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An Analysis of Factors Impacting K-12 Technology-Infused Design

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AN ANALYSIS OF FACTORS IMPACTING K-12 TECHNOLOGY-INFUSED LESSON DESIGN

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AN ANALYSIS OF FACTORS IMPACTING K-12 TECHNOLOGY-INFUSED LESSON DESIGN

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To my parents—for instilling in me faith in God, a sense of determination, the value of hard work, and the importance of education; for making sacrifices throughout their lives to provide opportunities they never had.

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"A journey of a thousand miles begins with a single step."—Lao-tzu

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

AN ANALYSIS OF FACTORS IMPACTING K-12 TECHNOLOGY-INFUSED LESSON DESIGN

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Directed by: William Schlinker, Kyong Hee Chon, Martha Day, and Marge Maxwell

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Public education in the 21st Century can be characterized as being in a period of unparalleled change, including the adoption of Common Core State Standards, increased public accountability, and renewed emphasis on the educational needs of every student. Simultaneously, as public education seeks to address these demands, the digital divide between traditional classroom instruction and learning needs of 21st Century students continues to grow, despite considerable fiscal investments in educational technology.

This study examined two questions: What teacher-related factors positively impact the level of technology-infused lesson design? and To what degree does the use of an instructional framework to guide lesson design and provide feedback impact the level of technology-infused lesson design over time? The HEAT framework (Moersch, 2002) was used to guide and measure technology-infused lesson design among K-12 classroom teachers in a rural south central Kentucky school district. The HEAT framework addressed Higher-order thinking, Engagement of students, Authentic learning, and Technology use. In addition to a quarterly review of lesson plans from 151 teachers during the selected school year, a survey of teachers provided quantitative and qualitative data to address the research questions.

Analysis indicated that teacher-related factors that are commonly examined in relation to technology integration, such as age, years experience, educational level, content area, grade level, and level of training, do not significantly impact the level of

technology-infused lesson design. Among the factors considered in the study, the confidence level of teachers as users of technology was the only factor that significantly impacted the level of lesson design. Analysis further indicated that the implementation of the HEAT framework to guide lesson design and provide feedback to teachers significantly increased the level of technology-infused lesson design, most notably within the areas of higher-order thinking, engagement of students, and authentic instruction.

The results indicated the need to examine which specific factors influence the confidence level of teachers as users of technology, as well as to focus technology integration efforts on leadership and behavioral factors. Moreover, the results indicated that technology integration should occur as part of a comprehensive plan to improve student learning.

CHAPTER I: INTRODUCTION

A growing body of research indicates an ever-increasing chasm between the needs of 21st Century digital learners in comparison to instructional methods associated with traditional classroom instruction. Although the quantity and accessibility of technological resources continue to increase in contemporary public schools, in many instances technology is used to automate traditional pencil-and-paper tasks instead of making instruction more authentic, engaging, and challenging for students (Trotter, 2007). Simultaneously, today's students present learning needs and modalities that are significantly different than prior generations of students and the majority of today's teachers (Jukes, McCain, & Crockett, 2010). Therefore, the issue of effective technology integration transcends mere mastery of technical skills and command of pedagogy. Effective use of technology must engage students in high-level, content-focused activities perceived as meaningful and significant by students in order to maximize learning. To be effective and sustained, integration of technology must be part of a larger, comprehensive plan to impact the overall instructional program.

Significance of the Problem

As will be evidenced as part of the literature review in Chapter II, one of the underlying tenets for the need for effective technology integration is the engagement of students in meaningful learning. The cognitive scientist Willingham (2009) found that many students are not engaged in school because of the emphasis on teacher-directed instruction that does not appeal to students who cognitively demand moderately-challenging problems that they consider both relevant and solvable through exploration and research. Similar conclusions by other authorities in the field of 21st Century learning such as Rosen (2010), Prensky (2010), and Kozma (2003) are validated by statistics related to students' school experiences. Across the nation, 33% of students fail to graduate from high school each year, including nearly 50% of minority students (Jukes et al., 2010). Among the students who complete high school, many of them do not view school as relevant or engaging. According to the National Center for Education Statistics (2002), in a survey of 12th grade students, only 28% considered their coursework to be meaningful, only 21% considered courses to be interesting, and only 39% indicated the belief that their school experience would impact their future. The need to identify the elements that enable teachers to engage students in meaningful instruction and learning experiences through technology integration is evident.

These findings are even more disconcerting when placed within the context of life-long ramifications and further support the significance of the problem. As a nation, one of our core principles includes the civic responsibility to educate our citizens. Without an educated citizenry, we are at risk of undermining the efficacy of public school instruction, expanding a cycle of poverty and illiteracy, and threatening our international competitiveness. A study commissioned by the Bill and Melinda Gates Foundation found that high school dropouts are more likely to be imprisoned, unhealthy, on public assistance, in poverty, on death row, divorced, and head of single-parent households whose children are more likely to drop out of school (Bridgeland, DiIulio, & Morison, 2006). According to Babb (2006), as students drop out of school, the role of public education in socialization, nurturing, learning, and providing a commonly shared experience is further minimized. In short, the number of high school dropouts, that can surely be attributed in part to the lack of meeting students' learning needs, threatens our ability to compete in a global society (Alliance for Excellent Education, 2010).

Problem Statement

The problem addressed by this study is that the mere inclusion of technology as part of or in support of the curriculum does not automatically engage students in higher levels of learning; a distinct need exists to assist teachers with the meaningful integration of technology as a powerful tool for teaching and learning. As purported by Dwyer (2002), the use of technology itself does not improve the teaching and learning process or student achievement. In order to actually have an impact, technology must be perceived and adopted as a tool for teaching and learning—not another tool or content area to be taught. The value of technology is not found in teaching specific programs, skills, or products surrounding hardware and software but in engaging students in meaningful levels of learning that would not be achieved without the integration of technology to address concepts and thought-provoking questions (Prensky, 2010). Kozma (2003) also reinforced the importance of an integrated approach to technology implementation, indicating that the quantity of the technology available for students and teachers is not as important as how the technology is used within the context of teaching and learning. The findings of Kozma's international study are echoed by the demands of current legislation and federal funding mechanisms. For example, the Elementary and Secondary Education Act and No Child Left Behind Act mandate specific accountability measures, including Title II Part D, that require evidence of research-based instruction to meet technology standards (Moersch, 2002).

In regard to standards, the recent adoption of the Common Core State Standards continues to emphasize accountability for public schools and the demand for higher levels of learning. As state educational agencies, district educational leaders, school principals, and classroom teachers work to develop understanding of the new standards and how to best enable students to reach them, the process provides an opportunity to re-examine the increasingly vital role of student engagement through effective use of technology during a critical juncture of educational change. Historically, teachers have tended to use technology to implement old tasks in new ways (Prensky, 2005). For instance, teachers who find themselves entrenched in the lecture and note-taking mode via an overhead projector and transparencies may predominantly use an interactive whiteboard for dispensing classroom notes as opposed to interactive learning activities with students. Similarly, teachers who administer an obligatory weekly chapter exam consisting of primarily low-level multiple choice items may automate the process using an electronic student response system, without harnessing the capability of immediate feedback on results or the potential to modify instruction based on formative assessments using such devices. Current research suggests that, even when teachers teach more creatively with technology, such as with interactive white boards, students continue to assume a passive role unless teachers intentionally engage them in higher-order thinking and student-centered activities (Lemke, Coughlin, & Reifsneider, 2009). Given the educational and technological needs of today's learners, this study specifically addresses the problem of identifying what factors potentially impact teachers' abilities to plan the effective integration of technology for increased student learning.

Significance of the Study

Identification of factors that influence technology-infused lesson design will potentially enable their intentional refinement among existing teachers and development among future teachers, as well as hold specific ramifications for technology planning, professional development, teacher preparation, curriculum design, and classroom practice. The study also is significant in that the majority of research related to technology integration appears to focus on the changing needs of students and specific technology-based initiatives as opposed to a broad-scale perspective for effective infusion of technology. Moreover, much of the existing literature that examines end-user traits and technology use focuses on post-secondary institutions or countries beyond the United States. As more schools and districts acquire updated technology such as interactive handheld devices and laptops, as well as delve into the arena of one-to-one computing, it is critical that a planned approach optimize the financial investment and educational potential (Pence & McIntosh, 2010). Schools continue to invest in an increasing amount of technology in the quest to improve student learning despite the current economic environment. American schools invested over $66 billion in technology in just 10 years (Quality Education Data, 2004). Yet, Burkman (1987) found that the wide-spread acceptance of educational technology upon its introduction in the 1980s was lacking. Unfortunately, educators continue to struggle to optimize the impact of educational technology as an instructional tool to shift the teaching and learning paradigm toward higher-order thinking and authentic problem solving (Bangkok, 2004). Considering such sizable investments of time and resources in educational technology, it is incumbent upon school leaders to both ensure the effective use of technology and assume an active leadership role in the process of technology use.

Technological devices, media, and information in general advance rapidly, making it nearly impossible for educators to remain current on all areas of technology, especially amid a profession engulfed by change in all facets such as assessment, curriculum standards, research-based instructional strategies, and differentiated instruction. According to Gantz and Reinsel (2009), the digital universe totaled 500 exabytes of data in 2007; the equivalent number of books stacked together would cover over 70,000 linear miles and exceed our capacity to store the actual output. In general, advances in technology continue to double every 18 months (McGinnis, 2006). Given this unprecedented level of change in the profession and across the technology spectrum, identification of critical factors of technology implementation is paramount to assisting schools in connecting with students both academically and emotionally.

The purpose of this study is to identify critical factors that can be emulated across grade levels and content areas using a consistent instructional framework that focuses on learning outcomes as opposed to specific instructional technology. In short, this study examines both the roles of selected teacher factors and an instructional framework in developing critical skills of today's learners: mastery of academic content, critical thinking and problem solving, collaborative work, effective communication, and self-directed learning based on feedback (Alliance for Excellent Education, 2011).

Research Questions and Hypotheses

Two research questions guide this study:

Research Question 1: Is there a relationship between levels of instructional design and each of the following factors controlling for teachers' demographic factors (e.g., education level, years of experience, grade level, etc.)?

a. level of technology training
b. confidence level as a user of technology
c. teachers' perceived accessibility to technology as provided by the school/district
d. teachers' perceived impact of the HEAT framework

Research Question 2: How does providing feedback to teachers using a research-based framework affect the change in levels of instructional design over sequential periods of lesson review?

Two hypotheses, including related sub dimensions for question one, were developed based upon the research questions:

Hypothesis 1: There is a relationship between the level of instructional design and each of the following factors controlling for teachers' demographic factors (e.g., education level, years of experience, grade level, etc.).

a. level of technology training
b. confidence level as a user of technology
c. teachers' perceived accessibility to technology as provided by the school/district
d. teachers' perceived impact of the HEAT framework

Hypothesis 1.1: There is a positive relationship between the level of instructional design and level of technology training.

Hypothesis 1.2: There is a positive relationship between the level of instructional design and confidence level as a user of technology.

Hypothesis 1.3: There is a positive relationship between the level of instructional design and teachers' perceived accessibility to technology as provided by the school/district.

Hypothesis 1.4: There is a positive relationship between the level of instructional design and teachers' perceived impact of the HEAT framework

Hypothesis 2: The use of a research-based framework to provide quarterly feedback to teachers regarding the quality of technology-infused lesson plans will significantly increase the level of lesson design over each quarter.

Definition of Key Terms

21st Century skills: The attainment of content area standards along with life/career, learning/innovation, and information/media/technology/skills for students to succeed in work, school, and life within the global context of the 21st Century (Partnership for 21st Century Skills, 2009).

Authentic learning/instruction: Learning that occurs through the application and transfer of knowledge to new and varied situations, with the most meaningful learning occurring when students process information in order to solve problems (Mayer, 2002).

Digital natives: Individuals born during or after the universal introduction of digital technology in the 1980s who think and process information differently than those individuals who did not come of age with ubiquitous technology (Prensky, 2001); students who have internalized digital tools as part of daily life as opposed to adopting them (Jukes et al., 2010).

HEAT framework: Rubric that measures four factors of classroom instruction, including higher-order thinking, engaged learning, authentic connections, and technology use along a six-level continuum based on the Levels of Teaching Innovation framework (Moersch, 2001).

Instructional framework: A document that guides alignment of learning goals, activities, and assessments at higher levels to improve both instruction and student learning (Raths, 2002).

Levels: Varying degrees of implementation of instructional strategies, specifically related to technology integration and student engagement, along a continuum ranging from non-use to refinement (Moersch, 2002).

Student engagement: The degree to which students consider work to be meaningful and worthwhile (Hart, Natale, & Starr, 2010).

Technology: Computers and computer-related equipment (such as interactive whiteboards, document cameras, projectors, interactive student response systems, and other digital tools) as well as educational and productivity software and online resources.

Technology integration: The inclusion of technology as a seamless component of instruction that engages students at high levels of thinking with meaningful content.

CHAPTER II: REVIEW OF LITERATURE

Establishing the context of the impact of selected teacher factors on the level of technology-infused lesson design in the K-12 setting requires an overview of the related conceptual framework, theoretical perspectives, and current empirical research related to the rationale behind and elements associated with effective technology integration.

Specifically, this chapter is devoted to an overview of active learning theory, change theory, contemporary students' needs, 21st Century skill development, measurement instruments related to technology integration, and findings of significant empirical studies regarding integration of instructional technology.

Conceptual Framework

The overriding conceptual framework for this study is active learning theory. The current body of literature clearly delineates a major rift between the needs of 21st Century students as multi-tasking, ever-connected technology users who learn best in interactive, on-demand environments—a stark contrast to the expectation of linear, methodical application of facts often associated with traditional education. Addressing this disparity through the educational system does not hinge on technology as a substitute for curriculum or content but on the conceptual elements of active learning and change (Rosen, 2010). In regard to this type of monumental change, Project RED (<u>Re</u>volutionizing <u>Ed</u>ucation) examined the level of technology integration among 997 schools using 11 measures and 136 independent variables across 22 categories. The study identified the leadership of change among the key elements for successful technology integration (Greaves, Hayes, Wilson, Gielniak, & Peterson, 2010).

Active Learning Theory

The concept of active learning is not new; in fact, many educators consider it to be a component or underling theory of the constructivist approach to education through which teachers engage students in meaningful learning that connects to prior knowledge so that they can select and transform information, generate hypotheses, and make informed decisions (Bruner, 1966). Dewey, Dale, and Bruner each contributed to the related concept of experiential learning, reinforcing the critical role of students' meaningful engagement or experience with content (Garrett, 1997). Depicted in Figure 1, Dale (1969) developed the "Cone of Learning" model which illustrates the relative impact of varying degrees of activity on student learning; as the active role of the student increases in the learning process, the level and retention of learning also increases.

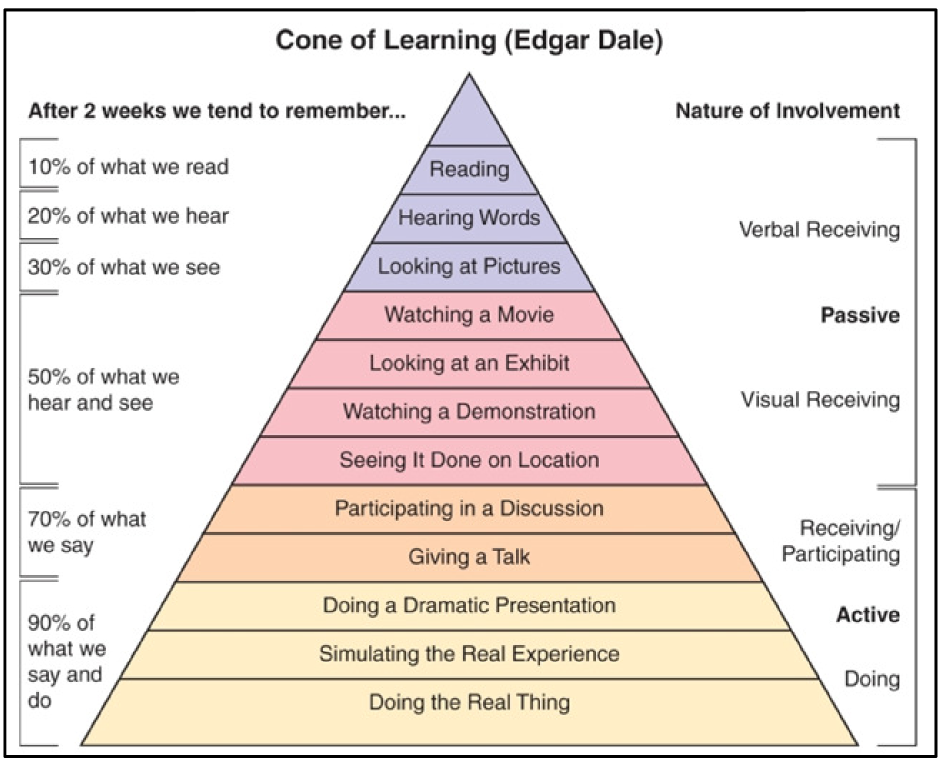

Figure 1. Edgar Dale's "Cone of Learning" pyramid model (Dale, 1969; North Carolina State University Agricultural and Extension Education, 2011).

Although the research supporting the retention rates associated with Dale's model is sometimes questioned, current literature continues to support the theory that learning increases as students become more active in the learning process (Jukes et al., 2010). Fredericks, Blumenfeld, Friedel, and Paris (2004) contended that substantial evidence exists in the literature between student engagement and positive academic results. More recently, Marzano (2007) conducted a meta-analysis involving over 75 distinct studies that found students in highly engaging classrooms perform an average of nearly 30 percentile points better than other students. Active learning's emphasis on skill development, higher order thinking, engagement in meaningful activity, and exploration of ideas (Bonwell & Eison, 1991) parallel the needs of contemporary students as will be further explained in this chapter.

Relevance of content is another key concept of active learning. In addition to the students' assuming a direct role in the learning process, they also must perceive the information or task as meaningful. For students to actively attend to and retain information, it must be relevant to their interests or foreseeable future needs (Sousa, 2006). Zemke (1985) and Wurman (2000) referred to relevance as "velcro learning," indicating that students must have some prior knowledge or experience with which to connect new learning in an active environment. Project-based learning is a more specific example of active learning through which students can become actively engaged with content. Traditionally, projects often are the culminating event after a series of lectures, textbook examples, and written assessments, but the most effective form of project-based learning pulls students through the content as they seek to solve a leading question or authentic problem (Boss, Krauss, & Conery, 2008).

A newly-proposed concept within the realm of active learning is Active-Passive-Intuitive (API) learning theory (Sigette, 2009), which provides both an educational perspective and emphasis on the immediate relevance of the effective integration of technology. API integrates the historical educational psychology theories with advances in cognitive understanding over the last few decades to characterize learning in three phases: active, passive, and intuitive (Slavin, 2008). Intuitive learning is the most rudimentary form of learning, in that it occurs without conscious consideration such as when a child removes her fingertips from a hot surface. Passive learning occurs when an individual is not particularly interested in a learning opportunity but is aware that teaching is occurring. In many instances, contemporary students might describe the typical classroom setting (that includes taking notes from teacher-directed sources, viewing videos, and listening to lectures) as passive (Certo, Cauley, Moxley, & Chafin, 2008). Finally, the third type of learning described by API is active learning. At the highest level of learning, active learning involves a situation in which students make intentional choices to guide their own learning. The learning continuum presented by API parallels several theoretical perspectives related to technology integration, namely the juxtaposition of contemporary students' learning needs and traditional teacher-centered classroom instruction, the professional responsibility and public mandate for mastery of 21st Century skills, current measures of technology integration, and key elements of effective classroom instruction.

Current literature supports the positive impact of active learning theory on instruction, including the effective integration of technology. Knight and Wood (2005); Johnson and McLeod (2004); and Conderman, Bresnahan, and Hedin (2011) all documented the positive impact of active learning strategies on student learning within individual classrooms. Schmidt (2003) conducted research that further demonstrated the positive relationship between active learning and web-based simulations to actively engage students.

Change Theory

While the concept of active learning is relatively easy to define and the primary conceptual framework for this study, change theory also is an important consideration. Transforming the traditional classroom setting toward more student-centered, active learning can be considerably challenging. According to Jukes et al. (2010), a large number of experienced teachers are reluctant to modify their instructional practices to include technology. On the other hand, many new teachers do not possess the skills necessary to successfully implement technology since they are the product of K-12 and university environments characterized by a heavy reliance on lecture and other traditional instructional methods. Rosen (2010) reported that a national study indicated over half of teachers used technology to communicate with parents and students and nearly three-fourths of teachers used the Internet or multimedia devices as part of teaching; however, the vast majority of teachers did not use interactive devices and other tools that have been shown to be most effective in instruction. Pink (2005) also found that schools traditionally focus on left-brain thinking that emphasized linear, logical, and sequential reasoning at the expense of right-brain activities such as randomization and creativity.

In regard to leadership, research findings from the K-12 Computing Blueprint (2011) emphasized the critical importance of a consistent focus on change when implementing technology. To achieve systemic change, educational leaders must develop and pursue comprehensive goals and a vision for how technology can transform teaching and learning. Similarly, Bebell and O'Dwyer (2010) completed a review of four empirical studies examining the issue of technology integration. Across the four studies, they concluded that technology is best implemented as part of a comprehensive plan for change and that teachers benefit from very specific professional development. They also concluded that students are not only more engaged as part of the educational process but become more improved researchers and users of technology through intentional and frequent integration as opposed to sporadic and occasional use.

Three specific theories can guide teachers and administrators in effecting the necessary change to transform both instructional practices and the integration of technology. Especially from the administrative perspective, Blake and Mouton's (1982) Leadership Grid provides a framework for considering the task or results-oriented demands of leadership with the people or relationship-oriented needs. Arranged on an axis from 0 to 9, the goal is to operate at the upper right-hand "team leader" quadrant where high emphasis on both results and relationships are maintained. In regard to technology implementation, educational leaders must dedicate significant attention to each area, ensuring that the exhaustive list of procedural demands such as hardware acquisition, planning, and training are implemented appropriately but not at the expense of leading and supporting teachers. Otherwise, educational leaders risk succumbing to the "country club" mentality where task orientation is low (little is accomplished), but everyone feels content merely because of the high emphasis on relationships. Blake and Mouton (1982) minimally recommended that a "middle of the road" approach be taken, in which equal but moderate emphasis is placed on both task and people. However, an "impoverished" style of leadership (low task, low relationship) and "authoritarian" approach (high task, low relationship) should be avoided altogether, as minimal success can be maintained under these types of leadership styles. In an impoverished environment, progress will likely only be made by a few teachers who personally realize the potential impact of instructional technology based on their own motivation despite the lack of leadership and support. In an authoritative environment, initial implementation and change may occur as a means of compliance, but growth cannot be sustained without sufficient attention to the relationship and humanistic needs such as reflective feedback, encouragement, and freedom to experiment with technology. Research-based examples of this type of leadership change in technology integration were cited in 2010 by the State Educational Technology Directors Association (SETDA) using the comprehensive term "scaling up success" (p. 6). Specific examples included the blending of updated technology with intensive professional development centered around inquiry-based instruction, higher-order thinking, and collaborative learning as implemented by the Maine Learning Technology Initiative, Missouri's Instructional Networked Teaching Strategies, North Carolina's Impact Program, and the Texas Immersion Pilot (SETDA, 2010).

Beyond balancing the demands of the conflicting administrative and interpersonal tasks of technology implementation, leading the overall change in the culture of the school also must be addressed. Smith and Lindsay (2001) identified six concepts of change with related questions:

1. Imagination: What can we do to improve? What might we be able to accomplish? What are we doing now that we could do better?

2. Illumination: What steps would have to take place to improve? Who would need to be involved? What might be the advantages and disadvantages?
3. Destination: What is our specific goal or mission? How will we know when we have achieved our goal? What specific things must we do to reach our goals?
4. Determination: What detractors from success can be identified and minimized? How will we respond to obstacles? How do we maintain a sense of purpose and positive attitude if things do not go as planned?
5. Coordination: How can we best integrate resources to be most effective? What skills, talents, and knowledge can be applied toward our intended outcome?
6. Culmination: How will we celebrate successes? What was effective or ineffective? How will we refine and move forward?

Smith and Lindsay (2001) used these concepts as the foundation for a cyclical model for change: determine the need for change; determine the leadership styles; collaborate with the leadership team; develop a shared vision; implement the plan; and evaluate, assess, and refine as appropriate.

Not only is this model reflective of the current literature regarding school leadership and technology implementation, but also it provides an identifiable process by which leaders can facilitate change, including those related to instructional technology. Change models such as the one presented by Smith and Lindsay (2001) provide a framework through which educational leaders and classroom practitioners can approach the dual philosophies of technology integration as identified by Bull, Bell, and Kajderc

(2003): using technology to deliver existing curriculum more effectively and using technology innovatively to reconceptualize teaching and learning. In addition to the cyclical nature of the model, Smith and Lindsay's approach suggests multiple interconnections among every state of the cycle, indicating that leaders can never cease in their efforts to involve stakeholders in the process, assess results, respond to results through collaborative problem solving, and adjust key factors as needed throughout the process.

From the perspective of the individual classroom teacher, the impetus to learn and integrate the broad range of ever-changing technology as part of one's teaching repertoire may be guided by theory of transformation developed by Ainsworth-Land (1986). According to Ainsworth-Land's S-curve model, all organisms, organizations, and individuals experience three phases of growth: phase one involves acclimation to a new environment (or change); phase two is characterized by consistent growth as the change is fully adopted; and during phase three individuals must consider another change or refinement in order to avoid becoming complacent and experiencing a decline in performance. Shallcross (1981) suggested that the transformation model be used as a method to observe and assess growth and development. These concepts of continual growth and self-assessment to promote development directly mirror the emphasis on continuous improvement as part of teaching, learning, and partnering with students through technology to empower learning (Prensky, 2010).

Theoretical Perspectives

In order to understand the complete context of the factors and changes associated with increased integration of technology as an instructional tool, there are several elements that merit further discussion. These theoretical perspectives include analysis of the learning needs of contemporary students, delineation of 21st Century skills, and a review of measurement tools for assessing technology integration.

Learning Needs of Contemporary Students

Prensky (2001) introduced the term "digital natives" to describe those students who have not experienced a world without the convenience of—and to a large degree demand for—digital technology including personal computing, Internet connectivity, and social networking. However, the literature refers to the current generation of learners who possess very specific learning needs by a broad collection of monikers. Common terms for "Generation Y," or students who were born after 1980, include the Millennials, Generation N, Net Generation, Dot-coms, Echo-Boomers, iGeneration, Generation-D (as in digital), and Nexters (Fiertag & Berge, 2008; Garfinkel, 2003). Although the labels applied to the contemporary generation of students may vary, the identification of their learning needs is primarily consistent throughout the literature. In general, their learning styles can be characterized as non-linear, hands-on, and visual (Henderson & Livingston, 2011). On a deeper level, these students prefer technology-based, collaborative learning experiences that involve the authentic or real-life application of concepts (Oblinger, 2003).

Some of the more prolific authors on the subject of the learning needs of contemporary students have developed more exhaustive lists of their specific learning tendencies. Rosen (2010) identified 13 characteristics of the iGeneration, including the demand for constant media, ability to multitask, fervor for communication technologies, and love of virtual social worlds and anything Internet related. He also identified the ability to create technology-based content, need for constant motivation, confidence, acceptance of change, need for collective reflection, and a desire for immediacy as key features of the generation. Prensky (2010) framed his identification of digital learners' needs not in the context of technology but in terms of their behavioral preferences resulting from their digital upbringing: an environment of respect and trust in which their opinions are valued; freedom to pursue their own interests and passions; opportunities to create meaningful content and products using tools of their generation; latitude to work collaboratively with accountability for everyone; liberty to share in decision making and control their learning; and ability to connect, collaborate, cooperate, and compete with peers in class and beyond. Further, Prensky (2010) emphasized the digital natives' demand for relevant learning with a real-world connection. However, he expanded the concept of "real-world" by distinguishing between "relevant" and "real." According to Prensky (2010), "relevant" refers to an activity or content to which students can connect in a real-world sense; in other words, students understand why something is important. To truly meet the learning needs of digital natives, students must benefit from a "real" connection to the content—a personal instance or example of how the concept applies to their immediate environment or themselves.

As depicted in Figure 2 on the following page, Jukes et al. (2010) presented the learning needs of digital learners in juxtaposition to the traditional preferences of educators.

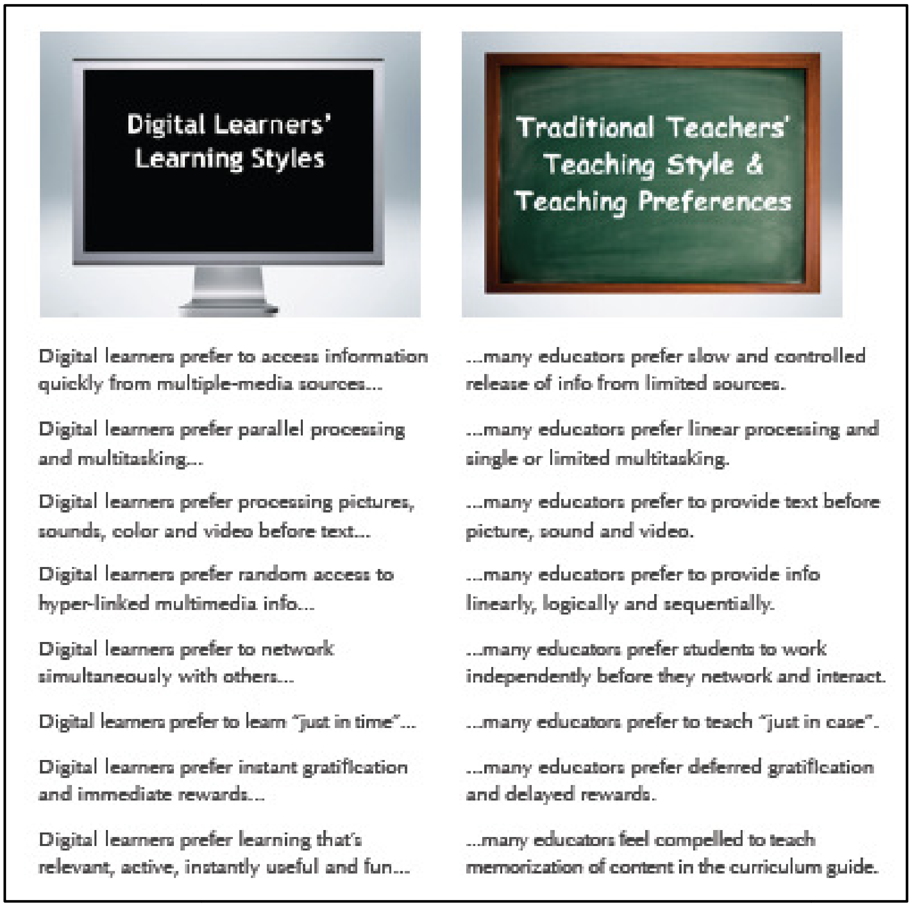

Figure 2. Key aspects of digital learners as compared to traditional instruction

It is apparent from reviewing the contradiction among the seven areas of learning preferences identified by Jukes et al. (2010) that the learning needs of digital natives reside on the opposite end of the spectrum of traditional education. Considering the continued proliferation of technology, changes in family structure, increased percentage of women in the workplace, and 24/7/365 lifestyle, these distinct learning needs of digital natives will become more predominant each year (Jukes et al., 2010; Lenhart, Madden, Smith, & Macgill, 2007).

Although current literature reflects a strong consensus regarding the learning needs and preferences of contemporary students, some divergence on the topic exists.

While Medina (2008) concurred that digital natives have unique learning needs as compared to other generations, he maintained that even these students are not productive multi-taskers within the context of challenging tasks that require concentrated attention, especially when dealing with new situations or details. McMahon and Jung (2011) found that the adoption of technology among digital natives is sometimes over generalized, indicating that varying levels of expertise and use exist across the generation. Henderson and Livingston (2011) also noted this disparity of skill among digital natives, as well as an inability or reluctance to apply technological skills to the educational or workplace environments. Although the exact degree to which their needs are different from both prior generations and within their own generation may be uncertain, the literature reveals significant and definite differences in the needs of contemporary students.

Delineation of 21st Century Skills

Just as the technological and educational needs of contemporary students are significantly different from prior generations, there has been a renewed focus on what skills are critical at the turn of the 21st Century. While some authorities may contend that the development of such skill lists are a duplication of past efforts as the educational pendulum continues its inevitable motion, the current skill lists emphasize students' application of knowledge as independent thinkers, consumers, and workers, as opposed to the mere acquisition of knowledge (Silva, 2009). The accountability measures and other mandates associated with No Child Left Behind, including standards for student technology competency through Title II Part D, further indicate the emphasis that states and school districts place on new teaching and learning standards reflective of the 21st Century (Gewertz, 2008).

While some K-12 educators may perceive the development of such skills as the responsibility of post-secondary education, in reality the challenge to prepare youth for career and personal readiness may primarily be borne at the K-12 level. According to the United States Census Bureau (2007), the United States Bureau of Labor reported that only 27.5% of the population earned a two- or four-year degree by age 25, indicating that most individuals either do not attend or complete traditional post-secondary programs directly after high school. Furthermore, with the continued advent of technology and outsourcing of low-level labor positions, frontline entry-level workers are increasingly expected to demonstrate higher-order thinking and operate within the context of the organization, as opposed to a single job or position (Friedman, 2005).

For these reasons, it is imperative to identify and understand the 21st Century skills that parents, community members, and businesses expect students to develop as part of their K-12 experience. Current literature includes a variety of interpretations on the subject of 21st Century learning skills. This section includes an overview of those interpretations from both the educational and business perspectives.

From the educational viewpoint, Bloom's taxonomy (1956) provided a clear cognitive hierarchy to guide the instructional level, cognitive expectations, and method of assessment to be applied in classrooms. The model differentiated between basic knowledge, application of that basic knowledge, and eventually the highest levels of thinking—synthesis and evaluation. In respect to 21st Century learning, the most recent revision of Bloom's taxonomy represents a broader application of knowledge in a variety of new situations with an increased emphasis on problem solving and creating new understanding (Mayer, 2002). Jukes et al. (2010) concur that the updated version of

Bloom's taxonomy reflects the "new era of creativity that has been facilitated by the emergence of the online digital world" (p. 69). This emphasis on creativity and problem solving as part of the digital landscape prompted Jukes et al. (2010) to develop a list of 21st Century competencies that they described as fluencies, indicating the increased ease and broader context in which the skills can be used. These fluencies were categorized into five areas that are learned within the realm of digital citizenship as characterized by the principles of leadership, ethics, accountability, financial and personal responsibility, environmental awareness, and a global perspective (Jukes et al., 2010):

1. Solution fluency: students think creatively to solve authentic problems
2. Information fluency: students access digital information and critically evaluate or assess its value and application
3. Collaboration fluency: students work cooperatively with virtual and real peers or partners in a digital environment to develop original work products
4. Creativity fluency: students add significance or worth through artistic actions such as design, art, storytelling, digital products, or other outlets
5. Media fluency: students determine the intended message(s) behind communications and evaluate the effectiveness and value of the message in relation to the chosen media, as well as create and publish their own digital products that maximize efficiency

The fluencies' focus on solving problems, creating authentic products, and analyzing sources and impact of information reflect the major components in the updated Bloom's taxonomy as identified by Krathwohl (2002).

This same attention to creativity, authentic problem solving, and preparation for community and work roles is reflected in the most recent national education standards adopted by the International Society for Technology in Education (ISTE). The national ISTE standards for students include creativity and innovation; communication and collaboration; research and information fluency; critical thinking, problem solving, and decision making; digital citizenship; and technology operations and concepts (Brooks-Young, 2007). The ISTE standards have evolved over the last 20 years to reflect the demands of 21st Century learning as well as key elements of school improvement (Roblyer, 2003) and reinforce the importance of effective integration of technology.

The Partnership for 21st Century Skills, a group of educational, government, and corporate entities dedicated to 21st Century readiness, also developed a vision for student performance in the contemporary global workplace. Their particular framework, as shown in Figure 3 on the following page, includes both the mastery of core subject areas and 21st Century themes including global awareness; financial, economic, business and entrepreneurial literacy; civic literacy; health literacy; and environmental literacy (Partnership for 21st Century Skills, 2011).

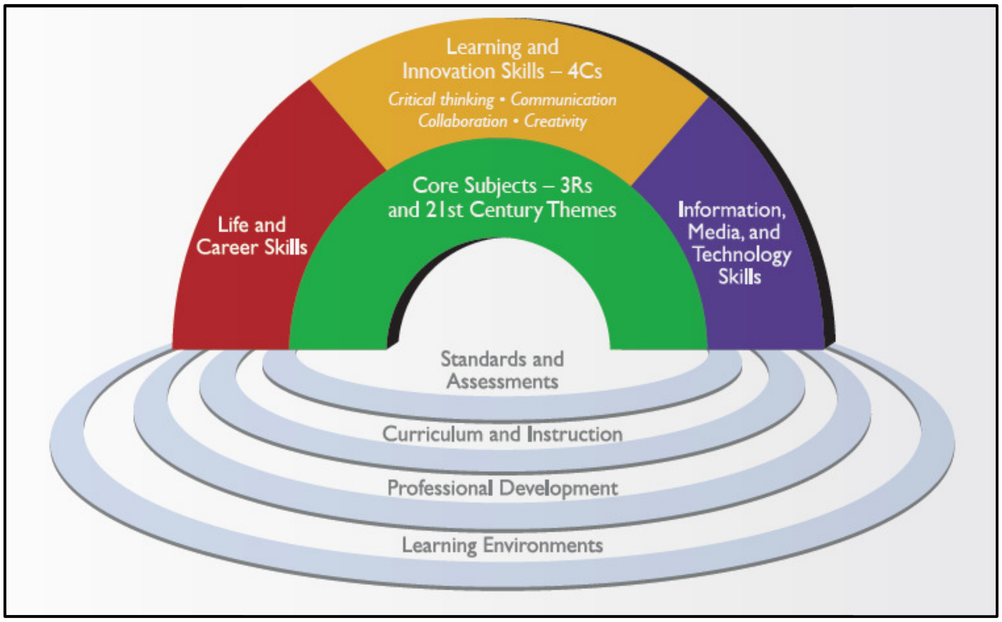

Figure 3. Framework for 21st Century Learning.

Beyond identifying what 21st Century student behaviors and skills should be developed alongside core curriculum knowledge, the framework also depicts the relationship of these goals relative to the teacher, school, and district responsibilities of standards and assessment, curriculum and instruction, professional development, and learning environments. Likewise, the model of 21st Century skills set forth by the North Central Regional Educational Laboratory (NCREL, currently known as Regional Educational Laboratory Midwest) focuses on key skill areas within the context of academic achievement. As depicted in Figure 4 on the following page, NCREL's enGauge model identified four key areas for 21st Century learning: digital-age literacy, inventive thinking, effective communication, and high productivity (NCREL, 2003).

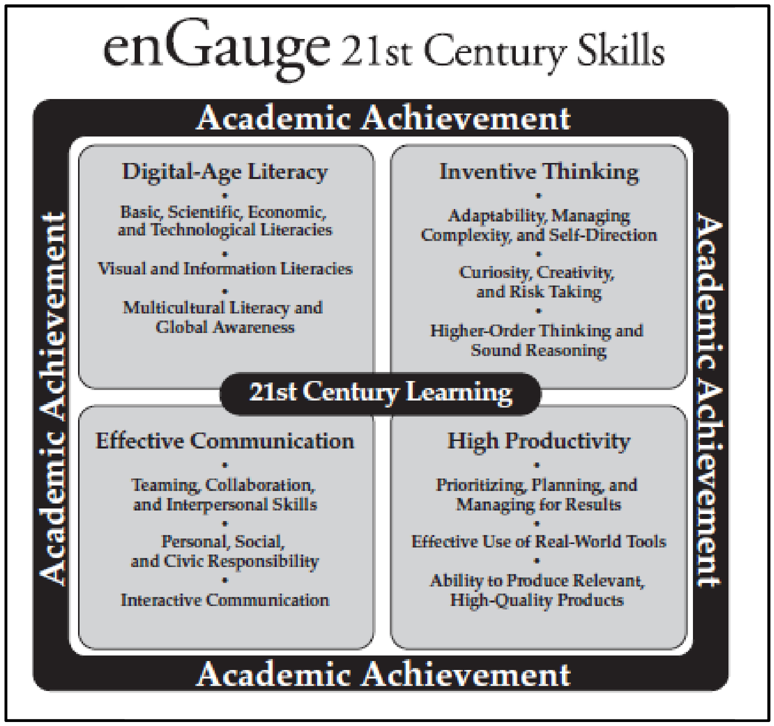

Figure 4. NCREL and Metiri Group model for 21st Century skills.

Not only do these four areas complement the 21st Century skill areas as proposed by the previously discussed models, but they also reflect the integration of linear, sequential thinking and more abstract, intuitive thinking as advocated by Pink (2005) and other futurists. Dwyer (2009) also advocated the integration of these same skills through engagement of students through relevant inquiry; development of core competencies such as collaboration, communication, and adaptability; allowance for variation in learning; and creation of learning communities and complex learning environments.

The emphasis on 21st Century learning also is apparent in business and industry. The Twenty-First Century Workforce Commission's (2000) National Alliance of Business maintained that, "The current and future health of America's 21st Century economy depends directly on how broadly and deeply Americans reach a new level of literacy—21st Century Literacy" (p. 4). Their alliance defined 21st Century literacy to include digital literacy, inventive thinking, interactive communication, and results-based thinking. With the state of flux resulting from the economic transition toward high-skill, information-based industries, students must develop 21st Century skills and proficiencies to meet workforce demands (Chao, 2001). However, a joint report from ISTE, the Partnership for 21st Century Skills, and SETDA (2007) suggested that the field of education was the least technology-intensive entity among 55 industry sectors in the United States.

Gordon (2011) reported that, despite all of their personal skill in using technology, employers indicated that young entrants into the workforce continue to lack the ability to combine knowledge and technology on the job: "Work readiness is no longer just about the three R's; now it's also about turning information into knowledge through web searching and vetting . . . developing effective multimedia presentations . . . [and] . . . seamlessly using digital tools to collaborate and problem-solve" (p. 32). Murnane and Levy (2004) also indicated that many routine, low-level tasks have been automated, thus, requiring a more skilled workforce that can analyze and solve increasingly complex problems. More recently, the Council on Competitiveness (2008) reported over 75% of all jobs in the United States are in the service industry that demands a complex skill set including problem solving, communications, entrepreneurship, computational analysis, and collaboration.

The literature reflects that education and business/industry agree on both the need and general definition of 21st Century skills. ISTE, the Partnership for 21st Century Skills, and SETDA (2007) reiterated the critical nature of such skill development and cited the comprehensive use of technology to support innovative teaching and learning as one of three primary keys for doing so. Therefore, it is important to examine the instruments available to measure the levels of technology integration.

Measurement of Technology Integration

As technology first entered the school setting, integration measures typically revolved around the number of devices, versions of software, time allocated to the use of technology, or student-to-computer ratios (Proctor, Watson, & Finger, 2003). However, as the level and use of technology began to evolve, the available measurement tools became more sophisticated and reflected the actual use of technology to support instructional objectives. While research findings vary widely in regard to the impact of technology use on student learning, research suggests that examining the *quality* of technology use is much more critical than the actual *quantity* of technology available (Lei, 2010).

Among the most widely researched instruments that address the quality of technology use in the classroom are the following tools: HEAT; EnGauge; Mankato Survey of Professional Technology Use, Ability, and Accessibility; TAGLit; and Technology Integration Matrix (TIM). Since the HEAT framework was selected as the measurement tool to examine the level of technology integration for this particular study, it is reviewed in depth before summarizing the key elements of other available measures.

HEAT. Moersch (2001) developed the LoTi (Levels of Technology Innovation) framework using a combination of his own observational research, the Concerns-Based Adoption Model (Hall, George, & Rutherford, 1977; Hall & Loucks, 1979), and Apple's Classrooms of Tomorrow (1995) findings. Since their original development, both LoTi and the accompanying HEAT framework have maintained a continuing role in educational technology research. Moersch (1995) first developed the LoTi (Levels of

Technology Implementation) questionnaire that measured teachers' effectiveness with technology use. After several iterations based upon experience and research, LoTi evolved into the current conceptual model that emphasizes technology integration to supporting learning (Levels of *Teaching Innovation*). The accompanying classroom framework (HEAT) addresses the interaction of **H**igher-order thinking, **E**ngagement of students, **A**uthenticity of instruction, and **T**echnology use along a six-point scale (Moersch, 2002). The HEAT framework may be used as a teacher self-assessment, walkthrough instrument, or source for administrative feedback on the level of technology integration to support 21st Century learning (Moersch, 2011). The framework was recently refined by Maxwell, Stobaugh, and Tassell (2011) to reflect more detailed explanations of each component across the varying levels and further clarify the critical roles of higher-order thinking and student-centered instruction.

Although the framework includes six levels of application of the four elements, the primary goal is to achieve level four instruction in which technology is seamlessly integrated to support high-level thinking with the content. The levels of teaching innovation range from level zero or non-use to level six or refinement (LoTi, Inc., 2011a). At level zero (non-use), instruction may reflect a variety of teaching strategies, but the use of digital tools and resources to engage students in high levels of learning is not evident. Level one (awareness) is characterized by digital tools and resources being used predominantly by the teacher to support traditional instructional techniques such as lectures or presentations; student use of technology, if any, is minimal and limited to unrelated or low-level tasks. In level two (exploration), students use technology for enrichment, extension, or research purposes as the teacher emphasizes direct instruction involving the lower levels of Bloom's taxonomy. Although the use of technology is significantly improved over level one, at level two the use of technology remains isolated and focused on low-level learning (Moersch, 2011).

Level three (infusion), however, marks an increased presence of technology to support learning at higher levels, although the students' use of technology remains an alternative or addition to the curriculum instead of being completely integrated as part of the instructional process (LoTi, Inc., 2011a). However, at the desired level of instruction, level 4 (integration), technology is fully assimilated as part of the teaching-learning process in which teachers and students engage in inquiry-based learning to address authentic problems at high levels of thought. A key distinction between levels three and four, Prensky (2010) defined this shared responsibility for learning as "partnering" (p. 3) that promotes the collaboration and ongoing dialogue between teacher and students to establish learning goals, vary learning activities, and personalize learning.

While level four is the intended goal for the level of classroom instruction, LoTi and HEAT also include levels five (expansion) and six (refinement). Each of these levels represents advancement in the level of thought, student ownership of learning, and application of real-world problem solving. At level five, students are actively engaged in solving problems that transcend the school environment, thereby, affecting their local community and including collaboration with subject matter experts (LoTi, Inc., 2011a). The level of sophistication in terms of student learning, collaboration, and problem-solving are highest at level six at which students engage in projects with a global impact and create expert quality products (Maxwell, Stobaugh, & Tassell, 2011).

Since its original introduction in 1995 and 2009, the LoTi assessment and accompanying HEAT framework have been found to be statistically valid in terms of content-, construct-, and criterion-evidenced validity (LoTi, Inc., 2011b). Moses (2006) identified strong correlations between estimated LoTi levels based on interview data with actual LoTi survey results. Moreover, she found that the LoTi questionnaire demonstrated significant internal consistency ($r = 0.743$) when comparing the survey questions with the levels of implementation that are the basis for the HEAT framework. Figure 5 depicts the corresponding LoTi questions for each level associated with the HEAT framework (Moses, 2006). The remaining 10 questions among the 50-item LoTi survey were correlated with "personal computer use" and "current instructional practice" that are not reflected in the HEAT framework (Moses, 2006, p. 60).

Levels of Implementation	**LoTi Survey Questions**
Level 0: Non-Use	12, 19, 25, 42, 38
Level 1: Awareness	2, 9, 17, 23, 24
Level 2: Exploration	4, 11, 16, 38, 45
Level 3: Infusion	1, 5, 8, 37, 40
Level 4: Integration (mechanical)	3, 27, 30, 31, 44
Level 4: Integration (routine)	33, 34, 35, 43, 46
Level 5: Expansion	10, 21, 22, 35, 39
Level 6: Refinement	7, 14, 28, 29, 47

Figure 5. Correlation of LoTi Questionnaire and Levels Associated with HEAT Framework

Stoltzfus (2006) also confirmed similar reliability and construct validity when she examined the LoTi instrument as part of an analysis of a related survey called "Determining Educational Technology and Instructional Learning Skill Sets."

In addition to being supported by statistical methodology, the individual components of the HEAT framework also are supported by current research. The critical nature of higher-order thinking, engagement of students, and authenticity of instruction is well documented, especially in relation to the learning needs of 21st Century students.

In regard to higher-order thinking, the work of Marzano, Pickering, and Pollock (2004) advocated research-based instructional strategies to promote increased student learning through higher-order thinking. Their work underscores the emphasis on higher-order thinking purported by the taxonomy of thought created by Bloom (1956) and later refined by Krathwohl (2002). The HEAT framework delineates between basic knowledge, application of that basic knowledge, and eventually the highest levels of thinking (synthesis and evaluation) as suggested by Bloom's taxonomy (1956). This definition of higher-level thinking has been expanded with the revision of Bloom's original taxonomy, with a shift toward the application and transfer of knowledge to new and varied situations, with the most meaningful learning occurring when students process information in order to solve problems (Mayer, 2002), also a major element of the HEAT framework. According to Maxwell, Stobaugh, and Tassell (2011), instruction must occur at or above Bloom's Analyzing level in order to meet the HEAT level of three or higher. Moreover, Marzano (2010) also determined through his analysis of cognitive skills (including writing techniques, thinking techniques, and general information processing strategies) that traditional classroom instruction neglected inferential methods, but such processes are the foundation of higher-order thinking. When learning goals, instructional activities, and assessments are aligned at higher levels of thought as inherent in the

HEAT framework, the level of instruction and student learning are elevated (Raths, 2002).

Similarly, the literature also supports the emphasis on student engagement, another critical factor of the HEAT framework. Connell and Wellborn (1991) found that engaged learning promotes increased skill development among students. Forkosh-Baruch, Nachmias, Mioduser, and Tubin (2005) concluded that, as teachers embraced technology as a teaching and learning tool, both teacher and student roles became more enriched and versatile, additional content was introduced into the curriculum, and the traditional restrictions of space and time were transcended, thereby, maximizing the opportunity to engage students. Further, Raphael, Pressley and Mohan (2008) collected work samples from nine middle grades classrooms and classified the engagement levels along a three-level continuum. Their findings indicated that opportunities for choice (a primary component of engaged learning in the HEAT framework) combined with a broad variety of instructional strategies resulted in the highest levels of engagement.

HEAT's focus on a variety of instructional strategies to engage students is further supported by the work of Gregory and Chapman (2006). They advocated the strategic, data-based selection of a variety of instructional strategies to engage students based on their learning needs and preferences. Their findings indicated that a diverse collection of instructional strategies should be paired with students' prior knowledge and readiness to learn in order to promote student engagement. However, the level and complexity of the varied instructional strategies and activities must also be challenging as indicated by the HEAT framework. Blumenfeld and Meece (1988), as well as Nystrand and Gamoran (1991), found that activities focused on procedures and rudimentary tasks, as opposed to cognitively-demanding learning opportunities, actually impeded student engagement. To engage students at high levels cognitively, emotionally, and behaviorally, lesson design should integrate higher-order thinking and meaningful collaboration (Wu & Huang, 2007). In short, the focus on student engagement reflects the needs of contemporary learners to use digital tools to locate information, assimilate meaning, create products, and collaborate during the learning process (Maxwell, Constant, Stobaugh, & Tassell, 2011; Silver & Perini, 2010).

Other research supports authentic learning, the third element of the HEAT framework. Certo et al. (2008) interviewed a group of high school students to determine what activities students perceived as most authentic. The students identified lecture, note taking, and worksheets as the least authentic work. They clearly identified hands-on activities that provide opportunity for discussion and debate as most authentic, noting that the best classes were often the ones they found most challenging because they presented new experiences or the opportunity to solve real-world problems. Moreover, as discussed earlier in this chapter, Prensky (2010) reinforced the importance of authentic learning through his expanded concept of “real-world” learning (including the delineation between “relevant” and “real” learning) that is embedded in the updated HEAT framework. Jones, Valdez, Nowakowksi, and Rasmussen (1995) also reinforced the importance of using technology to engage students in real-world problems that focus on research and inquiry as part of their guidance to teachers in selecting and implementing technology. Their findings mirror the work of Willingham (2009) who, as mentioned earlier, confirmed that 21st Century learners learn best when given the opportunity to apply content to solve real-life problems. Splitter (2008) compared this need for authenticity to the earliest works of Plato and Rousseau. Driscoll (2000) defined authentic learning as a change in performance or potential to perform that results from a learner's experience or real-world interaction. Regardless of the source or historical significance of the concept of authenticity, Lin (2006) found that the teachers' awareness of the composition of the classroom and ability to draw upon real-life experiences to connect the content to learners' needs improve learning. Therefore, the role of the teacher is transformed from sole source of information in the classroom to informed guide and expert facilitator of authentic learning experiences (Renzulli, Gentry, & Reis, 2004) as embedded in the authentic learning component of HEAT, particularly in levels four through six.

In regard to the overall HEAT framework, the research consistently supports the use of instructional technology to integrate active learning, higher-order thinking, and authentic learning opportunities to improve student achievement. However, the combination of these elements may exert the most significant impact on teaching and learning. Maxwell, Stobaugh, and Tassell (2011) found that the "dynamic interaction of these [HEAT] components" (p. 26) impacted the potential for student learning more so than any single component, including technology.

Other measurement tools. In addition to the HEAT framework, a number of measurement tools exist in the current literature.

EnGauge. This web-based tool enables school and district leaders to evaluate educational technology from a system-wide perspective. It was developed by NCREL in coordination with the Metiri Group to provide a comprehensive assessment of six vital factors that impact technology integration (Learning Point Associates, 2011). EnGauge was based on literature reviews, nationally-recognized skill sets, feedback from constituent groups, educational survey data, and input from educators (Lemke, 2002). Despite the collective input on the measurement tool, it specifically addresses only three of the ISTE student standards according to Bowes, D'Onofrio, and Marker (2006). However, the lack of relevance to a greater number of ISTE standards is attributable to the instrument's purpose for system-wide use of technology by teachers to engage students, as opposed to measuring student use of technology. Regardless, the EnGauge approach does seek to measure the relationship between technology use and student outcomes (Proctor, Watson, Finger, Grimbeek, & Burnett, 2007).

Mankato Survey of Professional Technology Use, Ability, and Accessibility. Unlike most readily available technology evaluation tools or surveys, the Mankato survey is not a commercially-prepared instrument. Instead, the survey is the result of the efforts of the Mankato Public School district in Mankato, Minnesota. The school system readily shares the survey as a resource and encourages other districts to modify the 60-item questionnaire as relevant to their needs. Although designed as a self-analysis tool, the Mankato survey does reveal teacher strengths and weaknesses and is loosely aligned with ISTE's national educational technology standards (Bowes et al., 2006). Unlike other evaluations, this single survey allows teachers to reflect upon the availability, importance, frequency of use, and their proficiency of use in a single instrument. While the reflective nature of the survey and exhaustive number of available items may be useful, the lack of an objective evaluative perspective and precise items for measurement may make the survey results less statistically meaningful than other types of measurements (McKenzie, 2002).

TAGLit. The Taking a Good Look at Instructional Technology instrument consists of a collection of online assessment tools to provide schools and educational organizations a strategy for collecting and evaluating the use of technology. Unlike other instruments that focus on analysis of data from teachers, school staff, and administrators, TAGLit also provides a survey instrument for students. The school leader assessment focuses on policy, planning, and budgetary issues related to technology use, while the teacher and student instruments focus more on actual implementation and support of technology at the classroom level (Test, Inc., 2007). The surveys result in findings placed along a 4-point scale: embarking, progressing, emerging, and transforming (Sweetsir, 2011). These four areas somewhat emulate the graduated levels of other measurement tools; however, the TAGLit suite of surveys generates five specific reports related to integration: technology planning, teachers, community, students, and a miscellaneous category (Yoho, 2010). These reports enable school leaders to analyze technology within an overall context of planning and instructional approach, while also examining some specific behaviors and strategies at the classroom level.

Technology Integration Matrix. Produced by the Florida Center for Instructional Technology and University of South Florida College of Education, the purpose of the Technology Integration Matrix (TIM) is twofold: assist teachers in evaluating the level of technology use in their classrooms and provide models of effective technology integration. The model places the class learning environment and level of technology integration along a grid, ranging from entry to transformation for technology use, and from goal directed to active learning in terms of environment. The actual grid is accompanied with two tools, an observation tool for use by principals and other school leaders as well as a "technology comfort measure" that is a 35-item self-assessment to be completed by teachers (Florida Center for Instructional Technology, 2011). In addition to the 100 sample videos that provide specific examples of each descriptor associated with the 25-cell matrix, another key feature of TIM is the descriptors that include explanations of both observable teacher behavior and student tasks appropriate to the 21st Century learning as opposed to less engaging instruction (Thomas, 2011).

Review of Empirical Studies

According to Liu and Velasquez-Bryant (2003), the purpose of technology integration is to pursue improved student achievement, not to showcase the latest advances in technology. Several researchers have indicated that teachers have the most direct impact on the quality of technology use in schools; therefore, factors relating to teachers are increasingly examined as influencing technology integration (Levin & Wadmany, 2008). The final section of this chapter reviews the result of significant empirical studies on the topic of technology integration with particular attention to the teacher factors.

Teaching Philosophy and Perceptions

Dexter, Anderson, and Becker (1999) concluded that teachers' perceptions of technology's role in the classroom are a strong indicator of the level and frequency of technology integration. Their data collection served as the foundation for a national survey regarding teaching beliefs and behaviors. Forty-seven teachers with varied years of experience and philosophical perspectives from across the country responded to a questionnaire that supplemented data from teacher interviews and classroom observations. Observations were conducted in an equal number of classrooms in New

York, Minnesota, and California. According to survey data, the opportunity for teachers to reflect on instructional practice with peers and administrators served as the primary agent for change in addition to their individual coursework and culture of their schools. The introduction of computers and other technology alone did not prompt a change in teaching methodology.

Baylor and Ritchie (2002) conducted a comprehensive study involving 94 classrooms in four states across different geographic regions of the United States. The quantitative study examined the impact of seven factors related to technology integration including planning, leadership, curriculum alignment, professional development, technology use, teacher openness to change, and teacher non-school computer use. Data collection methods included structured administrator and teacher interviews, review of school technology use plans, and teacher surveys resulting in 11,924 data points. Using a stepwise regression model, the impact of technology on higher-order thinking skills was predicted by the openness to change, amount of technology use by students working individually (negatively), and the level of constructivist modes of technology use ($R^2 = 0.608$). The level of technology integration was predicted by openness to change and technology use with others ($R^2 = 0.391$). Overall, Baylor and Ritchie (2002) identified teachers' openness to change to be the most critical recurring factor in their study. Similarly, Shapley, Maloney, Caranikas-Walker, and Sheehan (2009) concluded in the review of data associated with the Texas Technology Immersion Pilot (discussed later in the teacher demographic factors subsection) that teachers with more constructivist views on instruction demonstrated higher levels of technology integration. Interestingly, data from the initial two years of the pilot program indicated that the introduction of one-to-one technology positively impacted teachers' perception of the school's overall culture and increased collegial interactions (Shapley et al., 2009).

Vannatta and Fordham (2004) made very similar conclusions based upon their study involving over 170 K-12 teachers in six Northwestern Ohio schools. Using a forward multiple regression model to examine teacher attributes such as self-efficacy, philosophy, openness to change, and amount of available technology, they identified three best predictors of overall classroom technology use. Those predictors included amount of technology training, number of hours worked beyond the contractual work week, and openness to change ($R^2 = 0.184$, $R^2 = 01.70$; $F(3,166) = 12.524$, $p < .001$).

Judson (2006) found, however, that teachers' beliefs regarding teaching and learning were not always fully reflected in actual classroom practice. When comparing results of classroom observation data to the Conditions that Support Uses of Technology survey results from 32 practicing K-12 classroom teachers, he found no significant correlation between teachers' reported philosophy and instructional practice ($r = 0.151$, $p = 0.410$). Judson (2006) attributed this incongruence to the variance in teaching experience among the participating teachers, assuming that more experienced teachers were more adept at implementing their self-reported philosophies. However, no specific data was provided to support this explanation.

Moses (2006) examined teachers' perceptions in relation to their principals' projected leadership styles. After analyzing results from a demographic survey and administration of the LoTi instrument to 390 K-12 teachers and 26 principals (who also completed a LEAD leadership-style survey), she found that teachers' perceptions of administrative encouragement, supportive leadership, and training opportunities were more important than the principals' perceived skill in actual technology use and adaptability.

Teacher Attitudes Toward Technology Integration

In regard to selected teacher factors, Hastings (2009) found that technology-related factors such as risk-taking behaviors and comfort level with technology, beliefs about technology's role in instruction, teacher support for technology use, teacher proficiency in technology use, and technology professional development were stronger indicators of technology integration than general factors such as self-efficacy, instructional philosophy, or professionalism. The study employed a correlational research design using data collected through a two-part administration of the Cooperating Teacher Technology Integration Survey along with the Tiers of Technology Integration into the Classroom Indicators framework involving over 450 Northwest Ohio K-12 classroom teachers.

Similarly, Ertmer (2005) found that teacher attitudes and beliefs also influenced the degree of technology integration in the classroom. However, she noted that teachers' attitudes and philosophical preferences may be overridden by time, a sense of accountability to teach more fundamental prerequisite skills, and access to technology.

Al-Bataineh, Anderson, Toledo, and Wellinski (2008) conducted a study of teachers in grades 6 through 12 in a mid-western K-12 school district. Their research study was conducted using a survey with checklist, rank-order, and open-ended items completed by 49 respondents. The results indicated that all teachers were using some level of technology. Despite unfamiliarity with technology being cited as the strongest barrier to integration, 88% of respondents indicated they were either confident or very confident in the use of technology.

Wozney, Venkatesh, and Abrami (2006) also determined teachers' expectancy of success and perceived value of technology to be the most important factors in differentiating the levels of computer use by teachers. They developed the following formula as a measure of teacher motivation based upon the survey results of 764 elementary and secondary teachers in Quebec: (.39 x expectancy) + (1.5 x value) – (.14 x cost) = technology use.

Pan (2010), also, found that teachers' level of professional development, along with self-efficacy, were the most influential factors in the integration of Web 2.0 tools as instructional tools, while school administrative support, access to technology, e-safety issues, and need for technology resources were of less concern to teachers.

Barriers to Technology Integration

Based on a meta-analysis of research studies ranging from 2005 to 2009, Lemke et al. (2009) cited several reasons for the sluggish rate of technology integration, including access to functioning technology, access to current technology, instructional vision, school leadership, teacher proficiency, professional development, and school culture. These and other potential barriers appear to be somewhat universal as they have been substantiated by a number of empirical studies across grade levels, public and private institutions, K-12 and post-secondary environments, and varied geographic regions in the United States and beyond.

Garthwait and Weller (2005) conducted an interpretive case study that involved two middle school science/math teachers during the first year of Maine's one-to-one technology initiative. The qualitative study specifically addressed the effects of technological issues and policy on the level of technology integration through analysis of varied artifacts including interviews, classroom observations, emails, classroom handouts, teacher webpages, and news articles. They found that technical expertise and general beliefs about teaching and learning had the most impact on technology integration. Specifically, they concluded that barriers to technology integration will persist as long as teachers view technology as a method for automating traditional instructional methods instead of a method to implement constructivist, student-centered strategies.

Similarly, Windschitl and Sahl (2002) also completed a qualitative two-year study in the one-to-one computing environment of a private Catholic co-educational middle school in an urban-suburban area of a large Northwestern city. They used a multi-case study approach from an ethnographic perspective to examine a number of research questions, including what conditions contribute to more constructivist integration of technology. They concluded that access to technology was not indicative of meaningful integration, but the teachers were mostly guided by their beliefs regarding learners' needs, perceptions of critical learning activities in specific content areas, and locus of control in the learning environment as dictated by their educational philosophy.

In contrast, Bauer and Kenton (2005) conducted a mixed-method study involving 30 teachers in 4 schools (2 elementary, 1 middle, and 1 high school) in two separate urban school districts (one city and one county district) in a southern state. Through analysis of data resulting from teacher surveys, classroom observations, and post-observation interviews, they identified both limited access to hardware and time as significant barriers to technology integration. Franklin (2007) also identified lack of time as a significant barrier to integration, in addition to too much curriculum to cover and the demands of accountability testing as perceived barriers at the elementary level; however, she found no differences according to specific grade levels.

Another mixed-methods study by Lewis (2010) involving 27 teachers among five rural West coast K-12 school districts identified needs-based technology training, time, and limited access to technology support as significant barriers to technology integration.

Teacher Demographic Factors

Research also points to a number of demographic factors that may impact the level of technology integration. In their review of empirical research studies, Afshari, Bakar, Luan, Samah, and Fooi (2009) described demographic teacher traits such as age, teaching experience, gender, and external support systems as "non-manipulative factors" (p. 79), as they cannot be controlled by the school or district.

The National Center for Education Statistics (2000) reported that teachers with 20 or more years experience were less likely to integrate computer technology as part of instruction as compared to less experienced teachers. Teachers with 20 or more years experience reported using computers 33% of the time, which was significantly less than the other reported age groups: 0-3 years (48%); 4-9 years (45%), and 10-19 years (47%).

Park, Ma, Kim, and Kim (2007) examined a number of factors related to technology integration, including a broad range of demographic elements. Their study involved over 700 elementary school teachers in urban cities across Korea using a Likert-style survey instrument piloted and validated through their research process. In regard to gender, a significant difference (male performance was higher in the area of teaching-learning and expertise development; reliability = 95 % and probability > 0.05) was found. In regard to age, a one-way ANOVA revealed a significant difference (probability < 0.05), in that technology integration among teachers in their 30s was highest as compared to teachers in their 20s, 40s, and 50s, respectively. The difference in integration among age groups was attributed to the level of training that individuals with 6 to 15 years teaching experience had received compared to the other age groups. Additionally, their study found no significant difference in the level of integration between classroom and resource teachers (probability > 0.05).

Bebell, Russell, and O'Dwyer (2004) also indicated that years of teaching experience influenced the level of technology use in the classroom. Teachers with 10 or more years of teaching experience were more likely to cite lack of time as a barrier to learning, practicing, and implementing classroom technology as compared to teachers with three or fewer years' experience (National Center for Education Statistics, 2000).

The Texas Education Agency completed a four-year pilot of one-to-one computing involving 21 junior high campuses across Texas and another 21 campuses selected as control campuses as part of a quasi-experimental research study funded by a $12 million Title II Part D grant award (Fryer, 2004). Each year of the pilot program was closely monitored and evaluated. Data collection methods included surveys, interviews, structured conversations, focus groups, and site visits. Although the emphasis of each year's research focused on issues related to complete immersion of technology, the research process also yielded significant data related to teachers' demographic factors. In Year 3, Shapley et al. (2008) reported that teachers with the highest classroom immersion rates included a mix of Caucasian (68%), Hispanic (21%), and African American (11%)

teachers. The lower immersion teachers were primarily Caucasian (83%). They also found that teachers with fewer years of experience (12.3) demonstrated higher levels of technology integration than more experienced teachers (16.8 years), citing that newer teachers were usually more familiar with technology and late-career teachers perceived fewer long-term benefits in professional growth and training (Shapley et al., 2008).

Fourth year data reflected variation in the levels of technology immersion across subject areas, as did the prior years. Teachers of English language arts, science, and social studies integrated student use of technology significantly more than mathematics teachers (Shapley et al., 2009).

Summary of Chapter

As with many aspects of the teaching and learning process, the concept of technology integration, while somewhat easily defined, is much more difficult to quantify, sustain, and replicate. Technology integration is impacted by a broad variety of interrelated economic, social, educational, interpersonal, demographic, and philosophical factors. Nevertheless, current research supports the use of technology as an active learning tool to engage students in high-level, authentic learning and problem solving as a means for teaching existing content and expanding the curriculum. Although a variety of interpretations abound for 21st Century skills and learning, there is a clear consensus that educators are preparing a unique generation of students for a distinct and challenging workplace and lifestyle. Educational leaders and classroom teachers have the responsibility to embrace change and integrate technology as a critical instructional tool for preparing students for their future.

CHAPTER III: METHOD

A clear and distinct need exists to assist teachers with the meaningful integration of technology as a powerful tool for teaching and learning. Because the learning needs of contemporary students will continue to evolve as educators prepare them for an increasingly complex future, this study addresses the need to fully implement technology to support high-level learning. The mere inclusion of technology as part of or in support of the curriculum does not automatically engage students in higher levels of learning. According to Dwyer (2002), the addition of technological devices does not improve the teaching and learning process or student achievement. In order to actually have an impact, technology must be viewed and adopted as a tool for revolutionizing teaching and learning, rather than regarded as merely a tool or content area to be taught. The value of technology is not found in teaching students specific programs, skills, or products surrounding hardware and software but in engaging students in meaningful levels of learning that would not be achieved without the integration of technology to address concepts and thought-provoking questions (Prensky, 2010).

As discussed in Chapter I, the purpose of this study is to identify critical factors that can be emulated across grade levels and content areas using a consistent instructional framework that focuses on learning outcomes as opposed to specific instructional technology. This study examines both the roles of selected teacher factors and an instructional framework in developing lesson plans that meet the critical skills of today's learners: mastery of academic content, critical thinking and problem solving, collaborative work, effective communication, and self-directed learning based on feedback (Alliance for Excellent Education, 2011).

Identification of factors that influence technology-infused lesson design will potentially enable their intentional refinement among existing teachers and development among future teachers. These factors include demographic elements such as age, educational level, and years in the profession, as well as teachers' specific perceptions related to technology integration, confidence in using technology, level of training, and access to instructional technology. The identification of the impact of such factors may provide useful insights for technology planning, professional development, teacher preparation, curriculum design, and classroom practice. The study also is significant in that the majority of research related to technology integration appears to focus on the changing needs of students and specific technology-based initiatives, as opposed to a broad-scale perspective for effective infusion of technology.

This chapter details the research methods used to examine the impact of a selected instructional framework to promote technology-infused lesson design as well as teacher-related factors that potentially impact technology integration. The research was guided by two specific questions:

Research Question 1: Is there a relationship between levels of instructional design and each of the following factors controlling for teachers' demographic factors (e.g., education level, years of experience, grade level, etc.)?

a. level of technology training
b. confidence level as a user of technology
c. teachers' perceived accessibility to technology as provided by the school/district
d. teachers' perceived impact of the HEAT framework

Research Question 2: How does providing feedback to teachers using a research-based framework affect the change in levels of instructional design over sequential periods of lesson review?

A description of participants and the selected school district is provided, including relevant demographic data related to the students, teachers, and community in general. An explanation of the research design, measures, procedures, and data analysis also is included.

Participants

This study was conducted in a rural, south central Kentucky school district that serves over 2,200 students in grades K-12. The students are ethnically homogenous; nearly 95% of the student population is Caucasian, with the remaining student population identified as African American (2.5%), Hispanic (1.9%), or other (1.1%). The district includes five K-8 elementary schools and one high school. The district instructional staff includes 174 certified positions (including classroom and resource teachers, media specialists, counselors, speech pathologists, and school psychologists), 42 instructional assistants, and 19 district and school administrators. The average length of teaching experience is 9.7 years, as compared to the state average of 11.7 years (Commonwealth of Kentucky, 2010). Nearly 68% of teachers have earned a master’s degree or Rank I (30 or more graduate hours beyond a master’s degree), including eight national board certified teachers.

In terms of academic achievement, the district has maintained a consistent and positive level of student progress over the past few years, having met all No Child Left Behind learning targets since the 2006-2007 accountability cycle. Learning targets are defined by the required percentage of students demonstrating proficiency in reading and mathematics each year. According to No Child Left Behind regulations, ten or more students per grade level within a particular demographic across a school district constitute a significant population. Because the school district is not particularly diverse in regard to race, no subpopulation data were reported except for Caucasian students. Since this data were included in the official NCLB report, it is also included here as a point of reference. As indicated in Table 1, the overall student population and statistically significant subpopulations exceeded the NCLB learning target of 68.89% proficiency in 2010; the district performance level also exceeded the state average for reading in all areas.

Table 1

*2010 No Child Left Behind Percent of Students Scoring Proficient in Reading**

	District	State
All Students	77.92	71.86
Caucasian Students	77.75	74.37
Students with Disabilities	71.67	48.69
Economically Disadvantaged Students	71.87	63.45
Male Students	72.03	66.59
Female Students	84.01	77.45

*Proficiency goal = 68.89%

As indicated in Table 2 on the following page, the district's overall student population and statistically significant subpopulations surpassed the NCLB mathematics learning target of 59.79% proficiency in 2010; as with reading, the district performance level exceeded the state average for mathematics in all areas.

Table 2

*2010 No Child Left Behind Percent of Students Scoring Proficient in Mathematics**

	District	State
All Students	70.47	64.14
Caucasian Students	71.40	67.08
Students with Disabilities	68.75	43.41
Economically Disadvantaged Students	65.40	58.35
Male Students	69.88	63.04
Female Students	71.08	65.32

*Proficiency goal = 59.79%

The district's non-academic measures also demonstrated favorable statistics in comparison to the state averages as indicated in Table 3 below.

Table 3

2010 Non-Academic Measures

	District	State
Attendance Rate	95.12%	94.2%
Retention Rate	1.01%	2.6%
Dropout Rate	1.05%	2.3%
Graduation Rate	87.79%	84.5%

The indicated levels of academic and non-academic success are especially notable in the context of the county's demographics. The entire county encompassed a population of 18,199 residents in 2010. Only 64.8% of residents age 25 or older hold a high school diploma, as compared to the state average of 80.3% (United States Census Bureau, 2011). Of persons age 25 or older, only 9.2% have obtained a bachelor's degree or higher, as compared to the state average of 20%. In 2009, the per capita income was $16,663, as compared to the state average of $22,284, which contributed to 66% of students qualifying for the national free or reduced lunch program in 2010. Geographically, the county covers just over 415 square miles, which results in just over an average of 43 people per square mile, as compared to the state average of 109.

Despite the rural nature of the school district and community, access to instructional technology has been a priority for the district and individual schools. In 2006, the district completed a three-year initiative through which 95% of classrooms were equipped with interactive technology including interactive white boards, projectors, student response systems, interactive slates, and document cameras. The district also implemented a one-to-one laptop initiative for all high school students in October 2010. Additionally, individual schools have supplemented these resources through acquisition of educational software and subscriptions to varied online research and content-based resources. These initiatives are reflected by the 2010 spending per student ($11,557) by the district, as compared to the state average ($10,742), and the average student computer age (83.6% five years or newer), as compared to the state average (76.6%).

In February 2010, the district was awarded a competitive Title II Part D grant award from the state of Kentucky. The grant initiative included the collection and review of technology-infused lesson plans during the 2010-2011 school year in an effort to measure and improve the degree of technology integration in classrooms across the district. This study examines the existing data made available by the district as a result of the grant initiative in addition to supplemental data secured for the purposes of this study through a teacher survey and review of demographic personnel data.

Research Design

This quantitative study applied a descriptive design to determine the relationship between a number of selected teacher factors as well as the impact of the use of an instructional framework for technology-infused lesson design. Because the study identified no control group, it can be categorized as exploratory research to examine, analyze, and investigate a particular area in the social sciences (Stebbins, 2001). One purpose of this study was to determine to what degree the use of an instructional framework to guide technology-infused lesson design and review would impact the level of planned technology integration. Further, the researcher was interested in comparing the teachers' perceived value of the instructional framework to the actual changes, if any, in the level of technology integration evidenced by the review of lesson plans. Finally, the study provided the opportunity to examine the potential relationship of the level of lesson design (dependent variable) with selected factors (independent variables), while controlling for demographic factors such as years of teaching experience, level of education, content area, grade level, confidence in using technology, self-reported level of technology training, and perceived level of access to technology.

Procedures

Beginning in the fall of 2010, one technology-infused lesson plan, along with three student work samples, was submitted by each teacher in the district each instructional quarter during the 2010-2011 instructional year for review by a district-wide panel. Both the development and review of lesson plans were guided by use of the HEAT framework (Appendix A) based on the original LoTi questionnaire (Moersch, 2002) and later refined by Maxwell, Stobaugh, and Tassell (2011). Teachers were required to submit lesson plans using a template (Appendix B) developed by the district's instructional staff that emphasized key lesson components such as content standards, unit and lesson objectives, instructional strategies and activities, and student assessment.

The district had trained all teachers in the district on the concepts of LoTi and HEAT through a train-the-trainer model. In July 2010, Green River Regional

Educational Cooperative staff conducted a two-day training for identified district leaders on the elements and application of LoTi and HEAT. From within the group of district leaders, a designated lead administrator trained a group of certified teachers representing each building to serve as lead teachers in the technology-infused lesson design and review process. This group of lead teachers provided LoTi and HEAT training to all certified staff in each building through a variety of delivery methods including team meetings, professional learning communities, and traditional faculty meetings.

At the conclusion of each collection period, the district-wide review panel convened to analyze lesson plans and provide written feedback to teachers in the form of HEAT scores (for each individual component and a composite score) and anecdotal notes. Since training regarding LoTi and HEAT concepts was delivered across the district through a train-the-trainer model, and ultimately through a variety of modes at the individual school level, the initial review session in the fall of 2010 included review training conducted by a nationally-endorsed LoTi trainer from a regional university to promote consistency in application of the HEAT framework during lesson review. The first and each subsequent review session also began with review and practice scoring of sample benchmark lessons to calibrate scoring and promote validity and reliability of scores. The benchmark lessons were obtained from a committee at a regional state university engaged in research activities related to the HEAT framework.

Each scoring session was completed using double-blind scoring, meaning that each lesson plan (in the context of the accompanying student work samples) was scored once by two separate scorers with neither scorer having knowledge of the other score. Lesson plans were coded so that only the grade level and content area were evident to the scorers. Likewise, scorer identification codes were used so that scorer confidentiality was maintained. Although lesson plans were randomly assigned to pairs of scorers according to grade-level expertise, the panel maintained the norm of individually scoring without discussion among scorers. As plans were scored, data were entered according to each HEAT element (higher-order thinking, engaged learning, authentic learning, and technology use) as well as an overall composite score. When comparing the two sets of scores for each lesson plan, any plans with scores that did not appear in adjacent cells (in other words, a difference of two or more) for either individual components or the composite score were referred to another scorer for a third review. In the event of a third scoring, the two scores that were identified as consistent (all scores in the same or adjacent cells on the HEAT instrument) were considered the official scores.

To obtain data related to teachers' perceptions of use of the selected instructional framework and other related factors, a year-end survey (Appendix C) was administered to teachers to collect data related to their perceptions of technology training, confidence, level of access, and impact of the HEAT framework after internal review board approval (Appendix D). The survey was developed by the researcher in consultation with the district's leadership team, endorsed LoTi trainer, dissertation committee chairperson, and methodologist. Prior to administration, the revised survey was administered and discussed with a small focus group of district teachers to ensure clarity of questions and ease of use.

During a general professional development day near the end of the school year, teachers in each school were provided with the letter of consent (Appendix E) and a verbal explanation of the research project. Those teachers who consented to participate in the survey were able to complete the survey electronically at that time; for the few teachers across the district not in attendance during the professional development day, the online survey remained open for an additional week for those desiring to participate. Teachers were provided a unique access code to ensure anonymity and confidentiality of responses. The survey was made available and data collected using the web-based tool Survey Monkey. Data collected through this online tool was password protected and not available to the public or individual respondents.

The online survey was designed so that teacher respondents could select only one answer for each of the seven multiple-choice items. Answer choices consisted of a 4-item Likert scale ranging from *no impact* to *strong impact* or similar wording depending on the context of the question. The survey concluded with a single open-ended question designed to permit respondents to enter comments regarding the perceived value, if any, of the HEAT framework.

Additionally, demographic data such as age, gender, years experience, level of educational attainment, grade level, and content area were provided by the district administrative office. Data from the lesson plan review, online survey, and demographic records were accumulated into one electronic spreadsheet file that was then imported into the SPSS software program for statistical analysis.

Data Analysis

The research project utilized descriptive and inferential statistics to determine to what degree the use of the HEAT framework affected the level of technology-infused lesson design (including higher order thinking, engaged learning, authentic learning, and technology use), as well as other teacher practices such as collaboration with other teachers or community resources, student choice in class activities, and reflection upon lesson design or results. With the inclusion of the one open-ended survey item, the study technically utilized a mixed-methods approach by integrating both qualitative and quantitative analysis in order to reinforce the validity of the study (Fraenkel & Wallen, 2006).

Regarding Research Question 1: Is there a relationship between levels of instructional design and each of the following factors controlling for teachers' demographic factors (e.g., education level, years of experience, grade level, etc.)?

a. level of technology training

b. confidence level as a user of technology

c. teachers' perceived accessibility to technology as provided by the school/district

d. teachers' perceived impact of the HEAT framework

The identified factors were measured in relation to the individual and component HEAT scores using a Multiple Regression Analysis (MRA). According to Shavelson (1996), the MRA may be utilized in an exploratory approach in the effort to identify characteristics that are associated with a desired outcome. An MRA was selected as opposed to a simple linear regression since the study examined the potential impact of a set of independent variables (level of technology training, confidence as users of technology, teachers' perceptions of accessibility to technology, and impact of HEAT). The use of the MRA also enabled the consideration of the individual impact of each independent variable on the dependent variable (change in HEAT scores). Therefore, the collective impact of the four identified factors on the level of lesson design could be examined, as well as the individual impact of each factor. For the purpose of research question one, the MRA was applied to the composite HEAT score. The composite HEAT score was calculated by combining the analytic scores assigned by each evaluator for each HEAT component and calculating the mean score for each scoring session to determine the degree of the linear relationship between the level of instructional design and the four identified factors.

Since all of the independent and demographic variables included in this study were mentioned in current literature, but there appeared to be no consensus regarding which factors may be most predictive, an enter method of regression was selected to conduct an initial MRA. This decision reflects the reasoning that, in the absence of a clear research base, methods such as stepwise regression may be unduly influenced by arbitrary variation in the data (Field, 2009). To place emphasis upon factors which most often appeared in the research and to control for demographic factors, a hierarchical approach to variable selection was used, and the factors were entered in three stages (the five independent factors, teacher demographics, and content area). Hierarchical linear modeling enabled researchers to adjust for naturally occurring clusters of data within educational settings (McCoach, 2010). Therefore, Research Question 1 is based on a hierarchical regression model that hypothesizes the level of technology-infused lesson design can be predicted by a linear combination of the level of technology training, confidence level as users of technology, level of access to technology, and the perceived value of the HEAT framework, plus a set of teacher demographics and content area as control factors. The regression model tested in this model is as follows.

$$\text{HEAT SCORE} = \beta_0 + \beta_1(\text{TRAIN}) + \beta_2(\text{CONF}) + \beta_3(\text{ACCESS}) + \beta_4(\text{IMPACT}) + \beta_5(\text{VALUE}) + \beta_6(\text{GENDER}) + \beta_7(\text{GRADE}) + \beta_8(\text{EXP}) + \beta_9(\text{DEGREE}) + \beta_{10}(\text{AGE}) + \beta_{11}(\text{CONTENT})$$

where HEAT SCORE = composite mean HEAT score for the selected academic year; TRAIN = self-reported level of training; CONF = self-reported level of confidence as a user of technology; ACCESS = self-reported level of access to technology provided by the school/district; IMPACT = self-reported perceived impact of the level of access to technology; VALUE = self-reported perceived value of the HEAT framework; GENDER = gender; GRADE = grade level currently taught; EXP = years of experience in the teaching profession; DEGREE = level of educational degree earned; AGE = chronological age at the time of the study; and CONTENT = primary content area taught during the academic year.

This study included two categorical variables that were recoded into a number of separate dichotomous variables referred to as dummy coding. The dummy coding approach was used for gender and content area. The aforementioned regression model has been simplified, in that the dichotomous variables for gender and content area are not included.

Once the initial MRA was complete, additional MRAs were completed to determine if the same factors had an impact on the individual scores for higher-order thinking, engaged learning, authentic learning, and technology use. Because the MRAs were used to consider what, if any, relationship existed between the selected factors and the level of instructional design, for data analysis purposes the original hypotheses and related sub dimensions were accompanied by both null and alternate hypotheses.

Hypothesis 1: There is a relationship between the level of instructional design and each of the following factors controlling for teachers' demographic factors (e.g., education level, years of experience, grade level, etc.).

a. level of technology training

b. confidence level as a user of technology

c. teachers' perceived accessibility to technology as provided by the school/district

d. teachers' perceived impact of the HEAT framework

Hypothesis 1.1: There is a positive relationship between the level of instructional design and level of technology training.

H_o: $\beta_{\text{Technology Training}} = 0$ (no relationship)

H_1: $\beta_{\text{Technology Training}} \neq 0$ (significant relationship)

Hypothesis 1.2: There is a positive relationship between the level of instructional design and confidence level as a user of technology.

H_o: $\beta_{\text{Confidence Level of Technology Use}} = 0$ (no relationship)

H_1: $\beta_{\text{Confidence Level of Technology Use}} \neq 0$ (significant relationship)

Hypothesis 1.3: There is a positive relationship between the level of instructional design and teachers' perceived accessibility to technology as provided by the school/district.

H_o: $\beta_{\text{Accessibility to Technology}} = 0$ (no relationship)

H_1: $\beta_{\text{Accessibility to Technology}} \neq 0$ (significant relationship)

Hypothesis 1.4: There is a positive relationship between the level of instructional design and teachers' perceived impact of the HEAT framework

H_o: $\beta_{\text{Impact of the HEAT Framework}} = 0$ (no relationship)

H_1: $\beta_{\text{Impact of the HEAT Framework}} \neq 0$ (significant relationship)

In the statistical form of hypotheses, the null hypothesis (H_o) states that the relationship of each factor is not significant, and the alternative hypothesis (H_1) states that the relationship is significant.

Regarding Research Question 2: How does providing feedback to teachers using a research-based framework affect the change in levels of instructional design over sequential periods of lesson review? The repeated-measures ANOVA was used to determine if significant changes in either HEAT component or composite scores occurred over the course of the four collection periods throughout the academic year, with the sequential periods of lesson review being the independent variable and the composite and component HEAT scores being the dependent variable. The repeated-measures ANOVA enables examination of the same parameter under different conditions (in this situation with increased application of the HEAT framework) over time (Popham, 2000).

Because the repeated-measures ANOVA was used to consider what, if any, impact the use of a research-based framework would have on the level of instructional design over time, the hypothesis was accompanied by both null and alternate hypotheses. Hypothesis 2: The use of a research-based framework to provide quarterly feedback to teachers regarding the quality of technology-infused lesson plans will significantly increase the level of lesson design over each quarter.

H_o: $\mu_0=\mu_1=\mu_2=\mu_3$

H_1: One or more μ will be different than the other μ

The null hypothesis (H_o) states that the effect of providing feedback using the HEAT framework is not significant at any time interval, and the alternative hypothesis (H_1)

states that the effect or change in the level of technology-infused lesson design is significant for one or more time intervals. To further examine the significance of any observed changes between time intervals, a post hoc analysis using the Bonferroni method was conducted. The Bonferroni method is often recommended as a technique to adjust for the effects of multiplicity when examining results over time (Aickin & Gensler, 1996).

Additionally, the responses from the teachers' open-ended survey question (Item H, Appendix C) regarding the perceived value, if any, of the HEAT framework were examined to supplement the results of the quantitative methods. Content analysis involves the systematic review of written text to identify common themes or concepts that emerge to support new understanding of the data (Krippendorff & Bock, 2008). Identifying the recurring or similar words and phrases enables the researcher to categorize the open-ended responses into related portions of information that can lend a new level of understanding to the raw data from quantitative measures. In coordination with the quantitative results, content analysis can provide further validation, invalidation, or expansion of findings based on the reported information (Holsti, 1969).

For this study, the inferential data potentially reflects the attitudes and beliefs of the responding population that may contribute to the validity of the quantitative survey items and analysis of lesson plan scores, as well as address the interaction of philosophical, social, and political influences on technology integration. Content analysis of the teacher responses resulted in the following categories: lesson innovation/creativity, student choice, performance standards, collaboration, and distraction from teaching. Responses were also coded separately using a 4-point Likert scale according to their overall tone (negative, partially negative, partially positive, and positive) in terms of teachers' perceived value of the instructional framework.

Fidelity of the Study

To support quality research procedures, unbiased data collection, and validity of the eventual findings, several areas specific to this study were emphasized.

Rater Reliability

The study used existing data that resulted from the school district's double-blind scoring of teacher lesson plans accompanied by student work samples. The confidential nature of the double-blind scoring promoted independent scoring and consistency of those scores (and when necessary, a third score). To determine the reliability of scores between pairs of scorers for the overall HEAT score consistency among the four component scores within each rater, an intraclass correlation was used. According to Shrout and Fleiss (1979), intraclass correlation is an appropriate measure to examine reliability when considering numerous targets assessed by multiple judges or scorers. The intraclass correlation coefficients were 0.59, 0.84, 0.87, and 0.60 for each nine-week review period one through four, respectively ($p = .000$; $CI = 0.95$). These results indicate a moderate to strong correlation among raters, thereby, supporting the reliability of the double-blind scoring process.

Role of the Researcher

This study was somewhat unique in that the researcher was involved as an employee of the participating district with a direct role in the Title II Part D grant implementation. Recognizing the research potential for the data resulting from the project, however, the researcher took reasonable and necessary actions to remove or minimize his roles in grant activities that may have presented the potential for bias or undue influence. For example, the initial training on the HEAT framework was provided to all district instructional leaders as opposed to solely the researcher. The researcher coordinated the details of the lesson plan scoring sessions but did not actually score the lessons. Although the researcher was present in all sessions, a nationally-endorsed LoTi trainer from a regional university led each scoring session and conducted the calibration of the scoring process. The researcher also reinforced the volunteer and confidential nature of the year-end teacher perception survey to teachers so that respondents did not feel obligated to either participate or respond in any particular way.

Adherence to Scoring Protocol

As described earlier, a double-blind scoring procedure was used to ensure confidentiality of the teachers who had submitted lesson plans, anonymity of the scorers, and consistency of assigned scores. Throughout each scoring session the researcher, nationally-endorsed LoTi trainer, and the district's instructional supervisors were present to monitor the process, assist scorers, and ensure adherence to the scoring protocol. Their role in ensuring compliance to the scoring protocol included minimizing discussion among scorers, emphasizing the importance of anecdotal feedback on the lesson plans, maintaining integrity of data entry, and reviewing scores to determine when a third score was necessary. Moreover, each scoring session began with a review of the HEAT framework and calibration of scoring with the group reviewing and independently scoring sample lessons in preparation for the review of actual lesson plans.

Summary of Chapter

Although a considerable number of studies exist in regard to measurement tools for analyzing the degree of and elements associated with technology integration, few studies have examined the interaction of specific teacher factors and the concentrated use of an instructional framework to guide technology-infused lesson design. It is worthwhile to consider what trends or patterns emerge in the development of higher-order thinking, engaged learning, authentic learning, and technology use and their potential relationship with teacher-related factors.

CHAPTER IV: RESULTS

This study sought to identify critical factors that impact the level of technology-infused lesson design in the classroom setting, as well as to identify to what degree the consistent use of an instructional framework to guide lesson design and feedback on those lessons would impact the level of design over time. Specifically, the study provided the opportunity to examine the potential relationship of the level of lesson design (dependent variable) with selected factors such as level of technology training, confidence level as a user of technology, teachers' perceived access to technology, and teachers' perceived impact of the HEAT framework (independent variables). Results were analyzed in relation to identified demographic factors (control variables) including education level, years teaching experience, content area, age, grade level, and gender. The first research question, which examined the relationship between the level of instructional design and identified factors, was analyzed through a Multiple Regression Analysis (MRA). The second question, which examined the change of the level of lesson design over time, was analyzed using a repeated-measures ANOVA. After a summary of descriptive statistics related to the study, each section is organized by an analysis of statistics specific to each research question.

Descriptive Statistics

The study involved the quarterly collection and review of technology-infused lesson plans from 151 certified classroom teachers in a rural south central Kentucky school district. The teaching experience of the population ranged from 1 to 36 years, with a mean of 10.8 years and a standard deviation of 7.7 years. The mean age of the population was 38 years, ranging from age 22 to 64, with a standard deviation of 10. The study population was 79.5% female and 20.5% male. In terms of level of education, 42.4% of the population had earned a bachelor's degree, 40.4% a master's degree, and 17.2% a Rank I (30 or more hours beyond a master's degree). A broad range of content areas was represented across the population, with the largest percentage of teachers (27.2%) working in a self-contained general classroom as shown in Table 4.

Table 4

Summary of Descriptive Statistics for Content Area

Content Area	*N*	%
Arts & Humanities	11	7.3
General/Self-Contained	41	27.2
Language Arts	15	9.9
Mathematics	13	8.6
Media/Technology	5	3.3
Other	6	4.0
Physical Education	8	5.3
Science	10	6.6
Social Studies	17	11.3
Special Education	25	16.6

N = 151

Factors Impacting Level of Instructional Design Hypothesis Analysis

The independent variables associated with the first hypothesis, which considered the relationship between identified variables and the level of instructional design, included level of technology training, confidence level as a user of technology, teachers' perceived access to the technology and the impact of access, and teachers' perceived impact of the HEAT framework. Survey respondents used a 4-item Likert scale ranging from *completely inadequate* (1) to *highly adequate* (4) or similar wording depending on the context of the question, as shown in Appendix C, to rate the independent variables. Descriptive statistics and intercorrelations for these variables are summarized in Table 5. Level of access to technology was the highest rated item (M = 3.47) followed closely by the impact of the level of access to technology (M = 3.40). Among the five variables, the teacher's perceived impact of the HEAT framework received the lowest rating (M = 2.66) and was the only item not meeting a mean threshold of 3.0 (*somewhat adequate or somewhat valuable*).

Table 5

Summary of Intercorrelations, Means, and Standard Deviations for Factors Related to Level of Instructional Design

Factor	1	2	3	4	5	*M*	*SD*
TRAIN	—	.695*	.583*	.537*	.454*	3.11	.72
CONF	.695*	—	.542*	.594*	.447*	3.09	.76
ACCESS	.583*	.542*	—	.465*	.379*	3.47	.89
IMPACT	.537*	.594*	.465*	—	.334*	3.40	.78
VALUE	.454*	.447*	.379*	.334*	—	2.66	.86

Note. TRAIN = level of technology training; CONF = level of confidence as a user of technology; ACCESS = level of access to technology provided by the school/district; IMPACT = perceived level of impact of technology; VALUE = perceived value of the HEAT framework
*$p < 0.01$; $N = 151$

Results of correlation analysis confirmed the use of an MRA to examine the relationship of the independent variables on the level of instructional design, while controlling for the demographic factors described earlier. As shown in Table 6, the correlation coefficient (r) was significant for three of the five target variables. The r value was less than 0.3 for four of the five factors, indicating only a small effect.

However, the variable for confidence level as a user of technology demonstrated a medium effect ($r = 0.346$) since it was greater than 0.3. The correlation coefficient for the control variables was not significant. In addition, the Variance Inflation Factor (VIF) further supported the use of an MRA. Since the VIF was less than 10 for each factor, the results indicated a lack of multicollinearity (Myers, 1990), indicating that the predictors in the regression model are not highly correlated.

Table 6

Pearson's Correlation Coefficient and Variance Inflation Factor for Values in Relation to Composite HEAT Score

Factor	*r*	*VIF*
Level of Training	0.192*	2.309
Confidence Level as a User of Technology	0.346**	2.351
Level of Access to Technology	0.108	1.659
Impact of Access to Technology	0.147	1.659
Perceived Value of HEAT Framework	0.217**	1.334

*$p < 0.05$
**$p < 0.01$

Since all of the factors considered in this study are mentioned throughout current literature, but the literature does not consistently reflect which factors may be most predictive, an enter method of regression was selected to conduct an initial MRA. This decision reflects the reasoning that, without a clear research base to support a hierarchical methodology, methods such as stepwise regression may be unduly influenced by arbitrary variation in the data (Field, 2009). However, to place emphasis upon factors most often appearing in the research and to control for demographic factors, the factors were entered in three stages (the five independent factors, teacher demographics, and content area).

Table 7 indicates the significance of the regression model [i.e., HEAT SCORE = $\beta_0 + \beta_1$(TRAIN) + β_2(CONF) + β_3 (ACCESS) + β_4 (IMPACT)+ β_5 (VALUE) + β_6(GENDER) + β_7(GRADE)+ β_8(EXP) + β_9(DEGREE) + β_{10}(AGE) + β_{11}(CONTENT); F = 4.797; p = 0.000]. The resulting R-squared value of 0.142 indicates that 14.2% of the variation in composite HEAT scores was predicted by the independent target variables: level of technology training, confidence as a user of technology, access to technology, perceived impact of access to technology, and perceived impact of the HEAT framework.

Table 7

Multiple Regression Source Table for Independent Variables

Source	*SS*	*df*	*MS*	*F*
Regression	4.510	5	0.902	4.797*
Residual	27.264	145	0.188	
Total	31.774	150		

**p < .05*

Data is not reported for models two and three (teacher demographics and content area, respectively) in Table 7 since the variance in scores was explained by the target variables; therefore, the control variables did not contribute to the prediction of HEAT scores. However, Table 8 reports the complete analyses of all variables related to the prediction of HEAT scores; confidence level as a user of technology was the only variable that demonstrated a significant relationship with predicted HEAT score.

Table 8

Hierarchical Multiple Regression Analyses Predicting Composite HEAT Score

Predictor	ΔF	β
Step 1	4.797*	
Level of Training		-.070
Confidence Level		.437*
Access to Technology		-.100
Impact of Access		-.067
Value of HEAT Framework		.113
Step 2	.392	
Gender		-.056
Grade Level		.095
Years Experience		-.004
Educational Degree		-.050
Age		-.049
Step 3	3.615	
Content area		.197

$*p < .05$

Additional MRAs regarding the independent variables and each individual element of the HEAT framework indicated that the Stage 1 variables (training, confidence, access, impact of access, and perceived value of the HEAT framework) predicted over 9% of each component score, including 9.4% for higher-order thinking, 9.1% for engagement of students, 9.7% for authentic instruction, and 9.4 % for technology integration.

Change in Level of Instructional Design Over Time Hypothesis Analysis

The second research question examined the increase in the level of instructional design when teachers were provided feedback using the HEAT instructional framework. A repeated-measures ANOVA was used to examine the composite overall HEAT scores, as well as the composite scores for each element of HEAT for each nine-week period of the academic year.

Descriptive statistics of the composite HEAT scores are summarized for the four nine-week review periods in Table 9; the mean of each pair of composite scores for each lesson plan was used as the composite HEAT score for each nine-week period. Possible scores on the HEAT framework ranged from 0 (non-use) to 6 (refinement), with a goal of 3 (infusion) or 4 (integration) considered the minimal desired result.

Examination of the mean scores by nine-week period indicates that both the composite and component scores increased steadily across periods one, two, and three. A slight decrease occurred in the composite and component scores between the third and fourth nine-week periods. Review of the standard deviation *(SD)* of the composite HEAT scores suggested a broader range of scores among teachers' plans throughout the year, again with the exception of the fourth nine weeks when the *SD* decreased slightly. The increase in *SD*s suggests a greater variance of scores, as some teachers' lesson plans demonstrated a higher level of increase in instructional design than others each nine-week period.

Table 9

Descriptive Statistics of HEAT Scores for each Nine-Week Review Period

Score	Nine-Week Period	*M*	*SD*
Composite HEAT	1	1.85	0.569
	2	2.36	0.727
	3	2.72	0.831
	4	2.58	0.742
Higher-Order Thinking	1	1.91	0.656
	2	2.32	0.834
	3	2.75	0.806
	4	2.60	0.699
Engagement of Students	1	1.68	0.533
	2	2.32	0.732
	3	2.75	0.794
	4	2.60	0.681
Authentic Instruction	1	1.76	0.646
	2	2.34	0.779
	3	2.70	0.869
	4	2.50	0.750
Technology Integration	1	1.68	0.606
	2	2.22	0.723
	3	2.75	0.782
	4	2.60	0.756

N = 128

Table 10 presents the results of the repeated-measures ANOVA of the composite HEAT scores. The Mauchly test statistic (0.916) was not significant ($p = .052$), indicating the equality of the variances between levels of the repeated measures factor is assumed. Thus, results of the repeated measures ANOVA can be trusted.

Table 10

ANOVA Results for Composite HEAT Scores

Factor	*SS*	*df*	*MS*	*F*	η^2
Nine-Week Period	55.935	3	18.645	45.305*	0.263
Error	156.799	381	.412		

* $p < .05$

The significant within-subjects effect for composite HEAT Scores ($F = 45.305$, $p = .000$) suggests that the composite HEAT scores increased significantly over time, as depicted in Figure 6.

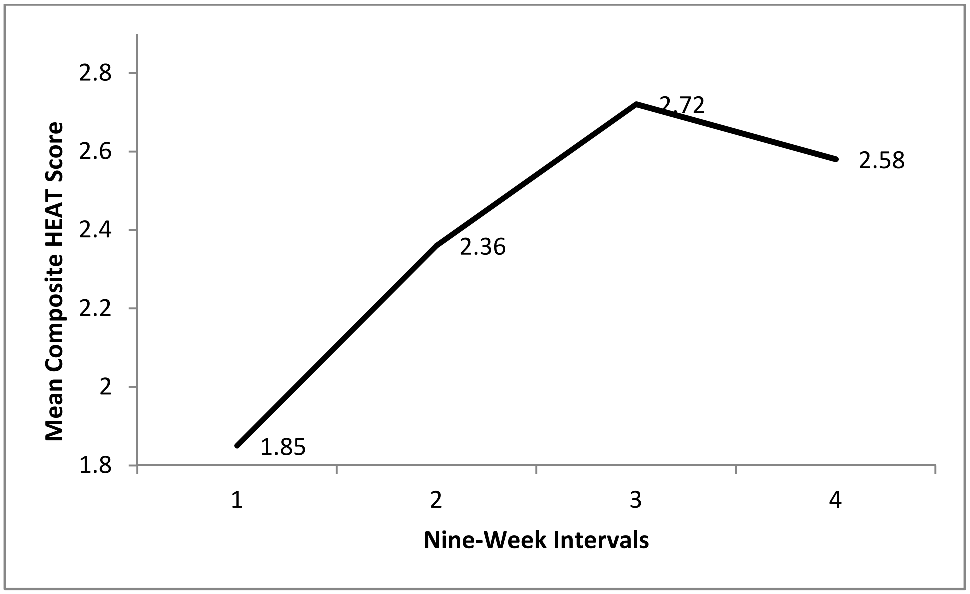

Figure 6. Mean differences of composite HEAT scores across nine-week intervals.

Based on the repeated-measures ANOVA, the use of the HEAT framework to guide lesson design and provide feedback over time accounts for 26.3% of the variation in composite HEAT scores ($\eta^2 = .263$). However, when a linear trend ($p = .000$) is applied to the results, 44.8% of the variation over time can be attributed to the HEAT framework ($\eta^2 = .448$). A quadratic trend in which 20.7% of the variation can be attributed to the HEAT framework is also statistically significant ($\eta^2 = .207$, $p = .000$) and also could be applied.

Post hoc analysis was conducted for the significant increase in level of lesson design as measured by composite HEAT scores using the Bonferroni adjustment. The post hoc comparison results are summarized in Table 11 using the first nine-week interval as the baseline. The results indicate that the increases demonstrated at each time interval between the first nine weeks, the second nine weeks, and the third nine weeks are significantly different from one another. This result suggests that the noted gains in composite HEAT scores are significant across time. However, the decrease in scores from the third to the fourth nine weeks is not significantly different between the two periods.

Table 11

Post Hoc Comparisons of Composite HEAT Scores Across Nine-Week Intervals

Nine-Week Period	Nine-Week Period	Mean Difference	*SE*
Baseline (1st Nine Weeks)	2nd Nine Weeks	-0.514*	0.067
	3rd Nine Weeks	-0.869*	0.084
	4th Nine Weeks	-0.732*	0.076
2nd Nine Weeks	Baseline	0.514*	0.067
	3rd Nine Weeks	-0.355*	0.084
	4th Nine Weeks	-0.218*	0.079
3rd Nine Weeks	Baseline	0.869*	0.084
	2nd Nine Weeks	0.355*	0.084
	4th Nine Weeks	0.137	0.088
4th Nine Weeks	Baseline	0.732*	0.076
	2nd Nine Weeks	0.218*	0.079
	3rd Nine Weeks	-0.137	0.088

*$p < 0.05$

Since the study included the collection of scores for each element of HEAT (higher-order thinking, engagement of learners, authentic instruction, and technology integration) in addition to a composite HEAT score, data also was available to examine the increase in individual elements across time using the repeated-measures ANOVA. Table 12 presents the results of the repeated-measures ANOVA of the composite scores for higher-order thinking. The Mauchly test statistic (0.968) was not significant ($p = .469$), indicating the equality of the variances between levels of the repeated measures factor is assumed. Thus, results of the repeated measures ANOVA can be trusted.

Table 12

ANOVA Results of Composite Higher-Order Thinking Scores

Factor	*SS*	*df*	*MS*	*F*	η^2
Nine-Week Period	59.539	3	19.846	44.954*	0.239
Error	189.398	429	.441		

*$p < .05$

The significant within-subjects effect for composite higher-order thinking scores ($F = 44.954$, $p = .000$) suggests that the composite higher-order thinking scores increased significantly over time as depicted in Figure 7.

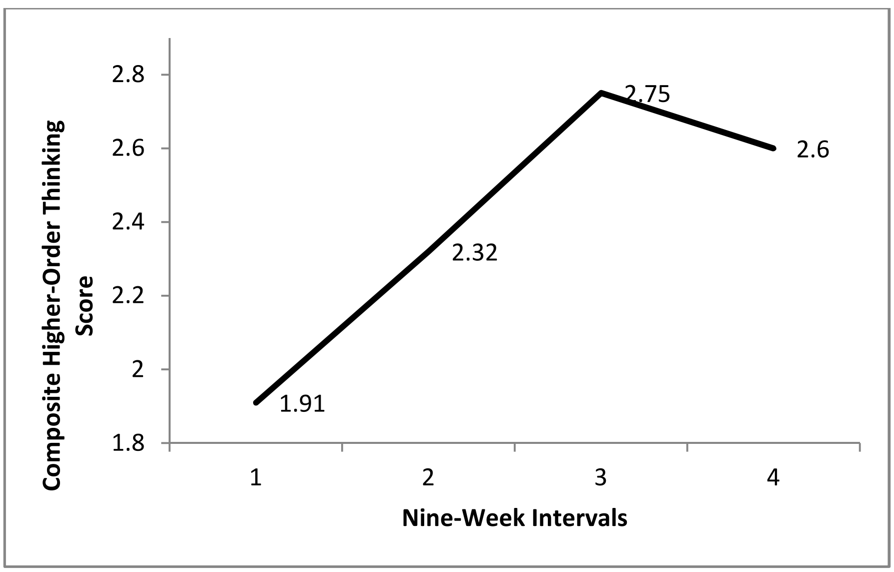

Figure 7. Mean differences of higher-order thinking scores across nine-week intervals.

Based on the repeated-measures ANOVA, the use of the HEAT framework to guide lesson design and provide feedback over time accounts for 23.9% of the variation in composite higher-order thinking scores ($\eta^2 = .239$). However, when a linear trend

(p = .000) is applied to the results, 45.2% of the variation over time can be attributed to the HEAT framework ($\eta^2 = .452$). A quadratic trend in which 15.4% of the variation can be attributed to the HEAT framework is also statistically significant ($\eta^2 = .154$, $p = .000$) and also could be applied.

Post hoc analysis also was conducted for the significant increase in the higher-order thinking scores using the Bonferroni adjustment. The post hoc comparison results are summarized in Table 13, using the first nine-week interval as the baseline. The results indicate that the increases observed at each time interval between the first nine weeks, the second nine weeks, and the third nine weeks are significantly different from one another. This suggests that the noted gains in higher-order thinking scores are significant across time. However, the decrease in scores from the third to the fourth nine weeks is not significantly different from each other.

Table 13

Post Hoc Comparisons of Composite Higher-Order Thinking Scores Across Nine-Week Intervals

Nine-Week Period	Nine-Week Period	Mean Difference	*SE*
Baseline (1st Nine Weeks)	2nd Nine Weeks	-0.417*	0.077
	3rd Nine Weeks	-0.847*	0.080
	4th Nine Weeks	-0.691*	0.071
2nd Nine Weeks	Baseline	0.417*	0.077
	3rd Nine Weeks	-0.431*	0.084
	4th Nine Weeks	-0.274*	0.078
3rd Nine Weeks	Baseline	0.847*	0.080
	2nd Nine Weeks	0.431*	0.084
	4th Nine Weeks	0.156	0.080
4th Nine Weeks	Baseline	0.691*	0.071
	2nd Nine Weeks	0.274*	0.078
	3rd Nine Weeks	-0.156	0.080

*$p < 0.05$

Table 14 presents the results of the repeated-measures ANOVA of the composite score for engagement of students. The Greenhouse-Geisser measure (0.950) was used to adjust for sphericity since the Mauchly test statistic (0.923, p = .044) was significant.

Table 14

ANOVA Results of Composite Engagement of Students Scores

Factor	*SS*	*df*	*MS*	*F*	η^2
Nine-Week Period	77.962	2.85	27.352	69.88*	0.328
Error	159.538	407.58	.391		

*p < .05

After adjustment for sphericity, the significant within-subjects effect for the composite scores for engagement (F = 69.88, p = .000) suggests that the composite scores for engagement of students increased significantly over time as depicted in Figure 8.

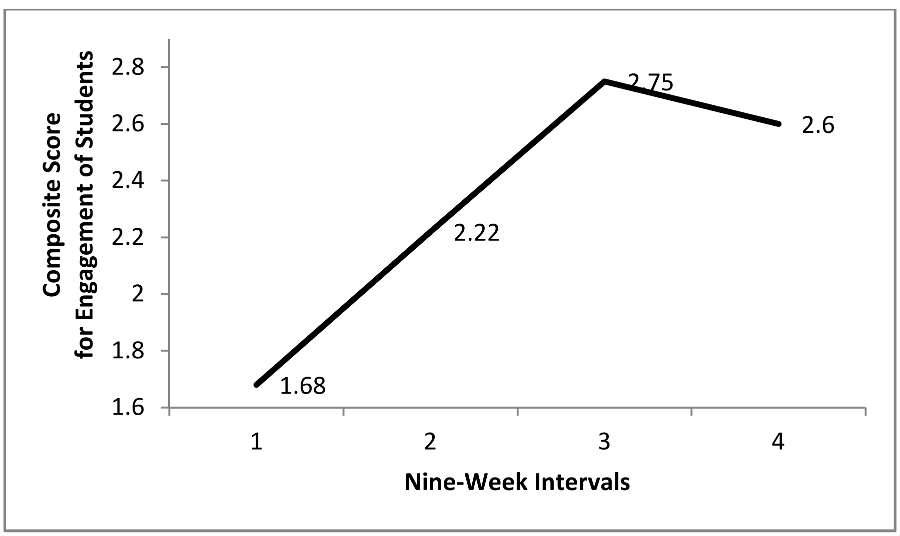

Figure 8. Mean differences of scores for engagement of students across nine-week intervals.

Based on the repeated-measures ANOVA, the use of the HEAT framework to guide lesson design and provide feedback over time accounts for 32.8% of the variation in composite scores for engagement of students (η^2= .328). However, when a linear trend (p = .000) is applied to the results, 56.8% of the variation over time can be attributed to the HEAT framework (η^2 = .568). A quadratic trend in which 20.4% of the variation can be attributed to the HEAT framework is also statistically significant (η^2 = .204, p = .000) and also could be applied.

Post hoc analysis was also conducted for the significant increase in the composite scores for engagement of students using the Bonferroni adjustment. The post hoc comparison results are summarized in Table 15, using the first nine-week interval as the baseline. The results indicate that the increases demonstrated at each time interval between the first nine weeks, the second nine weeks, and the third nine weeks are significantly different from one another. This suggests that the noted gains in composite scores for the engagement of students are significant across time. Likewise, the decrease in scores from the third to the fourth nine weeks is not significantly different from each other. This result suggests the decrease in scores for engagement of students occurring in the fourth nine weeks is not significant.

Table 15

Post Hoc Comparisons of Composite Scores for Engagement of Students Across Nine-Week Intervals

Nine-Week Period	Nine-Week Period	Mean Difference	*SE*
Baseline (1st Nine Weeks)	2nd Nine Weeks	-0.542*	0.065
	3rd Nine Weeks	-0.941*	0.078
	4th Nine Weeks	-0.851*	0.064
2nd Nine Weeks	Baseline	0.542*	0.065
	3rd Nine Weeks	-0.399*	0.078
	4th Nine Weeks	-0.309*	0.071
3rd Nine Weeks	Baseline	0.941*	0.078
	2nd Nine Weeks	0.399*	0.078
	4th Nine Weeks	0.090	0.074
4th Nine Weeks	Baseline	0.851*	0.064
	2nd Nine Weeks	0.309*	0.071
	3rd Nine Weeks	-0.090	0.074

$^*p < 0.05$

Table 16 presents the results of the repeated-measures ANOVA of the composite score for authentic learning. The Mauchly test statistic (0.942) was not significant (p = .130), indicating the equality of the variances between levels of the repeated measures factor is assumed. Therefore, results of the repeated measures ANOVA can be trusted.

Table 16

ANOVA Results of Composite Authentic Learning Scores

Factor	*SS*	*df*	*MS*	*F*	η^2
Nine-Week Period	72.115	3	24.038	50.548*	0.261
Error	204.010	429	.476		

$^*p < .05$

The significant within-subjects effect for composite authentic learning scores (F = 50.548, p = .000) suggests that the composite authentic learning scores increased significantly over time as depicted in Figure 9.

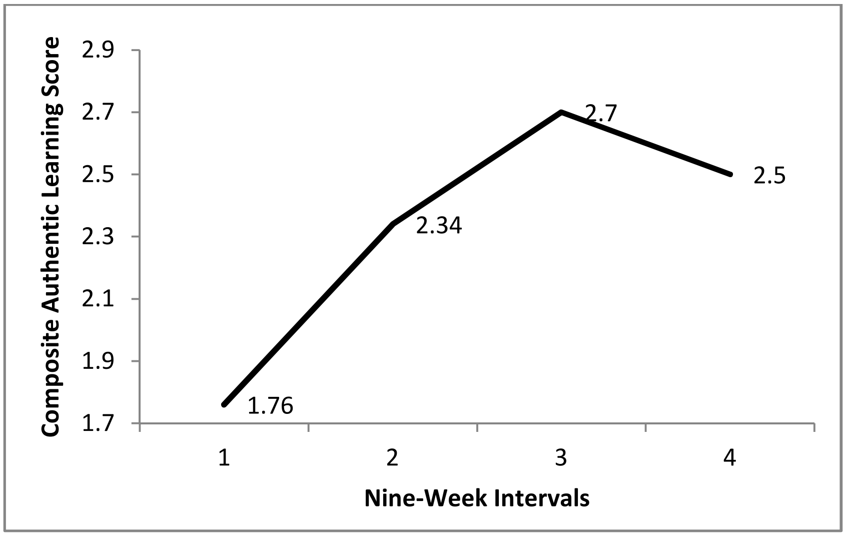

Figure 9. Mean differences of authentic learning scores across nine-week intervals.

Based on the repeated-measures ANOVA, the use of the HEAT framework to guide lesson design and provide feedback over time accounts for 26.1% of the variation in composite authentic learning scores (η^2 = .261). However, when a linear trend (p = .000) is applied to the results, 39.8% of the variation over time can be attributed to the HEAT framework (η^2 = .398). A quadratic trend in which 25.6% of the variation can be attributed to the HEAT framework is also statistically significant (η^2 = .256, p = .000) and also could be applied.

Post hoc analysis also was conducted for the significant increase in the authentic learning scores using the Bonferroni adjustment. The post hoc comparison results are summarized in Table 17, using the first nine-week interval as the baseline. The results are primarily similar to those for the composite scores for HEAT, higher-order thinking, and engagement of students. The results indicate that the increases demonstrated at each time interval between the first, second, and third nine weeks significantly differ from one another. This suggests that the noted gains in authentic learning composite scores are significant across time. Unlike the previous areas, the increase between the second nine weeks and fourth nine weeks scores for authentic learning was not a significant difference. Likewise, the decrease in scores from the third to the fourth nine weeks is not significantly different. This result suggests the decrease in authentic learning scores occurring in the fourth nine weeks is not significant.

Table 17

Post Hoc Comparisons of Composite Authentic Learning Scores Across Nine-Week Intervals

Nine-Week Period	Nine-Week Period	Mean Difference	*SE*
Baseline (1st Nine Weeks)	2nd Nine Weeks	-0.642*	0.074
	3rd Nine Weeks	-0.944*	0.089
	4th Nine Weeks	-0.747*	0.078
2nd Nine Weeks	Baseline	0.642*	0.074
	3rd Nine Weeks	-0.302*	0.081
	4th Nine Weeks	-0.104	0.082
3rd Nine Weeks	Baseline	0.944*	0.089
	2nd Nine Weeks	0.302*	0.081
	4th Nine Weeks	0.198	0.083
4th Nine Weeks	Baseline	0.747*	0.078
	2nd Nine Weeks	0.104	0.082
	3rd Nine Weeks	-0.198	0.083

*$p < 0.05$

Table 18 presents the results of the repeated-measures ANOVA of the composite score for technology integration. The Mauchly test statistic (0.961) was not significant

(p = .347), indicating the equality of the variances between levels of the repeated measures factor is assumed. Therefore, results of the repeated measures ANOVA can be trusted.

Table 18

ANOVA Results of Composite Technology Integration Scores

Factor	*SS*	*df*	*MS*	*F*	η^2
Nine-Week Period	38.701	3	12.90	31.414*	0.18
Error	176.174	429	.411		

*p < .05

The significant within-subjects effect for composite technology integration scores (F = 31.414, p = *.000*) suggests that the composite technology integration scores increased significantly over time as depicted in Figure 10.

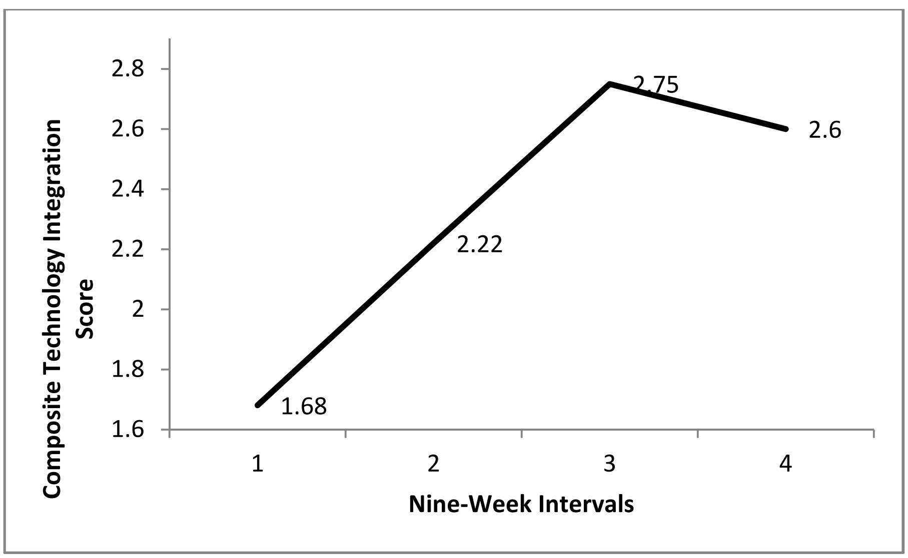

Figure 10. Mean differences of technology integration scores across nine-week intervals.

Based on the repeated-measures ANOVA, the use of the HEAT framework to guide lesson design and provide feedback over time accounts for 18% of the variation in composite technology integration scores (η^2 = .18). However, when a linear trend

(p = .000) is applied to the results, 32.4% of the variation over time can be attributed to the HEAT framework (η^2=.324). A quadratic trend in which 17.1% of the variation can be attributed to the HEAT framework is also statistically significant (η^2 = .171, p = .000) and also could be applied.

Post hoc analysis was also conducted for the significant increase in the technology integration scores using the Bonferroni adjustment. The post hoc comparison results are summarized in Table 19, using the first nine-week interval as the baseline. The results are considerably different than for the other three elements of HEAT. While the noted gains when comparing first nine-week scores with the remaining intervals are statistically significant, none of the changes between the second, third, and fourth nine-week periods are statistically significant.

Table 19

Post Hoc Comparisons of Composite Technology Integration Scores Across Nine-Week Intervals

Nine-Week Period	Nine-Week Period	Mean Difference	*SE*
Baseline (1st Nine Weeks)	2nd Nine Weeks	-0.486*	0.069
	3rd Nine Weeks	-0.674*	0.076
	4th Nine Weeks	-0.576*	0.074
2nd Nine Weeks	Baseline	0.486*	0.069
	3rd Nine Weeks	-0.188	0.077
	4th Nine Weeks	-0.090	0.074
3rd Nine Weeks	Baseline	0.674*	0.076
	2nd Nine Weeks	0.188	0.077
	4th Nine Weeks	0.097	0.083
4th Nine Weeks	Baseline	0.576*	0.074
	2nd Nine Weeks	0.900	0.074
	3rd Nine Weeks	-0.097	0.083

*$p < 0.05$

Content Analysis of Open-Ended Question

An open-ended question (see Item H in Appendix C) was included in the year-end teacher survey to gather supplemental data related to the perceived value of the HEAT framework. Since the open-ended question was descriptive rather than quantitative, content analysis was used to examine the responses. Content analysis is a research procedure that includes systematically reading relatively small sections of text as a method for identifying themes among data (Krippendorff, 2004), thereby categorizing similar words or phrases into meaningful portions of information that can lead to increased understanding of the subject of study and further support or question quantitative results.

Teachers were presented the following question: In what way, if any, has use of the HEAT framework most benefitted you as a teacher? Of the 151 teachers surveyed, 131 teachers responded to the open-ended question, representing nearly an 87% response rate. The process of inductive content analysis was used to code the respondents' answers. Responses were systematically categorized, with new categories being created as needed to adequately capture the sentiment of the comments. Table 20 lists the resulting categories.

In addition to the content analysis, responses to the open-ended survey item were also coded using a 4-point Likert scale that paralleled the quantitative survey item choices: 1= negative response, 2 = mostly negative, 3 = mostly positive, and 4 = positive response. The mean score for the coded responses was 3.57, indicating that the majority of the responding teachers viewed the HEAT framework as useful in some way. These results demonstrated a moderate correlation ($r = 0.492$, $p = .000$) with the quantitative survey item related to the perceived value of the HEAT framework.

Table 20

Categories of Open-Ended Question Responses

Category	Description
Lesson Innovation/Creativity	Development of new or inventive lesson resources that teachers indicated they may not have used or been made aware of previously
Student Choice	Increased opportunities for students to make meaningful choices in content, process, and/or product
Performance Standards	Increased awareness of teachers and students regarding learning outcomes, expectations, and higher-order thinking
Collaboration	More opportunities to connect learning within the school and into the community
Distraction from Teaching	Unnecessary process that required time away from direct instruction

Lesson Innovation/Creativity was the first category identified. Teachers frequently commented that the development and review of technology-infused lesson plans prompted them to reflect upon their teaching practices and either experiment with a broader range of existing learning strategies and resources or implement new approaches altogether. In several instances, teachers commented on the use of technology in new ways to teach content or ignite student interest in learning. Table 21 presents verbatim teacher comments that prompted the creation of this particular category.

Table 21

Supporting Quotations from Teacher Responses in the Lesson Innovation/Creativity Category

Description of Category	Supporting Quotations
Use of new or inventive lesson resources that teachers indicated they may not have used or been made aware of previously	"The framework has required me to think more creatively and critically about student technology projects. I have had to think outside my comfort zone . . ."
	"I learned new programs available for classroom use."
	"Expanded ideas of ways to improve classroom instruction."
	"Incorporating new and differentiated instruction . . ."
	". . . raising the HEAT level has given me tools and ideas to improve."
	" . . . encouraged me to think of more innovative ways to use technology in the classroom."
	"Using assorted resources rather than only one or two resources per lesson."

The second category identified was Student Choice. References to student choice appeared frequently among responses, with teachers citing both an increased awareness to provide students choice as part of classroom instruction and the positive impact that increased student choice had on student engagement. Technology was mentioned consistently as a method to provide various choices for student learning, as well as a way to engage students with the choices made available to them. Table 22 contains verbatim teacher comments representative of those placed in this category.

Table 22

Supporting Quotations from Teacher Responses in the Student Choice Category

Description of Category	Supporting Quotations
Increased opportunities for students to make meaningful choices in content, process, and/or product	" . . . helped me focus on the benefits of student choice when developing projects and activities."
	". . . allowed me to give more choice to students as to what content they research and how they choose to present what they learn."
	"It has helped me create a more student-led environment."
	"I am more conscious of allowing my students freedom of choice to spark their interest. The classroom has become more student centered and less teacher centered."

Performance Standards was the third category resulting from the content analysis. Although the comments within this category were the most diverse among all the groups, teachers were clear in expressing how the use of the HEAT framework clarified performance standards and expectations of high performance for them and their students. Comments within this category also emphasized the impact that HEAT had in developing higher-order thinking tasks as part of the lesson design and promoting higher-order thinking among students. Several comments also reflected the concept that higher-order thinking was achievable through use of technology as a teaching tool, not as a separate curriculum or stand-alone activity. Table 23 contains verbatim teacher comments representative of those placed in this category.

Table 23

Supporting Quotations from Teacher Responses in the Performance Standards Category

Description of Category	Supporting Quotations
Increased awareness of teachers and students regarding learning outcomes, expectations, and higher-order thinking	"It has required me to think of ways to integrate technology at a level that suits, yet challenges, my students ."
	". . . I give more choice in what they [students] do while incorporating higher-level thinking into learning."
	"It has made me realize that my instruction is not high-level thinking for the students a majority of the time."
	" . . . has encouraged reflection upon higher learning."
	" . . . instruction that involves students learning 'with technology' as opposed to 'from technology'."

The fourth category identified was Collaboration. This is a broad category that includes responses related to collaborative learning activities, collaboration with other teachers, collaboration with community resources, and connections with real-world content through collaboration. Regardless of the particular type of collaboration, it was evident from the qualitative responses that the HEAT framework made a positive impact toward increasing collaboration. Several of the responses expressed the sentiment that the HEAT framework provided additional opportunities or impetus to collaborate with support staff and content specialists that ordinarily may have not occurred. Table 24 presents verbatim comments characteristic of those placed in this category.

Table 24

Supporting Quotations from Teacher Responses in the Collaboration Category

Description of Category	Supporting Quotations
More opportunities to connect learning within the school and into the community	"It has allowed us, as teachers, to converse about what we have done, what went right, and what went wrong." "I have enjoyed working with my co-workers . . . we have become more of a team working toward the same goals." "It has given me a reason and desire to collaborate with coworkers and other resources." "Using resources from the community to bolster the use of technology." "I actually got to see my students' work benefit the community, and the students got to see that they can have a positive impact."

While 86.3% of the qualitative responses were coded as "positive" or "mostly positive," the remaining "mostly negative" and "negative" responses could be summarized into a single category identified as Distraction from Teaching. While a minority of respondents within this category were vague in their description as to why they found the HEAT framework to be a distraction, several expressed exact sentiments. Recurring concerns included viewing the technology-infused lesson plans as an added task or burden in an already burgeoning workload, lamenting the amount of time required to implement lessons, and artificially forcing technology integration with content at inopportune times. Table 25 presents verbatim comments representative of those placed in this category.

Table 25

Supporting Quotations from Teacher Responses in the Distraction from Teaching Category

Description of Category	Supporting Quotations
Unnecessary process that required time away from direct instruction.	"It has put more work on me and made me feel less successful." "It has hindered the process of learning. It is an unneeded burden . . ." "I will use it [HEAT framework] to help plan and monitor the levels of thinking and learning styles. It has created one more obstacle in teaching by having to create and prove what I do in the classroom." "It took a lot of time that could have been used otherwise." "There have been times I have had to take away from the students and content to fit something in . . ."

In regard to the content analysis of the open-ended question and Research Question 1, the qualitative results reinforce the quantitative results, since 86.3% of the qualitative responses could be characterized as partially or completely positive; and the mean value for the quantitative question regarding respondent's perceived value of the HEAT framework (M = 2.66, SD = 0.86) approached the "moderate improvement" score of 3.0. Conversely, although the quantitative statistical results did not indicate a significant relationship between teachers' perceived value of the impact of the HEAT framework and the level of lesson design, the qualitative data indicates that 86.3% of the respondents (representing 87% of the total population) cited a positive benefit of the framework within the identified categories of lesson innovation/creativity, student choice, performance standards, collaboration, and distraction from teaching.

Summary of Chapter

A hierarchical, enter-method MRA was conducted to examine whether a positive relationship existed between the five selected independent variables and the level of technology-infused lesson design. The independent variables included level of technology training, confidence as a technology user, level of access to technology, impact of the level of access to technology, and teachers' perceived value of the HEAT framework. Additionally, the MRAs controlled for teacher demographic factors (age, years experience, educational degree, grade level, and gender) and content area. The analysis indicated that among the five independent variables, confidence as a user of technology demonstrated a positive relationship on the level of technology-infused lesson design. Similar impact of the confidence level as a user of technology was confirmed for each element of the HEAT framework through an additional MRA for each component. The remaining variables, including the independent and control variables, did not demonstrate a relationship, either positive or negative, with the level of technology-infused lesson design.

The second research question considered the increase in the level of technology-infused lesson design while using the HEAT framework to guide lesson design and feedback over time. Five repeated-measures ANOVAs were used to examine the composite HEAT score for each nine-week interval of the selected academic year, as well as composite scores for each individual component of HEAT (higher-order thinking, engagement of students, authentic learning, and technology integration). The analysis indicated that the composite HEAT score, as well as the scores for each individual element, increased significantly over time, with the exception of the fourth nine-week interval in which a decrease was observed in all areas. The decrease in the fourth nine-week period is attributable to loss of instructional time due to the state accountability testing schedule and other year-end activities.

The quantitative measures and methodology were accompanied with qualitative analysis of a single open-ended survey item related to teachers' perceived benefit of the HEAT instructional framework. The results of the qualitative analysis closely paralleled the quantitative results but also provided specific examples of teachers' perceived benefit of the application of the HEAT framework.

These results hold implications for classroom practitioners, school and district leaders, staff developers, and others involved with educational decision making in the 21st Century. The results of the statistical analysis and related implications are discussed in the Chapter V.

CHAPTER V: DISCUSSION

The focus of this study was the identification of factors that demonstrate a positive relationship with the level of technology-infused lesson design in the K-12 setting. Additionally, the study examined the impact of the HEAT instructional framework on the level of technology-infused lesson design over time when used to guide lesson development and provide feedback to teachers. The topic of this study is especially important when considered in the context of the 21st Century educational setting.

Current literature indicates an ever-increasing divide between the needs of 21st Century digital learners and the instructional methods associated with traditional classroom instruction. Although the quantity and accessibility of instructional technology continue to increase in modern public schools, in many instances technology is used to streamline traditional learning tasks instead of making instruction more authentic, engaging, and challenging for students (Trotter, 2007). Concurrently, students' learning needs and modalities are significantly different than prior generations of students and the majority of today's teachers (Jukes et al., 2010).

Therefore, the issue of effective technology integration goes beyond mere inclusion of technology as an occasional teaching tool or as a separate curricular topic. To be genuinely effective, technology must be integrated as part of regular instruction to engage students in high-level, content-focused activities perceived as meaningful and significant by students in order to maximize learning. Willingham (2009) concluded that many students are not engaged in school because of the emphasis on teacher-directed instruction that does not appeal to students who cognitively demand moderately-challenging, yet solvable problems. The literature is replete with similar conclusions by other authorities in the field of 21st Century learning such as Rosen (2010), Prensky (2010), Jukes et al. (2010), and Kozma (2003).

This study was guided by the following research questions:

Research Question 1: Is there a relationship between levels of instructional design and each of the following factors controlling for teachers' demographic factors (e.g., education level, years of experience, grade level, etc.)?

a. level of technology training
b. confidence level as a user of technology
c. teachers' perceived accessibility to technology as provided by the school/district
d. teachers' perceived impact of the HEAT framework

Research Question 2: How does providing feedback to teachers using a research-based framework affect the change in levels of instructional design over sequential periods of lesson review?

Discussion of Findings

The analysis of factors impacting the level of K-12 technology-infused lesson design yielded some significant findings that both support existing literature and suggest areas for future research.

Discussion of Findings for Research Question 1

Results indicated that, among the three stages of variables (independent, demographic, and content area) considered in the study, only the five independent variables demonstrated a positive relationship on the level of technology-infused lesson plan design. The independent variables demonstrated a 14.2% contribution to the composite HEAT score. Within these variables, confidence as a user of technology was the only stage-one variable to demonstrate a statistically significant impact on the predicted HEAT score. The remaining independent variables and control variables did not demonstrate any relationship, positive or negative, on the level of technology-infused lesson design. Therefore, Hypotheses 1.1, 1.3, and 1.4 that predicted a positive relationship between the level of technology training, perceived access to technology, and perceived value of the HEAT framework with the level of technology-infused lesson design are rejected. Hypotheses 1.2 that predicted a positive relationship between the confidence level as a user of technology and the level of technology-infused lesson design is accepted. In addition, the importance of confidence as a user of technology was further confirmed by the additional enter-method MRAs that confirmed a 9% or greater contribution for each individual element of the HEAT framework.

This finding is particularly significant when considering the demographic data of the population, as well as the teachers' self-reported ratings of the five independent variables. Given the age (M = 38 years), years experience (M = 10.8 years), and education level (over 57% held a master's degree or beyond) of the study population, this finding cannot be attributed to a young, inexperienced, or under-educated teaching staff. Likewise, since the teachers reported their level of training (M = 3.11), confidence as a user of technology (M = 3.09), level of access to technology (M = 3.47), and the impact of access to technology (M = 3.40) to be "mostly adequate" according to the Likert scale survey items, this finding is not reflective of a poorly-trained population that is ill-equipped in the area of technology.

Additionally, while the teachers' perception of the impact of the HEAT framework (M = 2.66) was generally lower than their self-reported ratings for the other four independent variables and demonstrated a lower correlation ($r = 0.217$) with the composite HEAT score than the other variables, the teachers' perception of the HEAT framework was generally positive. The results of coding the open-ended survey item responses regarding the possible benefits of the HEAT framework indicated that 86.3% of the respondents identified at least one benefit of the framework as mostly positive or positive. Likewise, four of the five categories resulting from the content analysis were positive in nature (lesson innovation/creativity, performance standards, student choice, and collaboration). Statistically, the teachers' perception of impact of the framework was not significant in increasing the level of technology-infused lesson design, but teachers clearly identified benefits from the framework related to their instructional practice. Since the HEAT framework was an integral component of this study, these findings indicate that the use of the framework did not arbitrarily influence the overall results. Even though analysis indicates that teachers overall viewed the HEAT framework positively, it did not bias their response to the corresponding quantitative survey item regarding HEAT's impact or their participation in the study.

The finding related to the confidence level as a user of technology both concurs with and extends existing themes in the current literature. Little consistency exists in the literature concerning which factors, especially teacher factors, contribute to the successful integration of technology. A number of studies cite age, experience, training level, content area, gender, and other similar factors as significant, while other studies minimize such findings and emphasize the importance of school leadership in technology, attitude toward technology, and school cultures centered upon change and collegial support. Since this study identified no relationship between age, gender, education level, years experience, content area, grade level, level of training, and access to technology, it would suggest the need for an increased emphasis on humanistic and leadership factors as substantiated by other studies. This finding reinforces the emphasis on teachers' attitude toward technology as part of technology integration measurements, such as the technology comfort measure developed by the Florida Center for Instructional Technology (2011).

Moreover, this finding reflects one of the conceptual frameworks of the study, change theory. The importance of ensuring teachers are confident in their use of technology as they are charged with the task of successful technology integration parallels the relationship-oriented needs of the leadership grid presented by Blake and Mouton (1982). The finding suggests that attention to teachers' personal comfort level with technology is more critical than task-oriented needs such as specific training or the quantity or availability of technology. This finding on the critical nature of confidence as a user of technology when developing technology-infused lessons also directly relates to determination as a required element of change (Smith & Lindsay, 2001). Successful use of technology to impact learning requires the personal commitment and confidence to effect change in teaching practice through the use of technology.

Discussion of Findings for Research Question 2

The analysis of the change in the level of technology-infused lesson design, as measured by composite HEAT scores over time, indicated a significant increase in three of the four time intervals. The results of the repeated-measures ANOVA indicated that the mean composite HEAT score increased steadily from 1.85 in the first nine weeks to 2.36 and 2.72 in the second and third nine-week periods, respectively. The mean composite score decreased to 2.58 during the fourth nine weeks. Therefore, the null hypothesis, which predicted no significant change would occur between periods, is rejected. The alternate hypothesis, which predicted a difference in scores across one or more time intervals, is accepted.

In regard to the positive change in scores from across periods one, two, and three and the decrease in the final time period, it is important to note that the researcher anticipated a decline in scores for the fourth nine-week period. In consideration of other conflicting priorities associated with year-end activities during the fourth nine weeks and the state accountability testing occurring during the same period, teachers had less instructional time in which to develop and implement lessons as compared to the preceding three quarters. Although this assumption is not supported by quantifiable data, it is the general consensus of both building administrators and district instructional supervisors. Other possible factors that may have contributed to the decrease in period four include interruption of instructional sequence due to spring break, focus on cumulative review at the end of the year, attention to an impending change in curriculum standards, fewer opportunities to collaborate and acquire peer coaching during the final time period, and complacency with the individual improvement of scores up to that point.

The results of the repeated-measures ANOVA further indicated that 26.3% of the significant increase in scores was attributable to the use of the HEAT framework to guide lesson design and provide feedback to teachers. Based upon concerns for reduced instructional time during the fourth quarter of the year, when a linear trend is applied, the percent of increase as a result of use of the HEAT framework changes from 26.3% to 44.8%. In contrast, if a quadratic trend is applied to the results, which considers the fourth nine weeks composite score as a single point of change within the data, the impact of the use of the HEAT framework decreases to 20.7% of the increase in the level of technology-infused lesson design over time. Statistical analysis suggests that the linear trend, attributing 44.8% of the improvement in scores to use of the HEAT framework, is the most likely conclusion. Since the one change in the pattern occurred during the final time interval, there are no subsequent time intervals to determine if the quadratic trend would continue. Conversely, the linear pattern was maintained over three time intervals.

The application of the linear trend is supported by post hoc analysis that examined whether the increase in composite HEAT scores was significant from period to period in addition to data resulting from the repeated-measures ANOVA. The post hoc analysis indicated that the increase in composite HEAT scores between all periods was statistically significant; however, the decrease in scores in period four was not statistically significant in comparison with any of the preceding periods. Although the exact percentage of improvement in the level of technology-infused lesson design as a result of the HEAT framework may vary based upon the applied trend, the finding remains the same: The use of the HEAT framework to guide lesson development and to provide feedback to teachers significantly improves the quality of lesson design.

This finding is consistent with the current research related to effective technology integration. Research findings from the K-12 Computing Blueprint (2011) emphasized the critical importance of a consistent focus on change when implementing technology. To achieve systemic change, educational leaders must develop and pursue comprehensive goals and a vision for how technology can transform teaching and learning. Similarly, Bebell and O'Dwyer (2010) concluded that technology is best implemented as part of a comprehensive plan for change and teachers benefit from very specific support and training during the process. The findings of this study indicate that the HEAT framework can be an effective tool for supporting teachers in the development of technology-infused lesson plans. Moreover, the findings suggest that the HEAT framework can be an effective and key component of a comprehensive plan for technology integration since the framework includes elements in addition to the use of technology. This finding also parallels the work of Dexter et al. (1999), which concluded that the opportunity for teacher reflection with peers and administrators, such as provided through the application of the HEAT framework in this study, can serve as the primary basis for change in instructional practice.

Because the study involved collection of quarterly scores for each of the individual elements of HEAT as well as the composite score, repeated-measures ANOVAs and post hoc analysis were conducted on each individual element as well. The results of these analyses were primarily consistent with the findings related to the HEAT composite score, with all scores increasing each quarter until a decrease occurred in the fourth quarter. However, an interesting finding resulted from the post hoc analysis of the individual HEAT components. Although the improvements in the level of higher-order thinking, engagement of students, and authentic instruction were statistically significant among all intervals for the first, second, and third nine-week periods (with only one exception for authentic learning between periods two and three), this significance of increased scores was not observed for technology integration. When comparing the changes in the composite scores for the level of technology integration, the only significant changes were evident between the first nine weeks and the remaining intervals. No changes in scores between periods two, three, or four were significant for the level of technology integration. Additionally, when considering the percentage of impact on the change in scores from the first nine weeks to the fourth nine weeks, the repeated-measures ANOVAs indicated the smallest percentage of impact for technology use (18%) as compared to higher-order thinking (23.9%), engagement of students (32.8%), and authentic learning (26.1%).

As indicated in the literature, these findings indicate that, as change occurs and teachers embrace technology as a teaching tool, the actual use of technology becomes secondary to the actual impact of learning at high levels, authenticity of the task, and engagement of students. According to Raths (2002), when learning goals, instructional activities, and assessments are aligned at higher levels, instruction and student learning also are elevated. This finding also supports the previous assertion of Maxwell, Stobaugh, and Tassell (2011) that the interaction of the HEAT components impacted the potential for student learning more so than any single component, including technology. Moreover, this finding reflects a second conceptual framework for the study, active learning. Higher-order thinking, engagement of students, and authentic learning are all key elements of active learning theory. The pronounced significance of these three elements as they relate to the HEAT framework and the increase of composite scores over time reinforces that connection.

The qualitative analysis of the open-ended survey item also supports the findings related to the impact of the HEAT framework, as well as the prominent statistical significance of higher-order thinking, engaged students, and authentic learning. As stated during the earlier discussion of research question one findings, 86.3% of the responding teachers' responses identified one or more positive or primarily positive benefit of the HEAT framework. Among the five categories resulting from the content analysis of those same responses, it is important to note that "technology integration" did not appear as a stand-alone category. Instead, the responses were best categorized by the teachers' reported beneficial use of technology to improve instructional practice: lesson innovation/creativity, performance standards, student choice, and collaboration.

Implications

The results and related findings of this study have several implications for individuals and organizations involved with educational technology. First, while factors such as training, accessibility to technology, educational level, gender, age, grade level, and content area do not appear to significantly impact the level of technology integration, teachers' confidence as users of technology is paramount. Therefore, technology integration specialists, principals, district leaders, providers of professional development, and others must always consider the confidence level of teachers while supporting their use of technology as an instructional tool. Awareness of the importance of confidence level may potentially guide decisions regarding fiscal expenditures, training design and delivery, staff assignments, and the overall approach to developing competence in technology integration.

A second implication is that an increased level of technology-infused lesson design occurs as part of a sustained growth process, not an isolated event. With the exception of the final nine-week interval, steady increases occurred in both the composite HEAT scores and the scores for each individual element. As teachers received feedback on their lessons and refined classroom practice throughout the year, the improvement in scores and the responses on the year-end survey indicated they both internalized the concepts of the HEAT framework and benefitted from the ongoing support inherent in the process. Consequently, as distractions from the process, such as year-end activities and state accountability testing, arose during the fourth nine-week interval, a slight decrease occurred in all measurements, indicating the need to view and support technology integration as an ongoing work in progress. Therefore, teacher leaders, school and district administrators, and others who are stewards of technology integration must provide ongoing support and advocacy for the process.

A third implication is that a research-based instructional tool such as the HEAT framework can have significant impact on both technology integration and overall instructional practice. This implication is poignantly stated within one of the teacher responses to the open-ended survey item regarding the potential benefit of the HEAT framework:

> Being a National Board Certified teacher, I clearly see the similarities with both. However, the HEAT document and training have made it much clearer. Teaching in this manner has made me allow for student choice, making lessons real to students, and to use higher levels of Bloom's Taxonomy. It has definitely changed my lessons to make me a stronger teacher, but the strongest impact has been to my students. They understand these concepts as well, and when they help me design lessons they use these concepts.

Conversely, attempts to increase technology use that are not part of a comprehensive, systemic approach may be less successful and reinforce the misguided approach that technology is a supplementary tool that requires separate instruction at the expense of other content. The costs of technology integration, including personnel, equipment, staff, etc., should be viewed as an investment in the total educational process and not solely a technology line item.

A fourth implication is that, as the level of technology integration increases, the actual technology becomes secondary to the content and is the vehicle through which to engage students in high-level learning through authentic instruction. While initiatives to support technology integration should obviously address technical, budgetary, training, and other logistical matters, emphasis on the desired end result of student mastery of content at high levels should guide the process. Successful technology integration efforts should begin with the question, “How can I teach this content at a high level using technology?” instead of the question, “What technology can I use to teach?”

Acknowledgement of Limitations

Limitations of the study included issues with the nature of an internal study and the generalizability of the results. As noted in Chapter III, the researcher was directly involved in the grant initiative from which the data for the study was derived. Although adequate precautions were taken to minimize bias and to ensure uniform data collection, the researcher maintained a dual role as district employee and researcher. Additionally, the study was limited to the initial year of implementation of the lesson review process. Longitudinal data would provide additional opportunities to identify data trends and also minimize the impact, whether positive or negative, of data collection from year one of the initiative.

Another limitation of the study was the use of the HEAT framework to review lesson plans and guide lesson plan development. Although the validity of the LoTi questionnaire and original HEAT framework have been the subject of numerous validity studies, the validity of the revised version developed by Maxwell, Stobaugh, and Tassell (2011) has not yet been subjected to the same level of scrutiny. The version of the HEAT framework used for this study does not depart in terms of levels or components of the LoTi framework, and each updated descriptor is supported by current literature regarding student learning and technology integration.

Another limitation involves the generalizability of the results of the study. Because the study focused on a single school district in rural south central Kentucky, the results are not generalizable to all public K-12 school districts. Moreover, given the high level of adoption of technology at the district and school level across the district, the study did not account for or attempt to measure the attitudes or perceptions of school leadership that the literature identifies as a key factor in technology integration.

Recommendations for Future Research

The results of the study point to several recommendations for future research. First, although the factor of confidence of teachers as users of technology was clearly identified as a critical factor in the level of technology-infused lesson design, identifying what elements contribute to a high level of confidence was beyond the scope of this study. However, the strong intercorrelations between confidence level and the remaining independent variables suggest potential areas for study. Although a limited number of studies have addressed teacher attitudes toward technology, few, if any, in current literature address neither the factor of confidence level nor what factors may contribute to an improved confidence level as a user of technology.

This study was limited to the initial year of implementation of the HEAT framework in a rural south central Kentucky school district. A second recommendation is that additional studies that replicate a similar research design for longer periods of time with more varied populations would provide additional findings, including potential longitudinal data, beyond the limits of this study.

Another recommendation for future research is the comparative analysis of the HEAT framework with other research-based technology integration frameworks that are used to guide lesson design and provide feedback over time. While a number of studies have examined the research base that supports a variety of technology integration frameworks or compared their relative merits from a content perspective, few studies have explored the results of application of the frameworks in an educational setting.

A fourth recommendation for future research is the exploration of the value of the periodic review of lesson plans and feedback provided to teachers as part of the review process. While this study examined the HEAT framework as the methodology to guide lesson development and feedback, the study did not seek to measure solely the value or impact of the review-feedback process separate from the selected framework. Additional research could examine the difference between the impact of implementing the HEAT framework versus the impact of the review-feedback process itself.

Similarly, a final recommendation for future research is that studies related to technology integration focus more on the process (implementation of instructional frameworks, support systems for teachers, etc.) and behavioral elements of effective technology integration (school leadership, teacher attitudes toward technology, etc.) than specific demographic or teacher traits. Since the impact of demographic and teacher-specific traits may vary among school environments, examination of more systemic variables may yield results with more universal application.

Conclusion

This study intended to identify a variety of factors that impact the level of technology-infused lesson design. Surprisingly, the results identified confidence level of teachers as users of technology as the only statistically significant factor. As school districts grapple with an educational environment characterized by a level of unprecedented change, this finding should be somewhat encouraging. While individual learning and behavioral needs of teachers should always be considered, this finding provides a primary focus through which increased technology integration can be approached. As teachers' confidence as a user of technology can be increased, the integration of technology as an instructional tool can be advanced regardless of age, content area, grade level, level of training, educational level, or years experience.

In addition, this study examined the impact of using a research-based framework to provide feedback to teachers over time. Consistently, the data reflected a significant improvement in the level of technology-infused lesson design as a result of the use of the HEAT framework to guide lesson design and provide feedback. Again, this finding can provide direction and reassurance to school and district leaders in the area of technology integration. The HEAT framework is one of several research-based frameworks that are readily available, and the lesson review-feedback process, although time intensive, can easily be replicated within teaching teams, departments, schools, districts, or educational consortia.

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APPENDIX A: HEAT Instructional Framework

	HEAT Levels	Higher-Order Thinking	Engaged Learning	Authentic Learning	Technology Integration	
Lower-order Thinking	**Level 0 Non-Use**	• Lecture; Students • Taking notes only • No questions asked	• Teacher directed completely • No student interaction	• No connection to real world	• No technology use is evident by students or teacher	Teacher-directed
	Level 1 Awareness	• Students learning at Remembering and Understanding level of Bloom's Taxonomy	• Students report facts they have learned on tests or questions posed by teacher • One single correct answer	• Non-relevant problems using textbook/ worksheets • Short one-method/one-answer problems	• Teacher uses technology for demonstration or lecture • Minimal or no student technology use	
	Level 2 Application	• Students learning at Applying level of Bloom's Taxonomy • Teacher questioning	• Students are engaged in a task or activity directed by the teacher • Multiple solutions accepted	• Learning experiences use real world objects or topics and provide some application to real world	• Students technology use for lower-order thinking tasks	
Higher-order Thinking	**Level 3 Exploration**	• Students learning at an Analyzing, Evaluating, or Creating levels of Bloom's Taxonomy • Teacher-directed questioning and instruction	• Student choice for projects or to solve a problem posed by teacher • Students are engaged in projects based on preferred learning styles, interests or passions • Used multiple instructional strategies	• Learning may be relevant to the real world or the past • Learning occurs in a simulated real-world situation such as a class store	• Technology use appears to be an add-on or alternative—not essential for task completion • Technology is used for higher-order thinking tasks such as analysis and decision-making	
	Level 4 Integration	• Student-generated questions/projects at Analyzing, Evaluating, or Creating levels of Bloom's Taxonomy • Multiple indicators of learning	• Students partner with the teacher to help define the task, process, and/or solution • Problem solving based on student questions • Students partner with other students to collaborate on learning projects	• The learning experience provides real world tasks which can be integrated across subject areas • Learning has a classroom or school emphasis and impact	• Technology use is integrated and essential to task completion • Technology use promotes collaboration among students for planning, implementing, and/or evaluating their work. • Technology is used as a tool to help students identify and solve higher-order thinking, authentic problems relating to an overall theme/concept	Student-directed

	Level 5 Expansion	• Student learning/questioning at Analyzing, Evaluating, or Creating level of Bloom’s Taxonomy • Complex thinking involves extensive non-linear problem solving, decision making, experimental inquiry and investigation over time	• Students partner with the teacher to help define the task, the process, and/or the solution • Students partner with local community/field experts on learning projects • Opportunity to express different points of view • Mutual feedback between teacher and student	• The learner experiences the real world and has opportunity to apply their learning to a real world current issue • Authentic assessment; Access to expert thinking and modeling processes • Learning has a local or community emphasis and makes a positive impact • Student beginning to think like a field expert or discipline	• Technology use is directly connected to task completion involving one or more applications • Technology extends the classroom by expanding student experiences and collaboration beyond the school to the local community. • Technology supports collaboration, higher-order thinking, and productivity.	
	Level 6 Refinement	• Student learning/questioning at Analyzing, Evaluating, or Creating level of Bloom’s Taxonomy • Complex, open-ended learning environment	• Students partner with the teacher to help define the task, the process, and the solution • Students partner with global experts on learning projects on global issues • Student-designed problem-solving and issues resolution are the norm	• The learner experiences and makes a positive impact on real, global issues and events. • Student produce products like a field expert •	• Technology use is directly connected and needed for task completion and students determine which application(s) would best address their needs • Technology is a seamless tool used by students through their own initiative to find solutions related to an identified “real” global problem or issue of significance to them. • Technology provides a seamless medium for information queries, problem solving, and/or product development.	

Guidance for Applying the HEAT Framework** (Moersch, 2001)**:

1. Components H, E, and A are based on the student’s interaction with the <u>content</u>, not the technology. Don’t be overly impressed with the glitz of technology. If a student creates a multimedia presentation about facts on a topic, it is a level 2.
2. Note the thick black line separating levels 3 and 4. The lower levels 0-3 are teacher-directed, and the higher levels 4-6 are more student-directed; i.e., students have more choices; they partner with other

students, teachers, and outside experts in designing tasks, process, and solutions. In other words, they are more responsible for their own learning.

3. Note the buff colored shading for levels 3 and 4. This indicates the target levels for teachers to provide consistent instruction. While a Level 3 is still teacher-directed, students are using higher-order thinking of Bloom's Taxonomy. Students are beginning to take more responsibility for their own learning in Level 4. Levels 5 and 6 could be attained after consistent learning at levels 3 and 4 and could be accomplished a few times a year.
4. What is the difference between "*relevant*" and "*real*" learning? According to Prensky (2010) "r*elevant*" means that students can relate something you are teaching, or you say, to something they know such as a recent film or TV show rather than an old classic or something less familiar to them. Relevant, for example, means taking readings from current newspapers rather than dated textbooks. "*Real*" means there is a perceived connection by the students between what they are learning and their ability to use that learning to do something useful in the world. Examples of *real* learning include measuring a company's carbon footprint and proposing how they can save money by going green, how did reading a book change your life, analyzing a tweet stream from Afghanistan and sending our own tweets, applying science concepts to change your family's eating or drinking habits, or improving the local drinking water.
5. How much of a particular cell must be fulfilled to achieve the level? The primary determinants are the type of learning environment (Is the lesson primarily teacher-directed or student directed?) and the level of learning (lower-order thinking or higher-order thinking). Most of the indicators in a cell must be accomplished to rate at that level after it is determined if it is teacher-directed or student-directed and if it is lower- or higher-order thinking.

Moersch, C. (2001). Next steps: Using LoTi as a research tool. *Learning and Leading with Technology*, *29(3)*, 22-27.

Prensky, M. (2010). *Teaching digital natives: Partnering for real learning*. Thousand Oaks, CA: Corwin.

APPENDIX B: Lesson Plan Template

Hart County Schools

Technology-Infused Lesson Plan

Teacher:	Grade Level:	HEAT Level:
School:	Course/Class:	Date of Lesson:

Content Connection *(Common Core State Standard for reading, math, writing across the curriculum or CC4.1 for other content areas. See CCCS Crosswalk if needed):*

Overall Unit Goal:

Learning Targets/Objectives:

Lesson Description *(Brief overview of this specific lesson as it relates to overall unit and general description of how the lesson is to be implemented):*

Sequence of Strategies & Activities

Strategy and/or Activity	*Time Required*	*Specific Skill or Content Connection*	*Student Assessment (Describe and specify formative or summative)*	*Planned Differentiation*

Sequence of Strategies & Activities *(continued as needed)*				

Attachments:

1. *Please attach three samples of student work associated with this lesson. **required***
2. *Please attach any supporting files or resources (PowerPoint files, graphic organizers, etc.). **encouraged but not required***

Questions for Reflection:

1. What went especially well with this lesson and why?

2. What lesson components would you refine when/if delivering the lesson again?

3. How did (or could) the use of technology impact student engagement, delivery of content, and/or student performance associated with this lesson?

APPENDIX C: Year-End Survey of Teachers

Teacher Survey of Factors Related to Technology Integration

INSTRUCTIONS: In follow-up to the district's review of technology-infused lesson plans, please respond to the following items. Please select <u>one checkbox</u> for each question which best describes your answer.

PLEASE NOTE: For the purposes of this survey, "technology" refers to computers and computer-related equipment (such as interactive whiteboards, document cameras, projectors, interactive student response systems, and other digital tools) as well as educational and productivity software and online resources.

A. Rate your current <u>level of training</u> for using technology in the classroom.

- ☐ 1—completely inadequate
- ☐ 2—somewhat inadequate
- ☐ 3—somewhat adequate
- ☐ 4—highly adequate

B. Rate your <u>confidence level</u> with using technology as an instructional tool in your classroom.

- ☐ 1—completely unconfident
- ☐ 2—somewhat unconfident
- ☐ 3—somewhat confident
- ☐ 4—highly confident

C. Rate the <u>level of access</u> you have to technology provided by your school/district to support learning in your classroom.

- ☐ 1—completely inadequate
- ☐ 2—somewhat inadequate
- ☐ 3—somewhat adequate
- ☐ 4—highly adequate

D. To what degree do you feel the level of access to technology you selected in item C impacts your capacity to integrate technology as an instructional tool in your classroom?

- ☐ 1—no impact
- ☐ 2—minimal impact
- ☐ 3—moderate impact
- ☐ 4—strong impact

To what degree has the use of the HEAT framework improved your use of technology as an instructional tool in your classroom?

- ☐ 1—no improvement
- ☐ 2—minimal improvement
- ☐ 3—moderate improvement
- ☐ 4—strong improvement

E. To what degree has the <u>feedback/follow-up</u> process at your school as part of the HEAT lesson plan review improved your use of technology as an instructional tool in your classroom?

- ☐ 1—no improvement
- ☐ 2—minimal improvement
- ☐ 3—moderate improvement
- ☐ 4—strong improvement

F. Using the scale below, to what degree has use of the HEAT framework increased the frequency of the following factors in your classroom?

1=no increase 2=minimal increase 3=moderate increase 4=strong increase

	1	2	3	4
Collaboration with other teachers	☐	☐	☐	☐
Student choice in projects/activities	☐	☐	☐	☐
Student choice in content	☐	☐	☐	☐
Collaboration with community resources	☐	☐	☐	☐
Reflection upon lesson design	☐	☐	☐	☐
Reflection upon lesson results	☐	☐	☐	☐
High level of student thinking with the content	☐	☐	☐	☐

G. In what way, if any, has use of the HEAT framework most benefitted you as a teacher?

Thank you for completing this survey. All responses will remain completely confidential. Please click the "Submit" button to conclude the survey process.

APPENDIX D: Institutional Review Board Approval

WKU®

A LEADING AMERICAN UNIVERSITY WITH INTERNATIONAL REACH
HUMAN SUBJECTS REVIEW BOARD

In future correspondence, please refer to HS11-265, April 11, 2011

Wesley A. Waddle
c/o Dr. Schlinker
Educational Administration, Leadership, & Research
WKU

Wesley A. Waddle:

Your research project, *An Analysis of the Impact of Selected Teacher Factors on the Level of K-12 Technology-Infused Lesson Design*, was reviewed by the IRB and it has been determined that risks to subjects are: (1) minimized and reasonable; and that (2) research procedures are consistent with a sound research design and do not expose the subjects to unnecessary risk. Reviewers determined that: (1) benefits to subjects are considered along with the importance of the topic and that outcomes are reasonable; (2) selection of subjects is equitable; and (3) the purposes of the research and the research setting is amenable to subjects' welfare and producing desired outcomes; that indications of coercion or prejudice are absent, and that participation is clearly voluntary.

1. In addition, the IRB found that you need to orient participants as follows: (1) signed informed consent is required; (2) Provision is made for collecting, using and storing data in a manner that protects the safety and privacy of the subjects and the confidentiality of the data. (3) Appropriate safeguards are included to protect the rights and welfare of the subjects.

This project is therefore approved at the Expedited Review Level until December 1, 2011.

2. Please note that the institution is not responsible for any actions regarding this protocol before approval. If you expand the project at a later date to use other instruments please re-apply. Copies of your request for human subjects review, your application, and this approval, are maintained in the Office of Sponsored Programs at the above address. Please report any changes to this approved protocol to this office. A Continuing Review protocol will be sent to you in the future to determine the status of the project. Also, please use the stamped approval forms to assure participants of compliance with The Office of Human Research Protections regulations.

Sincerely,

Paul J. Mooney, M.S.T.M.
Compliance Manager
Office of Research
Western Kentucky University

INSTITUTIONAL REVIEW BOARD
WKU
APPROVED

IRB APPLICATION # 11-265
APPROVED 4/11/11 to 12/1/11
EXEMPT EXPEDITED FULLBOARD
DATE APPROVED 4/11/11

cc: HS file number Waddle HS11-265

The Spirit Makes the Master

Office of Sponsored Programs | Western Kentucky University | 1906 College Heights Blvd. #11026 | Bowling Green, KY 42101-1026
phone: 270.745.4652 | fax: 270.745.4211 | email: paul.mooney@wku.edu | web: http://www.wku.edu/Dept/Support/SponsPrg/grants/index.php?page=research-compliance

APPENDIX E: Teacher Informed Consent

PARTICIPANT INFORMED CONSENT DOCUMENT

An Analysis of Factors Impacting
K-12 Technology-Infused Lesson Design

Wesley Waddle, Investigator
WKU Doctoral Program
270-473-0029

You are being asked to participate in a project conducted through Western Kentucky University and Hart County Schools. The University requires that you give your signed agreement to participate in this project.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask him/her any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign on the last page of this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:** A growing body of research indicates an ever-increasing gap between the needs of 21st century digital learners in comparison to traditional instructional methods. Since your school district has addressed this need by the periodic review of lesson plans, the purpose of this project is to identify what factors most significantly impact the levels of technology integration.

2. **Explanation of Procedures:** The school district has provided a release of lesson plan review results and demographic data (such as year's teaching experience, educational level, content area, etc.) associated with lesson plan reviews. Your participation in an accompanying survey is requested to also measure teachers' perceptions of the level of technology training, confidence in using technology, and accessibility to instructional technology. You will be provided with an individual user code to access the online survey.

3. **Discomfort and Risks:** The online survey is brief and will require a minimal investment of time by participants. There are no anticipated risks in participating in the survey.

4. **Benefits:** Teachers and administrators will receive a summary of results which will help guide instructional and administrative decisions regarding the use of and support of instructional technology.

5. **Confidentiality:** Complete confidentiality will be maintained. No names, individual responses, nor data which would compromise the identity of individual participants will be shared or reported. Any information that is obtained in connection with this study and that can be identified with a specific participant will remain confidential and will be only be disclosed with your express written permission.

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University or Hart County Schools. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

Authorization

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

____ ________________
Signature of Participant Date

____ ________________
Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-4652