the overall scale raw scores comparison, middle schools showed a higher average score compared with high schools irrespective of country. Additionally, analysis using the procedure of MANOVA and subsequent ANOVAs revealed that middle schools had received higher average factor scores in all three factors compared with high schools regardless of the schools' country categorization. However, the main effect of grade on STL was not found by using the procedure. Descriptive data analyses in this study were found to support some of the quantitative findings and to contradict some other findings about STL and STTL across country and grade.

Findings with respect to other data for STL across country and grade. Interviews, observations, and document reviews conducted in the U.S. and Chinese schools revealed several findings for addressing Research Question 3. First, both the U.S. and Chinese schools were found to relate their technology leadership and educational changes or school improvement. According to Spillane et al.'s (2004) definition of distributed leadership, this type of technology leadership was identified in several of the schools in both countries, though it was not found in others. Instead, these schools displayed *Great man* leadership (Carlyle, 1840/2008) through the principal or bureaucratic leadership through bureaucratic organizations. Second, the U.S. school leaders and teachers emphasized the role of ICTs in school education. In contrast, although most of the Chinese counterparts' ICT visions were positive, some were still unsure about positive effects of ICTs on education when discussing the role of ICT on secondary education. For example, some senior Chinese teachers stuck to traditional textbooks and labs rather than ICT-integrated instruction with simulated labs. Third, as revealed by artifacts review, most of the U.S. schools had ICT policy planning. For example, one of the American high schools had both long- and short-term planning for their ICT policies. For example, this school's technology coordinator provided the researcher with their ICT planning in this school year and next several years. By contrast, Chinese schools had only short-term plans, lacking planning such as ICT financial planning in a long run. Fourth, according to analysis of observations, the U.S. schools had relatively strong ICT infrastructure. For example, this school's ICT-integration instruction covered subjects in STEM; they aligned their students' learning to college preparation. In contrast, Chinese schools' ICT infrastructure was relatively weak, as exemplified by their lower computer-to-student ratios and computer-to-classroom ratios compared with their U.S. counterparts. One of Chinese middle schools demonstrated this weak infrastructure particularly well, as low computer-to-teacher ratio and computer-to-student ratio stood out in contrast to its solid academic program. Fourth, Chinese schools had some strengths in ICT-related school conditions: their professional development and ICT-enriched curriculum. Each of the Chinese schools was found to have an ICT department. The faculty members in the department were experts in ICT-integrated education. They not only helped other faculty members with technological and pedagogical support but also offered information technology courses to their students. This practice was not found in the U.S. schools. Thus, it may explain why Chinese schools received higher scores in STL ICT-related school conditions factor than their counterparts in the U.S. did. In conclusion, these analyses indicated that schools in both countries had their own strong and weak points in ICT-related school conditions. Chinese schools' centralized curriculum verses the U.S. schools' more localized curriculum may partially explain why the U.S. schools received substantially lower scores in ICT-related school conditions compared to Chinese counterparts. However, more research may need to be carried out on this topic.

Quantitative findings with STTL across country and grade. Like analysis of STL measurement, MANOVA multivariate tests, and continual univariate ANOVAs were conducted with STTL measurement to check the main effects of culture, grade, and the interaction effect of the two on science teacher technology leadership. MANOVA multivariate tests revealed statistical significances of the two main effects of culture and grade, together with their interaction effect on STTL. However, subsequent two-way ANOVAs revealed the statistical significance of the main effect of country on ICT learning environment and science teacher ICT competence as well as interaction effect of country and grade on ICT-enriched curriculum, whereas the univariate ANOVAs failed to reveal any significant main effect of grade on STTL. Specifically, according to descriptive statistics of the factor scores (see Table 11), Chinese school science teachers' ICT learning environment was stronger compared with the U.S. teachers', whereas the U.S. school science teachers' ICT competences were higher compared with the Chinese teachers. Additionally, the statistically significant interaction effect of country and grade on ICT-enriched curriculum indicated that the differences in ICT-enriched curriculum between the U.S. and Chinese science teachers depended on their grade levels.

Like in STL analysis, MANOVA and ANOVAs displayed an interesting differentiation of schools' STTL across grade levels. In the overall scale raw scores comparison, high school teachers showed a higher average score than the middle schools did when ignoring the schools' membership in either country. Additionally, analysis using MANOVA and subsequent ANOVAs revealed that high schools' science teachers had received higher average factor scores in two out of the three factors compared with teachers in the middle schools, regardless of the schools' country categorization. However, the main effect of grade on STTL was not found by using this procedure.

Findings with respect to other data for STTL across country and grade. Descriptive data analysis in this study may also help explain country's main effect and interaction effect on STTL factors for addressing Research Question 3. First, for ICT-learning environment, interviews, observations, and artifact review revealed that science teachers in Chinese schools had provincial academic standards, ICT-enriched curriculum, classroom disciplinary climate, and teachers' self-efficacy. Even though their ICT infrastructure was relatively weaker compared with teachers in U.S. schools, the professional development they received was strong. Most impressively, they focused on integrating the ICT facilities within the curriculum to maximize ICT-integrated instruction. Thus, their ICT-learning environment was strong—perhaps stronger than their American counterparts. This may explain the Chinese schools' higher score in ICT learning environment. Second, for science teachers' ICT competence, descriptive data analysis revealed that American science teachers enjoyed higher level of ICT infrastructure compared with their Chinese counterparts. For example, in one of the U.S. high schools, science teachers enhanced their ICT competences by taking advantage of their high-quality computers, a rich spectrum of software, and computer-based assessment, which was not found in the Chinese schools. This may explain the U.S. schools' higher scores in teachers' ICT competence. Third, for science teachers' ICT-enriched curriculum, descriptive data analysis revealed that Chinese science teachers made great effort to search relevant ICT resources and link them to their existing curriculum. For example, science teachers in one of Chinese middle schools worked hard in team to create ICT-enriched curriculum plans, keeping an ongoing updating process in order to maintain the ICT-linked curriculum at a high level. This process of upgrading curriculum with ICTs was emphasized by all other schools in China. Additionally, they all added ICT as a mandatory course to their curricula. These practices may explain the Chinese schools' high scores in ICT-enriched curriculum. However, the interactive effect of country and grade on the curriculum was complex, which was shown by both quantitative and descriptive studies. Thus, more studies may be needed in the future.

Findings with respect to prior research about STL and STTL. In case studies of three Flemish schools, Vanderlinde, van Braak, and Dexter (2012) found that significant differences appeared in various schools' ICT policy planning conditions. Additionally, they contended that school ICT policy was related to the school's culture and climate. In this study, they also discovered that school culture and classroom climate may affect school and science teacher technology leaderships. For example, descriptive studies in this study revealed that two American high schools had different classroom climates, which may result in their substantially different average scores in STL and STTL. Meanwhile, the four U.S. schools had American culture while the four Chinese schools had Asian culture; their cultural difference may influence their various STL and STTL scores. For example, the U.S. schools' flexible culture and tolerant classroom climate was found to be contrasted with the Chinese schools' rigid culture and disciplinary climate. This contrast may explain their differences in both STL and STTL. For example, descriptive examination of the study found that the U.S. schools had more supportive ICT policies compared with Chinese schools'. Thus, more research studies on acceptable use policies using a larger sample size may be needed in the future.

Correlations between STL and STTL. Bivariate correlation analysis helped clarify the relationships between STL and STTL and their factors. The correlations categorized in the very strong category ($p < .01$) include leadership and school improvement and ICT-enriched curriculum ($r = .83$, $p < .01$), STL total and STTL total ($r = .81$, $p < .01$), leadership and school improvement and STTL total ($r = .78$, $p < .01$), and ICT learning environment and STL total ($r = .78$, $p < .01$). Several findings can be summarized on the basis of bivariate correlation results. First, school technology leadership and school improvement was strongly correlated with science teachers' ICT curriculum. Second, school technology leadership and science teacher technology leadership was strongly correlated. Third, school technology leadership and school improvement was strongly correlated with science teachers' technology leadership. Fourth, science teachers' ICT learning environment and ICT-integrated instruction was strongly correlated with school technology leadership.

Findings with respect to other data about STL and STTL correlation. Interviews, observation, and artifacts review displayed that STL and STTL were positively correlated. First, in most schools in this study, science teachers who highly valued their own technology leadership in the interviews praised their schools' STL higher compared with the science teachers who lowly evaluated their technology leadership. They believed that their technology leadership contributed to and hence affected STL, especially in the factor of leadership approach and school improvement. For example, science teachers in one of American high schools believed that their ICT competences advanced the whole school's level of ICT-integrated instruction. Second, most science teachers contended that a school with strong school technology leadership provided a context in which science teachers received quality ICT facilities, professional development, and technological and pedagogical support. These effects would increase science teachers' STTL. Particularly, science teachers maintained that a strong STL would help them to develop their own technology leadership, construct a stronger ICT-enriched curriculum, and provide a better ICT-integrated instruction.

Findings with respect to prior research about school/teacher leadership correlation. Interestingly, I found some consistency between the results of this study and Leithwood and Mascall's empirical study about educational leadership in their correlation section: they found that school distributed leadership correlated with teachers' competence ($r = .36$, $p < .01$) and their motivation ($r = .55$, $p < .01$). This was the first finding in correlation analysis, as shown above. Additionally, their teachers' shared leadership correlated with the setting or school conditions. This study's finding was similar to theirs: STTL was correlated with school conditions ($r = .69$, $p < .01$). Although their study was about educational leadership while this one focused on technology leadership, the comparison indicated that these two leaderships shared some characteristics or properties. That is, they were correlated. The correlation between

STL and STTL was also reflected in Vanderlinde and van Braak's studies (2010). Although they did not specifically study STTL, their results showed a significant correlation (r = .75) between teachers' professional development in ICT—one component of STL (ICT school conditions)—and teachers' ICT competencies, one component of STTL. The correlation results of this study are also consistent with Chang's findings (Chang, 2012): school leaders' technology leadership influences science teachers' technology leadership; school leaders encouraged teachers to improve their ICT competences and supported teachers to integrate technology with their curriculum and instruction. In turn, teachers' technology leadership affected their construction of learning environments and their instructional effectiveness. School leaders' ICT vision influenced schools' ICT policies that affect teachers' ICT-related conditions, improvement and development of school education.

Participating schools' STL. The eight schools' average scores on the factorized STL scale and its subscales were compared and summarized. Several findings were identified. First, in the U.S. schools, middle schools' mean scores were higher compared with high schools'. Likewise, Chinese middle schools' mean scores were also higher compared with high schools'. This indicated that middle schools scored higher in STL measurement than high schools regardless of countries in this study. Second, at the high school level, the Chinese schools' mean scores were higher compared with the U.S. schools. Similarly, in the middle school level, the Chinese schools' mean scores were also higher compared with the U.S. schools. This indicated that Chinese schools scored higher on average than the U.S. schools in STL measurement regardless of grades.

Participating schools' STTL. Each of the eight schools' average scores on a factorized STTL scale and its three subscales were analyzed. These schools' science teachers' ICT learning environments, ICT competences, and ICT-enriched curriculum, as well as their overall technology leadership in ICT-integrated instruction, were compared. Some findings were identified. First, in both the U.S. schools and Chinese schools, high school science teachers' mean scores were higher than those of middle school teachers. This indicated that high school science teachers scored higher in STTL measurement than their middle school counterparts, regardless of countries in this study. Second, at both the high school and middle school level, Chinese science teachers' mean scores were higher than those of U.S. science teachers. This indicated that Chinese schools scored higher on average than the U.S. schools in STTL measurement, regardless of grade level.

Findings with respect to other data about participating schools' STL and STTL. In this study, interviews identified several findings about participating schools' and science teachers' technology leaderships. Observations and artifacts review complemented these findings.

In the interviews, science teachers at one of the U.S. high schools highly appreciated the school's distributed technology leadership, ICT infrastructure, and ICT-enriched curriculum and positively evaluated their own technology leadership, whereas science teachers at the other American high school complained about their limited ICT infrastructure and low level of integration of ICT with existing curriculum and gave low evaluation of their technology leadership. Similarly, teachers at one of the U.S. middle schools positively commented on their school's technology infrastructure and effects of ICTs on their students' learning in science, whereas teachers at the other U.S. middle school complained about the school's insufficient ICT infrastructure and investment on ICT device purchase and maintenance. In the interviews conducted in the Chinese schools, teachers at one of Chinese high schools were more enthusiastic about the use of educational technologies than the teachers at the other Chinese high school were. One of the Chinese middle schools displayed better ICT infrastructure compared with the other middle school; this school's science teachers also exhibited more enthusiasm in ICT-integrated instruction.

In the observation and artifacts review, the following findings were identified. First, the U.S. schools were found to have stronger ICT infrastructure, with more and better quality of ICT tools and devices compared with Chinese schools. For example, the U.S. schools had higher computer-to-student ratios than the Chinese schools: the U.S. schools' ratios ranged from 0.3:1 to 0.7:1, which was about 6 times higher than the Chinese schools' ratios. Additionally, U.S. students had access to higher quality ICT devices, like laptops and media carts, than Chinese students did. The U.S. schools' AUPs were generally more facilitating and practical than the AUPs of the Chinese schools. For the U.S. schools, the purposes of AUPs were facilitating school education. For Chinese schools, AUPs were limited, so students could not benefit from their own ICT devices during weekdays. However, analysis of observation and artifacts data revealed that Chinese schools had their strong points as well. Generally, they had solid ICT vision, curriculum, and professional development programs. For example, there was an information technology department in both high and middle Chinese schools. Teachers in the department were experts who provided school teachers and administrators with both technological and pedagogical support for ICT-integrated instruction. Meanwhile, they provided school students with ICT courses as mandatorily required by the curriculum. Thus, Chinese teachers used existing ICTs in their schools to high capacity.

As the effect of grade on STL and STTL was concerned, observation and artifacts data revealed that high schools had some specific centers for ICT applications. For example, the U.S. high schools had ICT centers for information medium, engineering, and logistics. The Chinese schools also had ICT centers. For example, one of Chinese high schools had an ICT psychological clinic center where psychologic teachers or doctors could diagnose and treat students' psychological problems with ICT tools. In contrast to high schools, both the U.S. and Chinese middle schools focused on investing more on ICT facilities in their computer rooms and regular classrooms.

Findings with regard to prior research on tech leadership in individual schools. Importance of the relationships among curriculum, leadership, and school's core technology had been emphasized by Doolittle & Browne (2011). This present study confirmed the important roles of these key constructs in school technology leadership and science teacher technology leadership. Dexter (2011a) discovered that team-based leadership approaches ensured implementation of a complex school improvement effort. This present study found that distributed technology leadership maximized ICT-integrated educational changes and school improvement. In contrast, Great man leadership may cause an unsustainable ICT environment in schools, and bureaucratic leadership causes schools' slow responses to the environment in a digital world. Additionally, Dexter found key technology leadership practices that included sharing an ICT vision, providing instructional support, aligning technology resources to the curriculum, and ensuring teachers' opportunities to learn, share, and provide input to the leadership team. These artifacts were all identified by this present study and included in the factors of the STL and STTL measurements.

Contextualizing quantitative results with descriptive data for Research Question 3. Analysis of descriptive studies (interview, observation, and artifacts review) in this study helped contextualize quantitative findings and assisted in addressing Research Question 3. Some differences in the contexts between the U.S. and China were found in this study. Examining these differences help contextualize quantitative data with descriptive data. First, the U.S. and China have different cultures and participants from the two countries had dissimilar personalities. The American participants were found to express their opinions and evaluations of STL and STTL more openly while Chinese participants were reluctant to directly criticize. This may help tease out the effect of culture limiting self-reporting on data of the study. Second, the two countries have different curricula in their school education. In China, the curricula were more centralized at the provincial or national level, whereas the U.S. schools had a more localized approach. This may impact integration of ICT in school education.

Descriptive data examination for STL. Interviews, observations, and document review conducted in U.S. schools and Chinese schools revealed several points for addressing Research Question 3. First, both the U.S. and Chinese schools were observed to connect their technology leadership and educational changes. According to Spillane et al.'s definition of distributed leadership (2004), this type of technology leadership was identified in some of the schools in both countries, even though it was not in all of the schools. Second, the U.S. school leaders and teachers had a clear ICT vision; they emphasized the role of ICTs in school education. In contrast, although most of the Chinese counterparts' ICT visions were positive, some still got confused or even had a negative attitude when discussing the role of ICT in secondary education. Third, as revealed by artifacts review, most of the U.S. schools had ICT policy planning. For example, one of the American high schools had a long-term plan for their ICT policies. In contrast, Chinese schools had only short-term plans, lacking planning such as ICT financial planning in the long run. Fourth, according to analysis of observations, the U.S. schools had relatively strong ICT infrastructure. For example, one of the U.S. high Schools' ICT-integration instruction covered subjects in STEM; teachers and administrators there aligned their students' learning to college preparation. In contrast, Chinese schools' ICT infrastructure was relatively weak, as exemplified by their lower computer-to-student ratios and computer-to-classroom ratios compared with their U.S. counterparts. One of the Chinese middle schools embodied this dissimilarity; despite having a solid academic program, it suffered from a lack of ICT infrastructure. However, Chinese schools had some strengths, namely their professional development and ICT-enriched curriculum. Each of the Chinese schools was found to have an ICT department. The faculty in the department were experts in ICT-integrated education. They not only helped other faculty members with technological and pedagogical support but also offered students information technology courses. This practice was not found in the U.S. schools. The difference may be connected to more centralized curriculum in Chinese schools and more localized approach in the U.S. Thus, it may explain why Chinese schools received higher scores in ICT-related school conditions than their counterparts in the U.S. did. Overall, these analyses indicated that schools in both countries had their own strong and weak points in ICT-related school conditions. This made it hard to explain why the U.S. schools received substantially lower scores in ICT-related school conditions compared to Chinese counterparts. More research may need to be carried out on this topic.

Descriptive data examination for STTL. Descriptive data analysis in this study may also help explain the main effect of country and interaction on STTL factors for addressing Research Question 3. First, for ICT-learning environment, interviews, observations, and artifact review revealed that science teachers in Chinese schools had solid academic standards and ICT-enriched curriculum. Even though their ICT infrastructure was relatively weaker than that in the U.S. schools, the professional development they received was strong. Most impressively, they focused on integrating the ICT facilities within the curriculum to maximize ICT-integrated instruction. Thus, their ICT-learning environment was strong—perhaps stronger than their American counterpart. This may explain the Chinese schools' higher score in ICT learning environment. Second, for science teachers' ICT competence, descriptive data analysis revealed that American science teachers enjoyed a higher level of ICT infrastructure compared with their Chinese counterparts. For example, in one of the U.S. schools, science teachers enhanced their ICT competences by taking advantage of their high-quality computers, a rich spectrum of software, and computer-based assessment, which was not found in the Chinese schools. This may explain the U.S. schools' higher scores in science teacher ICT competence. Third, for science teachers' ICT-enriched curriculum, descriptive data analysis revealed that Chinese science teachers made great efforts to search relevant ICT resources and link them to their existing curriculum. For example, science teachers in one of Chinese middle schools worked hard as a team to create ICT-enriched curriculum plans. They kept an on-going updating process in order to maintain the ICT-linked curriculum at a high level. This process of upgrading curriculum with ICTs was emphasized by all other schools in China. Additionally, they all added ICT as a mandatory course to their curricula. These practices may explain the Chinese schools' high scores in ICT-enriched curriculum. However, the interactive effects of country and grade on the curriculum were complex, as shown by quantitative studies of this study. Thus, more studies may be needed in the future.

Implications of the Study

For research. The presented study indicated that Vanderlinde and van Braak's e-capacity model was a great theory for measurement of school technology leadership. However, this study implied that Vanderlinde and van Braak's model may need to be modified for measurement of secondary school technology leadership. For example, teachers' actual use of ICT was not considered as the salient aspect of STL for participants in this study. Rather, it took leadership approach and educational changes as important factors. Thus, the theory should be continually developed. Based on quantitative and descriptive studies in this study, two arguments are presented: First, school and teacher technology leaderships are correlated, but they are not equivalent. Mixing the two measures in one scale may cause misunderstanding of some critical characteristics of each. For example, this study showed that STL and STTL were correlated, but different in many aspects. For instance, general teachers' conditions as measured by e-capacity model cannot exactly represent science teachers' ICT learning environment and their ICT-integrated instruction. Second, measurement of school technology leadership in primary schools may differ from secondary schools' technology leadership measurement. Using the same scale for measurement of technology leadership in a variety of schools and teachers in different grade levels may be inappropriate. The e-capacity model was generated and used for measurement of ICT effect on elementary or primary schools' improvement and policy planning (Vanderlinde & van Braak's, 2010; Vanderlinde, van Braak, & Dexter, 2012). However, the present study revealed that in secondary schools the focus may need to be shifted to a more comprehensive, higher level of measurement because of their more sophisticated ICT infrastructure and higher need for professional development compared with primary schools.

The data in this study suggest that the measurement of science teachers' technology leadership should be constructed by incorporating relevant research models or theories. For example, on the basis of the TPACK framework (Keating and Evans, 2001), Yurdakul et al. (2012) developed a scale for measurement of preservice teachers' educational competence. Researchers' development work on this theory included the following major stages: 1) they enriched constructs in the original model from two terms—pedagogical technology knowledge (PTK)—to three terms of pedagogy, technology, and content (PTC); 2) they clarified the term technology as informational and communication technology (Angeli & Valanides, 2005; Margerum-Leys & Marx, 2002); 3) they formally defined the model TPACK (Koehlerr & Midhra, 2009); and 4) they developed a scale for measurement of TPACK (Yurdakul et al., 2012). This conceptual development process reflected the fast going status of ICT and its deep diffusion in educational changes. The data in this study suggest that TPACK is useful for identifying salient aspects of teachers' technology leadership measurement in school education. Factor analysis revealed that science teachers' competence was a critical factor that covers teachers' capability of integrating ICT, pedagogy, and science content in science education. In the interviews, most teachers contended that teachers' ICT competence was very important in the digital world. Most interviewees ranked technology as the most important component in science teachers' competence. Summarizing their responses suggests more research questions for educational researchers. For example, 1) How should one integrate ICT, pedagogy, and content strategically as a teacher leader? 2) What other constructs should be covered in ICT competence? 3) Are there any other salient aspects of STL and STTL?

For practice. This study provided a systematic study of school technology leadership together with school science teacher technology leadership. Some implications for educational practice arose.

For school leaders. Several implications were obtained for school leaders. First, school leaders' technology leadership is important for ICT-integrated education in school. This study implicated that a distributed, supportive, achievement-oriented leadership (Spillane, 2005) helped with schools' development of ICT-integrated education from a school improvement perspective. However, Great man leadership—a leadership centralized at the hands of the school principal—and bureaucratic leadership—a leadership shared by several offices in a bureaucratic school structures or systems (Leithwood & Mascall, 2008; Overbay, Mollette, & Vasu, 2011; Pearce & Conger, 2003)—may impede schools' development and improvement in a digital age. Second, taking a distributed leadership perspective, school leaders should pay attention to leadership practices or ICT-related school conditions that include a school's ICT vision and policy planning, ICT infrastructure, professional development and other technological and pedagogical support for teachers in ICT-integrated instruction. A school's clear vision on ICT-integration is a foundation that may generate both long and short ICT policies guiding its improvement and development. Implementation of strategic ICT policies may lead to a strong school ICT infrastructure. In order to take advantage of the solid ICT infrastructure for sustainable school development, the school must have a strong professional development program that can provide teachers and staff with effective technological and pedagogical support. Third, to additionally support distributed leadership practices, school leaders should attend to ICT-related teacher conditions in their school. They need to interact with teachers, students, parents, ICT vendors and community leaders actively. This active interaction with stakeholders in ICT-integrated education may help school leaders examine whether teachers' ICT vision is aligned with the school's, and whether teachers effectively used ICTs to the school's ICT capacity in support of students' learning in line with the school's improvement and development goals. School leaders must be great coordinators (Banoglu, 2011).

For science teachers. Some implications were also obtained for science teachers. First, science teachers must actively and strategically construct their ICT learning environment. They need to take advantages of their schools' ICT infrastructures for construction of ICT-supported learning environments (Chang, Chen, Lin, & Sung, 2008; Wu, 2010). As shown by factor analysis, this study indicated that science teachers' learning environments are critical for their ICT-integrated instruction. Additionally, science teachers' ICT-learning environments include academic standards, curriculum, ICT tools, training and communication. Most interviewees in this study contended that science teachers are supposed to be ready to shift from a teacher-centered learning mode in a traditional learning environment to a student-centered learning mode in an ICT-supported learning environment. However, some interviewees argued that in an ICT learning environment, teacher-centered and student-centered modes should be alternated depending on the content topics. Second, science teachers should take all opportunities to improve their ICT competence. This competence includes not only proficiency with ICT itself, but also the integration of ICT with pedagogy and science content in teachers' ICT-integrated instruction. Most interviewees ranked ICT competence as the vital factor that influenced their ICT-integrated instruction. However, they cited divergent ways of gaining their ICT competences: college education, professional development, self-education and practice. Third, science teachers should attend to the role of their ICT curriculum in their ICT-related instruction and make real efforts to enrich their curriculum with ICTs. According to the results of the study, three levels of work can be done in this area: 1) If an existing curriculum has no ICT linkage, science teachers should find quality sources of ICT information and set up ICT links to the curriculum; 2) If the ICT links in their current curriculum were outdated, they should keep locating the fresh ICT links because ICTs are continually changing; and 3) They should not only use the ICT to implement exiting curriculum—instead, they need to integrate ICTs with the curriculum and reform it in alignment with educational goals (Gerard, Varma, Corliss, & Linn, 2011).

For education and training. For educational practitioners and trainers, some implications have been derived from this study. First, school technology leadership and science teacher technology leadership are two correlated domains, so educators should envision the correlation of the two and approaches to get the synergy from the integration of the two. Second, educators and trainers should recognize the critical role of ICT in today's school education (Gerard, Varma, Corliss, & Linn, 2011). They should understand and teach how to foster and develop positive school and teacher technology leadership. They need to show beginners how to accomplish a distributed, supportive, and achievement-oriented technology leadership. They may use several approaches: 1) aligning ICT with school improvement goals; 2) examining school's ICT vision, ICT infrastructure, and professional development programs; and 3) developing teachers' levels in their ICT visions, their ICT skills, and their interactions with school leaders and other stakeholders for ICT-integrated education. Third, educators and trainers should recognize the important role of teachers' technology leadership in today's school education. They may focus on development of that leadership. Specifically, they need to show how to build up teachers' ICT learning environments; develop teachers' ICT competence; and upgrade ICT curriculum to guide ICT-integrated education. Educators and trainers should be experts in both technology and pedagogy. Thus, they can provide teachers with sufficient educational technology training in order to assure that the trainees can skillfully integrate a school's ICTs with instruction.

For educational policy. Some implications were drawn for policymakers. The first one is about AUPs for ICTs in schools. The second one is pertinent to ICT policy planning.

Acceptable use policies. The present study showed that a school's AUPs are critical for the school's development in its e-capacity. For example, interview, observation, and artifacts review revealed that in general, the U.S. schools' AUPs are more favorable for students' use of ICTs on the campus, and the U.S, schools' ICT infrastructure was stronger than that of the Chinese schools (Tang, interviews, observations & artifacts, 2015). This implied that more facilitating AUPs may have helped the U.S. schools in ICT-integrated instructions. Thus, policymakers may need to make more appropriate AUPs in order to develop school's capability of using ICT as a lever for educational change.

ICT policy planning. This study indicated that schools' policy planning is critical for their e-capacity construction and school improvement. Making appropriate ICT policies is a systematic engineering process (Vanderlinde, van Braak, & Dexter, 2012). First, a school must have clear policy for ICT vision development. For example, one of the U.S. high schools in this study had a vision development plan, so they constructed a STEM program that was equipped with strong ICT facilities outstanding in the district. This helped lead the growth of the whole school's e-capacity. Second, schools' ICT curriculum policy is the central part of the ICT policy planning. As shown by Vanderlinde & van Braak (2010), the ICT curriculum policy was the core of the e-capacity model. For example, science teachers in one of Chinese high schools created ICT-linked curriculum with a collection of videos, audios, and pictures, and enforced updating on an ongoing basis. Their solid ICT-enriched curriculum guided their great performance in science instruction. Third, when a school's vision and curriculum are established, its financial planning should be in place for substantial development of its infrastructure. For example, one of the U.S. high schools had a financial plan for ICT infrastructure early among the U.S. schools, so the school's e-capacity was well developed. Fourth, ICT infrastructure planning is another important part of the ICT policy planning. Policymakers should focus on this part of planning because school ICT infrastructure provided a stage for teachers and students to perform ICT-integrated teaching and learning. The infrastructure must fit the school's improvement and development goals. Symbolically, too large a stage with a small lay waste to resources while too small a stage with a grand play may cause the play to end up with an impossible mission. For example, one of Chinese middle schools had a good team of science teachers, but their short ICT infrastructure rendered the school to poor ICT-related conditions. This can be symbolized as good players dancing on a poor stage, so the school's development was impeded. Fifth, a strong professional development plan is critical for the ICT programs to be sustained. For example, one of Chinese middle schools had a great professional development program that sustained the school's good ICT programs with a sophisticated ICT infrastructure. They had weekly PLC meetings with major speakers and topics about ICT-integrated instruction to discuss how to integrate ICTs with each science subject. This enabled the school to be a city model in ICT-integrated education.

Recommendations for Future Research

Future researchers may need to use more schools or a larger sample size to examine differences in STL and STTL and their factors across cultures and grades. Some questions emerging from the present study may need to be addressed in further research studies. First, it is still unclear why quantitative analyses revealed Chinese respondents' mean raw score and factor score on ICT-related school conditions were higher than those of the U.S. respondents while descriptive analyses showed that the U.S. schools' ICT AUPs were more liberal and their ICT infrastructure was stronger than those in the Chinese schools. This made it hard to explain why the U.S. schools received substantially lower scores in STL factor-ICT school condition-compared to their Chinese counterparts. More research may need to be carried out on this topic. Second, more research studies could be performed in order to clarify why Chinese science teachers' mean raw score on the overall STTL scale and their factor score on their ICT learning environment was more positive compared with the U.S. science teachers while the U.S. teachers' ICT competences were more solid than Chinese teachers'.

More importantly, future studies may be needed to add students to the research study design. The effects of STL and STTL on student science learning and achievement should be examined because students' learning is always the center of school education; there is no exception for ICT-integrated education.

Concluding Thoughts

Based on this present study, several conclusions can be formulated. First of all, quantitative research design with descriptive data examination is beneficial for addressing the three research questions in this study. This design helps address the three exploratory, descriptive, and explanatory research questions. Additionally, quantitative and descriptive studies complement each other and provide opportunities for examining each other's reliability and validity. Secondly, exploratory factor analysis with Cronbach alpha technique is a good method to reduce sizable variables that are involved in the STL and STTL scales into several meaningful clusters and assure the structural validity of the scales and the reliability coefficient of the scales. Pearson correlation helps clarify that STL and STTL and their factors are correlated. The procedure of using MANOVA (multivariate tests) and subsequent 2-way ANOVA (univariate ANOVAs) provides a strategic procedure for examination of effects of independent variables on STL and STTL. The integration of MANOVA for multivariate tests and univariate ANOVAs for between-subjects tests with more rigid alphas increases tests' effectiveness as well as the reliability and validity of statistical analysis of the data.

Overall, the U.S. schools and Chinese schools have their own strong points and weak points in STL and STTL. The U.S. schools are strong in ICT infrastructure and ICT tools. American science teachers demonstrate strong ICT competence. The Chinese schools have solid professional development programs with sustainable technological and pedagogical support for teaching and learning. Chinese science teachers' ICT learning environments are strong, which is manifested by their academic standards, ICT curriculum, training and communication. Although Chinese science teachers' ICT tools were weaker compared to their U.S. counterparts, they used their current ICT tools to their full capacity for their ICT-integrated instruction and their students' learning. While no significant main effect of grade on STL and STTL is identified by this study, the effect of interaction of country and grade on science teachers' ICT curriculum is found. These results suggest that further studies with larger sample sizes may need to be conducted in order to confirm some of the findings and clarify a couple of contradictions between the quantitative and descriptive studies in this study.

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Appendices

Appendix A. Consent Form

Study Title	Study on School and Science Technology Leadership and Their Effect on Science Education in Case Study Schools
Why will this research be done?	This is a research study being conducted by Ying Tang with his Ed.D dissertation advisors at the University of North Florida. The purpose of this research is to investigate school and science teachers' technology leadership and their effect on secondary school science education. Only school principals, assistant principals, technology coordinators, and science teachers may participate in this study.
What will I be asked to do?	Should you choose to participate in our study, you will be asked to complete a survey on school technology leadership lasting about 25 minutes online. As a science teacher, you will be asked to complete the second survey about science teacher technology leadership lasting about 27 minutes online. You may also be asked to have an interview about your technology leadership in instruction.
What about confidentiality?	Participation is voluntary and all survey responses are anonymous. Interview of science teachers is audio recorded with a code that replaces identifiers. Access to these data will be limited to the project investigator and authorized personnel.
What are the risks of this research?	There are no known risks associated with participating in this study.
What are the benefits of this research?	First, this study will inform you how to improve your school education by integrating educational technology with teaching and learning. Second, it will help you identify the effect of educational technology and technology leadership on school science education. Third, it will assist you to generate strategic, effective technology policy and plan for improvement of student academic learning and achievement.
Do I have to be in this research? May I stop at any time?	Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits.
What if I have questions?	This research is being conducted by Ying Tang with his dissertation advisors Brian Zoellner, Daniel Dinsmore, James Garner at the University of North Florida. If you have any questions about the research study itself, please contact Ying Tang, tangy@duvalschools.org, (904)3431514, or his chair Brian Zoellner, Foundations and Secondary Education, Bldg 57, 1 UNF Drive, Jacksonville, FL 32224; b.zoellner@unf.edu . If you have questions about your rights as a research participant, please contact the chair of the UNF Institutional Review board by calling (904) 620-2498 or emailing irb@unf.edu. This research has been reviewed according to the UNF IRB procedures for research involving human subjects and approved by both UNF IRB and Duval County Public Schools.

By typing your name in the box below you are indicating that the research has been explained to you, your questions have been fully answered; and you freely and voluntarily choose to participate in this research study. Please print a copy of this consent form for your records.

[Text Box for Participant Name]
[Text Box for Participant Email]

Appendix B. Recruitment Letter

Dear potential participant,

I am Ying Tang, an Ed.D candidate who is working on his dissertation research at the University of North Florida. I am conducting this research with my advisors, Drs. Zoellner, Dinsmore, and Garner. We are inviting you to participate in our research study on school technology leadership and science teacher's technology leadership in case study schools.

As an educational administrator, technology coordinator, or science teacher, if you agree to participate in the research, you will be asked to fill out a survey about your school technology leadership. Your school's use of educational technology, infrastructure of information and communication technology, and e-capacity will be observed. Your school's public educational technology policy and artifacts about school technology leadership will be collected for a review. For science teachers, in addition to the survey about school technology leadership, you will be asked to complete the second survey about science teacher technology leadership in your school. In addition, a couple of science teachers in your school will be invited for an interview about technology leadership in science instruction.

The benefits of the research include, but not limited to, the following aspects: First, the study may inform science educators how to improve secondary science education by integrating educational technology in instruction. Second, it may help educational researchers identify the effect of educational technology and technology leadership on science education. Third, it may assist administrators and policy makers to generate strategic, effective policies on integration of technologies in K-12 education. Lastly, the study may advise students how to use educational technology more strategically in science learning or STEM learning in general. In contrast, no risks or discomforts are anticipated for this study.

Your personal information will be kept highly confidential by the following means: 1) your response to the survey will be collected anonymously; 2) interview data of individuals will be recorded with a code rather than identifiers; 3) facility observation will be conducted under guidance of your tech coordinator without class activity; and 4) artifact review data will be collected with school's permission. All these data will be kept confidential throughout the research process. Your right as a participant is also protected: your participation in this research is completely voluntary; you may choose not to participate in the study; and you may ask questions and have them answered at any time.

If you have any questions regarding this study, please contact me, the principal investigator, by using the or my advisors Dr. Zoellner and Dr. Dinsmore If you have questions about your rights as a participant, please contact Institutional Review Board, University of North Florida, at (904) 620-2498 or emailing irb@unf.edu.

Thank you in advance for your support to studies that aim at bettering our education.

Sincerely,
Principal Investigator: Ying Tang ________________________________
Committee Chair: Dr. Brian Zoellner______________________________

Appendix C. Survey on School Technology Leadership

Item 1: My school has a clear vision on the role of information and communication technology (ICT) in education.

Item 2: In our school, teachers and staff receive adequate technical support while working with information and communication technology.

Item 3: The school's hardware (e.g., computers, laptops, e-readers) is sufficient to incorporate information and communication technology into classroom practice.

Item 4: School leaders in our school have communicated clear expectations and performance standards to teachers for the use of technology in classroom practice.

Item 5: The school's vision about the role of information and communication technology in education is accepted by all colleagues.

Item 6: In our school, teachers can receive support from pedagogical coach or expert to improve their information and communication technology-based instruction.

Item 7: I am satisfied with the schools' software (e.g., e-reader applications, iPad applications, computer programs) that is available for me to use with my students.

Item 8: Our school leaders communicate school priorities & goals clearly to teachers.

Item 9: Teachers at my school know the school's information and communication technology policy plan.

Item 10: In our school, colleagues help each other when facing problems with information and communication technology equipment.

Item 11: My school's information and communication technology infrastructure is appropriate for support of technologically based educational activities.

Item 12: When my school teachers and leaders commit to a program or priority, they follow through.

Item 13: The information and communication policy plan of my school begins with a shared vision about “effective” education.

Item 14: The schools’ technology coordinator has a clear overview of the information and communication technology-related activities performed at my school.

Item 15: In our school, classrooms are equipped with a sufficient amount of computers for information and communication technology –related educational activities.

Item 16: In my school, teachers communicate and cooperate well with each other when making educational decisions.

Item 17: Administrators in our school have a strong and clear vision for the efficient use of educational technology in school.

Item 18: School leaders and teachers are informed about the role and tasks assigned to the technology coordinator.

Item 19: In our school, classrooms are equipped with smartboards for ICT-related educational activities.

Item 20: In my school, teachers participate in the decision making in school improvement.

Item 21: Administrators in our school share their vision for the efficient use of educational technology in school with the faculty.

Item 22: School teachers and leaders use the school’s ICTs in communicating and building collaborative working relationships with parents.

Item 23: In our school, classrooms are equipped with digital projectors for ICT-related educational activities.

Item 24: In my school, we have a shared vision of purposeful change that maximizes the use of digital-age resources to meet and exceed learning goals.

Item 25: Our school has long-term plans for the advancement of technology when applied to the classroom.

Item 26: School leaders and teachers use information and communication technology in communicating and cooperating with the community.

Item 27: In our school, classrooms are equipped with digital documental cameras for ICT-related educational activities.

Item 28: Our school leaders encourage the teachers to learn (through activities like professional development and conferences) about the use of educational technology.

Item 29: Our school leaders seek input from teachers and staff (e.g., surveys) to assess the educational technology needs in school.

Item 30: School leaders gather opinions from various members of the school about how to effectively integrate the technological advancement into the teaching and learning process.

Item 31: School leaders and teachers evaluate the influence of educational technology on the students' academic achievement.

Item 32: Our school leaders and teachers effectively identify the appropriate educational technology to facilitate teaching activities to best meet the learning goals of the school.

Item 33: School leaders have created a technology team that represents all members of the school to incorporate educational technology into the teaching and learning process.

Item 34: In our school, classrooms are equipped with iPads for ICT-related educational activities.

Item 35: Our school leaders ask the teachers for their views on the effective use of educational technology in their classrooms.

(0) strongly disagree, (1) disagree, (2) neither disagree or agree, (3) agree, (4) strongly agree.

Appendix D. Survey on Science Teacher Technology Leadership

Item 1: I attend in-service teacher training about the use of information and communication technology (ICT) for instructional purposes.

Item 2: I read about things that have to do with educational technology.

Item 3: I attend in-service teacher training in educational technologies courses.

Item 4: I talk with experts to learn about things that have to do with educational technology.

Item 5: I go to conferences to learn about things to do with the use of communication and informational technology for science education.

Item 6: I engage in professional learning community (PLC) opportunities about educational technology at school or district levels.

Item 7: I have sufficient technical knowledge and skills to use information and communication technology in classroom.

Item 8: I can easily fix technical problems related to information and communication technology.

Item 9: I have sufficient pedagogical skills to integrate technology into my science curriculum.

Item 10: I have training to use variety of software in my classroom for instructional purposes.

Item 11: I have sufficient prior knowledge to use the Internet for pedagogy.

Item 12: I can use a computer skillfully to prepare multimedia presentations in my instruction.

Item 13: I provide and facilitate productive technological experiences in my science instruction that advances student learning, creativity, and innovation.

Item 14: I design and develop learning experiences and assessments that incorporate contemporary educational technology tools (e.g., video instructional games) and resources (e.g., Internet) to maximize the learning of science concepts.

Item 15: I incorporate digital tool such as video instructional games to customize learning activities in science education to address differences in student background knowledge and interest.

Item 16: I collaborate with my colleagues using current educational technologies (e.g., e-mail and interactive blogs) to communicate and share information.

Item 17: I model my students using current educational technologies (e.g., digital demonstration) to enrich their understanding of scientific concepts.

Item 18: I provide my students with varied and multiple formative and summative assessment to assess their learning using educational technology tools.

Item 19: I provide my students with technology-integrated activity (e.g., experimental design using technology) to help them identify conceptual and practical relations between science, technology, engineering, and mathematics.

Item 20: I use computer-simulated labs (e.g., Gizmo) in my science instruction.

Item 21: I incorporate digital textbooks (e.g., e-Text, e-Readers) in my instruction to enrich students' learning experience.

Item 22: I encourage students to incorporate educational technology for data collection and analysis in inquiry-based science project.

Item 23: I advocate legal and ethical responsibility and respect in a digital world.

Item 24: I use a technology-enriched curriculum (e.g., contemporary science curriculum with "Technology Connections") as the guidelines and resources for your instruction.

Item 25: I select e-reading, e-lab and other digital learning materials to enrich the science curriculum provided by the district or state.

Item 26: I use information and communication technology methods, activities, and materials that I learn from my colleagues and professional development staff to enrich my curriculum.

Item 27: I apply the state or national standards (such as the Common Core) to my technology-enriched curriculum materials in order to align my instruction with their expectations.

Item 28: I seek help from my school leader, technology coordinator, and teacher coach to make appropriate changes in my technology-enriched curriculum and practice.

Item 29: I am effective in structuring my science curriculum when integrating technologies into my lesson and class activities.

Item 30: The procedures in my classroom with technology-enriched curriculum maximize the time students spend on learning.

Item 31: I strengthen my curriculum for science teaching by utilizing educational technologies and social media to enhance student engagement.

Item 32: I have used the National Educational Technology Standards (NETS) or International Society for Technology in Education (ISTE) as guides for my teaching practice.

Item 33: I look at how educational technologies can transform the science curriculum rather just working with technology in the existing curriculum.

Item 34: I use educational technologies to promote student engagement, reflection and collaboration through inquiry-based learning environment in my science classroom.

Item 35: I allow students to bring their own digital devices such as lap-tops, iPads, and smart phones to the classroom and use them for instructional purposes.

Item 36: I encourage my students to take advantages of the school's electronic resources such as digital technology center, computer lab, and wireless internet for their learning in science.

Item 37: I use computer-based data system at school or district level to analyze my students' progress such as their scores in Curriculum Guide Assessment (CGA) tests to customize my teaching/learning.

Item 38: I discuss with my colleagues about how to use technology to support inquiry-based learning environment to promote students' higher–order thinking skills.

Item 39: In my science classroom, I establish a technology-supported learning environment that encourages students to explore the relation among science, technology, and society.

Item 40: In my science classroom, the teacher and students understand that social, ethical and legal issues and responsibilities are important in a digital world; we need to follow relevant rules.

(0) strongly disagree, (1) disagree, (2) neither disagree or agree, (3) agree, (4) strongly agree

Appendix E. Protocol for Interview with Science Teachers

1. What is science teacher's perspective of their school's e-capacity and technology leadership?
    1) In your opinion, does the school provide teachers with sufficient ICT equipment (e.g., hardware and software) for your integration of technology in your science instruction?
    2) Do you think the professional development sessions held by the district/school provided useful information on integrating educational technology into your instruction?
    3) Which of the educational technologies do you use in your classroom?
    4) Last year, the internet speed and reliability at your school was?

2. What is science teachers' technology competence? (Science teachers' knowledge and skills in ICT concepts and operations)
    5) Do you understand how to meaningfully integrate technology, pedagogy, and content into your science instruction?
    6) What level do you think of you and you colleagues' using ETs in science instruction?
    7) How often did you use the educational technologies (ETs) in your classroom last year?

3. How do science teacher use ICTs to plan and design student learning experiences? (Whether science teachers are able to design effective learning environments supported by technology)
    8) Did you use simulated labs (e.g., Gizmo developed by Explorelearning company) as student's learning experience compared with traditional, real-world labs?
    9) Did you use software such as *achieve.3000* to plan and design your student reading relevant to science content?
    10) How often did you design science projects that require students to use computer, internet, and other digital tools to collect data, analyze data, create report, and make presentation?

4. How do science teacher integrate ICT with existing curriculum and implement curriculum plans for integrating technology to maximize student science learning?
    11) Did you use district technology-integrated curriculum and implement curriculum plans for your science teaching?
    12) When finding weak integration of technology in science content in district curriculum, what did you do?
    13) What do you think about using technology such as *Explorelearning*'s science simulation to manage student learning activities in a technology-enhanced environment?

5. How do science teachers apply ICTs for assessment and evaluation of students' gains in digital learning?

    14) In your opinion, using traditional methods (e.g. paper and pencil) and using technology for assessment and evaluation, which one is more effective for science teaching and learning?
    15) In what way have you used ICT resources for assessment and evaluation of teaching and learning?
    16) What do you think about applying technology (e.g., *Achieve.3000*, *Turnitin*) in assessing student learning?

6. How do science teacher integrate ICT to optimize their productivity and professional practice?

    17) For what purposes did you use educational technologies for science instruction?
    18) Which do you think is most important for science teacher to practice and accomplish technology leadership in school science education?
    19) What technology resources have you used to engage in ongoing professional development and lifelong learning?

7. What do science teachers think about the interactive effect of STL and STTL on their students' science learning and achievement?

    20) Do you think integrating educational technology in science instruction has improved students' participation and engagement in your science class?
    21) In your opinion, what area in students' learning has educational technology increased?
    22) Do you support the statement that the more a science teacher integrates ICT in science instruction, the more students use technology in their science learning?
    23) What do you evaluate the impact of the integration of educational technology in science education on student science learning and achievement?

8. Demographic Questions

    24) How many years have you taught science in the school you are currently working with?
    25) How many years have you worked as a science teacher in secondary schools?
    26) What subject(s) do you teach in science at your current school?

Appendix F. Protocol for Observation of School ICT Infrastructure

1. School ICT Equipment
   1) Teacher laptop computer
   2) Teacher desktop computer
   3) Teacher iPad or Tablet
   4) Desktop computer for students
   5) Laptop computer for students
   6) Media cart for students
   7) iPad cart for students

2. School ICT Infrastructure
   1) ICT classroom
   2) ICT lab
   3) ICT center

3. School Software
   1) Simulated lab (e.g., Gizmo lab)
   2) E-Reader and e-Text (e.g., Achieve3000)
   3) Student databank and data analysis (e.g., Performance Matters)
   4) Other

4. School Regular Classroom ICT Facilities and Peripheral Equipment
   1) Computers
   2) Smart board
   3) Digital projector
   4) Digital camera
   5) Digital printer
   6) Wired Internet
   7) Wireless Internet
   8) Other

Appendix G: Protocol for Artifacts Review

1. School/district acceptable use policies (AUPs), (e.g., BYOD) for internet, mobile devices, and other digital learning devices in school education
2. School-based ICT policy planning artifacts
   1) Vision development
   2) Financial policy
   3) Infrastructural policy
   4) Sustainable professional development policy
   5) Curriculum policy
3. School website artifacts about school's
   1) Use of educational technology
   2) School's e-capacity, and
   3) School technology leadership approach
4. School newspaper/magazine artifacts about school's
   1) Use of educational technology
   2) School's e-capacity
   3) School technology leadership approach
5. School other document artifacts about
   1) School technology leadership
   2) Teachers technology leadership
   3) Science or ICT teachers' technology leadership

Appendix H. Approval Letter from DCPS

dcps
Duval County Public Schools

Accountability and Assessment
Andrew B. Post, Asst. Superintendent
1701 Prudential Drive
Jacksonville, FL 32207
(904) 390-2976
www.duvalschools.org/reseval

April 9, 2015

Ying Tang
8558 Lori Ann Ct.
Jacksonville, FL 32220

Dear Mr. Tang:

Your request to conduct research in Duval County Schools has been approved. This approval applies to your project *Study on school and science teacher technology leadership and their effect on science education in case study schools* in the form and content as supplied to this office for review. Any variations or modifications to the approved protocol must be cleared with this office prior to implementing such changes.

Participation in studies of this nature is voluntary on the part of principals, teachers, staff, and students. Our approval does not obligate any principal, teacher, staff member, or student to participate in your study. **A signed copy of the full approval letter must accompany any initial contact with principals, teachers, parents, and students.**

This approval for research runs through June 30th of 2016. If your research will extend beyond that date, you will have to submit a request for an extension at the appropriate time. You will be required to identify any changes to the original protocol at that time and to supply any revised documents you plan to use, as well as an updated IRB. If there have been no changes to the approved protocol you may refer to the previously submitted paperwork.

The Chief Officer of Human Resources has advised that neither you nor your students/colleagues are to be on any Duval County Public School campus nor have any contact with students until you have gone through the fingerprinting process at DCPS. Please schedule an appointment with the School Police at 904-858-6100 and bring a copy of this approval letter with you to your appointment.

Upon completion of the study, it is customary to forward a copy of the finished report to the Office of Accountability and Assessment, 1701 Prudential Dr., rm. 327, Jacksonville, Florida 32207. Approval from this department must be sought and granted, in advance, of the publication of any reports/articles in which Duval County or any of its schools are mentioned by name.

If you have questions or concerns, please don't hesitate to call me at 390-2976.

Sincerely,

Signature Deleted

Andrew B. Post
Asst. Supt. of Accountability and Assessment
Duval County Public Schools

Appendix I. Human Subjects Research Training Certificate (CITI Certificate)

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI)

BASIC/REFRESHER COURSE - HUMAN SUBJECTS RESEARCH CURRICULUM COMPLETION REPORT
Printed on 05/10/2014
LEARNER
Ying Tang (ID:)

United States of America
DEPARTMENT College of Education and Human Service
PHONE
EMAIL
INSTITUTION University of North Florida
EXPIRATION DATE 05/08/2017
GROUP 2 SOCIAL BEHAVIORAL RESEARCHER INVESTIGATORS AND KEY PERSONNEL
COURSE/STAGE: Basic Course/1
PASSED ON: 05/09/2014
REFERENCE ID:
REQUIRED MODULES DATE COMPLETED
International Studies 05/06/14
Students in Research 05/06/14
Introduction 05/07/14
History and Ethical Principles - SBE 05/07/14
Defining Research with Human Subjects - SBE 05/07/14
The Regulations - SBE 05/07/14
Assessing Risk - SBE 05/07/14
Informed Consent - SBE 05/09/14
Privacy and Confidentiality - SBE 05/09/14
Research with Prisoners - SBE 05/09/14
Research with Children - SBE 05/09/14
Research in Public Elementary and Secondary Schools - SBE 05/09/14
International Research - SBE 05/09/14
Internet Research - SBE 05/09/14
Research and HIPAA Privacy Protections 05/09/14
Vulnerable Subjects - Research Involving Workers/Employees 05/09/14
Hot Topics 05/09/14
Conflicts of Interest in Research Involving Human Subjects 05/09/14
University of North Florida 05/09/14
For this Completion Report to be valid, the learner listed above must be affiliated with a CITI Program participating institution or be a paid
Independent Learner. Falsified information and unauthorized use of the CITI Progam course site is unethical, and may be considered
research misconduct by your institution.
Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Program Course Coordinator

Appendix J. IRB Approval from UNF

UNF
UNIVERSITY *of*
NORTH FLORIDA.

Office of Research and Sponsored Programs
1 UNF Drive
Jacksonville, FL 32224-2665
904-620-2455 FAX 904-620-2457
Equal Opportunity/Equal Access/Affirmative Action Institution

MEMORANDUM

UNF IRB Number: 714425-2
Exemption Date: 04-03-2015
Status Report Due Date: 04-03-2018
Processed on behalf of UNF's IRB KLC

DATE: April 3, 2015

TO: Mr. Ying Tang, Masters

VIA: Dr. Brian Zoellner
Foundations and Secondary Education

FROM: Dr. Jennifer Wesely, Chairperson
On behalf of the UNF Institutional Review Board

RE: Declaration of Exempt Status for IRB#714425-2:
"Study on School Technology Leadership and Science Teacher Technology Leadership and Their Effect on Science Education in Case Study Schools"

Your project, "Study on School Technology Leadership and Science Teacher Technology Leadership and Their Effect on Science Education in Case Study Schools" was reviewed on behalf of the UNF Institutional Review Board and declared "Exempt" categories 2 & 4. Based on the recently revised Standard Operating Procedures regarding exempt projects, the UNF IRB no longer reviews and approves exempt research according to the 45 CFR 46 regulations. Projects declared exempt review are only reviewed to the extent necessary to confirm exempt status.

Once data collection under the exempt status begins, the researchers agree to abide by these requirements:

- All investigators and co-investigators, or those who obtain informed consent, collect data, or have access to identifiable data are trained in the ethical principles and federal, state, and institutional policies governing human subjects research (please see the FAQs on UNF IRB CITI Training for more information).
- An informed consent process will be used, when necessary, to ensure that participants voluntarily consent to participate in the research and are provided with pertinent information such as identification of the activity as research; a description of the procedures, right to withdraw at any time, risks, and benefits; and contact information for the PI and IRB chair.
- Human subjects will be selected equitably so that the risks and benefits of research are justly distributed.
- The IRB will be informed as soon as practicable but no later than 3 business days from receipt of any complaints from participants regarding risks and benefits of the research.

- The IRB will be informed as soon as practicable but no later than 3 business days from receipt of the complaint of any information and unexpected or adverse events that would increase the risk to the participants and cause the level of review to change. Please use the Event Report Form to submit information about such events.
- The confidentiality and privacy of the participants and the research data will be maintained appropriately.

Although you already received *provisional* approval from the Duval County Public Schools (DCPS), the UNF IRB understands that DCPS requires you to obtain *final* approval from the Accountability and Assessment department before you can utilize staff, facilities, students, or data associated with DCPS. Please include a copy of this memo when you apply for *final* DCPS approval. Because your project was declared exempt from further UNF IRB review, you will not be required to submit your *final* DCPS approval to the UNF IRB. However, you will need to present a copy of the DCPS approval along with this Declaration of Exempt Status Memo to school principals, teachers, staff and others when you approach them about this research.

Thank you for submitting letters of support from both of the schools in China documenting that the authorities at each school have reviewed and approved the research. Via those letters and the assurance provided by the Principal Investigator, the UNF IRB understands that those approvals are official and that no additional ethical oversight is required by authorities in China. In good faith the UNF IRB trusts that the Principal Investigator has done due diligence in confirming that no additional oversight is required in China. Although this project has been declared Exempt from further UNF IRB review, this exemption does not affect any international, state or local laws, regulations, or policies which may otherwise be applicable and which provide additional protections for human subjects. If you are unsure of the requirements in China, please consider contacting the Hunan Province and Guangdong Province Ministries of Health before conducting research in China to confirm that no additional oversight in China is required. If additional oversight is required and the authorities ask you to make changes to your documents or procedures before initiating your research in China, please contact a UNF research integrity administrator before initiating those changes in order to determine if it will be necessary to submit an amendment to the UNF IRB before moving forward with the revised documents or procedures. Additional details about changes to Exempt projects that require formal amendments are provided below.

While the exempt status is effective for the life of the study, if it is modified, all substantive changes must be submitted to the IRB for prospective review. In some circumstances, changes to the protocol may disqualify the project from exempt status. Revisions in procedures that would change the review level from exempt to expedited or full board review include, but are not limited to, the following:

- New knowledge that increases the risk level;
- Use of methods that do not meet the exempt criteria;
- Surveying or interview children or participating in the activities being observed;
- Change in the way identifiers are recorded so that participants can be identified;
- Addition of an instrument, survey questions, or other change in instrumentation that could pose more than minimal risk;
- Addition of prisoners as research participants;
- Addition of other vulnerable populations;
- Under certain circumstances, addition of a funding source

Investigators who plan to make any of the above changes should contact the IRB staff so that the review level can be changed as necessary. If investigators are unsure of whether a revision needs to be submitted, they should contact the IRB staff for clarification.

UNF IRB Number: 714425-2
Exemption Date: 04-03-2015
Status Report Due Date: 04-03-2018
Processed on behalf of UNF's IRB KLC

Your study was declared exempt effective 4/03/2015. Please submit an Exempt Status Report by **4/03/2018** if this project is still active at the end of three years. However, if the project is complete and you would like to close the project, please submit a Closing Report Form. This will remove the project from the group of projects subject to an audit. An investigator must close a project when the research no longer meets the definition of human subject research (e.g., data collection is complete and data are de-identified so the researcher does not have the ability to match data to participants) or data collection *and* analysis are complete. If the IRB has not received correspondence at the three-year anniversary, you will be reminded to submit an Exempt Status Report. If no Exempt Status Report is received from the Principal Investigator within 90 days of the status report due date listed above, then the IRB will close the research file. The closing report or exempt status report will need to be submitted as a new package in IRBNet.

All principal investigators, co-investigators, those who obtain informed consent, collect data, or have access to identifiable data must be CITI certified in the protection of human subjects. As you may know, **CITI Course Completion Reports are valid for 3 years**. Your completion report is valid through 5/08/2017 and Dr. Zoellner's completion report is valid through 4/02/2017. The CITI training for renewal will become available 90 days before your CITI training expires. Please renew your CITI training within that time period by following this link: http://www.citiprogram.org/. Should you have questions regarding your project or any other IRB issues, please contact the research integrity unit of the Office of Research and Sponsored Programs by emailing IRB@unf.edu or calling (904) 620-2455.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within UNF's records. All records shall be accessible for inspection and copying by authorized representatives of the department or agency at reasonable times and in a reasonable manner. A copy of this memo may also be sent to the dean and/or chair of your department.

UNF IRB Number: 714425-2
Exemption Date: 04-03-2015
Status Report Due Date: 04-03-2018
Processed on behalf of UNF's IRB KLC

Curriculum Vita

Ying Tang

Experience

Douglas Anderson School of the Arts
Science Teacher, 2007-current
American Rubber Technologies, Inc.
Research and Development Director, 1997-2007
Auburn University
Research Associate, 1993-1997
Teaching and Research Assistant, 1990-1993
Wuhan University of Science and Technology
Assistant Professor, 1986-1990

Education

University of North Florida
Doctor of Education, Educational Leadership, April 2016
University of North Florida
Master of Business Management, December 2004
Auburn University
Master of Science, August 2003
Wuhan University of Science and Technology
Bachelor of Science, January 1982

Publication

Variable effects in factor analysis and regression analysis of relationship between students' cognitive abilities and their academic performance.
2014 EERA Annual Conference, February 19-22, Jacksonville, Florida.

Membership

Eastern Educational Research Association
Florida Science Teacher Association