FACTORS IMPACTING THE ACCURACY OF SELF-REPORT PERCEPTIONS OF EXPERTISE IN TECHNOLOGY INTEGRATION

Garry W. Mayes, B.S., M.S.

Dissertation prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

December 2014

APPROVED:

Gerald Knezek, Major Professor
Rhonda Christensen, Committee Member
Greg Jones, Committee Member
Tandra Tyler-Wood, Committee Member
Jeff Allen, Chair of the Department of Learning Technologies
Herman Totten, Dean of the College of Information
Mark Wardell, Dean of the Toulouse Graduate School

Mayes, Garry W. Factors Impacting the Accuracy of Self-Report Perceptions of Expertise in Technology Integration. Doctor of Philosophy (Learning Technologies), December 2014, 128 pp., 28 tables, 12 figures, references, 111 titles.

The focus of this study is to determine how closely self-report perceptions of technology integration skills align with the observations of an external evaluator. Participants were elementary and secondary teachers in a north Texas school district. The district is in the process of implementing a one-to-one initiative using a major vendor's tablet devices. The study utilized both quantitative survey methodology, and a qualitative observational tool to record learning activities in the K-12 classroom. For the quantitative phase, three validated single-item self-report instruments were administered to the teachers via an online survey; the instruments utilized were the Concerns-Based Adoption Model—Levels of Use (CBAM-LoU); Stages of Adoption of Technology; and the Apple Classroom of Tomorrow (ACOT). In the qualitative portion of the study, classroom teachers involved in the one-to-one innovation were observed and rated by the Technology Integration Matrix, an instrument specifically designed to observe technology integration skills and practices in K-12 instructional settings. Kendall's tau correlations between the various self-report instruments and the external observer rating are: CBAM, $r = .51$ (p is not significant); Stages, $r = .58$ ($p < .05$); ACOT, $r = .82$ ($p < .01$). Additionally, regression models were run using all three self-reports as predictors of the observation score, and using only the ACOT as a predictor. The regression model for the three-predictor model is TIM = .68Stages - .82CBAM + 1.61ACOT - 1.23 (R2 = .94, $p < .05$), while the model for the ACOT-only predictor is TIM = 1.1ACOT - 1.1 (R2 = .80, $p < .01$). These results demonstrate a strong correlation between the ratings reported by the teachers and the ratings given by the external observer, indicating that these self-report measures show a strong propensity for indicating actual technology skills.

ACKNOWLEDGMENTS

I would like to thank my wife, Florence, for her support and encouragement to persevere in this endeavor. I also would like to express my appreciation for my committee: to Dr. Knezek for his example of being an exemplary researcher; to Dr. Tyler-Wood for her support and efforts to enable me to finish this course of study and research; to Dr. Jones for his helpful tips and access to the research venue, and to Dr. Christensen for her encouragement and cheerful support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Accurate measurement is essential to the proper implementation of all science. The physical sciences have had a long history of identifying the quantitative structures that underlie the measurement of physical properties. While there is debate as to what constitutes quantifiable measurement in psychology (Michell, 1997), behavioral sciences likewise must define and develop structures and measurable constructs, and develop instruments that can measure these constructs. However, measurement in the field of educational psychology is particularly challenging, because it must contend with "complex and changing networks of social interaction" (Berlinger, 2002, p. 19). In other words, those very constructs we wish to measure are often ambiguous, nebulous, and subject to an almost infinite range of variables that are impacted when any two or more humans interact in any social context. The complexities of human interactions make it difficult to generalize across different contexts.

The problem is further compounded when the researcher desires to investigate the realm of educational technology. The issues range from defining what is exactly technology integration (Painter, 2001; Wetzel, Zambo, & Ryan, 2007), to determining what should be the parameters to investigate (Roblyer & Knezek, 2003), and finally what sort of instrumentation is most appropriate to capture the view of technology integration we wish to measure (Bebell, Russell, & O'Dwyer, 2004). Given the wide range of definitions concerning the specifics of what is meant by "technology integration," a lack of consistency in determining, reporting, and comparing the extent and depth of technology use in education is all too readily apparent.

Against the backdrop of these difficulties of defining the scope of educational measurement, the question of how to measure intrudes. Instrumentation is the science and process of making visible in a quantifiable manner theoretically derived psychological constructs. In measuring the extent of technology integration in the K-12 classroom, an ongoing debate has developed as to whether self-report perceptions (Scordias, Hoagland, & Ferguson, 2010) can be considered as having an equal validity to that of an outside observation. The implication is that a perceptual observation of oneself has a lower level of trustworthiness than that of the rating of an outside, external observer. The continued use of perceptual surveys appears to be more of a concession to the ease of gathering data, as opposed to the more expensive and time-consuming method of employing outside observers. With the widespread use of self-report surveys in educational psychology, a crucial question needs to be addressed: can these forms of data be considered germane in their own right, and perhaps even excel over other measures in certain contexts?

Terminology

The following are definitions of key terms as used in this study:

- Behavioral observation—As used in this study, a behavioral observation refers to the record of specific behaviors and actions noted in some given time frame, and recorded by an independent observer separate from the subject being observed.
- Construct—A construct is a group of interrelated variables, a model that is designed to relate some observable behavior to a theoretical framework. It is some "thing" that is being measured.
- Educational technology (also known as Instructional technology)—Educational technology is "the theory and practice of design, development, utilization, management, and evaluation processes and resources for learning" (Seels & Richey, 1994, p. 9). In essence, this concept encompasses not merely hardware tools, but the broader aspect of the processes of teaching

and learning.

- Epistemology—Epistemology literally asks the question, "How do you know what you know?" As used in this paper, it refers to verbalizing the foundational starting point for one's framework or worldview for interpreting a set of data or information.
- Postpositivism—A philosophical research stance most typically associated with quantitative methods, positivism and postpositivism hold the view that there is one reality or truth that can be known with relative certainty, and such reality can be observed objectively from a dispassionate viewpoint (Mertens, 2003, p.140-141).
- Pragmatism—As a philosophical base for research, pragmatism as defined in this study draws from both an epistemological as well as a methodological underpinning. Epistemologically, pragmatism is concerned less with being founded on some network of interwoven beliefs, but more with constructing knowledge as an "exercise of thought on experience," and a focus on seeking resolution or closure to a problem (Maxcy, 2003, p. 76). Methodological pragmatism concerns itself with seeking a method, or mix of methods, that produces the most "effectiveness"; that is, a system that "works" to solve the problem at hand (Maxcy, 2003, p. 81; Tashakkori & Teddlie, 1998).
- Self-efficacy—Perceived self-efficacy "refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997).
- Self-report—An observation of an individual's own perception of one's skills, knowledge, and abilities, as recorded by use of a written instrument covering some specific set of constructs.
- Technology integration—Technology integration means the inclusion of technology resources (hardware and software) and technology-based practices (Hur, Cullen, & Brush,

2010) such that literacy is acquired in information skills, communications skills, and technological skills (Scott, Frieden, & Mills, 2002) that builds content knowledge (Dexter, Doering, & Riedel, 2006), leading to improvement in student learning outcomes (Kozma, 2003). Earle (2002) sums up technology integration in this manner: "Integrating technology is not about technology—it is primarily about content and effective instructional practices. Technology involves the tools with which we deliver content and implement practices in better ways. Its focus must be on curriculum and learning. Integration is defined not by the amount or type of technology used, but by how and why it is used" (p. 11)

Statement of the Problem

Self-report instruments are often denigrated as unreliable sources of information in the evaluation of psychological constructs in general, and of technology integration in particular (Podsakoff & Organ, 1986; Judson, 2006). However, researchers seem to offer very little hard evidence that self-reports are inherently inferior to (typically) direct observation of technology use, often simply assuming their lack of reliability (Padgett & Buss, 2004; Agyei & Voogt, 2011). The debate between the validity of self-report observations versus direct observations of teacher use of technology in the classroom is in reality only a piece of a larger question—how does one define technology integration, and then how is it measured (i.e., what factors are measured)? These questions demonstrate that bias is not just a problem with self-report measures (Spector, 1994; Howard, 1994), but that there are a number of issues that arise in the development of any observation instrument, whether the instrument is conducted as a self-report or by an outside observer. All assessments represent only an estimate of some given construct at some given point in time (Howard, Maxwell, Wiener, Boynton, & Rooney, 1980). Educational researchers have to accept that educational phenomena are embedded in social life; this phenomena results in the myriad interactions that complicate measurement in the behavioral sciences.

Concerns raised about self-report observations can easily be ascribed to other means of measurement as well. For instance, Howard (1994) poses this question: “What measurement strategy do you propose to use instead of a self-report (e.g. behavioral, physiological, significant-other, expert judge, archival), and what are the grounds for believing that your alternative measurement strategy is less fallible than a self-report?” (p. 399). In a study evaluating various methods of measuring teacher effectiveness, self-rated evaluations had a higher construct validity than both that of trained observer and colleague-rater evaluations (Howard, Conway, & Maxwell, 1985).

Painter (2001) raises five issues that relate to the difficulties inherent in observation of technology integration in the classroom:

1. The complexity of the technology innovation—there may be a variety of hardware or software applications involved, involving questions of what should be measured, or how it should be measured
2. The issue of confounding of technology integration with the aspect of the quality of teaching
3. The issue that any observation instrument assumes a particular philosophy of teaching;
4. An observation does not necessarily take into account the factors that led to the selection of a particular technology teaching strategy
5. The pace of technology implementation makes it difficult to have up-to-date, reliable and validated instruments

Clearly, the issue of properly evaluating the nature and degree of any technology integration implementation goes beyond the issue of whether direct observation or self-report are better means of measuring any innovation. Limitations are inherent in both methods, and both methods share a common set of limitations as noted above. A better question to ask is: will a self-report give a sufficiently reliable measure of selected psychological constructs, from which valid and substantive conclusions can be drawn?

Purpose and Research Questions

The purpose of this study is to examine how accurately self-reported perceptions of technology integration skills align with ratings obtained by outside observers. Also, this research will attempt to determine the degree of impact various indicators of sound pedagogical technological practice such as self-efficacy, attitudes towards technology, and a general openness to change will have on the accuracy of self-reported data on perceived proficiency of technology integration. Specifically, all these factors will be examined in terms of the contribution they make in determining the level of teacher expertise, as previous research indicates that the veracity of self-report data seems to vary as a function of the level of expertise in managing integration of technology into teaching. All these tie together in defining what makes an expert technology integrator—self-efficacy (belief in one's capacity to work effectively with technology), attitudes towards computers, procedural knowledge, how technology can help students learn, and in general, epistemological beliefs about the nature of instruction (e.g., constructivist versus directed instruction). Self-efficacy, for example, has been shown to impact computer anxiety (Lambert, Gong, & Cuper, 2008). Research demonstrates that there is a causal relationship between what beliefs a teacher holds about instruction and how technology is integrated into a lesson (Judson, 2006).

The following research questions are the focus of this study:

1. Does self-report data constitute a consistently reliable indicator or measure of technology skill and implementation abilities of teachers?
2. If self-report data is reliable, how closely does it correlate to ratings by external observers?
3. Does a difference in levels of teacher expertise in technology integration impact the accuracy of self-report data?

Rationale

The issue of whether a self-report can be trusted has a long history of debate (Howard et al., 1980; Chan, 2009). Part of the impetus for this research concerning the debate over the ability to rely on self-reports grew out of a study found in the organizational and training literature, where the researchers discovered a consistent 27% decrement when they evaluated on-the-job performance relative to the employees' self-reported assessment of their projected work skills after a training session (Noonan, 1996). This concept was tested for some of the same self-report instruments used in this study, and found a similar trend (Knezek, Christensen, Mayes, & Morales, 2005). The rationale for the replication of this research is to test this concept through the use of a validated observation tool specifically designed to evaluate the proficiencies of teachers in the use of technology in the classroom, and whether the use of a technology-oriented observation tool will enable a more robust test of the degree of alignment of self-report ratings with ratings given by an outside observer.

CHAPTER 2

LITERATURE REVIEW

Fundamentally, this study is about the measurement of a psychological construct. This basic problem raises a number of questions. First, there is the challenge of psychological measurement: what does it mean to measure a psychological construct, and how does one do it? Since this is a study about measuring technology in an academic setting, a second question naturally arises: what does one mean by technology integration? When speaking of technology integration, how does one define and determine the parameters to investigate? Then there is a question of instrumentation; with the rapid advance of technology, how does one determine the validity and applicability of any instrument used to measure technology integration? This question gives rise to the focus of this study: will a self-report instrument be adequate to the task? The following sections of this literature review will examine the background surrounding the issues raised by these questions.

The Problem of Our Science

Various researchers have raised cautions concerning what constitutes “science” in conducting research in the social sciences, and the associated measurement of psychological constructs. Berliner (2002) first dealt with the common criticism lobbied at social science research: that “educational research is considered too soft, squishy, unreliable and imprecise to rely on as a basis for practice in the same way that other sciences are in involved in the design of bridges and electronic circuits, sending rockets to the moon, or developing new drugs” (p. 18). Berliner goes on to argue that the true distinction is not between the hard sciences and soft sciences (that is, social sciences), but rather should be characterized as between the hard and easy sciences, with easy-to-do sciences defined as physics, chemistry, etc. He even portrays educational research as the hardest-to-do science of all! A more accurate view of science entails much more than simply the "scientific method"; science is more than simply the process of inquiry. Scientific research is both descriptive and experimental; data in both its collection and arrangement is more characterized by its lack of homogeneity than its uniformity (Lederman, 2003).

The most difficult aspect of conducting research on the learning of people is—people! The "complex and changing networks of social interaction" introduces intricacies that make discovering and implementing scientific findings in the field of human learning a difficult task (Berliner, 2002, p. 19). Inherent in educational research is the problem of "ubiquitous interactions," stemming from the multitude of life events, internal motivations, beliefs, and reactions, and external environmental factors that "increases the difficulty of both isolating effects and of combining results across studies (Roblyer, 2005, p. 193). Lederman (2003) emphasizes that our "attempts to enhance teaching and learning from systematically collected empirical evidence…[should not] lose sight of the unpredictability and indeterminate nature of human behavior" (p. 10).

Unfortunately, a lack of acknowledgement of the limitations noted above leads those pursuing educational research to overestimate the power and applicability of educational research. Many among those inside and outside the field view educational research as perhaps a bit vacuous; for example, Burkhart & Schoenfeld (2003) note that "in general, education research does not have much credibility—even among its intended clients, teachers and administrators" (p. 3), and Roblyer (2005) notes that "past educational studies [have been] less than helpful" (p. 192). Trying to force-fit the "round peg" of amorphous human behavior into the "square hole" of a rigid scientific method leads to artificial descriptions of behavior that ultimately do not work in the real world. It is critical to keep in mind Berliner's (2002) observation: "a science that must always be sure the myriad particulars are well understood is harder to build than a science that can focus on the regularities of nature across contexts" (p. 19). A conscious awareness of this basic limitation in studying the learning human mind will help to prevent research as being "oversold" (Cuban, 2001).

Recognition of the limitations of research into the human condition needs to be a fundamental posture for any investigator in the behavioral sciences. We need to acknowledge, as Berliner (2002) points out, that broad theories and systemic generalizations often fail because of the complex contextual milieu of human interactions. Numerous researchers describe the problem of treating attempts to systematize learning behavior without regard for the broader application to practice:

> Education lags far behind in the range and reliability of its theories. By overestimating theories' strength (or perhaps better, by not constraining their application appropriately) damage has been done…the harm comes from overestimating their generality and power, and underestimating the need to specify the contexts in which they are effective and the steps necessary to implement them successfully. (Burkhart & Schoenfeld, 2003, p. 10)

> There has been a history of attempts to conduct carefully controlled experiments in classroom settings. However, the situation becomes so contrived that little external validity can be ascribed to the investigation. Quite simply, the situation is so deviant from general classroom life across settings that attempts to generalize to other situations have become futile at best. Much of the research conducted in "laboratory schools" suffered from this problem. (Lederman, 2003, p. 8–9)

> The common view of basic research, "that it needs to go on in some highly controlled setting," is outdated and wrongheaded…not only does it misconceive research, but it impoverishes our view of practice as divorced from fundamental inquiry. The two must be merged, supporting work on practical problems in classroom settings because it will also yield fundamental insights into the learning process. (Kaestle, 1993, p. 26)

Research into the effects of technology introduction and implementation into K-12 settings is not immune from the tribulations noted above.

> Those who evaluate technology integration must move ahead "with all deliberate speed" to recognize the complexities and contradictions inherent in their work. Perhaps the best we can do is proceed with a recognition of the inherent difficulties, provide the rationale for our decisions, and accept the limitations that necessarily accompany our work. (Painter, 2001, p. 25)

Are Self-Report Perceptions Inherently Inferior?

Self-report instruments are frequently used in behavioral research; these instruments are easy to administer (especially in today's world of online communications), and easy to tabulate and analyze. Yet they are often denigrated in the literature (Podsakoff & Organ, 1986; Judson, 2006; Agyei & Voogt, 2011), even being called a "second-class citizen" (Howard et al., 1980). Chan (2009) offers a cogent argument for rejecting the "urban myth" of the inferiority of self-report data, pointing out the two basic and related assumptions that undergird the widely held assessment of self-reports: 1) there is an inherent flaw in using self-reports to measure some intended construct, and 2) there is an inability to provide accurate estimates of inter-construct relationship parameters. Chans's observations have a basis in Cattell's (1958) development of the three media of personality measurement and observation. Cattell postulated three types of observational data: L-data, which are observations of an individual's behavior in the course of their everyday life; Q-data, which is derived from the individual's own self-observations and feelings, and T-data, which comes from observations by measuring actual behavior in a stimulus situation. The Q-data was believed by Cattell to reveal elusive internal states and viewpoints not readily apparent to an external observer (Cattell, 1973).

Two validity concerns arise based on these assumptions that Chan (2009) discusses. The first assumption indicates that there is an issue with measurement of a given single self-reported variable (construct validity issues); and the second assumption expresses concern surrounding correlated relationships between two or more variables gathered on the same instrument (referred to as common method variance or monomethod bias).

Reliability and validity are two issues that are a crucial characteristic of evaluating any instrument that attempts to measure some aspect of human behavior. Reliability is concerned with simply the extent to which assessments are consistent; in other words, will an instrument get the same results (within statistical limits) time after time. Reliability is the foundational need before validity can be addressed; any tool that gets widely varying results can not be depended upon to provide trustworthy data. Validity, on the other hand, is primarily concerned with accuracy—does the instrument really measure what it purports to measure.

Validity is expressed in three different types: content validity, criterion validity, and construct validity. Content validity can be seen as a sampling issue; the items on the test (the sample) must be an accurate representation of the total body of information the test is supposed to cover (the population). This validity is usually accomplished by review and input of experts familiar with the instrument's claimed domain. Criterion validity evaluates whether a test can be corroborated by a criterion test that has already been established. If data from the new instrument were collected at approximately the same time as the criterion measure was administered, then concurrent validity is established. Predictive validity is indicated when the new measure can accurately predict the results on some criterion measure in the future.

Construct validity concerns how well a measure or test reflects an underlying construct, where a construct refers to some underlying idea or theory that the instrument purports to assess. "Researchers typically establish construct validity by presenting correlations between a measure of a construct and a number of other measures that should, theoretically, be associated with it (convergent validity) or vary independently of it (discriminant validity)" (Westen & Rosenthal, 2003, p. 608). Perhaps the most critical aspect of establishing construct validity is to note that construct validation is dependent on the theory from which the construct is derived (Cronbach & Meehl, 1955). An instrument that is said to be valid is simply a statement that it's observed associations align with theoretical predictions of what associations the instrument is supposed to have. If the theory is wrong, then the correlations will actually invalidate the measure (Westen & Rosenthal, 2003).

In an article that compared accuracy between self-report and behavioral measures in three different studies, Howard et al. (1980) demonstrated that construct validity remains an empirical issue: "The form or method of the measure (e.g., self-report, behavioral, physiological), in and of itself, in no way speaks to its construct validity" (p. 309). In summarizing the research involving comparisons of a given construct between self-report and non-self-report indices, Howard (1994) found that the "construct validity coefficients were superior to validity coefficients of other measurement approaches" (p. 400). For example, in a study comparing five different measuring methods (student, former student, self, colleague, and trained observer) for evaluating teaching effectiveness, self-report showed greater validity than either colleague or trained observer ratings (Howard et al., 1985). In their analysis of a series of studies utilizing confirmatory factor analysis of performance ratings, Conway & Lance (2010) establish that self-reports exhibit construct validity, and that different rater sources, self-ratings included, are indicative of performance-related variance, and are not due to simply measurement method bias.

Campbell and Fiske (1959) defined common method variance to be variance attributable to the method used in the measurement rather than to trait variance, that is, variance attributable to the construct of interest (Spector, 1994). In other words, the relationships between the constructs measured by the same method (a self-report in this case) may be biased because of shared variance due to the effect of the shared method, basically resulting in an exaggerated correlation between the two constructs (Chan, 2009). While this inflated correlation is indeed a possibility, it is not an inevitable conclusion. For example, Spector (2006) notes that with large sample sizes, it would be possible to find very small statistically significant correlations, yet he notes studies where correlations are not significant or very low. He concludes that "counter to the CMV [common method variance] legend, using a self-report methodology is no guarantee of finding significant results, even with very large samples" (p. 224). A meta-study conducted by Conway and Lance (2010) confirmed similar results. In this study, same-method correlations (i.e., common method) were compared with trait factor correlations. The researchers discovered that the correlations of the same-method scores were actually slightly lower than the trait factor correlations, suggesting that the same-method scores were very accurate representations of their true-score counterparts. They likewise concluded "the widespread belief that common method bias serves to inflate common method correlations as compared to their true-score counterparts is substantially a myth" (Conway & Lance, 2010, p. 327).

If indeed it is the case that common method variance inexorably inflates correlations in self-report measures, then a systemic pattern should emerge across the spectrum of monomethod versus multimethod measures. Spector (2006) reports on one study, which showed that only 30% of the multimethod correlations were larger than the monomethod measures. Additionally, a large meta-study conducted by Crampton and Wagner (1994) compared 143 pairs of variables. In 27% of the cases, self-report (monomethod) correlations were higher than multimethod correlations, were attenuated in 12% of the comparisons, and they noted that there was no statistically discernible differences in 62% of the cases. It is readily apparent that methodology alone is not the sole (or perhaps even primary) determining factor in accounting for common method variance.

Specific potential biasing factors, or subject response style effects (Millham & Jacobsen, 1978), including social desirability (also called self-presentation bias), negative affectivity, and acquiescence, are typically proposed as candidates for impacting common method variance in self-reports. The first of these, social desirability, is often seen as so pervasive in self-report measurement that not much can be done to rectify it (Chan, 2009). Given, there are situations where social desirability has the potential to impact responses, such as in the case of high-stakes testing, or responses to personally sensitive questions, or where the "correct answer" of the intended construct of interest is obvious (Spector, 1994; Chan, 2009). However, it is a mistake to assume that social desirability will apply equally to all constructs that may possibly be measured, or that social desirability will inevitability lead to common method variance, resulting in the inflation of the correlation between two self-report measures.

Chan (2009) lists several situations where social desirability does not automatically result in common method variance: 1) different constructs have varying levels of susceptibility (demographic variables, for example); 2) the accuracy of the item responses are verifiable from other sources; 3) there is not a socially desirable norm to which the respondent feels compelled to align. After citing several studies which found that social desirability had little effect on various variables in self-report measurements, as well as demonstrating levels of inconsistency (in some cases, actually showing suppressor effects), Spector (2006) states that "evidence fails to support social desirability as a general source of correlation inflating CMV when self-reports are used" (p. 225).

Negative affectivity is another factor that may potentially bias self-report variables, as it is a measure of an individual's negative emotions, which can lead to a generally negative worldview perspective. While negative affectivity does appear to influence certain variables that relate to stress and some attitudinal constructs (Watson, Pennebaker, & Folger, 1987), Spector (2006) reports wide variation of the effect of negative affectivity, the extent of which depends a great deal on the variable of interest. Structural equation modeling studies that compared models with and without negative affectivity found little impact on relationships among variables (Williams & Anderson, 1994; Chan, 2001). Spector (2006) concludes “there is no consistent evidence that NA is a constant source of CMV with self- reports that inflate correlations. Even in specific cases in which NA might bias correlations, there is conflicting evidence that questions whether it is really bias at all” (p. 226).

Acquiescence, the tendency to agree with items regardless of content, can show up in agree-disagree type of response choices. However, this bias has been demonstrated to appear generally only within tests, but is not common across tests; in other words, the levels of acquiescence by respondents differed across tests (Spector, 2006). The effect of acquiescence would appear to either inflate or attenuate results in a given measurement, and so would appear to be a random variance that does not push common method variance into a consistent direction.

The Specific Application of Self-Report Data in Educational Technology

Studies looking at the validity of self-report data in educational technology are not nearly as extensive as in the organizational behavior literature (Kopcha & Sullivan, 2007). The Kopcha and Sullivan study did highlight a few noteworthy points of interest, however, in examining the role of social desirability (self-presentation) bias. This study examined self-perceptions in six areas of teachers’ use of instructional design and technology practices, including instructional design, curriculum alignment, assessment, learner-centered Instruction, attitudes about computers, and use of computers with students. The teachers responded to 30 items on these six topics; half of the items were worded in the first-person ("I do *a particular practice*"), and the other half were styled in the third-person ("Teachers do *a particular practice*"). The surveys themselves were set up in two sets: one-half had the first fifteen items in the "I" format, with the second fifteen in the "Teacher" format; this was reversed for the second set of surveys. One-half of the teacher subjects answered the 30-item survey utilizing the first set of surveys, and the remaining teachers responded to the second set. The rationale behind this arrangement of presenting the response items is that positive social desirability is likely higher on the first-person items than on the third-person items. Of the six dimensions tested in this study, four of them did show statistically significant differences favoring socially desirable responses on the first-person worded items; in other words, the means on the "I" items were higher than the means on the "Teacher" items. However, the two items that did not show any statistical difference were both of the computer-related categories. At least in this particular instance, the self-perceptions relating to the use of technology did not appear to be impacted by social desirability bias. One potential weakness should be noted in the Kopcha and Sullivan study: the standard deviations were not reported, so it was not possible to calculate Cohen's *d* effect sizes (Cohen, 1988). Even though statistically significant differences were reported, it is impossible to tell if there were any educationally significant effects. Without this, it is not possible to tell if the social desirability biases discovered had any real significance.

Another factor that is not addressed in the Kopcha and Sullivan study, but has implications for the use of self-report in educational technology concerns the level of expertise of the technology-using teacher. The few studies that compared self-report with observational data, and have generally reported differences between the self and outside observer assessments, typically have dealt with teaching philosophy versus actual practice (Simmons, Emory, Carter, Coker, Finnegan, Crockett, et al., 1999; Judson, 2006). For instance, Judson (2006) mused that "varying degrees of expertise" among the teachers he sampled may have accounted for in part for the disparity between the self-reported constructivist teaching practices and what was actually seen. As teachers gain experience, more congruence is realized between their beliefs and their actions (Simmons et al., 1999; Lambert, 2004). Comparisons of preservice and inservice teachers consistently demonstrate that the factor of teaching experience and expertise play a major role in the technology-related, instructional decision-making in the classroom, even when the preservice group had similar or even superior technology skills to the inservice instructors (Wetzel, Zambo, & Ryan, 2007; Pierson, 2001). Lambert and Converse-Lane (2004) noted a surprising finding: expert teachers by a small majority actually rated themselves *below* the rating given by an outside, objective standard; novice teachers, as might be expected, by a large majority rated themselves higher than the third-party observation rating.

Are Other Behavioral Measures Inherently Better?

In the previous section, an attempt has been made to demonstrate that self-report measures can have both validity (the specified constructs are indeed the ones being measured), and reliability (the specified constructs are measured consistently). A final argument that needs to be addressed concerns the purported superior quality of data collected by other types of behavioral (non-self-report) measures. Even if self-reports can be demonstrated to provide acceptable data, are these reports still simply a standby alternative to a preferable measure such as the use of outside observer ratings, for example? Howard (1994) challenges this proposition with the following lucid question: "What measurement strategy do you propose to use instead of a self-report (e.g. behavioral, physiological, significant-other, expert judge, archival), and what are the grounds for believing that your alternative measurement strategy is less fallible than a self-report?" (p. 399). Cattell (1958) refers to the "mental interiors," which gives the individual's perception of external behaviors noted by outside observers.

A common argument against self-reports concerns the known contaminants noted above (social desirability, acquiescence, etc.) that contribute to problem of common method variance. However, just as self-perceptual measures are subject to method effects, so are also outside rater-perceptual measures subject to the same response biases, and so can affect construct correlations, either by inflation or attenuation (Chan, 2009; Conway & Lance, 2010). For behavioral measures, some sources of biases that may affect construct estimates include (Howard et al., 1980; Howard, 1994):

1. Method variance—error attributable to specific measurement method used (as noted above for self-reports)
2. Situation variance—variance resulting out of the particular circumstances in which the measurements are obtained
3. Natural variability within a given method and situation—variation due to the same person in the same situation responding differently on different occurrences
4. Obtrusive measurement variance—variation attributable to the intrusion of the experimenter (observer) into the natural environment
5. Rater variance—variance resulting from the idiosyncrasies and unreliability of judgments by the rater(s); difference of divergent perspectives among outside observers or raters can lead to varying interpretations of the same construct (Chan, 2009)

The question then becomes, then, not which method is better, but how well sources of bias can be controlled. Conway and Lance (2010) conclude that "if all constructs are measured by the same measurement method (e.g., supervisory ratings, peer ratings), the measurement implications are identical to those…[in] the case of self-reports" (p. 327). Self-reports would be a stronger choice in situations where there is a need to assess constructs that are inherently perceptual and self-referential in nature (Chan, 2009). Chan goes on to list these difficulties with other behavioral measures for assessing self-referential perceptual constructs: 1) purely cognitive or mental constructs either simply are not observable, or there is not a strong enough link between an observable behavior or indicator that can be associated to the construct being measured; 2) lack of opportunity for outside observation by others 3) outside observers must be able to accurately infer an individual's specific perception, and the rationale for that perception, simply from observing a behavior.

In summary, the use of self-reports as a measurement tool cannot automatically be disqualified as a valid means of gaining information on a given construct. While there are known sources of biases that have the potential of distorting results (as do non-self-reports), the evidence suggests that such distortions are not as widespread or drastic as the popular wisdom would imply. Instead, in the field of study of human learning, it would appear that self-reports have a peculiar strength: the most accurate way to see what an individual understands is to ask the individual to be their own reporter. Howard et al. (1980) reminds the researcher of the fundamental challenge of attempting to measure what is happening in the human mind:

> Much of modern psychology has become overly enamoured with behavioral measures. Researchers often forget that any measure, whether behavioral or self-report, represents an estimate of some construct parameters. Given the existence of uncontrolled sources of contamination present in both behavioral and self-report measures, to arbitrarily select one over the other as a more appropriate estimate of behavioral parameters is inappropriate. The possibility exists that in some instances where discrepancies were found between behavioral measures and self-report measures, the differences might have represented the superiority, rather than the inferiority, of the self-report measures. (p. 295)

What is "Technology Integration"?

Before one can measure technology integration in schools, one must first define what is technology integration. Any attempted measure of technology use in a school environment will obviously be influenced (one could even go so far as to say "tainted") by the operative paradigm of the observer concerning what constitutes "integration." A brief survey of the literature concerning the use of the term "technology integration" shows the variety of directions (and non-directions) the concept has taken. As a conceptual paradigm, the term has been used in a variety of contexts by an innumerable corps of researchers and practitioners such that it loses any specific meaning—it is often used to simply allude to an effective use of technology (Liu, Maddux & Johnson, 2008). Researchers have observed that there is not a clear standard definition of technology integration in K-12 schools (Bebell, Russell, & O'Dwyer, 2004; Hew & Brush, 2007; Wetzel, Zambo, & Ryan, 2007; Pierson, 2001). Not only do definitions vary widely among researchers and practitioners, there is a fundamental difference in what has driven technology implementation in the classroom (Harris, 2005). Even within the school itself, teachers and administrators view integration differently: Smith (2011) demonstrates, for example, that teachers commonly view technology as a means of enhancing learning for students, whereas administrators focus more on what the teachers are doing.

As technology has advanced in both its complexity and its usage, our understanding of what "integration" means has also evolved. The varied perspectives on technology integration complicate the attempts to study and measure what is occurring in the school setting. The efforts to scrutinize technology infusion seem to suffer from a myopic vision—only examining small slices in what appears to be a hit-or-miss strategy. Even a brief survey of the literature gives ample demonstration of this deficiency. For example, one study viewed technology integration in terms of the ways teachers implemented student use of computers in the classroom, contrasting low-level use (typing reports, Internet searches), and high-level use (multimedia presentations, database analysis, original data interpretation) (Cuban, Kirkpatrick, & Peck, 2001). Teachers in another study viewed technology as a means to “support, enhance, and extend existing classroom practice,” (Hennessy, Ruthven, & Brindley, 2005, p. 173); in effect, “super-charging” core subject practice and pedagogy through more effective and productive implementation of classroom activities, and reshaping those activities with conduits such as dynamic visual representations for difficult mathematical and scientific concepts, use of simulations, and so on (Hew & Brush, 2007; Hennessy, Ruthven, & Brindley, 2005). A Singapore research project sought to cast the test of technology integration in terms of how well the higher-order thinking skills of the students were facilitated (Lim, Teo, Wong, Khine, Chai, & Divaharan, 2003). Protheroe (2005) sees technology primarily as a facilitator of new models of teaching and learning, which she defines as opportunities for collaboration and construction of knowledge. Pierson (2001) points out that technology integration connoted different things for different teachers, asserting that the way “technology was used determined the teachers’ personal definitions of technology integration” (p. 419).

Hart (2007) attempted to answer the question of what constitutes technology integration by utilizing a grounded theory approach through an extensive review of literature. What emerged from this study was a formalized a view of technology integration in K-12 instruction by organizing aspects of technology integration into five broad areas: curriculum, instruction, constructivist principles, teacher expertise, and tools. From this view, two overarching consolidating categories were developed along the two axes of curriculum and instruction—the curriculum alignment was styled “Mapping Tools to the Curriculum,” and the instruction component was specified as “Constructivist Teaching with Technology” (Hart, 2007, p. 45). Curriculum-mapping of technology was elaborated as technology being “used across curricula as a tool to improve learning experiences by aligning curriculum goals and instructional objectives with available technologies” (Hart, 2007, p. 48). In other words, technology supports the content, and is part of the background; to use an art metaphor, it is part of the canvas on which the mixture of oils is placed to create the painting.

The instructional aspect consisted of three basic constructs—constructivist principles, teacher expertise, and tools. These three components working concurrently are seen to be the “necessary conditions for technology integration to happen: the tools or resources that support curriculum goals, as well as teacher expertise and teacher inclinations toward constructivist ideals” (Hart, 2007, p. 51). First note that “tools” are a part of both of the major dimensions of curriculum and instruction: just as the technology tools support the curriculum, then the tools must be used the hand of a teacher as a means to support the construction of knowledge in the minds of the learners. Jonassen (2006) refers to this paradigm of technology simply being an extension of the learning capacity of the human mind as the concept of “mindtools”; that is, “technology-based modeling tools [that]…help learners construct models of what they are studying” (Jonassen, 2006, p. 4). Additionally, the principle of constructivism, with its emphasis on knowledge construction in the minds of the individual learner, is seen as consistent with this technology archetype. Technology becomes a means to recreate and reorganize the student-centered learning environment (Mills, & Tincher, 2003). Finally, the aspect of teacher expertise is the second avenue of the constructivist model by which technology integration is facilitated. Following Shulman’s (1986) pattern of viewing teaching skill as a combination of both content knowledge and pedagogical knowledge, a technology-integrating teacher must also possess technological skill, including not just bare procedural competency with computer tools, but also the ability to apply an "understanding of the unique characteristics of particular types of technologies that would lend themselves to particular aspects of the teaching and learning processes" (Pierson, 2001, p. 427).

Teaching and Technology Integration

Given the complexity of determining the definition of technology integration, how do we recognize and examine the use of technology in teaching and learning?

The focus of technology integration in this study is centered more on the pedagogical outcomes of the use of technology in the teaching and learning environment. Technology integration means the inclusion of technology resources (hardware and software) and technology-based practices (Hur, Cullen, & Brush, 2010) such that literacy is acquired in information skills, communications skills, and technological skills (Scott, Frieden, & Mills, 2002) that builds content knowledge (Dexter, Doering, & Riedel, 2006), leading to improvement in student learning outcomes (Kozma, 2003). Earle (2002) sums up technology integration in this manner: "Integrating technology is not about technology—it is primarily about content and effective instructional practices. Technology involves the tools with which we deliver content and implement practices in better ways. Its focus must be on curriculum and learning. Integration is defined not by the amount or type of technology used, but by how and why it is used" (p. 11).

Measuring Technology Use

Too often, measures of technology have been concerned with merely the amount of hardware present, or the number of hours of instructional activity that involves some form of technology use. Judson (2006) refers to this means of measurement as the "inventory" approach, literally focused on counting "how much"—of computers, instructional time, and so forth. One of the first steps in advancing the meaning of technology integration was by highlighting the distinction between bringing in technology *machinery* versus propagating technological *processes* (Earle, 2002). Pierson (2001) pointed out that "schools are so eager to purchase and have teachers begin using technology, that they mistake simply having and turning on a computer as integration" (p. 426). A recognition developed that simply placing technology in the classroom was not enough, but that there needed to be also a concern for changing teaching practices, learning experiences, and making the curriculum a vehicle for the technology.

Measuring technology integration also means more than just merely the skill set of the teacher practitioners. While technological skill is a necessary, but not sufficient, condition for successful technology integration, genuine technology integration is more than mere use of technology in a learning environment (Basham, Smeltzer, & Pianfetti, 2005). Hooper and Rieber (1999), for example, distinguish between mere computer technology use from actual integration; in their view, integration is only present when there is full-time, daily operation use within a lesson.

Current conceptions of technology integration seek to encompass a broader range of visualization beyond that of merely quantifiable measures of hardware or minutes of use in a classroom lesson. For example, a somewhat generic definition is that technology integration is "the incorporation of technology resources and technology-based practices into the daily routines, work, and management of schools" (National Center for Education Statistics, 2002, p. 75). This basically views integration as occurring when computer tools and practices are part of the interwoven practices of everyday life in the educational environment. However, just because a technology tool is used regularly and frequently does not mean it is being used in a pedagogically distinctive manner—for example, use of the Internet just for information acquisition does not, from an instructional perspective, differ substantially from going to the school library for research. Research indicates that, all too often, use of technology in the classroom centers around low-end applications (Lambert & Converse-Lane, 2004).

Vital technology integration must include more than measures of amounts of hardware and software present; integration is best visualized as determining to what extent it is being use to facilitate teaching and learning, and how it is being used to achieve multidisciplinary learning goals (Ertmer, 1999). Fulton (1997) coined the term “technological fluency,” which, according to Scott, Frieden, & Mills (2002) is described as a “combination of the information skills and literacy, communications skills and literacy, and the technology skills necessary to function in a technological environment” (p. 1597).

Issues in Observation and Evaluation of Technology Integration

Given the complexity of first determining what constitutes technology integration, and then considering what constitutes a legitimate measurement of technology use, the next question to consider involves how to capture valid data concerning the effectiveness of technology implementation in the classroom. The issues of self-report validity have been addressed earlier in this chapter, concluding that there is no reason to exclude self-reports in and of themselves from consideration for gathering data on technology practice. While the complaint is often raised about the utilization of self-report data (e.g., Judson, 2006), this section will attempt to explore the problems inherent in observational data, and discuss the limitations of employment of observations in light of the problems associated with observing and measuring technology integration noted previously.

Painter (2001) asks the basic question that must be addressed: “What observable behaviors will indicate that technology integration is successful in this setting?” (p. 22) Five issues are raised that relate to the difficulties inherent in observation of technology integration in the classroom (Painter, 2001):

1. The complexity of the technology innovation—there may be a variety of hardware or software applications involved, involving questions of what should be measured, or how it should be measured
2. The issue of confounding of technology integration with the aspect of the quality of teaching
3. The issue that any observation instrument assumes a particular philosophy of teaching;
4. An observation does not necessarily take into account the factors that led to the selection of a particular technology teaching strategy
5. The pace of technology implementation makes it difficult to have up-to-date, reliable and validated instruments

In this section, I utilize this basic framework, and examine the factors that undergird the issues and assumptions of each difficulty.

Researchers note the general difficulty of translating theoretical descriptions of what technology integration encompasses into practical "markers" that can be perceived and recorded in some tangible format. In posing the question of what observable behaviors comprehend the presence of technology integration in some form, Wetzel, Zambo, and Ryan (2007) claim that an abstract definition of technology infusion and a list of teacher skills is a "relatively straightforward process," but they do agree that observing technology use in the classroom has proven to be far more difficult. The process of "defining and measuring teachers' use of technology has increased in complexity as technology has become more advanced, varied, and pervasive in the educational system" (Bebell, Russell, & O'Dwyer, 2004, p. 48), a situation that has progressively developed throughout the steady rise of instructional technology in the K-12 classroom. Evaluation of technology use is therefore challenged to reflect the highly varied and complicated practice carried out in the modern classroom—the question extends beyond the question of not merely *what* is being used, but *how* technology is used and for what instructional purpose (Bebell, Russell, & O'Dwyer, 2004).

A second confounding factor, according to Painter (2001), is related to the difficulty in distinguishing the evaluation of technology integration apart from evaluating the quality of the instruction itself, as well as the philosophy that drives that instruction. For example, it is possible to have high levels of technological expertise, but have poor pedagogical ability to use technology effectively as a teacher (Keating & Evans, 2001). Conversely, having good pedagogical knowledge of an instructional methodology (such as using problem-based learning) does not guarantee that such knowledge will automatically produce a well-designed technology-integrated lesson (So & Kim, 2009). As Painter (2001) points out, a technology-using lesson that could potentially promote higher-order thinking, for example, may actually be implemented so poorly that it diminishes rather than enhances the instructional objective. In their study of student teachers, Brown and Warschauer (2006) found that "few participants consistently used technology at their placement sites for higher-order learning or problem-solving activities involving acquisition of information, analysis of ideas, and demonstration of content understanding" (p. 608). Lambert (2004) warns about situations where training gives teachers technological skills without corresponding strategies to integrate those skills into instruction, as well as the converse—giving teachers technology-rich constructivist activities without the technology skills to implement them. The conundrum of technological skill versus pedagogical skill is best summed up by Pierson (2001): a merely adequate teacher with technology does not have the experience to build it into sound teaching practice, while there is no guarantee that an exemplary teacher's use of technology will result in meaningful integration. For technology integration to be successful, skill in technology must be matched by skill in lesson design and execution.

The fact that technology adds a layer of complexity to the examination of an instructional activity stems from a basic question: what instructional purpose does it serve here? Not only must an accurate observation be made of what is occurring in the classroom, but also an accurate conclusion must be drawn as to what the observation reveals about the degree and appropriateness of the presumed technology integration (Wetzel, Zambo, & Ryan, 2007). True technology integration is the result (in part) of a clearly defined instructional goal. Unfortunately, the literature is replete with examples of the *presence* of technology devoid of a robust *purpose* for its application. For example, Keating and Evans (2001) aptly described an "add-on" model of technology use as the "three computers in the back of the room" model. Use of computers as a mere delivery medium (no real support for cognitive activities), lessons focused on simple tasks utilizing low-order thinking skills instead of high-order, ill-structured problems, and inappropriate scaffolding strategies, are all examples of misuse of computer technologies seen in the classroom (So & Kim, 2009). Common illustrations of disconnected use of technology from relevant instructional goals include: playing games as reward for other learning activities; mere substitution of one medium for another (PowerPoint slides instead of overhead transparencies); employing a computer simulation that is only peripherally or topically connected to the lesson objectives; and employing technology tools that are overkill for the task at hand (e.g., elementary students using Excel for a graphing activity where a simple hand-drawn graph would likely have been more pedagogically appropriate). Use of technology in itself is not proof of integration; a more important question to ask is this: was the use of technology *necessary* for the lesson (Painter, 2001).

The instructional philosophy is also intricately intertwined with the *what* and the *how* technology is deployed in the classroom. Whether a given technological use is deemed appropriate can be largely governed by the underlying philosophy concerning how students learn and what encompasses good teaching (Painter, 2001). Reviews of literature on the area of teaching philosophy suggest that a constructivist approach, where constructivism is defined as "knowledge is something that is created rather than found… people create meaning through experience as opposed to acquiring it (Soloman, 2000, p. 16), is the one most commonly associated with consummate technology integration practices (Becker, 2000; Brown & Warschauer, 2006; Hart, 2007; Pierson, 2001; Roblyer, 2004; So & Kim, 2009; Wetzel, Zambo, Ryan 2007). Roblyer (2004) claims that "there have been indications for some time that it is teachers whose belief system rests on students constructing knowledge, rather than as students receiving knowledge, that reap most benefits most from using technology in instruction" (p. 30). The philosophical filter will ultimately promote one set of instructional practices over another, leading to focusing on certain facets of classroom activity, ignoring others, and eventually impacting the interpretation of the data collected and conclusions drawn (Painter, 2001).

An additional complexity relating to observation of, and inferences reached, concerning technology integration draws from the difficulty of extrapolating understanding of cognitive processes from observing outside the practitioner's mind. Pierson (2001) claims that true integration is the intersection of multiple types of teacher knowledge, which includes "teachers' personal beliefs about teaching and learning, pedagogical knowledge, and technology integration" (So & Kim, 2009, p. 103). Not only do these types of knowledge impact the specific selection of teaching strategies employed, but the level of skill or expertise influences the degree of proficiency at which any given strategy is implemented. Experts differ in both behavior and efficiency from novices at any given task (Berliner, 1986). Judson (2006) points out how expertise is a factor in differing perceptions of instructional activity: teachers of varying expertise (novices to experts) identify different salient features of their teaching than that noted by outside expert observers. He postulates that expertise is likely a major element in the differences between what teachers consider effective teaching and what is observed in the classroom. These elucidations highlight a major impediment to relying on strictly observational data to extract interpretations concerning the degree of technology integration in a classroom setting. Without knowledge of the issues an expert teacher has considered in the selection and application of technology, it is difficult to appraise the effect of that application by observation alone (Painter, 2001). An obvious solution would be to interview the teachers concerning their thinking, but then this simply becomes a type of self-report.

A final problem in the observation and evaluation of technology infusion stems from the rapid pace of technological change occurring in the K-12 classroom. Not only does this situation affect the implementation of pedagogically sound, technology-enhanced instruction in the classroom, but also it has a direct bearing on our ability to investigate the impact our technology practices are having on student learning. Researchers note the general difficulty in conducting research in the field of educational technology: academics lament that "usable information available today is scant and scattered" (Bull, Knezek, Roblyer, Schrum, & Thompson, 2005, p. 218); and Franklin and Bolick (2007) attribute the "rapidly changing nature of the field" as one of the issues affecting the development of a coherent research agenda. Roblyer (2005) concurs with this assessment, and also notes that the variances induced by instructional design and teacher-effects complicates the comparison of comparing learning with, and without technology. Additionally, validity becomes in issue, as the development cycle for an instrument may outlive the timeframe of the innovation being examined (Painter, 2001). Research has struggled to keep up with the rapidly diversifying and expanding integration of evolving technologies (Hennessy, Ruthven, & Brindley, 2005), prompting calls for a more coherent and coordinated research schema (Roblyer & Knezek, 2003; Roblyer, 2005).

Implications for Reliance On an Observational Tool

Is the use of outside, third-party observations a feasible method to acquire data on the degree and impact of technology integration? In her article, Painter (2001) highlights several potential issues that should be considered before assuming that an observation will solve the problem of assessing whether some viable form of technology integration is present in an instructional setting. First, complexity in the classroom implementation forces a dichotomy of choosing between investigating a manageable, in-depth look of some small aspect of integration, or trying to gain more comprehensive overviews of a large-scale setting. By its very nature, a rich descriptive narrative has the potential to exclude many other details; to try to capture all that is going on may produce overwhelming data. On the other hand, pre-determined categories built into a closed instrument will, for one, as noted above, reflect the biases of the designer, and secondly, may forgo richness of detail in lieu of mere categorical data. Vannatta and Fordham (2004) discuss a twofold problem in developing research, and by extension, a reliable research instrument: 1) how to capture the “variety of teacher attributes (technology and non-technology) in relation to technology use”; and 2) how to create “valid and reliable instruments that measure the construct of classroom technology use as a whole, taking into account not just frequency but also quality, methods, outcomes, etc.” (p. 262) Considering all that has been discussed in the preceding sections, this is not a trivial task.

The issues addressed by Painter bring up other questions to consider in assessing the validity of observational measures for measuring technology integration. For instance, how would an observation protocol be able to differentiate between the effects of bad teaching from the effect of bad technology training (Painter, 2001)? This is particularly relevant in light of Lambert's (2004) comments noted above: a pedagogically-sound, high-level-thinking-skill lesson will fail dramatically if the training for, and sufficient practice of, any necessary technology skills are not in place. Additionally, an observation should reveal not only just the presence or absence of technology, or its extent, but also elucidate the quality of the integration into the lesson (Painter, 2001). Depending on how the observation instrument is structured, the quality factor may not be uncovered or only peripherally addressed. Much of technology-related preparation by the teacher may occur outside the observational lens in the classroom; such activities would fail to be captured by a traditional methodological tool of classroom observations (Bebell, Russell, & O'Dwyer, 2004).

A final point raised by Painter concerns the influence of instructional philosophy on both the teacher and the observer, and how that philosophical paradigm will impact the implementation of technology into the classroom, and the interpretation of those technology activities by an observer. Soloman (2000) describes the fields of information technology and educational psychology as being characterized by "a belief in pluralism, which can be described as respect for difference and resistance to single explanations ... pluralism in our field posits that there is no single best model or theory of learning" (p. 15). Painter warns of the danger that this pluralistic mindset will likely influence the conclusions drawn from an observation, possibly resulting in value judgments on whether one type of technology integration will be given precedence over another. While an outside observation may remove the subjectivity of a teacher doing a self-report, the subjectivity of both the instrument designers and the observer then becomes an issue (Bielefeldt, 2002). Instrumentation has to overcome the difficulty of trying to capture a complex, evolving construct to a set of reducible, measurable parameters, and may result in over-simplification, as noted in the caution given by Bebell et al. (2004) concerning the construction of instruments:

> Frequently these instruments collect information on a variety of different types of teachers' technology use and then collapse the data into a single generic "technology use" variable. Unfortunately, the amalgamated measure may be inadequate both for understanding the extent to which technology is being used by teachers and for assessing the impact of technology on learning outcomes. Moreover, there is a strong likelihood that the school leaders who rely upon this information for decision-making will interpret findings in a number of different ways. For example, some may interpret one measure of teachers' technology use solely as teachers' use of technology for delivery, while others may view it as a generic measure of the collected technology skills and uses of a teacher. (p. 48)

In agreeing with Bebell et al. (2004), Painter (2001) points out that "trying to reduce a varied and intricate set of instructional methods and materials to an observable set of behaviors may result in important components being ignored or trivialized and unimportant but easily observed behaviors getting more attention than they may warrant" (p. 45). What one sees as technology integration will be influenced by the underlying philosophy one possesses, and so will determine how any given instance of technology integration is reported.

CHAPTER 3

METHODOLOGY

Without a clear philosophical and theoretical base to define and measure technology integration, the challenge remains as to how to evaluate claims of technology infusion in K-12 education. Traditionally, there have been two fundamental types of research communities—quantitative and qualitative, with a third one (mixed methods) becoming more widely acknowledged in recent years. This study utilizes a mixed methods methodology as an application of the philosophical stance of pragmatism.

Mixed methods research is defined as:

> an approach to inquiry that combines or associates both quantitative and qualitative forms. It involves philosophical assumptions, the use of qualitative and quantitative approaches, and the mixing of both approaches in a study. Thus, it is more than simply collecting and analyzing both kinds of data; it also involves the use of both approaches in tandem so that the overall strength of the study is greater than either qualitative or quantitative research (Creswell, 2009, p. 4).

Quantitative methods of research presuppose an objective theory that is tested by examining the relationship among variables. One of the foundational questions concerns the validity of what is a self-report measuring, and whether it is measuring the postulated constructs; a quantitative methodology in this case is assuming the very things it is trying to test. On the other hand, qualitative methods of research are generally conceived as theory-building tools, in an attempt to explore and understand relationships among the various facets of a problem. The key here is to develop generalizable concepts inductively developed from the data. However, as one of the goals of this study is to assert the utility of a survey method (a quantitative process), a qualitative approach alone is not sufficient to establish a connection between theory and a specific quantifiable measure.

As this study is attempting to demonstrate the validity of a quantitative measure that can be tied to some theorized psychological construct, a mixed methods procedure appears to be the most feasible approach. A mixed methods research plan has the advantage of enabling “the researcher to simultaneously ask confirmatory and exploratory questions and therefore verify and generate theory in the same study” (Teddie & Tashakkori, 2009, p. 33). The choice of a mixed methods design is indicated, as neither a quantitative or qualitative approach by itself adequately incorporates all aspects of the research problem, and the strengths of both quantitative and qualitative research contributes to a fuller understanding of the research question (Creswell, 2009, p. 18).

The basic philosophical undergirding of a mixed methods approach is commonly called pragmatism. Pragmatism is a worldview that “arises out of actions, situations, and consequences rather than antecedent conditions (as in postpositivism)” commonly associated with quantitative methods (Creswell, 2009, p. 10). Pragmatism is concerned less with methods, and more about finding solutions to problems, that is, what works in a given situation. Given the lack of a consistent theoretical base concerning measurement of technology integration, as noted above, the pragmatic worldview has the advantage of focusing on resolving a particular aspect of the issue, and concerning itself with applications. Since the focus of this study is to find a workable solution to validating an efficient and accessible method of measuring technology integration, the pragmatic approach allows the researcher to emphasize the *what* and *how* to research in order to determine “what works” (Creswell, 2009, p. 11).

This study employs the mixed methods methodology known as the sequential explanatory strategy (Creswell, 2009, p 211). This mixed-methods design entails a two-phase data collection and analysis process: the quantitative data in the first phase, followed by the qualitative data that builds on the results of the initial quantitative phase. One of the primary purposes of the initial quantitative data results is to inform and direct the qualitative data collection to examine in more detail particular trends in the quantitative data. The resulting qualitative analysis is then used to help explain and interpret the quantitative results. The following diagram gives an overview of the overall process.

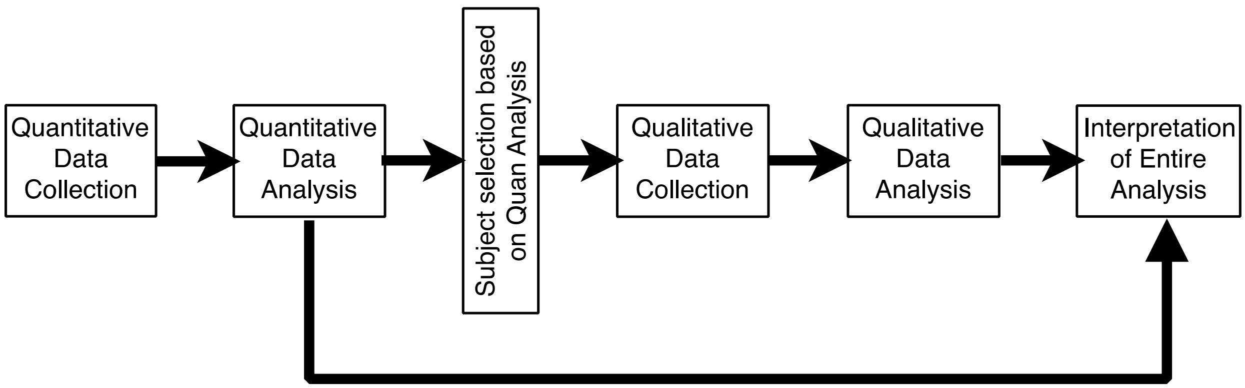

Figure 1. Flowchart of the mixed methods data collection process.

One aspect of dealing with a mixed methods process concerns the stage at which the quantitative and the qualitative data are integrated (Tashakkori & Teddlie, 1998). Integration simply means to combine quantitative and qualitative research at some stage of the research process (Creswell, Plano Clark, Gutmann, & Hanson, 2003). This integration may occur in a variety of places in the research process: within the research questions; within the data collection process itself; within data analysis; or in the interpretation phase (Creswell et al, 2003). In this study, the integration, as noted in the above diagram, takes place in the interpretation phase.

While the priority in a sequential explanatory design is usually given to the quantitative data set, in this study the qualitative data collection and analysis has precedence. As part of the design known as the participant selection model (Doyle, Brady, & Byrne, 2009), the initial quantitative phase of the study is used to generate a pool of individuals who appear to be high integration technology users, as characterized by the self-report surveys. Even though integration occurs at the interpretation phase, this is what Hanson, Creswell, Clark, Petska, & Creswell, (2005) refers to as "connecting" the quantitative and qualitative phases in the immediate stage, when the results of data analysis in the first phase of the study inform and guide the data collection in the second phase (Ivankova, Creswell & Stick, 2006). Participants are selected from particular groups generated in the quantitative stage for the qualitative observation phase as a purposeful sample in order to analyze and compare the self-report perceptions to the researcher's actual observations of classroom behavior (Creswell et al., 2003, p 227).

Participants

Data was collected from a school district in north central Texas. A purposeful sampling methodology was used to select the teacher participants, in order to have a sample from which particular insights and understanding can be gleaned in addressing specific research questions (Merriam, 1998). An email request for participation in the study was sent to the schools that were part of the one-to-one initiative (described below); seven teachers responded agreeing to take part in the observation phase of the study.

Context

Technology plays an important role at the school district. For example, the district requires all it's teachers to complete the Teacher School Technology and Readiness (STaR, 2011) Chart, an assessment tool that measures teachers' levels of technology implementation in the areas of Teaching and Learning; Educator Preparation and Development; Leadership, Administration, and Instructional support; and Infrastructure for Technology. The instrument measures four levels of progress: Early Tech, Developing Tech, Advanced Tech, and Target Tech. In 2009, the district was only at the Developing Tech level in the areas of Teaching and

Learning, and Educator Preparation and Development. By the academic year 2013–2014, the district had moved to the Advanced Tech status in all four areas the instrument addresses.

The technology plan implemented by the school district centers around a one-to-one initiative begun utilizing a major vendor's handheld tablet devices in the spring of 2013. The concept involves more than merely providing a computing tool for each of the students; the driving philosophy was to allow whatever technology tool was appropriate for the learning task at hand. The district additionally has a Bring Your Own Technology policy to further allow student choice of appropriate devices, or combination of devices, to engage in digital learning.

The initial implementation of the one-to-one initiative consisted of giving each student on three campuses a handheld tablet that the student could use in the classroom, and for use at home. The initial schools (Cohort 1) included two middle schools and a high school. In addition to the students receiving the tablets on these campuses, each teacher was given a desktop computer and a tablet, as well as installation in each classroom of five laptops. There were also placed in the library one to three mobile carts of laptops that could be checked out for additional technology resources for use in the classrooms.

The second phase of the one-to-one program (Cohort 2) was begun in the fall of 2013 where four elementary schools and one additional middle school were outfitted with tablets for students in grades 1 through 5, as well as the middle school students. Also, all other campuses in the district with 4^{th}, 7^{th}, 9^{th}, and 10^{th} grades were equipped with various numbers of laptop carts for distribution by the principals of the respective schools as they determined the instructional needs. The district plans to have system-wide implementation of tablets by the 2016 academic year.

The overall goal of the school district, according to its technology plan, is to seamlessly integrate technological tools throughout its instructional practices. To this end, the district integrates a number of software tools, such as Google Apps for Education, a content learning management system, a variety of apps on the handheld tablet, multimedia content creation tools, and online/on-demand content delivery systems, such as Edmodo or Discovery Learning. Other instructional innovations include utilizing the “flipped classroom” concept, where the teacher can prepare content (typically video materials) for use by the students at home, leaving classroom time for engaging and differentiated activities. Teachers are also given digital devices to enable them to manage their classes 24/7 from any Internet-accessible node.

The district only indirectly measures the use and growth of technology infusion by the faculty. According to the district technology office, the district’s content filter and bandwidth manager shows basically only group data, such as the amount of traffic by school. The tablet devices do not have logins *per se*, so individual use is not possible to track. The district gathers data on teacher instructional practices through fairly typical assessment mechanisms, such as: review of technology-integrated curriculum activities; interviews with teachers, students, and administrators to determine effectiveness of software, online instructional programs, etc.; review of mandated state tests; and from administrator walk-throughs and appraisals of classrooms.

Instrumentation

The following self-assessment instruments concerning measurement of technology use were administered to the teachers:

1. Concerns-Based Adoption Model—Levels of Use (CBAM-LoU)

The CBAM-LoU was developed by Griffin and Christensen (1999) as a self-assessment measure of technology-related behaviors to ascertain an innovator’s progress through various levels of use, ranging from non-use to managing to full integration of technology. It was adapted from the eight levels of use defined in the Levels of Use chart (Loucks, Newlove, & Hall, 1975). The levels of use include: (0) Non-Use, (I) Orientation, (II) Preparation, (III) Mechanical Use, (IVA) Routine, (IVB) Refinement, (V) Integration, and (VI) Renewal.

2. Stages of Adoption of Technology

Stages (Christensen, 1997) is a self-assessment instrument designed to measure a teacher's level of adoption of technology, based on Russell's (1995) work measuring use of email. It has six stages, including awareness, learning the process, understanding the application of the process, familiarity and confidence, adaptation to other contexts, and creative applications to new contexts.

3. Apple Classrooms of Tomorrow—ACOT

The ACOT instrument grew out of the Apple Classroom of Tomorrow Project, which was an eight-year collaborative project between Apple Computer and various public schools, universities and research agencies. Project analysis resulted in a five-stage model indicating a progression of attitudinal change concerning implementing technology tools and instructional practices. The five stages include: Entry, Adoption, Adaptation, Appropriation, and Invention. The ACOT instrument was developed by researchers at Apple Computer Inc., with Dwyer (1994) as the project manager and principal scientist.

Research has demonstrated that the use of these three scales together form a reliable, valid measure of the construct of technology integration, and show a high degree of association among the measures (Hancock, Knezek, & Christensen, 2007).

The observation instrument that was utilized was the Technology Integration Matrix (TIM) developed by the Florida Center for Instructional Technology at the University of South Florida (FCIT, 2011). The Technology Integration Matrix (TIM) is a matrix built on a melding of Jonassen's five characteristics of meaningful learning (Jonassen, Howland, Moore, & Marra, 2003), as elaborated in his constructive learning environments (Jonassen, Peck, & Wilson, 1999), with the stages and levels of adopting technology into the learning environment as developed by the Apple Classrooms of Tomorrow (ACOT) project (Dwyer, Ringstaf & Sandholtz, 1990). The combination of these two conceptual frameworks results in a rubric-like technology integration measuring instrument. The learning characteristics on the vertical scale provide the dimensions that are being measured, while the ACOT levels arrayed along the horizontal scale describe the increasing elaboration of each learning dimension. In effect, the TIM becomes an expanded, rubric-like version of the ACOT by taking the five ACOT levels and supplying detailed benchmarks in five categories under each ACOT dimension. The TIM measures three different domains: levels of technology integration by both the teacher and the students, as well as assessing the facilitation of the instructional setting for technology. For purposes of this study, only the data collected on the teacher implementation was used.

Observations were collected via utilization of the Technology Integration Matrix Observation Tool (TIM-O), the data collection adaptation of the Technology Integration Matrix. The observation tool is run from a password-protected online site, through which the observer administers the examination of the instructional setting, and which also records the results of the observation. The record of the observations are downloadable in a spreadsheet format. The TIM-O advances the observer through a series of branching questions regarding certain behaviors in the classroom setting, resulting in one cell in each dimension of the matrix being selected. Table 1 details a partial listing of the sequential questions presented by the TIM-O; Figure 2 shows what a completed matrix grid looks like. The instrument itself was run on an iPad tablet to record the researcher's observations.

Table 1

Partial Listing of Questions Presented by the TIM-O During the Course of an Observation

Is technology being used in the lesson/activity?

Are the students directly using technology?

Is the technology being used solely for drill-and-practice skills fluency activities?

Are the students working individually, without interaction with other students?

What kind of materials (including electronic resources) are the students using?

Are the students using technology to do any of the following?

- Setting goals
- Planning
- Monitoring progress
- Evaluating and reflecting on outcomes
- None of these

Are the students working through a specified set of procedures?

Are different groups of students using different technology tools within the same project or project time?

To what extent do learning activities involve access to or use of appropriate resources beyond the bounds of the instructional setting?

Who makes decisions about which type(s) of technology tool(s) to use during this lesson?

Who makes decisions about when to use technology tools during this lesson?

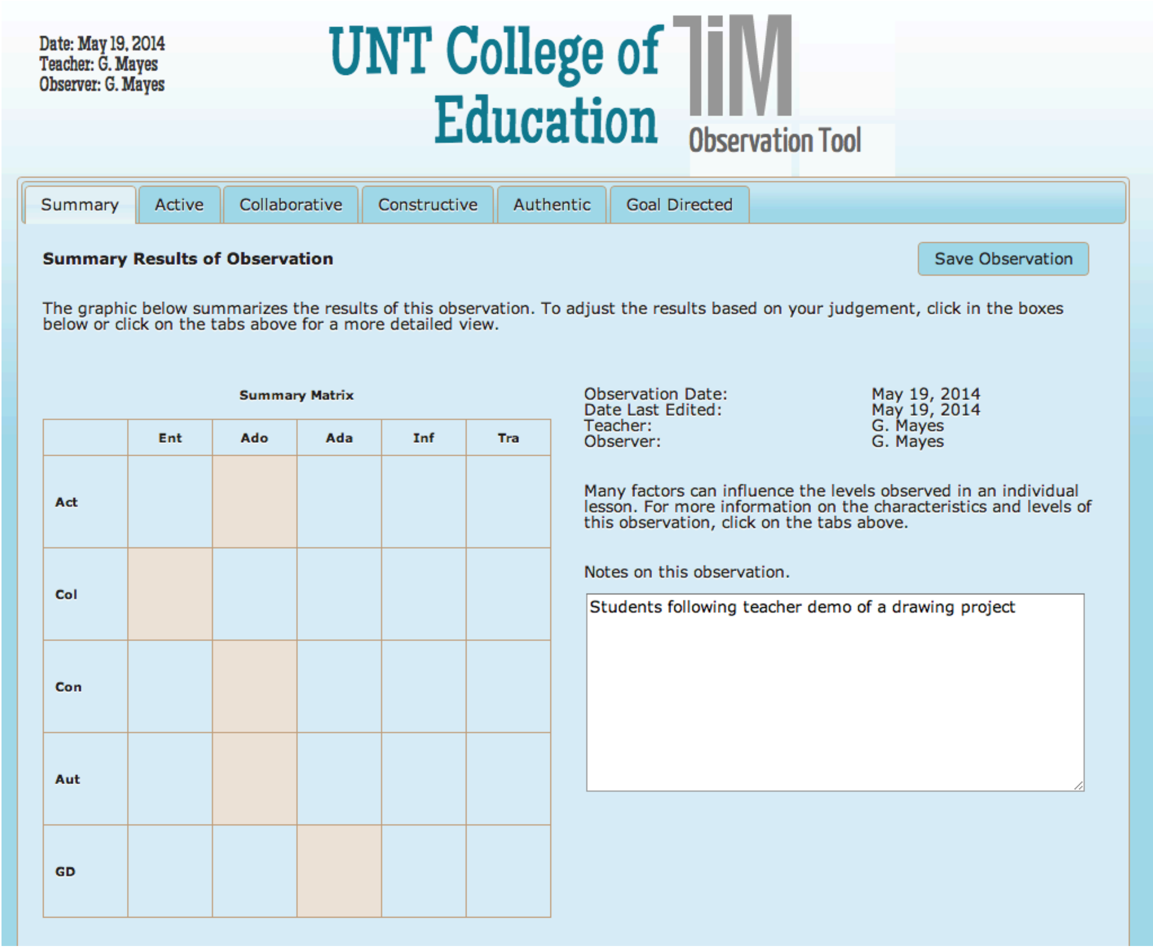

Figure 2. Sample screenshot of a completed TIM-O observation.

Procedures

The self-report data was collected via a web interface hosted on an online survey data-collection system. This included the instruments consisting of the CBAM, Stages, and the ACOT. Participation in the initial quantitative survey was requested via a district-wide email invitation sent out under the auspices of the technology department. The district-wide pool of subjects consisted of 3,295 teachers; of these, 1,484 were elementary teachers, and 1,811 were secondary. Survey responses consisted of 389 elementary teachers, and 450 secondary instructors, for response rates of 26.2% and 24.8%, respectively. All responses to the survey were voluntary. These responses were then sorted by the school, and then further sorted by the numerical score on the three instruments, so as to trichotomize the responses into the groups of low, intermediate, and high technology users (as diagrammed in Table 2 below).

Demographic information gathered from the survey sample included age, gender, level of educational attainment, years of teaching experience, and grade (in the case of elementary teachers) or subject (secondary teachers) taught. In order to gain a contextual technology picture, demographic data was also collected regarding the number of hours of use of computing devices at home, the number of hours of utilizing computing devices for instructional purposes in the classroom, how often students used computers for learning activities, and the number of computing devices accessible by students for classroom use. The nominal demographic data were analyzed via frequency counts to reveal trends among the teaching staff in terms of their education and teaching experience. In addition, independent samples *t*-tests were run to examine any differences in technology use between the faculty of the one-to-one schools and the other schools in the district where the technology initiative was not yet implemented.

In line with the mixed-methods sequential explanatory strategy, the results from the quantitative data collection/analysis were used to guide the selection of the purposeful sample in the qualitative phase. The following matrix depicts how the subjects were divided into low, intermediate, and high technology integrators, based on responses on the self-report instruments. In order to generate a pool of participants that had at least some interaction with technology, teachers were selected from the schools noted above that were involved in the one-to-one technology initiative. An email invitation was sent to teachers in the eight schools involved in the one-to-one initiative, which included 158 elementary teachers and 268 secondary teachers. For the qualitative phase, seven teachers volunteered for the follow-up classroom.

Table 2

Instrument Matrix for Low, Intermediate, and High Levels of Technology Integration

Level	Stages	CBAM	ACOT
Low	**Stage 1: Awareness** I am aware that technology exists but have not used it - perhaps I'm even avoiding it. I am anxious about the prospect of using computers	**Level 0: Non-use** I have little or no knowledge of information technology in education, no involvement with it, and I am doing nothing toward becoming involved.	**ACOT 1: Entry** I am trying to learn the basics of using technology.
		Level 1: Orientation I am seeking or acquiring information about information technology in education.	
	Stage 2: Learning the process I am currently trying to learn the basics. I am sometimes frustrated using computers. I lack confidence when using computers.	**Level 2: Preparation** I am preparing for the first use of information technology in education.	**ACOT 2: Adoption** I can successfully use technology on a basic level (e.g., use drill and practice software in classroom instruction).

(table continues)

Table 2 *(continued)*.

Level	Stages	CBAM	ACOT
Low		**Level 3: Mechanical Use** I focus most effort on the short-term, day-to-day use of information technology with little time for reflection. My effort is primarily directed toward mastering tasks required to use the information technology.	
Intermediate	**Stage 3: Understanding and application of the process** I am beginning to understand the process of using technology and can think of specific tasks in which it might be useful.	**Level 4 A: Routine** I feel comfortable using information technology in education. However, I am putting forth little effort and thought to improve information technology in education or its consequences.	**ACOT 3: Adaptation** I am discovering technology's potential for increased productivity (e.g., use of word processors for student writing).

(table continues)

Table 2 *(continued)*.

Level	Stages	CBAM	ACOT
Intermediate	**Stage 4: Familiarity and confidence** I am gaining a sense of confidence in using the computer for specific tasks. I am starting to feel comfortable using the computer.	**Level 4 B: Refinement** I vary the use of information technology in education to increase the expected benefits within the classroom. I am working on using information technology to maximize the effects with my students.	
High	**Stage 5: Adaptation to other contexts** I think about the computer as a tool to help me and am no longer concerned about it as technology. I can use it in many applications and as an instructional aid.	**Level 5: Integration** I am combining my own efforts with related activities of other teachers and colleagues to achieve impact in the classroom.	**ACOT 4: Appropriation** I can use technology "effortlessly" as a tool to accomplish a variety of instructional and management goals.
	Stage 6: Creative application to new contexts I can apply what I know about technology in the classroom. I am able to use it as an instructional tool and integrate it into the curriculum.	**Level 6: Renewal** I reevaluate the quality of use of information technology in education, seek major modifications of, or alternatives to, present innovation to achieve increased impact, examine new developments in the field, and explore new goals for myself and my school district.	**ACOT 5: Invention** I am prepared to develop entirely new learning environments that utilize technology as a flexible tool.

Once the purposeful sample of teachers had been selected, the researcher spent approximately one hour in each of the selected classrooms. The protocol for the observation instrument called for observing for ten to fifteen minutes before starting the process of answering the questions in the TIM observation tool. Anywhere from two to six separate iterations of working through the TIM observation questions were performed, depending on the pace and change of instructional activities that occurred while the observer was present. Each set of these observations for each subject was averaged to produce a final, overall "score" for each individual teacher. In order to be able to pair data gathered from the online system to the individual subjects observed in the classrooms, an ID identifier consisting of the last two digits of the employee ID number, was collected in the self-report phase. The school district's technology office used the ID information along with the demographic information collected in the quantitative survey phase to enable the researcher to match the self-report data with the individual teacher's observational data.

Each classroom was visited only once, as the qualitative analysis principle of saturation appeared to be satisfied in the hour-long observation period. Saturation occurs when sufficient data has been collected to support the conclusions reached (Suter, 2012); in this case, the degree and depth of technology integration instructional activities being observed. As described in the Context section previously, the district is in the process of executing a comprehensive technology plan; the one-to-one classrooms in particular have a robust technology environment. As noted in Chapter 4, and discussed in Chapter 5, the lessons observed in the classroom visits clearly indicate that technology was integral and necessary for the execution of the instructional activities; data collected through additional observations would only add limited new knowledge.

CHAPTER 4

DATA ANALYSIS

An overview of the data analysis is described below. Summary statistics from the quantitative online surveys for the elementary teachers and the secondary teachers are presented in separate sections, as well as various independent samples *t*-test comparisons of differences between the schools participating in the one-to-one initiative from those not yet in the program. Finally, the qualitative data of the researcher observations are reported, along with analysis of the degree of correspondence between the quantitative data and the results from the observation instrument.

Elementary Teachers Demographics

A total of 389 elementary teachers (grades PreK through 6) responded to the online surveys. The vast majority of the respondents are female, at 95% (n = 369); males are at 5% (n = 20). The ages of the teachers ranged from 23 to 65 years of age, with a mean of 42.4 years old, and a median age of 43. The distribution of teachers' ages shows a close to normal distribution, with almost one-third of the faculty falling in the 41 to 50 years of age range. Table 3 depicts the distribution of the teachers' ages.

Table 3

Elementary Teachers Age Distribution (n=385)

Age	Frequency	Percent	Cumulative Percent
21 - 25	13	3.4	3.4
26 - 30	43	11.2	14.5
31 - 35	55	14.3	28.8
36 - 40	54	14.0	42.9
41 - 45	63	16.4	59.2
46 - 50	62	16.1	75.3
51 - 55	57	14.8	90.1
56 - 60	26	6.8	96.9
61+	12	3.1	100.0
Total	385	100.0	

Length of time teaching ranged from first-year teachers to those with 38 years of teaching experience, with an average teaching time in the classroom being 13.3 years, and a median time of 12.0 years. The distribution shows a definite skew to the right, with over two-thirds of the teaching staff having 16 or less years teaching experience.

Table 4

Elementary Teachers—Number of Years Teaching (n=387)

Years Teaching	Frequency	Percent	Cumulative Percent
1st Year	8	2.1	2.1
1 - 4	54	14.0	16.0
5 - 8	67	17.3	33.3
9 - 12	66	17.1	50.4
13 - 16	65	16.8	67.2
17 - 20	45	11.6	78.8
21 - 24	38	9.8	88.6
25 - 28	25	6.5	95.1
29+	19	4.9	100.0
Total	387	100.0	

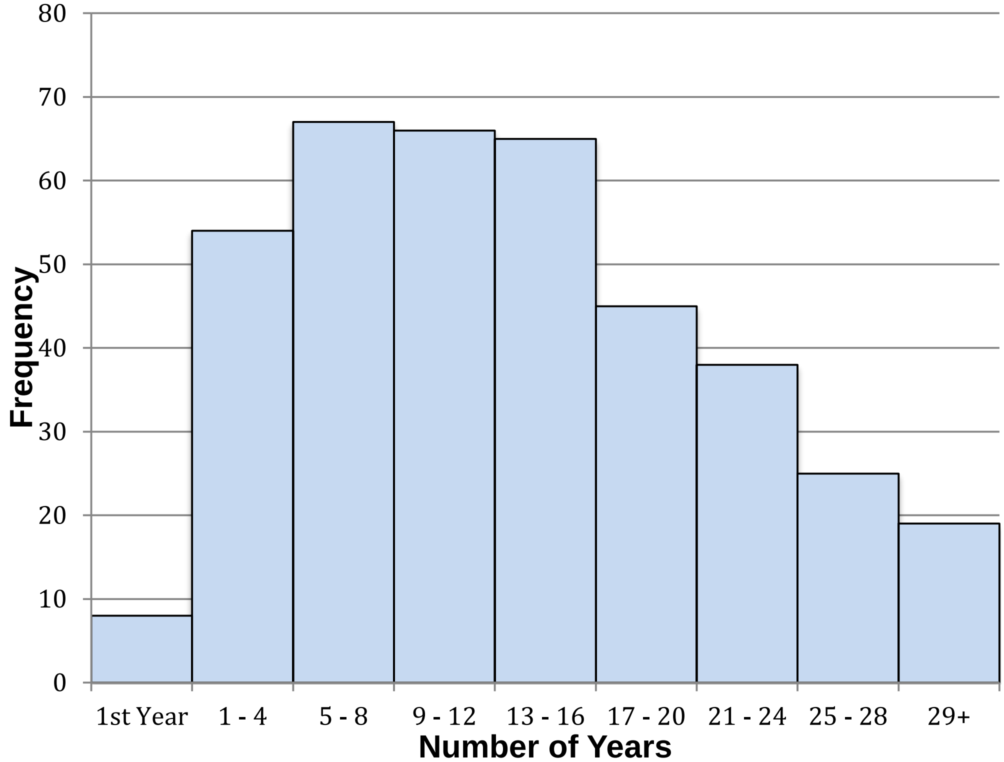

Figure 3. Frequency distribution of number of years teaching for elementary teachers.

The highest educational level attained by the elementary faculty is typically a bachelor's degree (66%), while almost one-third had obtained a master's degree (30%). Of those responding to the online surveys, 6% are pre-K teachers, 18% are K5, 8% teach 1st grade, 8% are 2nd grade teachers, 11% are 3rd grade, 12% instruct 4th grade, 31% are 5th grade teachers, and 5% cover 6th grade. Figure 2 shows the frequency distribution of the teaching sample that submitted data.

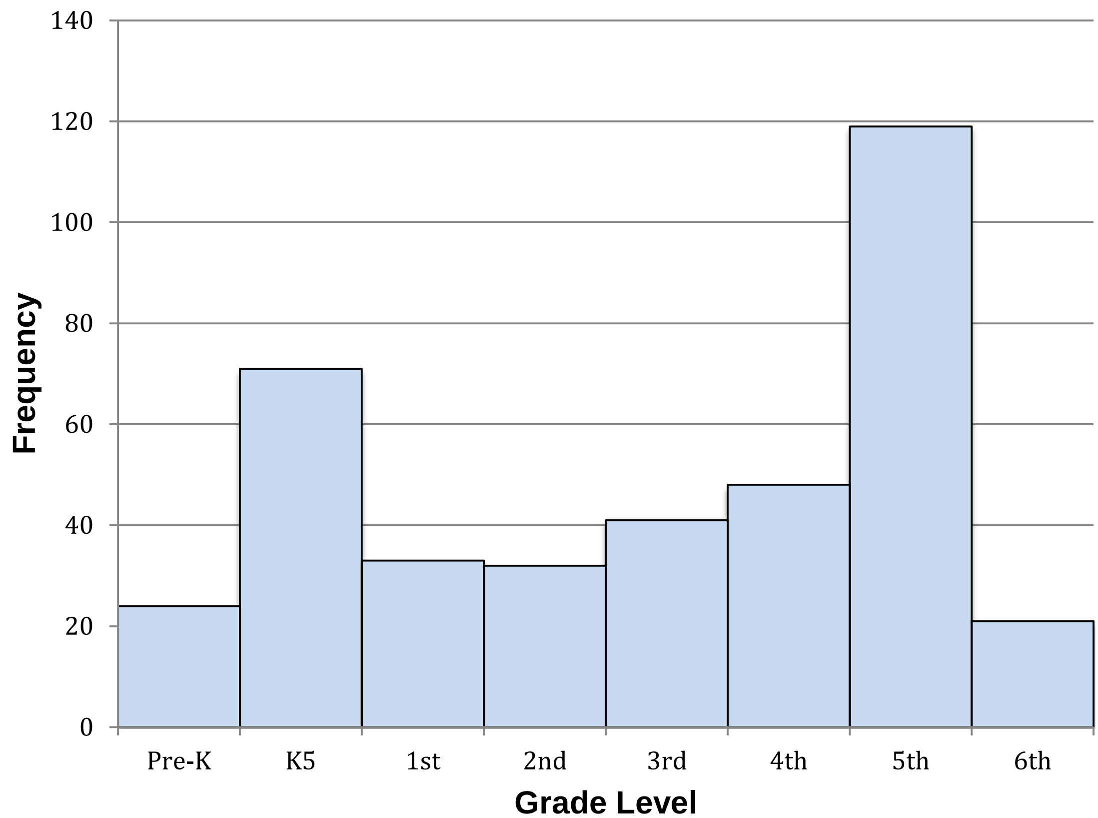

Figure 4. Frequency distribution by grade level taught of the elementary teachers who responded to the online self-report surveys.

Technology Snapshot—Elementary Teachers and Classrooms

To get a sense of the teachers' personal and classroom technology use, data were collected on hours spent using technology at home, the number of hours each week that computing devices (including desktops, laptops, tablets, and other handhelds) were used in the classroom, the number of computing devices in the classroom, and a general frequency of student use of technology for learning activities in school.

The elementary faculty evidenced high computer use at home; 39% reported using computing devices 16 or more hours per week. The exact breakdown included (n = 389): one hour per week—2%; two to three hours per week—8%; four to seven hours per week—19%;

eight to fifteen hours per week—32%; 16 to 31 hours—24%; and more than 31 hours per week—15%.

Gaining a picture of technology use in the classroom was accomplished by examining the instructor use of computers for instruction, the amount of computing devices available to the students in the classroom, and how often students used technology for learning activities in school.

The most typical time spent using computers for instruction ranged between 4 to 15 hours per week; this time range was indicated by 49% (*n* = 389) of the respondents. Table 5 details the frequencies of the teacher use of computers in classroom instruction.

Table 5

Elementary Teachers—Computer Use in the Classroom (n = 389)

Hours per week	Frequency	Percent	Cumulative Percent
0	9	2.3	2.3
1	16	4.1	6.4
2 - 3	53	13.6	20.1
4 - 7	93	23.9	44.0
8 - 15	97	24.9	68.9
16 - 31	72	18.5	87.4
More than 31	49	12.6	100.0
Total	389	100.0	

Most instructional staff reported that there were at least a few computing devices usable by the students in the classrooms. For the school district overall, 6% (*n* = 377) of the teachers surveyed indicated that there were not any student-accessible computing devices available in the classroom; 67% reported having from one to ten machines; 10% had from 11 to 20 devices; 15% indicated there being from 21 to 30 computers; 1% said there were 31 to 40 devices; and 1% listed having more than 51 machines. The frequency data is reported in Table 6. Note that differences between the one-to-one schools and the other schools on this and other parameters will be reported in a later section of this chapter.

Table 6

Elementary Schools—Number of Computing Devices in Classroom (n = 377)

Number of Devices	Frequency	Percent	Cumulative Percent
None	22	5.8	5.8
1 - 10	253	67.1	72.9
11 - 20	37	9.8	82.8
21 - 30	58	15.4	98.1
31 - 40	5	1.3	99.5
41 - 50	0	.0	99.5
51+	2	.5	100.0
Total	377	100.0	

Even given the somewhat comparative lack of student computers in the classroom, elementary teachers reported a high use of technology for learning activities. Two-thirds of the teaching staff (66%, n = 389) indicated daily use of computers for instructional work. The other categories included: 3% reported never using computers; 10% used them occasionally; and 21% used computers at least weekly. Figure 5 represents the overall use of computing devices for learning behaviors.

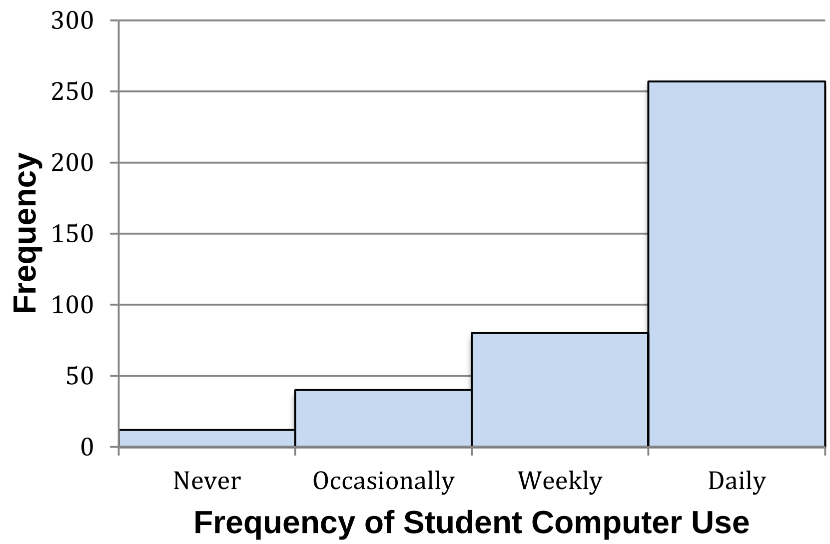

Figure 5. Frequency graph demonstrating how often students are using computers for learning activities in the elementary classroom.

Measuring the Technology Integration Perceptions—Elementary Teachers

Three self-report measures of technology integration were administered in the online surveys—the Concerns-Based Adoption Model–Levels of Use (CBAM-LoU), the Stages of Adoption of Technology, and the Apple Classrooms of Tomorrow (ACOT). All three instruments are single-item surveys in which the respondents rate themselves on their perceptions of their skill in integrating technology into classroom instruction. The scales range from one to six for the CBAM (levels 1, 2, 3, 4a, 4b, 5, 6, for a total of eight levels), one to six for Stages of Adoption (levels 1, 2, 3, 4, 5, 6), and the ACOT includes levels one through five. The overall means for the elementary faculty as a whole include: CBAM (n = 389)—mean is 6.14 (SD = 1.26); Stages (n = 389)—mean is 5.30 (SD = 0.87); and ACOT (n = 387)—mean is 3.76, (SD = 0.81). The scores from the three instruments were also combined into a single factor termed "technology integration" (Hancock, Knezek, & Christensen, 2007), giving a total possible score of nineteen. The mean of this total technology integration score is 15.19, (SD = 2.57).

Differences Between the One-to-One Elementary Schools and the Other Elementary Schools

Independent samples *t*-tests were run to examine what differences may exist between the schools where the one-to-one initiative is in place versus the rest of the elementary schools in the district. An alpha level of .05 was used for all statistical tests. Parameters that were tested include the hours of computer use at home, hours of teacher computer use in the classroom, number of student-accessible computing devices in the classroom, and frequency of student use of technology for learning activities. The three self-reports of technology integration and the calculated combined technology integration score were also compared. With the exception of the variable of student-accessible computing devices in the classroom, no significant statistical differences were found to exist in the various parameters between the two sets of schools. As would be expected, the one-to-one schools have a higher number of computing devices available for student use ($M = 15.82$, $SD = 12.19$, $N = 45$) than the other schools ($M = 8.42$, $SD = 8.04$, $N = 332$), $t(375) = -5.40$, $p < .0005$. The Cohen's effect size value ($d = .86$) suggests that the one-to-one implementation has had both a large, and clinically significant impact, on the number of student-accessible computing devices (Cohen, 1988).

The lack of statistical difference between the technology integration measures between the two sets of schools may be explained in part by the relative newness of the implementation of the one-to-one innovation in the elementary schools. The elementary schools' involvement in the program began in the second cohort, and the initiative had been in place for just over one semester at the time the online data collection took place. Though the data analysis indicated that some discrimination may be developing, there does not appear to have been sufficient time for the innovation to have been in place for a definitive trend to have become apparent.

Secondary Teachers Demographics

The number of the secondary teachers (grades 7 through 12) that responded to the online surveys totaled 450. The breakdown by gender is 22.9% male (*n* = 103) and 77.1% female (*n* = 347). The secondary teachers' mean age is 41.6 years of age, with a median of 41.0. The overall distribution of ages is illustrated in Table 7.

Table 7

Secondary Teachers Age Distribution (n = 447)

Age	Frequency	Percent	Cumulative Percent
21 - 25	32	7.2	7.2
26 - 30	52	11.6	18.8
31 - 35	68	15.2	34.0
36 - 40	65	14.5	48.5
41 - 45	61	13.6	62.2
46 - 50	57	12.8	74.9
51 - 55	57	12.8	87.7
56 - 60	33	7.4	95.1
61+	22	4.9	100.0
Total	447	100.0	

Length of time spent teaching ranged from first-year teachers to those with 45 years of teaching experience. The mean time of teaching is 12.1 years, and a median of 10.0 years; the skewed right distribution is depicted in Table 8, and graphically portrayed in Figure 6.

Table 8

Secondary Teachers—Number of Years Teaching (n = 443)

Years Teaching	Frequency	Percent	Cumulative Percent
1st year	7	1.6	1.6
1 - 4	86	19.4	21.0
5 - 8	84	19.0	40.0
9 - 12	89	20.1	60.0
13 - 16	71	16.0	76.1
17 - 20	36	8.1	84.2
21 - 24	26	5.9	90.1
25 - 28	14	3.2	93.2
29 - 32	14	3.2	96.4
33+	16	3.6	100.0
Total	443	100.0	

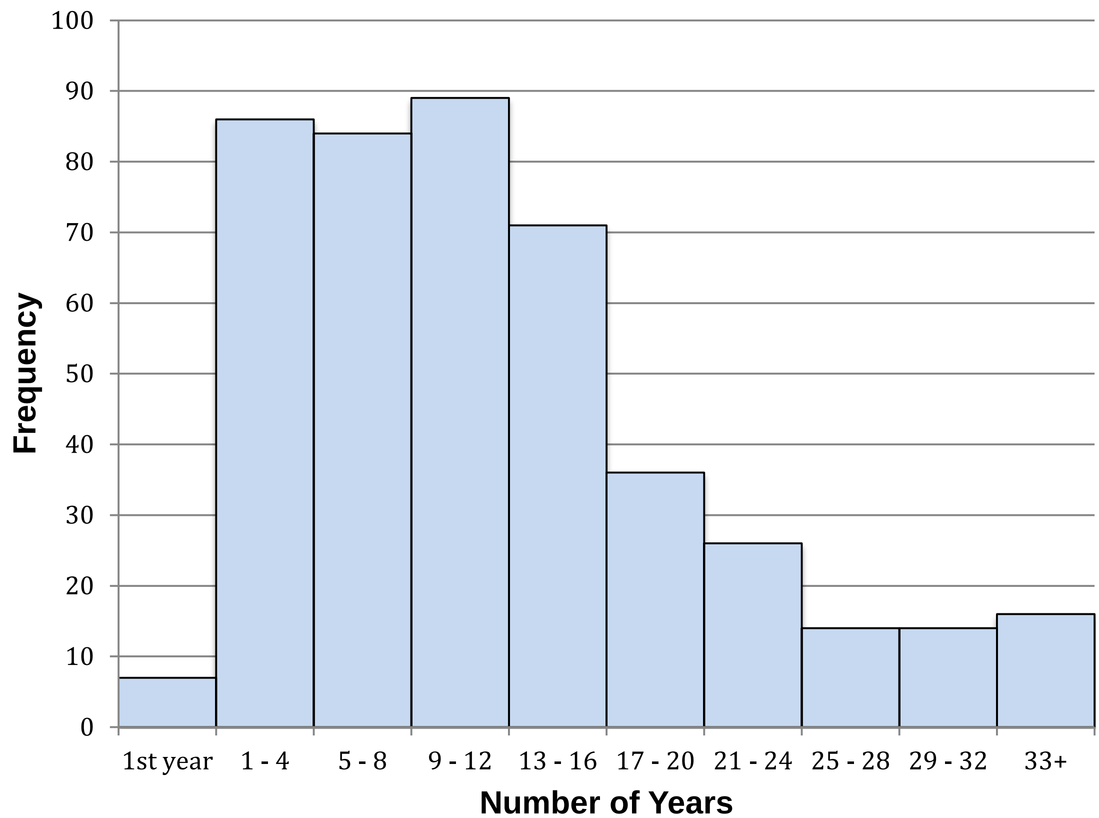

Figure 6. Frequency distribution of number of years teaching for secondary teachers.

Educational attainment by the secondary faculty is similar to that of the elementary staff: the bachelor’s is the highest degree held by 64% of the teachers; 33% hold master’s degrees, and 2% have achieved a doctorate degree. Content areas taught are distributed among the survey participants as noted in Table 9; Figure 7 illustrates the frequency distribution of the content areas taught by the secondary staff among those surveyed.

Table 9

Secondary Teachers—Subject Taught

Subject	Frequency	Percent	Cumulative Percent
Athletics	10	2.2	2.2
Computer Literacy	3	.7	2.9
Fine Arts	34	7.6	10.4
Business	5	1.1	11.6
Foreign Language	20	4.4	16.0
Language Arts	89	19.8	35.8
Math	66	14.7	50.4
Science	64	14.2	64.7
Social Studies	47	10.4	75.1
Other	53	11.8	86.9
Don't teach	19	4.2	91.1
Special Education	40	8.9	100.0
Total	450	100.0	

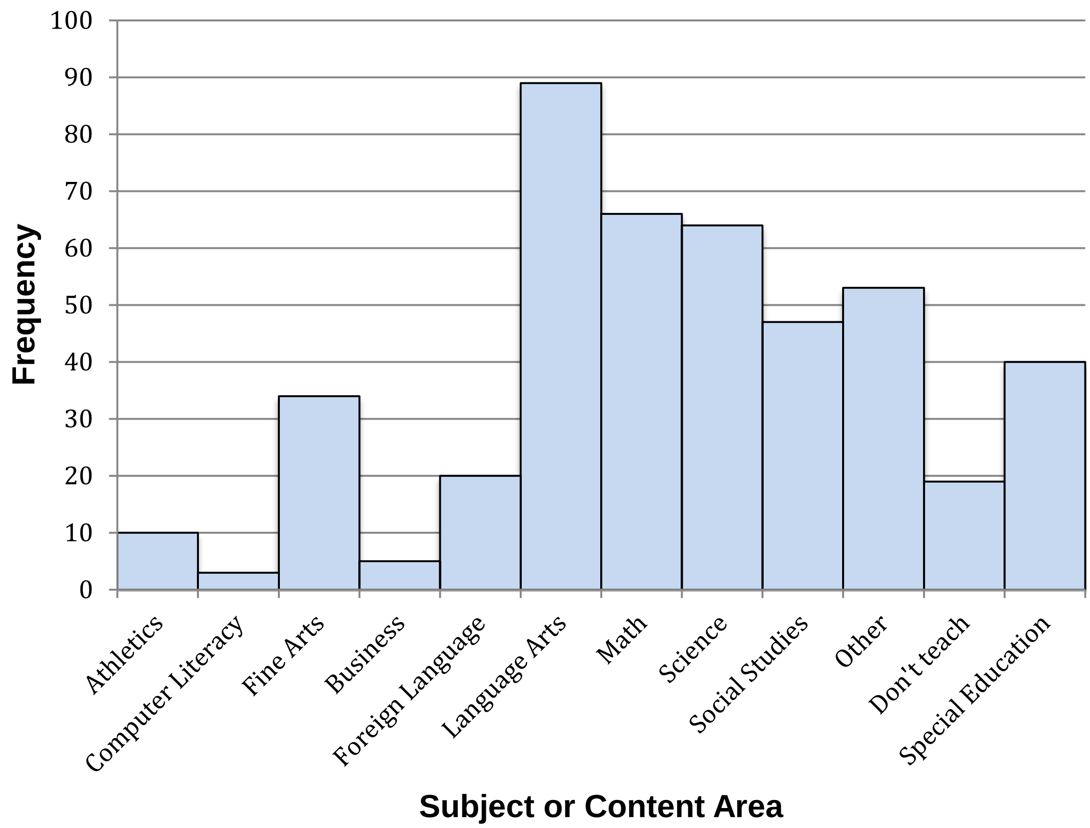

Figure 7. Frequency distribution of content areas taught by the secondary faculty.

Technology Snapshot of the Secondary Classrooms

As with the elementary teachers, the secondary faculty were surveyed regarding the amount of time spent using technology at home, the number of computing devices in the classroom to which students had access, and the number of hours computing devices were used in instruction.

Nearly half (47%) of the middle school and high school teachers reported 16 or more hours per week of technology use at home. Less than 1% each indicated zero or just one hour of home computing use; 9% reported two to three hours weekly; 16% used technology four to seven hours; 26% specified 8 to 15 hours each week; 25% showed the use of technology 16 to 31 hours weekly; and 22% reported using computing devices more than 31 hours a week.

In the area of the amount of time spent using computing devices in instruction, the secondary staff spent greater percentages of time using computers for instruction, perhaps reflecting the more advanced and technical nature of their content areas. The breakdown of time utilizing computing devices for instructional purposes is as follows: zero hours per week—2%; one hour—3%; two to three hours—10%; four to seven hours—14%; 8 to 15 hours—26%; 16 to 31 hours—29%; and more than 31 hours weekly—15%. Figure 8 compares the elementary teachers to secondary teachers use of computing devices for instruction.

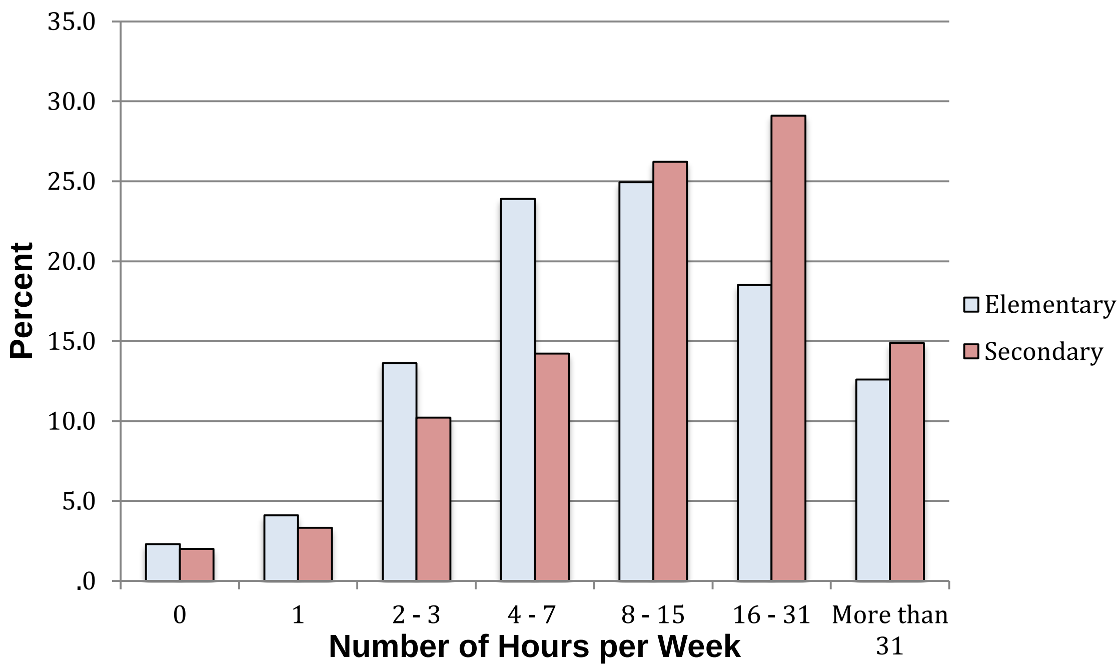

Figure 8. Comparison between elementary and secondary teachers on the number of hours computing devices are used in instruction.

Measuring the Technology Integration Perceptions—Secondary Teachers

The means for the secondary teachers on the three technology integration measures—the Concerns-Based Adoption Model, the Stages of Adoption of Technology, and the Apple Classrooms of Tomorrow—are: CBAM (*N* = 450, *M* = 6.16, *SD* = 1.25); Stages (*N* = 449, *M* = 5.21, *SD* = 0.95); ACOT (*N* = 447, *M* = 3.78, *SD* = 0.86). The combined technology integration score had a mean of 15.12 (*N* = 450, *SD* = 2.65).

Differences Between the One-to-One and the Other Secondary Schools

As with the elementary schools sample, independent samples t-tests were run to examine any differences between the one-to-one secondary schools with the other secondary schools in the district. The variables analyzed included the use of computers at home, use of computing devices at school, and number of student-accessible computing devices in the classroom, as well as the technology integration measures. As before, an alpha level of .05 was used for all statistical tests. Table 10 depicts the differences between the two categories of schools on the use of computers.

Table 10

Differences Between One-to-One Schools and Other Schools on Computer Use

	Group							
	One-to-One			Other				
Variable	Mean	*SD*	n	Mean	*SD*	n	*t*	*df*
Amt Hours Home Use	5.89	1.25	72	5.18	1.31	378	4.21*	448
Amt Hours Classroom Use	5.19	1.56	72	5.04	1.41	378	.85	448
Num. of Student Computers	13.28	13.52	69	9.32	10.50	359	2.73**	426

Note. *$p < .001$, **$p < .01$

As would be expected, the one-to-one schools have a higher number of computing devices available to students than the other schools; the Cohen's effect size (*d* = .36) is beyond the effect size of .3 benchmark, which is where an intervention is considered educationally meaningful according to Bialo and Sivin-Krachala (1996). It is likely that the secondary schools already had a greater amount of technology available for student use.

As with the elementary schools, there was not any significant difference on the amount of hours reported for technology use by the teacher in the classroom. It appears that the one-to-one initiative has not made a dramatic impact on the amount of technology use in the teachers' instructional practices, though this indicator alone does not speak to the level of pedagogical power in the classroom lessons. In contrast to the teacher technology utilization in the classroom, however, there is a highly significant difference in the number of hours the one-to-one teachers use computers at home; the level of the Cohen's effect size (d = .55) indicates a change that is clinically significant. Since it seems rather unlikely that the one-to-one faculty are dramatically more technology-immersed than the other teaching staff, it is reasonable to postulate that the one-to-one staff are utilizing more technology in the course of developing technology-rich lesson plans.

The self-report measures of technology integration (CBAM, Stages of Adoption, ACOT, Technology Integration) show significant differences between teachers in the one-to-one schools versus the other schools in the district. The independent samples *t*-tests are noted in Table 11.

Table 11

Secondary—Technology Integration Measures Between One-to-One & Other Schools

	Group							
	One-to-One			Other				
Variable	Mean	*SD*	n	Mean	*SD*	n	*t*	*df*
CBAM	6.49	1.11	72	6.1	1.27	378	2.44*	448
Stages	5.48	.77	71	5.16	.97	378	2.58**	447
ACOT	4.06	.81	71	3.73	.86	376	2.95**	445
Tech Integration	15.89	2.46	72	14.97	2.66	378	2.72**	448

Note. $*p < .02$, $**p \leq .01$

All four of the technology integration measures show Cohen's effect sizes to educationally significant (Cohen, 1988). The effect sizes are: CBAM, *d* = .31; Stages of Adoption, *d* = .34; ACOT, *d* = .39; Technology Integration, *d* = .35. These effect sizes are also considered to be educationally meaningful (Bialo & Sivin-Krachala, 1996). The North Central Regional Educational Laboratory (NCREL) has another measure of educational significance in its approximation that an effect size of .1 equates to one month difference in learning (NCREL, 2002). Based on this data, the faculty in the one-to-one initiative appear to be operating at higher levels of integrating technology into their instructional practices than teachers in the non-implementation schools.

Reliability Analysis of the Combined Technology Integration Scale

The three measures of the self-reported levels of technology integration— the Concerns-Based Adoption Model–Levels of Use (CBAM-LoU), the Stages of Adoption of Technology, and the Apple Classrooms of Tomorrow (ACOT)—were also combined into a single scale termed the "technology integration" scale. Previous studies (Hancock, Knezek, & Christensen, 2007; Morales, 2006) demonstrated that these three scales show a reliable and valid measure of technology integration. A reliability analysis on the combined elementary and secondary schools was run in the current study, giving a Cronbach's alpha for the three-item scale of r = .801. This falls within the range of "very good" according to the guidelines given by DeVellis (1991) for internal consistency reliability. Table 12 summarizes the reliability analysis.

Table 12

Reliability Analysis for Technology Integration Construct Composed of ACOT, CBAM-LoU, and Stages of Adoption Scales

Statistics for SCALE	Mean	Variance	*SD*	Variables
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CBAM	9.03	2.499	.654	.773
Stages	9.93	3.517	.680	.703
ACOT	11.41	3.778	.678	.721
Reliability Coefficients		N of Cases = 833	N of Items = 3	Alpha = .801

Classroom Observations of Technology-Infused Instruction

I conducted the observational segment of the study by visiting classrooms of teachers who volunteered for this phase. Observations were collected via the Technology Integration Matrix Observation Tool (TIM-O), the data collection adaptation of the Technology Integration Matrix, utilizing the sequential question format of the tool. Typical length of time given to each observation session ranged from one to one-and-a-half hours. Seven teachers from the one-to-one schools were observed and rated, including three elementary school teachers, three middle school teachers, and one high school instructor. Two to six separate administrations of the observational instrument were recorded of each teacher during the observation session, giving a robust snapshot of technology use during the entire instructional period.

In order to begin analysis and comparison with the corresponding self-report data, a process was developed to “quantify” (Onwuegbuzie & Teddlie, 2003) the observational data. Since the Technology Integration Matrix is built in part on the foundation of the ACOT instrument, the same numerical values of one through five were assigned to the benchmark levels from “Entry” at the low end to “Transformation” at the high end. Each of five dimensions (“Active,” Collaborative,” “Constructive,” “Authentic,” and “Goal-Directed”) then received a score of between one through five, depending on how far up the scale of the technology integration levels the rating fell. The values were then summed, and divided by five to in effect convert the 5 x 5 matrix score to a mean, giving a linear scale comparable to the values recorded on the self-report instruments. The process is illustrated by Figure 9.

Summary Matrix

	Ent	Ado	Ada	Inf	Tra
Act		2			
Col	1				
Con		2			
Aut				4	
GD			3		

Sum = 12
Divide by 5: 12/5 = 2.4 Overall score

Figure 9. Process of calculating a mean score from the TIM observation matrix.

The observational data as captured by the Technology Integration Matrix Observation Tool is noted in Table 13. The transformed observational data into mean scores is listed in Table 14. Table 15 gives an overall comparison of the scores from the self-reports with the mean observation score; the Technology Integration score has also been converted to an equivalent five-point for referencing against the mean observation score.

Table 13

Observation Data Collected Using the TIM-O Instrument

Demographics			Technology Integration Matrix Dimensions					
Teacher ID #	School ID #	Observation Date	Active	Collaborative	Constructive	Authentic	Goal Directed	Comments
94	E2	April 29, 2014	Transformation Transformation Transformation Adoption	Entry Entry Transformation Entry	Transformation Transformation Transformation Adoption	Transformation Transformation Transformation Adoption	Adaptation Infusion Infusion Infusion	Constructive, teacher facilitation of student decisions Multiple construction tools -- typing, audio recording, scanned pictures Graphic construction
56	E2	May 1, 2014	Transformation Transformation Infusion	Entry Entry Adaptation	Adoption Transformation Adaptation	Entry Adaptation Infusion	Entry Adaptation Infusion	Working on individual assignments while teacher is dealing with individual seat work Individual projects working on digital books Students generally engaged Independent learning

(table continues)

Table 13 *(continued)*.

Demographics			Technology Integration Matrix Dimensions					
Teacher ID #	School ID #	Observation Date	Active	Collaborative	Constructive	Authentic	Goal Directed	Comments
56	E2	May 1, 2014	Transformation	Entry	Transformation	Transformation	Infusion	Students mainly working on individual projects Use of student-generated materials Proficient with tech
75	S21	May 7, 2014	Transformation	Transformation	Transformation	Entry	Transformation	Independent learning, self-paced; students working on typical "textbook" physics problems
			Transformation	Transformation	Transformation	Transformation	Transformation	
			Transformation	Transformation	Transformation	Entry	Transformation	
			Infusion	Infusion	Transformation	Infusion	Transformation	Students working through various modules independently with assistance from teacher. Some are working together on assignments. Labs are online, using various tech tools. Tech is used to conduct experiments, etc. students are choosing what modules to work on.

(table continues)

Table 13 *(continued).*

Demographics			Technology Integration Matrix Dimensions					
Teacher ID #	School ID #	Observation Date	Active	Collaborative	Constructive	Authentic	Goal Directed	Comments
9	S2	May 7, 2014	Adoption	Adoption	Adoption	Adaptation	Infusion	Students working through a web quest
			Adoption	Entry	Adoption	Infusion	Adaptation	Webquest work
			Adoption	Entry	Adoption	Infusion	Infusion	
			Adoption	Entry	Adoption	Transformation	Transformation	Students creating book trailers with video editing software
			Transformation	Transformation	Transformation	Adaptation	Adaptation	Digital storytelling project
			Adoption	Adoption	Adoption	Adaptation	Infusion	Working thru web quests using student-generated questions
60	S11	May 15, 2014	Adoption	Adoption	Adoption	Entry	Adaptation	Collaborative work using Edmodo on grammar review
			Adoption	Entry	Adoption	Transformation	Infusion	Writing creative paragraph
			Adoption	Entry	Adoption	Transformation	Transformation	Writing a reflective paragraph Blooms level 6
			Adoption	Adoption	Adoption	Infusion	Adoption	Commenting on a current video news event

(table continues)

Table 13 *(continued)*.

Demographics			Technology Integration Matrix Dimensions					
Teacher ID #	School ID #	Observation Date	Active	Collaborative	Constructive	Authentic	Goal Directed	Comments
18	S11	May 15, 2014	Transformation Transformation	Entry Entry	Transformation Transformation	Transformation Transformation	Transformation Transformation	Students working on presentations Edmodo used by instructor Students using variety of tools like Prezi, Google prez, search tools Both laptops and iPads
55	E31	May 19, 2014	Entry Transformation Adoption	Entry Entry Entry	Entry Transformation Adoption	Adoption Adaptation Adoption	Entry Infusion Adaptation	Teacher demonstrating pictures with iPad projecting Students exploring different graphic tools to create own illusion Students following teacher demo of a drawing project

Note. E = Elementary school; S = Secondary school

Table 14

Observation Data Transformed to a Mean Scale

Demographics			Technology Integration Matrix Dimensions						
Teacher ID #	School ID #	Observation Date	Active	Collaborative	Constructive	Authentic	Goal Directed	Means	Overall Mean/ Participant
94	E2	April 29, 2014	5	1	5	5	3	3.8	3.70
			5	1	5	5	4	4.0	
			5	5	5	5	4	4.8	
			2	1	2	2	4	2.2	
56	E2	May 1, 2014	5	1	2	1	1	2.0	3.25
			5	1	5	3	3	3.4	
			4	3	3	4	4	3.6	
			5	1	5	5	4	4.0	
75	S21	May 7, 2014	5	5	5	1	5	4.2	4.45
			5	5	5	5	5	5.0	
			5	5	5	1	5	4.2	
			4	4	5	4	5	4.4	

(table continues)

Table 14 *(continued).*

Demographics			Technology Integration Matrix Dimensions						
Teacher ID #	School ID #	Observation Date	Active	Collaborative	Constructive	Authentic	Goal Directed	Means	Overall Mean/ Participant
9	S2	May 7, 2014	2	2	2	3	4	2.6	2.90
			2	1	2	4	3	2.4	
			2	1	2	4	4	2.6	
			2	1	2	5	5	3.0	
			5	5	5	3	3	4.2	
			2	2	2	3	4	2.6	
60	S11	May 15, 2014	2	2	2	1	3	2.0	2.55
			2	1	2	5	4	2.8	
			2	1	2	5	5	3.0	
			2	2	2	4	2	2.4	
18	S11	May 15, 2014	5	1	5	5	5	4.2	4.20
			5	1	5	5	5	4.2	
55	E31	May 19, 2014	1	1	1	2	1	1.2	2.27
			5	1	5	3	4	3.6	
			2	1	2	2	3	2.0	

Note. E = Elementary school; S = Secondary school

Table 15

Actual Data Values Obtained from Self-Reports and Observations

		Self-Report Instruments					
School ID	Teacher ID	CBAM	Stages	ACOT	Tech Integration	Tech Int - 5 pt Converted	TIM Observation Score
E2	56	7	5	4	16	4.21	3.25
E2	94	7	6	4	17	4.47	3.7
E31	55	4	3	3	10	2.63	2.27
S2	9	7	5	4	16	4.21	2.9
S21	75	8	6	5	19	5.00	4.45
S11	60	8	6	4	18	4.74	2.55
S11	18	8	6	5	19	5.00	4.2

Note. E = Elementary school, S = Secondary school

Correlations Between the Classroom Observations and the Self-Reports

The key aspect of the study was to examine the nature of the relationship between self-reports and evaluations by an outside observer—how well does a self-report align with the estimation given by another independent evaluator? To assess this relationship between the Technology Integration Matrix observations and the three self-report technology integration instruments, non-parametric correlations (Kendall's tau) were calculated between the TIM observations and each of the three instruments, as well as the combined score of the self-reports (the Technology Integration scale).

Table 16

Non-Parametric Correlations (Kendall's tau) Between the TIM and Self-Reports

Observed	Self-Reports			
	CBAM	Stages	ACOT	Tech Integration
TIM	0.51	0.58*	.82**	.65*

Note. **p* < .05, ***p* < .01, one-tailed. *N* = 7 for all analyses

As noted in Table 14, correlations between the TIM and the ACOT and the combined Technology Integration scale are significant at the .01 level and the .05 level, respectively. A high correlation between the ACOT and the TIM would perhaps be expected, given that the TIM was derived in part from the ACOT. However, given the high correlation, this does point to a strong alignment between the self-report and the outside observer report. Of more interest is the significant correlation between the TIM and the Technology Integration scale, demonstrating a strong relationship between the two. The coefficient of determination is .42, showing that 42% of the variance is shared between the two variables, that is, 42% of the variation in the summed self-reported Technology Integration scale can be explained by variation in the Technology Integration Matrix observational data.

The Decrement Between Observer Ratings and Self-Reports

As noted in Chapter 1, the issue of the alignment of the self-report ratings and the outside observer ratings provided the initial basis for the conceptual foundation for this study. The decrement between the observer ratings and the self-reported ratings, when using the combined Technology Integration scale, is 22.9%; if compared to the ACOT score, for which the highest correlation was found, the difference amounts to only 19.6%. Though not a major focus of this study, due to the small sample size, this continues to build the case that self-reports do appear to measure technology integration skills consistently.

Can the Three Self-Reports Predict What Would be Observed?

A Regression Model

To test the predictive ability of the Technology Integration scale, a regression model was run. Using the three self-report instruments, the regression model is summarized in Table 17. The TIM observation score was set as the dependent (criterion) variable, and the self-report observations were set as the predictor variables.

Table 17

Regression Coefficients for Three-Predictor Model

		Unstandardized Coefficients				95.0% Confidence Interval for B	
Model		B	Std. Error	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	-1.225	.688	-1.779	.173	-3.416	.967
	cbam	-.815	.301	-2.706	.073	-1.773	.143
	stages	.681	.337	2.023	.136	-.390	1.752
	acot	1.607	.315	5.100	.015	.604	2.610

The coefficient of determination (that is, the overall model fit) for this model is .94, which is statistically significant (p = .022), showing that the regression model provides excellent predictive ability to determine the observed score by the self-reports. The standard error of the estimate is .28. As might be expected from the correlations reported previously, only the ACOT instrument of the three self-reports shows significance at the $p < .05$ level.

Two assumptions that are necessary for performing a regression analysis which are relevant to this model are: 1) normality of the variation around the line of regression, and 2) equality of variation in the dependent variable scores for all values of the independent variables. To check for normality, a histogram was plotted and is depicted in Figure 10; Figure 11 gives an expected-versus-observed graph of the normality of the residuals.

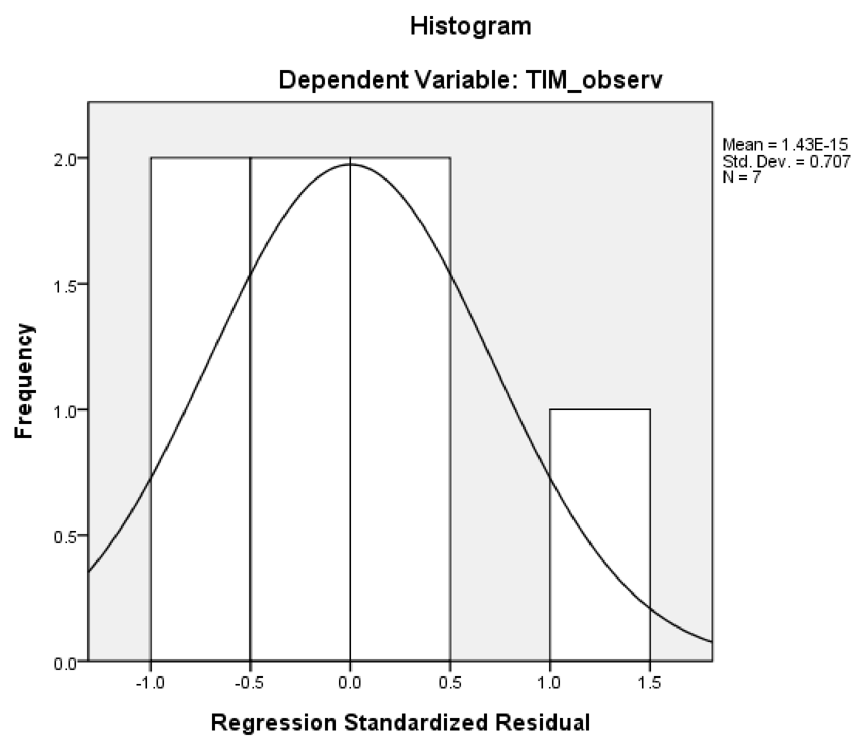

Figure 10. Normality histogram.

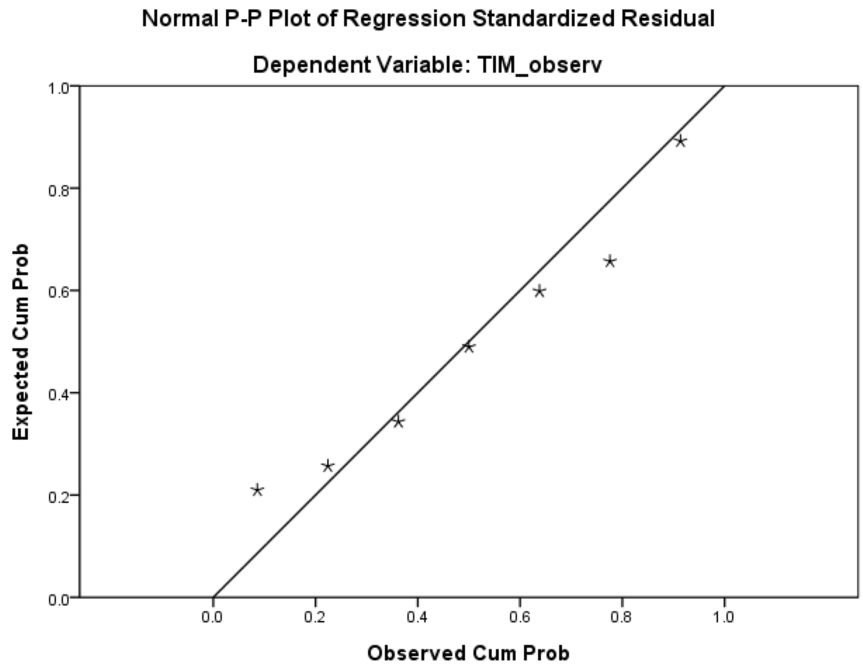

Figure 11. Expected versus observed residuals.

The normal curve shows a slight skewness to the right, but does not appear to be dramatically different from a normal curve, especially given the relatively few data points. The P-P probability chart additionally demonstrates that the residuals follow a straight line fairly closely.

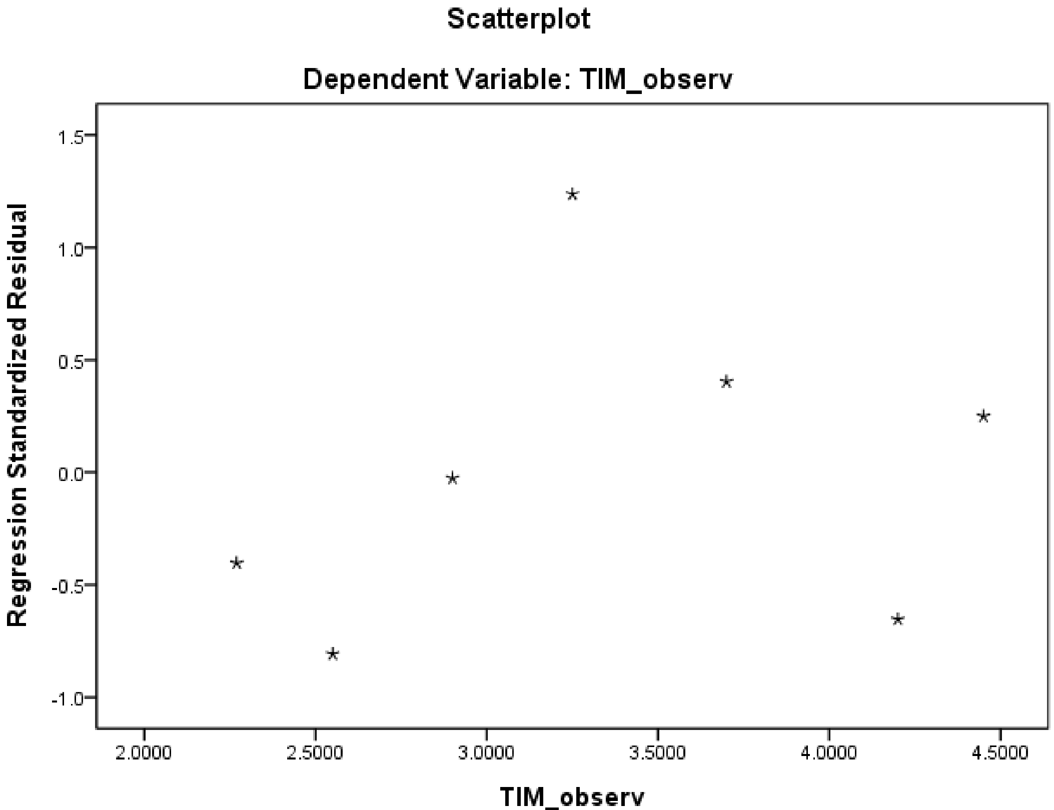

Figure 12. P-P Probability chart of residuals.

The scatterplot (Figure 12) verifies the assumption of the equality of variation. No apparent pattern or relationship exists between the residuals and the dependent variable. The pattern appears to be fairly random, with the dispersion falling mostly between +1 and -1.

To compare whether the three separate instruments or the combined score of the three into the Technology Integration scale would give a better model of fit, a regression model was run on the combined scales as a single predictor variable. The resulting equation is TIM = .19 x Tech Integration + .16; R^2 = .53, p = .064, std error of the estimate is .62. The Technology Integration as a scale compares rather poorly to the three individual instruments as predictors; not only was the Tech Integration scale not statistically significant at the .05 level, but the shared variance is considerably lower (.94 for the three-predictor model versus .53 for the combined single predictor variable).

Due to the lack of statistical significance for two of the predictor variables, CBAM and Stages, a third regression model was run on just the ACOT. The coefficient of determination for this model is .80 (p = .007; std error of estimate = .40). The ACOT instrument predicted the TIM classroom observation by the following equation: TIM = 1.07 x ACOT – 1.09. A simple approximation of this model is that subtracting one level from the ACOT self-rating will give the third-party observation score.

The minor difference in the coefficients of determination between the three-predictor model and the single-predictor ACOT model demonstrates the strength of the ACOT instrument in gauging the technology integration skills of the teachers. The betas are the standardized regression coefficients; each regression coefficient shows the strength of the relationship between the predictor variable and the criterion variable while controlling for the other predictor variables (Urdan, 2001). This indicates how much one predictor variable contributes to the variance while holding the other two constant. The strong R^2 for the ACOT model shows that the ACOT accounts for most of the variance, leaving little variance for the other two variables to predict.

CHAPTER 5

CONCLUSIONS

Summary of Findings

This study began with the problem of how to obtain a valid measure of a particular teaching and learning issue: measuring and evaluating the use of technology and its effectiveness in student learning. This section will summarize the results obtained.

In order to see and evaluate the use of technology in instruction, a school district in the initial stages of implementing a one-to-one handheld tablet initiative was selected to ascertain how the technology use was impacting teaching and student learning. The initiative was started in the spring of 2013 in three secondary schools, approximately one year before the data in this study was collected, with four elementary schools and one additional secondary school added in the fall of 2013. Based on the data collected, it is apparent that the district was already a high technology-using school system. In the elementary schools, for example, 56% of the teachers indicated that they used computing devices in teaching and instruction eight or more hours a week; 31% reported technology use 16 or more hours a week. This translates to mean that technology was used *at a minimum* for approximately 27% of the time in instructional activities by more than half of the teachers, based on an assumption of about 30 hours in a school week available for instructional time. Almost one-third of the instructors report utilizing technological tools at least for one-half or more of the instructional period. The faculty of the secondary schools reported even higher technology use: 70% of the teaching staff indicated the use of technology in classroom teaching for eight or more hours per week, and 44% reported using technology for 16 or more hours a week. Based on an approximate number of 32.5 instructional hours a week, more than two-thirds of the secondary faculty made use of computing devices for at least 25% of the instructional time-frame; a little less than half of the teachers used instructional technology at a minimum of one-half of classroom instruction.

These numbers demonstrate that technology plays a significant role in the instructional atmosphere of the school district, even with the one-to-one initiative still in its early stages. These basic statistics, of course, do not say anything about the pedagogical robustness of their use of technology. The examination of the self-reported results of the technology integration instruments is a good beginning point to gain an understanding of what the teachers are actually doing with the technology. Tables 18–23 list the descriptors for each of the self-report instruments, and the means for schools, followed by a short summary and analysis for each. Note that only the higher levels for CBAM and Stages are shown for conciseness and clarity.

Elementary Schools Self-Reports

Table 18

CBAM Mean—Elementary

CBAM	Assigned Value	School Mean
Level 4 A: Routine I feel comfortable using information technology in education. However, I am putting forth little effort and thought to improve information technology in education or its consequences.	5	6.14
Level 4 B: Refinement I vary the use of information technology in education to increase the expected benefits within the classroom. I am working on using information technology to maximize the effects with my students.	6	
Level 5: Integration I am combining my own efforts with related activities of other teachers and colleagues to achieve impact in the classroom.	7	
Level 6: Renewal I reevaluate the quality of use of information technology in education, seek major modifications of, or alternatives to, present innovation to achieve increased impact, examine new developments in the field, and explore new goals for myself and my school district.	8	

Table 19

Stages Mean—Elementary

Stages	Assigned Value	School Mean
Stage 4: Familiarity and confidence I am gaining a sense of confidence in using the computer for specific tasks. I am starting to feel comfortable using the computer.	4	
Stage 5: Adaptation to other contexts I think about the computer as a tool to help me and am no longer concerned about it as technology. I can use it in many applications and as an instructional aid.	5	5.30
Stage 6: Creative application to new contexts I can apply what I know about technology in the classroom. I am able to use it as an instructional tool and integrate it into the curriculum.	6	

Table 20

ACOT Mean—Elementary

ACOT	Assigned Value	School Mean
ACOT 1: Entry I am trying to learn the basics of using technology.	1	3.76
ACOT 2: Adoption I can successfully use technology on a basic level (e.g., use drill and practice software in classroom instruction).	2	
ACOT	**Assigned Value**	**School Mean**
ACOT 3: Adaptation I am discovering technology's potential for increased productivity (e.g., use of word processors for student writing).	3	3.76
ACOT 4: Appropriation I can use technology "effortlessly" as a tool to accomplish a variety of instructional and management goals.	4	
ACOT 5: Invention I am prepared to develop entirely new learning environments that utilize technology as a flexible tool.	5	

In examining the means of the instruments, especially in relation to where they fall within the total range of each scale, it is interesting to note how the CBAM score falls a little lower than the other two in the descriptor of the level of technology implementation. A careful perusal of the CBAM instrument shows that it is oriented more toward how much teachers use technology, whereas the Stages and ACOT instruments are more of a measure of teachers' confidence in their competence in integrating technology (Hancock & Knezek, 2007). As noted in Table 16 of Chapter 4, CBAM is the only self-report that did not show a statistically significant correlation with the external observation score, and additionally, it had the lowest correlation of the three self-reports to the external observation. While both the Stages of Adoption and the ACOT show a level of confidence in the teachers' technology integration skills that approaches the concept of Fulton's (1997) "technological fluency," it appears that the CBAM score perhaps reflects a level where teachers are actually operating.

Secondary Schools Self-Reports

Table 21

CBAM Mean—Secondary

CBAM	Assigned Value	School Mean
Level 4 A: Routine I feel comfortable using information technology in education. However, I am putting forth little effort and thought to improve information technology in education or its consequences.	5	6.16
Level 4 B: Refinement I vary the use of information technology in education to increase the expected benefits within the classroom. I am working on using information technology to maximize the effects with my students.	6	
Level 5: Integration I am combining my own efforts with related activities of other teachers and colleagues to achieve impact in the classroom.	7	
Level 6: Renewal I reevaluate the quality of use of information technology in education, seek major modifications of, or alternatives to, present innovation to achieve increased impact, examine new developments in the field, and explore new goals for myself and my school district.	8	

Table 22

Stages Mean—Secondary

<table>
<tr><th>Stages</th><th>Assigned Value</th><th>School Mean</th></tr>
<tr><td>Stage 4: Familiarity and confidence
I am gaining a sense of confidence in using the computer for specific tasks.
I am starting to feel comfortable using the computer.</td><td>4</td><td rowspan="3">5.21</td></tr>
<tr><td>Stage 5: Adaptation to other contexts
I think about the computer as a tool to help me and am no longer concerned about it as technology. I can use it in many applications and as an instructional aid.</td><td>5</td></tr>
<tr><td>Stage 6: Creative application to new contexts
I can apply what I know about technology in the classroom. I am able to use it as an instructional tool and integrate it into the curriculum.</td><td>6</td></tr>
</table>

Table 23

ACOT Mean—Secondary

ACOT	Assigned Value	School Mean
ACOT 1: Entry I am trying to learn the basics of using technology.	1	3.78
ACOT 2: Adoption I can successfully use technology on a basic level (e.g., use drill and practice software in classroom instruction).	2	
ACOT	**Assigned Value**	**School Mean**
ACOT 3: Adaptation I am discovering technology's potential for increased productivity (e.g., use of word processors for student writing).	3	3.78
ACOT 4: Appropriation I can use technology "effortlessly" as a tool to accomplish a variety of instructional and management goals.	4	
ACOT 5: Invention I am prepared to develop entirely new learning environments that utilize technology as a flexible tool.	5	

Means on the three self-report instruments for the secondary teachers show little difference from those of the elementary staff (Cohen's *d* effect sizes are negligible), even though the technology use is higher among the secondary faculty.

Comparisons with other districts with a similar technology focus will provide a context in which to interpret and evaluate the self-report scores on the teachers' self-ratings of their technology integration skills. For example, another north central Texas school district, which also had implemented a one-to-one initiative, demonstrated similar mean scores on the three self-report instruments. The teachers' ratings in 2011 (the last year for which data was available) were: CBAM, 5.98 (*SD* = 1.24, *n* = 1646); Stages, 5.20 (*SD* = .85, *n* = 1642); and ACOT, 3.79 (*SD* = .78, *n* = 1646) (Christensen, 2011). As an example of a school district in another state, teachers in middle schools of the State of Hawaii had an opportunity to participate in a STEM-rich professional development initiative. Results for the spring of 2013 of those teachers who were involved in the STEM program were: CBAM, 5.18 (*SD* = 1.98, *n* = 134); Stages, 4.96, (*SD* = 1.15, *n* = 134); and ACOT, 3.62 (*SD* = .94, *n* = 134) (Christensen, Knezek, & Tyler-Wood, 2014). The results for each of these districts is summarized in Table 24.

Table 24

Comparison of Self-Report Scores Across Three Districts

Instruments	This Study's School District	Other Texas School District	Hawaii Middle Schools
CBAM	6.16	5.98	5.18
Stages	5.25	5.20	4.96
ACOT	3.77	3.79	3.62

As can be seen from Table 24, school districts with a targeted technology focus appear to have comparable ratings by their instructional staff on their own technology infusion skills. Given this study's school district technology innovations that are being implemented, such as utilizing the "flipped classroom," aggressive use of Web 2.0 technologies, as well as the tablet initiative, the district teacher's self-ratings are consistent with teacher ratings at other technology-oriented schools.

Results of the Classroom Observations

All of the classroom observations except one took place in the one-to-one initiative schools. The most obvious question concerns how well did the observer rating of the teachers' technology integration align with the teachers' own evaluation of their skills. Since the observation instrument was adapted from the ACOT, the summary Table 25 below compares the self-report scores to the score obtained from the Technology Integration Matrix.

Table 25

Comparison of ACOT to TIM Scores

Teacher	ACOT	TIM
56	4	3.25
94	4	3.70
55	3	2.27
9	4	2.90
75	5	4.45
60	4	2.55
18	5	4.20

A correlation (Kendall's *tau*) between the ACOT and the TIM gives a value of .82, $p < .01$, demonstrating a very strong relationship between the self-report and the observed ratings. Stages of Adoption has a correlation value of .58 ($p < .05$), and CBAM's correlation is .051 (not significant at the .05 level). In terms of ranking the three self-report instruments, the ACOT proved to be the strongest predictor of the observed ratings, followed by the Stages of Adoption, and finally the CBAM. When the three instruments are combined into a single scale (named the

Technology Integration scale), its Kendall's *tau* correlation value of .65 ($p < .05$) shows a strong relationship with the external observer rating.

Given that the classroom observations took place mostly in the one-to-one tablet initiative schools, the strong correlations noted above are borne out by the kinds of instructional activities exhibited. While not all the observed classrooms show evidence of high levels of technology integration (as noted by the scores above), Table 26 below summarizes the kinds of instructional activities performed (the TIM is a converted five-point scale).

Table 26

Illumination of ACOT and TIM Scores By Learning Activities Descriptions

Teacher	ACOT	TIM Score	Activities
94	4	3.70	Elementary students working with a variety of productivity tools, such as audio editors for recording voice, word processing, and creating graphics. Students make decisions on technology tools with teacher facilitation.
56	4	3.25	Second-grade students are generally working independently on a digital book project to be used in a buddy capacity to help first-grade students with reading skills. Students write a simple story, illustrated with materials they locate or generate.

(table continues)

Table 26 *(continued).*

Teacher	ACOT	TIM Score	Activities
55	3	2.27	Elementary art classroom where mainly teacher-directed activity is taking place. The instructor projects from a tablet different types of optical illusions, and later demonstrates a simple drawing project for the students to complete. Students are allowed to explore different apps on their tablet devices for drawing, and are encouraged to create their own optical illusion, but this part of the lesson fails to reinforce the supposed learning objective, as very few can successfully complete an actual graphic (most time is spent just trying different apps).
75	5	4.45	Secondary science classroom where students are self-directed in choosing what modules the teacher has created. Collaboration is encouraged in solving experimental problems. Online lab modules hosted in a content management system are solved using various technology tools. Various types of technology resources are used to conduct experiments.
9	4	2.90	The majority of time students are working through a teacher-created webquest, so extensive Internet use for research is involved. Some time is spent on a knowledge-construction project in creating a book trailer video (basically a multi-media book report).
60	4	2.55	A fast-paced, teacher-led (teacher-driven may be a better term) classroom involving almost exclusively work on the handheld tablet. Both apps and Internet are used in primarily short writing assignments, some reflective (evaluative) thinking.

(table continues)

Table 26 *(continued)*.

Teacher	ACOT	TIM Score	Activities
18	5	4.20	Students working independently on presentations summarizing and depicting their knowledge on various topics of their choice; students choose and create using a wide variety of tools such as Prezi or Google docs.

As seen from the descriptions, even the one-to-one schools show a wide range of pedagogical applications in the use of technology. As noted in Basham et al. (2005), technology integration is more than a mere use of technology in a learning environment. The learning activities listed above serve to illustrate not only the context behind the empirical numbers, but also to validate the close alignment of the self-reported technology skills.

Discussion

This study has attempted to address one overarching research problem: does the use of a self-report perception constitute a valid and reliable means of gathering data and drawing insights about the presence and depth of technology integration by teachers in a K-12 instructional environment? The researcher has pointed out that in order to answer this question there must be proper consideration given to a number of purely philosophical issues before one even considers the empirical problems. Why is this important? In the opinion of this researcher, it is pointless to begin discussions of whether a self-report is valid without an understanding of the difficulties of "quantifying" the human mind, in particular with reference to human cognition and learning, and the problem of deriving internalized constructs from an outward behavioral observation. The debate between using a perceptual survey or a behavioral observation becomes ultimately a moot point if one fails to recognize the axiomatic suppositions that are being made about the nature of how one infers knowledge from observational data (whether from self-observation or from an external observer). Consequently, underlying assumptions must be examined to expose what "filters" may be in place regarding the placement and use of any given psychometric instrument. To begin addressing the first research question, a basic philosophical framework was laid out in Chapter 2 that described the limitations and constraints inherent in educational research. The purpose of this was to show that the argument of the validity of self-reports cannot be debated in a vacuum; due consideration must be made of the overall problem of attempting to gain an understanding of the processes of the human mind—a process that is applicable to all endeavors that acquire information (and consequently understanding) via instrumentation of any type. As demonstrated by the literature review, this is not a minor annoyance easily brushed aside; it is central to the process of conducting beneficial and applicable research.

Unlike the "easy-to-do" sciences (Berliner, 2002), with their inanimate (non-subjective) instruments, in the "hard-to-do" sciences, the ultimate instrument is the human mind itself. To illustrate the points made above from the present study, consider the case of teacher number 60. He rated himself a fairly high technology user, yet the external observer rated him less so; the difference in the ratings being 46%. Why is there such a dramatic difference in the ratings? The basic problem can be traced to two issues delineated in the literature review: the problem of a lack of a global definition of "technology integration," which flows into the problem of determining what observable behaviors constitutes technology integration. In this particular case, the observational lens of the Technology Integration Matrix observation tool defined technology integration in part by the constructive framework of Jonassen's "Five Characteristics of Meaningful Learning" (Jonassen, Howland, Moore, & Marra, 2003). Examining the learning activities utilized by this teacher demonstrates several characteristics: a great deal of teacher-directed activities, more individual work as opposed to more collaborative-type activities, and some work operating more at the lower levels of Bloom's Taxonomy of Cognitive Learning Domains (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). An examination of Table 27 will give an illustration of the impact of these general characteristics on the observation score.

Table 27

Rating of Teacher ID #60 for a Specific Instructional Activity

Instructional Activity Observed	TIM Dimensions	Observed Rating	Descriptors
Collaborative work using Edmodo on grammar review	Active	Adoption	The teacher controls the type of technology and how it is used. The teacher may be pacing the students through a project, making sure that they each complete each step in the same sequence with the same tool. Although the students are more active than students at the Entry level in their use of technology, the teacher still strongly regulates activities.
	Collaborative	Adoption	The teacher directs students in the conventional use of technology tools for working with others.

(table continues)

Table 27 *(continued).*

Instructional Activity Observed	TIM Dimensions	Observed Rating	Descriptors
Collaborative work using Edmodo on grammar review	Constructive	Adoption	The teacher provides some opportunities for students to use technology in conventional ways to build knowledge and experience. The students are constructing meaning about the relationships between prior knowledge and new learning, but the teacher is making the choices regarding technology use.
	Authentic	Entry	The teacher assigns work based on a predetermined curriculum unrelated to the students or issues beyond the instructional setting.
	Goal-Directed	Adaptation	The teacher selects the technology tools and clearly integrates them into the lesson. The teacher facilitates students' independent use of the technology tools to set goals, plan, monitor progress, and evaluate outcomes. For example, in a given project, the teacher may select a spreadsheet program that students use independently to plan and monitor progress. The teacher may provide guidance in breaking down tasks.

On the five-part scale of the TIM—Entry, Adoption, Adaptation, Infusion, Transformation—this teacher scored generally in the lower half of the scale. A perusal of the descriptors shows why—even though the instructor was using technology in a collaborative mode, the overall thread is the fact that the activity was primarily teacher-directed. While it may be argued that one reason for the low rating is the skill-centric level of the grammar review, this illustrates the tension noted by Painter (2001) discussed in Chapter 2: the constructive philosophical filter in the observation tool is biased against the presence of lower Bloom's levels of cognitive skills, and thus presupposes a lower level of technology integration. Apparently the teacher, in using the handheld tablets extensively in his class, defined his technology use as being "innovative" (at least for this observational period), though it basically consisted of substituting a technology tool for more conventional instructional mediums. The difference in the ratings can be traced back fundamentally to two differing definitions of technology integration—the constructivist, transformational approach versus the direct instruction, substitutional approach.

First Research Question

Does self-report data constitute a consistently reliable indicator or measure of technology skill and implementation abilities of teachers?

The first research question concerns itself with the reliability of self-report measures of technology use of teachers. Reliability, in its simplest form as a statistical concept, is concerned with whether the construct of interest is being measured consistently. The first step in answering this question is to examine the issue of internal consistency reliability, which tests if the individual items on a instrument are consistent with one another in that they represent one, and only one, construct of interest (Salkind, 2008). A Cronbach's Alpha was run on the combined three-item Technology Integration scale, obtaining a value of .801, which falls within the range of “very good” according to the guidelines given by DeVellis (1991). As a single scale, then, the three self-report instruments demonstrate a consistent measure of technology use.

Self-reports are fundamentally an observation made of one’s own abilities, attitudes, and skills. The debate over whether such an observation can be considered valid cannot be limited to self-reports alone. The literature review has demonstrated that observations share a number of common issues, especially when dealing with the issue of looking at technology use in classroom instruction. In brief, these problems include:

1. Construct validity—Construct validity is based on measuring some underlying construct or idea, particularly as one measurement relates to other measurements such that the measures mirror the relationships that underlie the constructs. The research shows that construct validity is independent of the form or method of the measurement tool (Howard et al, 1980).
2. Common method variance—Common method variance is variance caused by the measurement methodology instead of variance caused by the actual construct or trait being measured, typically assumed to inflate associations (correlations) among the variables. Studies demonstrate that common method variance in monomethod measurements does not give consistent patterns of either inflation or attenuation of the relationships among the constructs, in many cases causing no statistically discernible effect at all (Spector, 2006; Campton & Wagner, 1994; Chan, 2009; Conway & Lance, 2010).
3. Subject response style effects—Of the biasing factors due to attitudinal issues within the subjects themselves, social desirability (or self-presentation bias) is the most frequently cited issue. In certain types of situations (i.e., high-stakes testing), pressure

to select the “right” answers may indeed be a factor; however, in the absence of a socially desirable norm to which to align (Chan, 2009), social desirability seems to have little effect on variables generally (Spector, 2006), and, in one specific study involving a self-report on teaching practices and attitudes, self-presentation bias was not evident in the constructs involving technology use (Kopcha & Sullivan, 2007).

While this study was not structured in such a way to be able to measure or test this research question directly, the commonly held beliefs concerning the “obvious” inadequacies of self-reports does not appear to hold up under research scrutiny. Even though self-observations can introduce areas of bias and error into a measurement, this is not a problem unique to these types of measures, but share a problem common to all types of behavioral observations—uncontrolled sources of contamination (Howard et al., 1980) that must be considered.

Second Research Question

If self-report data is reliable, how closely does it correlate to ratings by external observers?

The key question of interest in this study was whether a self-report concerning one’s ability to integrate technology in a K-12 instructional setting can be relied upon to be an accurate representation of what is actually occurring in the classroom. An attempt to address this question was made by administering three single-item instruments asking the respondents to assess their perceived level of technology integration skill by selecting a given level described on the instrument. The researcher then observed selected teachers in their classrooms using an observational tool. A simple correlation is the most relevant statistical test to evaluate the relationship between the self-reports and the external observations, especially since causation is not an issue that needs to be addressed. A non-parametric statistical test was needed, resulting in the choice of Kendall’s *tau* correlation coefficient. A non-parametric test does not rely on any assumptions on the distributions of the two independent variables being examined. A one-tailed test was used since the alternate hypothesis is that the external observation scores obtained from the TIM will be more positive as the combined self-report technology scale becomes more positive, that is, both scores should move in the same direction.

A first glance of the correlations between the observational report and the self-reports show statistically significant correlations at either the $p < .05$ or $p < .01$ level. The most significant correlation is between the TIM observation and the ACOT self-report. Since the five benchmark levels on the TIM (the Levels of Technology Integration into the Curriculum) is based in part on the five ACOT levels of technology use, a high positive correlation is perhaps to be expected. However, two items are worthy of note in interpreting this correlation. First, with a *p* value of less than .01, there is less than a one percent probability that the correlation would be this high if the null hypothesis (i.e., no correlation between the two measures) were true. This level of statistical significance points to a strong likelihood that there is a true correspondence between what was reported by the teacher-participant, and what was actually observed in the classroom setting. Secondly, the value of .82 can be interpreted to show a very strong relationship between the self-report score and the observed score. Furthermore, the coefficient of determination for this correlation is .67, meaning that 67% of the variance in one instrument is accounted for by the variance in the other assessment tool. In other words, the level chosen by the teacher on the ACOT scale can explain a fairly robust amount of the activity that could be observed with the Technology Integration Matrix observation instrument.

An added confirmation of the strong relationship between the two measures can be ascertained by using Cohen's (1988) interpretative rules of effect size. In the case of a correlation, the effect size is simply the correlation value itself. An effect size value of .82 would be interpreted as a large effect following Cohen's rules for correlations (e.g., .1 = small; .3 = moderate; .5 = large). All of this indicates that at least for the ACOT self-report instrument, a value or score obtained by this instrument would point to a high probability of correspondence to what would be actually noted in an instructional setting.

The Technology Integration variable, which is derived from the sum of the three self-report instruments (Concerns-Based Adoption Model–Levels of Use, Stages of Adoption, and Apple Classrooms of Tomorrow) that were administered to the teachers, is used as the overarching self-report variable to quantify the teachers' perceived level of technology integration. Previous research (Hancock et al., 2007) had demonstrated a high degree of association among the instruments, when used as a measure of the construct of technology integration. The correlation between the TIM observation and the Technology Integration variable is .65 ($p < .05$), indicative of a strong relationship. The coefficient of determination for this relation is .42; this amount is the proportion of fluctuation of one variable that is predictable from the other variable, or the degree in which these two sets of numbers would vary together. A high score on the Technology Integration scale would tend to have a reasonable ability to predict a high score on the outside observation as captured by the Technology Integration Matrix observation instrument.

The correlations for the other two individual self-report instruments (CBAM and Stages), while lower than for the ACOT and the Technology Integration scale, reinforce the overall representation of the strong alignment between the self-reports and the outside observation. The Stages of Adoption value of .58 ($p < .05$), and the CBAM value of .51 (which just missed significance at the .05 level; actual value $p = .069$; one-tailed test) both exhibit moderate strength of relationship to the TIM observation scores.

The moderately strong correlation between the TIM classroom observations and the combined three-item (CBAM, Stages, and ACOT) Technology Integration scale points to the ultimate question that is the focal point of this study: can the self-reports accurately predict what would be actually observed in the classroom? If such a model does indeed adequately forecast the technology integration skills of the teachers, then the impetus for using classroom observations to ascertain this information is greatly lessened. A regression model using the three self-report instruments (CBAM, Stages, ACOT) gives a statistically significant ($p < .05$) coefficient of determination of .94, demonstrating a very strong relationship between the self-report ratings and the outsider observer ratings. A model using the ACOT alone gives a coefficient of determination of .80 ($p < .01$). Both models demonstrate that the predictor variables can explain a significant portion of the variance in the outcome variable of the observed technology integration the teacher exhibits in actual classroom practice.

The stated construct at the center of the investigation of this study is the construct of technology integration. Pierson (2001) commented that the way technology was used by a given teacher was a major factor in how that teacher defined technology. In his study on how teachers defined technology integration, James (2009) confirmed a similar rationale. He listed four markers that characterized and distinguished teachers who exemplified technology integration: 1) they provided rich, descriptive expressions to describe their technology activities; 2) they overcame environmental barriers, such as lack of resources, lack of professional development, and limited support from administration; 3) they exhibited a personal belief that technology was beneficial to student learning, and; 4) they believed that use of technology fit in well with how and what they taught. The common thread that connects these characteristics is that belief and attitude shapes pedagogy.

Third Research Question

Does a difference in levels of teacher expertise in technology integration impact the accuracy of self-report data?

This question will be difficult to answer with any great degree of confidence. The goal was to generate sufficient numbers of observed participants so as to be able to compare two groups of teachers: one group consisting of respondents who self-rated themselves as high technology integrators, and the second group drawn from those who rated themselves on the low end of the self-report instruments. The exact breakdown as to how the survey respondents were divided into three groups of low, intermediate, and high technology users is given in Table 2 in Chapter 3. However, the qualitative data gathered gives some hint of how the question of expertise impacts the self-ratings. A selected observational sample of teachers is depicted in Table 28.

Table 28

Comparison of "High" and "Low" Technology Integrators

Category	Teacher ID	Tech Int	TIM	Observed Activities
"High" Tech integrators	94	17	3.7	Elementary students working with a variety of productivity tools, such as audio editors for recording voice, word processing, and creating graphics. Students make decisions on technology tools with teacher facilitation.
	75	19	4.45	Secondary science classroom where students are self-directed in choosing what modules the teacher has created. Collaboration is encouraged in solving experimental problems. Online lab modules hosted in a content management system are solved using various technology tools. Various types of technology resources are used to conduct experiments.
	18	19	4.2	Students working independently on presentations summarizing and depicting their knowledge on various topics of their choice; students choose and create using a wide variety of tools such as Prezi or Google docs.

(table continues)

Table 28 *(continued)*.

Category	Teacher ID	Tech Int	TIM	Observed Activities
"Low" Tech Integrators	60	18	2.55	A fast-paced, teacher-led (teacher-driven may be a better term) classroom involving almost exclusively work on the handheld tablet. Both apps and Internet are used in primarily short writing assignments, some reflective (evaluative) thinking.
	9	16	2.9	The majority of time students are working through a teacher-created webquest, so extensive Internet use for research is involved. Some time is spent on a knowledge-construction project in creating a book trailer video (basically a multi-media book report).
	55	10	2.27	Elementary art classroom where mainly teacher-directed activity is taking place. The instructor projects from a tablet different types of optical illusions, and later demonstrates a simple drawing project for the students to complete. Students are allowed to explore different apps on their tablet devices for drawing, and are encouraged to create their own optical illusion, but this part of the lesson fails to reinforce the supposed learning objective, as very few can successfully complete an actual graphic (most time is spent just trying different apps).

Given that the classroom observations took place mostly in the one-to-one tablet initiative schools, the strong alignment between the self-reports and the external observations may be indicative of the postulated model that expertise may be a confounding variable in ascertaining the degree of correspondence between the two types of observations (Judson, 2006; Lambert &

Converse-Lane, 2004). For example, teacher ID number 75 received the highest observation score in this set, and gave himself the highest self-report rating possible. An inspection of his learning activities shows, when viewed through the "constructivist lens," that his instructional approach demonstrated a more transformational prototype in the student-centered, collaborative, "teacher-as-mentor," "technology facilitating knowledge construction" methodology. His expert self-rating corresponded closely with the observer's rating. This is in line with Becker's (2000) observations, which indicated that teachers whose personal philosophy supported a student-centered, constructivist pedagogy, were more likely to demonstrate high technology integration skills. On the other hand, the instructional activities of teacher number 60, who was discussed previously, clearly operated at the lower levels of the technology integration levels of the TIM, yet rated himself quite high. This would certainly collaborate the trend noted in the literature review (see Lambert & Converse-Lane, 2004) that novice technology-integrating teachers tend to over-rate themselves.

However, a contrary data point illustrates even an anomaly to this trend. Note that teacher number 55 gave himself a low rating, collaborated by the researcher's rating. An examination of the learning activities does indeed show the use of technology as mainly a delivery medium; even the short period of time devoted to student construction of optical illusions was more of an "add-on" activity and did not seem to serve much of a pedagogical purpose. In this case, at least, the novice technology-using teacher (judging by the evidenced learning activities) had a fairly accurate self-understanding of his technology skills. Teacher 9 falls between these two extremes: his learning activities did demonstrate a moderate amount of technology innovation, but his self-report score was somewhat high relative to the observer rating.

Limitations

As noted in other sections of this paper, the greatest limitation in the eyes of this researcher is the lack of an agreed upon view of what constitutes technology integration, and consequently, no agreed upon view of what to actually look for in a classroom setting. An observational tool, whether self-reported or other-reported, will of necessity reflect some preconditional perception or bias as to what the observer is rating. As Chan (2009) points out, a mental construct (in this case, a definition of technology integration and all that flows from it) is difficult to observe, and furthermore we cannot infer an individual's perception and rationale. An observation by an outside party can only capture a specific slice of time, and must infer the why; an individual completing a self-report can reflect on the total range of experience.

If expertise in the art of using technology in meaningful and pedagogical sound applications is indeed an important component (Judson's "confounding variable") of an observational rating of a teacher, then how is that to be assessed? Though at least one researcher (Lambert & Converse-Lane, 2004) has attempted to measure expertise levels by an external "gold standard," additional work is needed in this area to assess expertise as a factor influencing teachers' perceptions of their own technology integration (Judson, 2006).

Finally, the small sampling of teachers for the observational phase, while providing an illuminating insight into the quantitative data, is a limiting factor in the degree of confidence in the results due to the participant self-selection (no random selection). Conducting a study where all subjects in both the self-report stage and the observational stage participate as volunteers introduces an additional level of bias into the study.

Recommendations for Future Research

This research study made an attempt to determine if a self-observation of one's technology integration skills would provide a reliable estimate of an observation made by an external observer. In order to accomplish this task, a certain philosophical foundation was taken, and certain assumptions about teaching and learning, especially in a technology framework, were utilized. A particular view of what is meant by "technology integration" was adopted, derived from a particular construct of what constitutes human learning. The instruments selected (both self-report and observational) for use in this study reflected this paradigmatic stance. As this study was both limited in scope (a specific technology-rich school district) and size (being a small sample of observed participants), further research would be both insightful and warranted.

The most obvious starting point for future research would be a replication of this study with a larger sample of outside observations, both in number of participants, and in multiple longitudinal observations of each individual in a group of subjects by multiple observers. The larger sample should include an expansion of the range of the technology integration skill levels (as evidenced by the self-reports) of the teachers being observed in order to test more fully the impact of expertise has on the accuracy of self-report data. Additionally, a multiple-observation protocol for assessing each subject would give more depth and a richer picture of the actual technology use of an individual teacher. Reliance on a single "snapshot" approach to ascertaining the depth of technology integration serves to highlight some of the weaknesses inherent in trying to observe technology usage in the classroom (Painter, 2001; Babell et al., 2004). As noted in the literature review, technology use in the classroom is varied, perplexing, and complicated; therefore use of a single observation will not capture the full range of what an instructor has the capability of accomplishing, nor will it necessarily fully capture how technology is used and for what purpose in a variety of instructional settings and contexts.

While the use of easily selectable, single-item self-report instruments make for ease of administration, another way to generate a comparison between self-reports and external observations that draws on the level of detail in the observation matrix used in this study is to replicate the study with the participants self-reporting on the Technology Integration Matrix observational tool, as well as the third-party observer. This offers the benefit of granularity—a matrix offers more refined measurement than single-item instruments. The main difficulty with such an approach would concern how the participant could enter a self-evaluation at the same time as engaging in teaching a lesson, though perhaps completing the rubric in a post-lesson reflection would be sufficient.

Though not one of the foci of this study, a question to be explored in future research that arises naturally from the implications of this inquiry concerns itself with whether the assessment of behavioral traits such as self-efficacy, attitudes towards technology, and a general openness to change can be a predictor of teacher expertise in use of technology in instruction.

As reported by Lambert & Converse-Lane (2004), a difference appears to exist between the self-report ratings of experts and novices concerning their technology integration skills. The experts under-reported their technology integration abilities, while the novices by a wide margin gave themselves much higher rankings. The implication of this study is that a simple comparison between self-report and actual outside observation will result in skewing the self-report data lower than would be a true measure due to the extra influence of the novice users. Any sample that has a larger proportion of novice users will have greater impact on lowering the alignment between self-report versus the (assumed) actual skill level.

Conclusions

The stated goal of this study is to establish that a teacher's own observations of their technology integration skills will serve to be an accurate representation of what might be noted by an outside observer present in that teacher's classroom. The practical implications of answering this question affirmatively show the import of this issue. Implementation of self-reports offers several advantages over the use of third-party observers. Self-report instruments are generally easy to administer, especially if Internet communications are employed; self-reports are cost-effective— each participant contributes their own time and effort to record data, whether pen-and-paper or already established Internet services are utilized; and finally self-report tools are practical for wide-scale coverage of a population, as distribution of an instrument is relatively easily accomplished. On the other hand, utilization of outside observers to note and record data offers several difficulties. Third-party observers obviously involve bringing in additional personnel. Attendant problems associated with the use of these outside observers include: the additional expense in terms of both money and time incurred (Wetzel et al., 2007); time and location management issues of scheduling observers to be present in a given classroom at a given time; and the limited feasibility of observing anything beyond a rather small segment of the targeted population (Painter, 2001). Self-reports have been typically justified because of their ease-of-use (Kopcha & Sullivan, 2007); demonstrating that such tools can provide good data strengthens considerably the case for their use.

This study serves as a validation of the points noted above. The self-report instruments, along with some demographic questions, were administered via a Web server utilizing standard check-box webpage forms; the surveys could be completed in approximately five minutes. The time frame to collect over 800 responses took about two to three weeks. To collect observations on these same 800 individuals would have entailed considerable cost both in time and money. As the analysis has revealed, little information is lost in relying on the data gathered through self-report measures; using the ACOT rating minus one shows a good approximation of what the TIM observation instrument yields.

In summary, the regression model indicates that well-designed self-report instruments, whether singly or in combination, can serve as accurate predictor(s) of actual technology integration skills. As in curriculum alignment, alignment among philosophical assumptions, self-report instrument, and observational instrument seems to be critical for accurate assessment of a given instructional environment.

APPENDIX A

SELF-REPORT INSTRUMENTS

Concerns- Based Adoption Model (CBAM) Levels of Use of an Innovation Please mark one category that best indicates your overall level of use of information technology.
Level 0: Non-use I have little or no knowledge of information technology in education, no involvement with it, and I am doing nothing toward becoming involved.
Level 1: Orientation I am seeking or acquiring information about information technology in education.
Level 2: Preparation I am preparing for the first use of information technology in education.
Level 3: Mechanical Use I focus most effort on the short-term, day-to-day use of information technology with little time for reflection. My effort is primarily directed toward mastering tasks required to use the information technology.
Level 4 A: Routine I feel comfortable using information technology in education. However, I am putting forth little effort and thought to improve information technology in education or its consequences.
Level 4 B: Refinement I vary the use of information technology in education to increase the expected benefits within the classroom. I am working on using information technology to maximize the effects with my students.
Level 5: Integration I am combining my own efforts with related activities of other teachers and colleagues to achieve impact in the classroom.
Level 6: Renewal I reevaluate the quality of use of information technology in education, seek major modifications of, or alternatives to, present innovation to achieve increased impact, examine new developments in the field, and explore new goals for myself and my school district.

Griffin & Christensen (1999) based on Loucks, Newlove, & Hall (1975)

Stages of Adoption
Instructions: Please read the descriptions of each of the six stages related to adoption of technology. Choose the stage that best describes where you are in the adoption of technology.
Stage 1: Awareness I am aware that technology exists but have not used it - perhaps I'm even avoiding it. I am anxious about the prospect of using computers
Stage 2: Learning the process I am currently trying to learn the basics. I am sometimes frustrated using computers. I lack confidence when using computers.
Stage 3: Understanding and application of the process I am beginning to understand the process of using technology and can think of specific tasks in which it might be useful.
Stage 4: Familiarity and confidence I am gaining a sense of confidence in using the computer for specific tasks. I am starting to feel comfortable using the computer.
Stage 5: Adaptation to other contexts I think about the computer as a tool to help me and am no longer concerned about it as technology. I can use it in many applications and as an instructional aid.
Stage 6: Creative application to new contexts I can apply what I know about technology in the classroom. I am able to use it as an instructional tool and integrate it into the curriculum.

Stages: Christensen (1997) based on Russell (1995)

Apple Classrooms of Tomorrow
What would you estimate to be your current level of understanding and use of technology? Select from list below:
ACOT 1: Entry I am trying to learn the basics of using technology.
ACOT 2: Adoption I can successfully use technology on a basic level (e.g., use drill and practice software in classroom instruction).
ACOT 3: Adaptation I am discovering technology's potential for increased productivity (e.g., use of word processors for student writing).
ACOT 4: Appropriation I can use technology "effortlessly" as a tool to accomplish a variety of instructional and management goals.
ACOT 5: Invention I am prepared to develop entirely new learning environments that utilize technology as a flexible tool.

ACOT: Apple Classroom of Tomorrow Project, Dwyer (1994) Project Manager

APPINDEX B

IRB APPROVAL LETTER

UNT

A green light to greatness.

OFFICE OF RESEARCH INTEGRITY AND COMPLIANCE

January 15, 2013

Dr. Gerald Knezek
Student Investigator: Garry Mayes
Department of Learning Technologies
University of North Texas
RE: Human Subjects Application No. 13-581

Dear Dr. Knezek:

In accordance with 45 CFR Part 46 Section 46.101, your study titled "Factors Impacting the Accuracy of Self-Report Perceptions of Expertise in Technology Integration" has been determined to qualify for an exemption from further review by the UNT Institutional Review Board (IRB).

Enclosed are the consent documents with stamped IRB approval. Please copy and **use this form only** for your study subjects.

No changes may be made to your study's procedures or forms without prior written approval from the UNT IRB. Please contact Jordan Harmon, Research Compliance Analyst, ext. 4643, if you wish to make any such changes. Any changes to your procedures or forms after 3 years will require completion of a new IRB application.

We wish you success with your study.

Sincerely,

Boyd Herod for PLK

Patricia L. Kaminski, Ph.D.
Associate Professor
Chair, Institutional Review Board

PK:jh

UNIVERSITY OF NORTH TEXAS
1155 Union Circle #310979 Denton, Texas 76203-5017
940.369.4643 940.369.7486 fax www.research.unt.edu

REFERENCES

Agyei, D., & Voogt, J. (2011). Determining teachers' TPACK through observations and self-report data. In M. Koehler & P. Mishra (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2011* (pp. 2314-2319). Chesapeake, VA: AACE.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191-215.

Basham, J., Smeltzer, A., & Pianfetti, E. (2005). An integrated framework used to increase preservice teacher NETS-T ability. *Journal of Technology and Teacher Education*, *13*(2), 257-276.

Bebell, D., Russell, M., & O'Dwyer, L. (2004). Measuring teachers' technology uses: Why multiple-measures are more revealing. *Journal of Research on Technology in Education*, *37*(1), 45-63.

Becker, H. (2000). Findings from the teaching, learning, and computing survey: Is Larry Cuban right? *Education Policy Analysis Archives*, *8*(51).

Berliner, D.C. (1986). In pursuit of the expert pedagogue. *Educational Researcher*, *15*(7), 5-13.

Berliner, D. (2002). Educational research: The hardest science of all. *Educational Researcher*, *31*(8), 18-20.

Bialo, E. R., & Sivin-Kachala, J. (1996). The effectiveness of technology in schools: A summary of recent research. *School Library Media Quarterly, 25*(1), 51-57.

Bielefeldt, T. (2000). Teacher outcomes: Improved technology skills. In J. Johnston & L. T. Barker (Eds.), *Assessing the impact of technology in teaching and learning* (pp. 119–138). Ann Arbor, MI: University of Michigan Institute for Social Research.

Bloom, B. S., Englehart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives. Handbook 1: Cognitive domain*. New York: Longmans, Green.

Brown, D. & Warschauer, M. (2006). From the university to the elementary classroom: students' experiences in learning to integrate technology in instruction. *Journal of Technology and Teacher Education*. *14*(3), 599-621.

Bull, G., Knezek, G., Roblyer, M. D., Schrum, L., & Thompson, A. (2005). A proactive approach to a research agenda for educational technology. *Journal of Research on Technology in Education, 37*(3), 217-220.

Burkhart, H., & Schoenfeld, A. (2003). Improving educational research: Toward a more useful, more influential, and better-funded enterprise. *Educational Researcher, 32*(9), 3-14.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin, 56*, 81-105.

Cattell, R. B. (1958). What is “objective” in “objective personality tests?” *Journal of Counseling Psychology*, *5*(4), 285-289.

Cattell, R. B. (1973). *Personality and mood by questionnaire*. San Francisco: Jossey-Bass.

Chan, D. (2001). Method effects of positive affectivity, negative affectivity, and impression management in self-reports of work attitudes. *Human Performance*, *14*(1), 77-96.

Chan, D. (2009). So why ask me? Are self-report data really that bad? In C. E. Lance & R. J. Vandenberg (Eds.), *Statistical and methodological myths and urban legends: Doctrine, verity and fable in the organizational and social science*s (pp. 311–338). New York: Routledge.

Christensen, R. (1997). *Effect of technology integration education on the attitudes of teachers and their students*. Doctoral dissertation, University of North Texas. [Online].

Christensen, R. (2011). *Teacher annual needs assessment*. Unpublished manuscript.

Christensen, R., Knezek, G., & Tyler-Wood, T. (2014). Impact of science and technology professional development programs on integration levels and STEM dispositions of middle school teachers. In *Proceedings of the 12th Annual Hawaii International Conference on Education (HICE),* (pp. 1715–1726). Honolulu, Hawaii: HICE.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Conway, J. M., & Lance, C. E. (2010). What reviewers should expect from authors regarding common method bias in organizational research. *Journal of Business and Psychology, 25*(3), 325-334.

Crampton, S. M., & Wagner, J. A. (1994). Percept-percept inflation in microorganizational research: An investigation of prevalence and effect. *Journal of Applied Psychology*, *79*(1), 67-76.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches*. Los Angeles: Sage.

Creswell, J. W., Plano Clark, V. L., Gutmann, M., & Hanson, W. (2003). Advanced mixed methods research designs. In A. Tashakkori and C. Teddlie (Eds.), *Handbook of mixed methods in the behavioral and social sciences*, (pp. 209–240). Thousand Oaks, CA: Sage.

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin, 52*(4), 281–302.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge, MA:

Harvard University Press.

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal*, *38*(4), 813–834.

DeVellis, R.F. (1991). *Scale development*. Newbury Park, NJ: Sage Publications.

Dexter, S., Doering, A.H., & Riedel, E. (2006). Content area specific technology integration: a model for educating teachers. *Journal of Technology and Teacher Education*, *14*(2), 325–345.

Doyle, L., Brady, A., & Byrne, G. (2009). An overview of mixed methods research. *Journal of Research in Nursing*, *14*(2), 175-185.

Dwyer, D. (1994). Apple Classrooms of Tomorrow: What we've learned. *Educational Leadership, 51*(7), 4-10.

Dwyer, D. C., Ringstaf, C., & Sandholtz, J. H. (1990). *Teacher beliefs and practices Part I: Patterns of change.* Cupertino, CA: Apple Computer, Inc. Retrieved July 15, 2014, from https://www.apple.com/euro/pdfs/acotlibrary/rpt9.pdf and http://wildej.pbworks.com/f/rpt08.pdf

Earle, R. S. (2002). The integration of instructional technology into public education: Promises and challenges. *Educational Technology, 42*(1), 5–13.

Ertmer, P. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, *47*(4), 47–61.

Florida Center for Instructional Technology (FCIT). (2011). *Technology integration matrix*. Retrieved April 1, 2014, from http://fcit.usf.edu/matrix/index.php.

Fulton, K. (1997). *Learning in a digital age: Insights into the issues*. Santa Monica, CA: Milken Exchange on Education Technology.

Franklin, C., & Bolick, C. (2007). Technology integration: A review of the literature. In R. Carlsen et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2007* (pp. 1482-1488). Chesapeake, VA: AACE.

Griffin, D., & Christensen, R. (1999). *Concerns-Based Adoption Model Levels of Use of an Innovation (CBAM-LOU)* [Measurement instrument]. Adapted from Hall, Loucks, Rutherford, & Newlove (1975). Denton, Texas: Institute for the Integration of Technology into Teaching and Learning.

Hancock, R., & Knezek, G. (2007). Relationships between course management system (CMS) use and teacher technology adoption. *International Journal of Instructional Technology*

& Distance Learning, 26(9), Retrieved October 20, 2014, from http://itdl. org/Journal/Aug_07/article02.

Hancock, R., Knezek, G., & Christensen, R. (2007). Cross-validating measures of technology integration: A first step toward examining potential relationships between technology integration and student achievement. *Journal of Computing in Teacher Education, 24*(1), 15-21.

Hanson, W. E., Creswell, J. W., Clark, V., Petska, K. S., & Creswell, J. (2005). Mixed methods research designs in counseling psychology. *Journal of Counseling Psychology, 52*(2), 224-235.

Harris, J. (2005). Our agenda for technology integration: It's time to choose. *Contemporary Issues in Technology and Teacher Education*, *5*(2), 116-122, Retrieved July 15, 2014, from http://www.citejournal.org/articles/v5i2editorial1.pdf.

Hart, J.M. (2007). *What does it mean to integrate technology in education? A grounded theory study*. Ph.D. thesis, Hofstra University.

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

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Education Tech Research Dev*, *55*(3), 223–252.

Hooper, S., & Rieber, L.P. (1999). Teaching, instruction, and technology. In A.C. Ornstein & L.S. Behar-Horenstein (Eds.), *Contemporary issues in curriculum* (pp. 252-264). Boston: Allyn and Bacon.

Howard, G. S. (1994). Why do people say nasty things about self-reports? *Journal of Organizational Behavior, 15*(5), 399-404.

Howard, G. S., Conway, C. G., & Maxwell, S. E. (1985). Construct validity of measures of college teaching effectiveness. *Journal of Educational Psychology, 77*(2), 187-196.

Howard, G. S., Maxwell, S. E., Wiener, R. L., Boynton, K. S., & Rooney, W. M. (1980). Is a behavioral measure the best estimate of behavioral parameters? Perhaps not. *Applied Psychological Measurement*, *4*(3), 293-311.

Hur, J.W., Cullen, T., & Brush, T. (2010). Teaching for application: A model for assisting pre-service teachers with technology integration. *Journal of Technology and Teacher Education, 18*(1*),* 161-182.

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential explanatory design: From theory to practice. *Field Methods 18*(1), 3–20.

James, M.L. (2009). *Middle school teachers' understanding of technology integration*. Ph.D. thesis, the University of North Carolina at Chapel Hill.

Jonassen, D. H. (2006). *Modeling with technology: Mindtools for conceptual change.* Upper Saddle River, NJ: Prentice-Hall.

Jonassen, D., Peck, K., & Wilson, B. (1999). *Learning with technology: A constructivist perspective.* Upper Saddle River, NJ: Prentice-Hall.

Jonassen, D., Howland J., Moore, J., & Marra, R. (2003). *Learning to solve problems with technology: A constructivist perspective* (2nd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

Judson, E. (2006). How teachers integrate technology and their beliefs about learning: Is there a connection? *Journal of Technology and Teacher Education, 14*(3), 581-297.

Kaestle, C. F. (1993). The awful reputation of education research. *Educational Researcher, 22*(1), 23-31.

Keating, T., & Evans, E. (2001). Three computers in the back of the classroom: Preservice teachers' conceptions of technology integration. In J. Price et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2001* (pp. 1671-1676). Chesapeake, VA: AACE.

Knezek, G., Christensen, R., Mayes, G., & Morales, C. (2005). A comparison of self-report and observer ratings of educator technology integration proficiency. In C. Crawford et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2005* (pp. 892-897). Chesapeake, VA: AACE.

Kopcha, T. J., & Sullivan, H. (2007). Self-presentation bias in surveys of teachers' educational technology practices. *Educational Technology Research and Development, 55*(6), 627–646.

Kozma, R. B. (2003). Technology and classroom practices: an international study. *Journal of Research on Technology in Education, 36*(1), 1–14.

Lambert, J. (2004). Technology integration expertise in middle school social studies teachers: A study of multiplicity in thinking and practice. In R. Ferdig et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2004* (pp. 2365-2370). Chesapeake, VA: AACE.

Lambert, J. L., & Converse Lane, S. (2004). Technology integration expertise among middle school teachers. *Proceedings of the 48th Annual Meeting of the Human Factors and Ergonomics Society*, (pp. 463-467), New Orleans, LA. Santa Monica, CA: The Human Factors Society.

Lambert, J., Gong, Y., & Cuper, P. (2008). Technology, transfer, and teaching: The impact of a single technology course on perservice teachers' computer attitudes and ability. *Journal of Technology and Teacher Education, 16*(4), 385-410.

Lederman, N.G. (2003). What works: A commentary on the nature of scientific research. *Contemporary Issues in Technology and Teacher Education*, *3*(1), 3-11.

Lim, C.P., Teo, Y.H., Wong, P., Khine, M.S., Chai, C.S., & Divaharan, S. (2003). Creating a conducive learning environment for the effective integration of ICT: Classroom management issues. *Journal of Interactive Learning Research, 14*(4), 405-423.

Liu, L., Maddux, C., & Johnson, D. L. (2008) Assessment of integration of technology in education: Countering the "no significant differences" argument. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 25*(1-2), 1-9.

Loucks, S. F., Newlove, B. W., & Hall, G. E. (1975). *Measuring levels of use of the innovation: A manual for trainers, interviewers, and raters*. Austin: The University of Texas at Austin, Research and Development Center for Teacher Education.

Maxcy, S. J. (2003). Pragmatic threads in mixed methods research in the social sciences: The search for multiple modes of inquiry and the end of the philosophy of formalism. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in the behavioral and social sciences* (pp. 51–89). Thousand Oaks, CA: Sage.

Merriam, S.B. (1998). *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass.

Mertens, D. M. (2003). Mixed methods and the politics of human research: The transformative-emancipatory perspective. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in the behavioral and social sciences* (pp. 135–164). Thousand Oaks, CA: Sage.

Michell, J. (1997). Quantitative science and the definition of measurement in psychology. *British Journal of Psychology*, *88*(3), 355-383.

Millham, J., & Jacobson, L. I. (1978). The need for approval. In H. London & J. E. Exner, Jr. (Eds.), *Dimensions of personality* (pp. 365-390). New York: Wiley.

Mills, S., & Tincher, R. (2003). Be the technology: A developmental model for evaluating technology integration. *Journal of Research on Technology in Education, 35*(3), 382-384.

Morales, C. (2006). *Cross-cultural validation of the will, skill, tool model of technology integration.* Unpublished doctoral dissertation. University of North Texas, Denton, TX.

National Center for Education Statistics. (2002). *Technology in schools: Suggestions, tools, and guidelines for assessing technology in elementary and secondary education*. Washington, DC: United States Department of Education.

Noonan, J. (1993). How to escape corporate America's basement. *Training*, *30*(12), 39-42.

North Central Regional Educational Laboratory (NCREL). (2002). *An educator's guide to evaluating claims about educational software.*

Onwuegbuzie, A. J., & Teddlie, C. (2003). A framework for analyzing data in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in the behavioral and social sciences* (pp. 209–40). Thousand Oaks, CA: Sage.

Padgett, H.,0 & Buss, R. (2004). Second-year teachers – Implementers of change. In R. Ferdig et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2004* (pp. 2522-2527). Chesapeake, VA: AACE.

Painter, S.R. (2001). Issues in the observation and evaluation of technology integration in K-12 classrooms. *Journal of Computing in Teacher Education, 4*(17), 21–25.

Pierson, M.E. (2001). Technology integration practice as a function of pedagogical expertise. *Journal of Research on Computing in Education, 33*(4), 413-430.

Podsakoff, P. M., & Organ, D. W. (1986). Self-reports in organizational research: Problems and prospects. *Journal of Management*, *12*(4), 531-544.

Protheroe, N. (2005). Technology and student achievement. *Principal*, *85*(2), 46-48.

Roblyer, M.D. (2004). If technology is the answer, what's the question? Research to help make the case for why we use technology in teaching. In R. Ferdig et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2004* (pp. 27-38). Chesapeake, VA: AACE.

Roblyer, M.D. (2005). Educational technology research that makes a difference: Series introduction. *Contemporary Issues in Technology and Teacher Education*, *5*(2), 192-201.

Roblyer, M.D., & Knezek, G. A. (2003). New millennium research for educational technology: A call for a national research agenda. *Journal of Research on Technology in Education, 36*(1), 60–71.

Russell, A. L. (1995). Stages in learning new technology: Naive adult email users. *Computers in Education, 25*(4), 173-178.

Salkind, N. J. (2008). *Statistics for people who (think they) hate statistics* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Scordias, M., Hoagland, C., & Ferguson, M. (2010). eMINTS professional development changes pedagogical practice. In D. Gibson & B. Dodge (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2010* (pp. 1633-1640). Chesapeake, VA: AACE.

Scott, S., Frieden, B., & Mills, S. (2002). Technology integration: The pedagogy of the 21st century. In D. Willis et al. (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2002* (pp. 1597-1601). Chesapeake, VA: AACE.

Seels, B. B., & Richey, R. C. (1994). *Instructional technology: The definition and domains of the field*. Washington, DC: AECT.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Simmons, P.E., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D., et al. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching, 36*(8), 930-954.

Smith, B. (2011). Differences among students, teachers, and administrators on the quality and effectiveness of technology integration. In M. Koehler & P. Mishra (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2011* (pp. 3025-3033). Chesapeake, VA: AACE.

So, H., & Kim, B.(2009). Learning about problem based learning: Student teachers integrating technology, pedagogy and content knowledge. *Australasian Journal of Educational Technology, 25*(1), 101-116.

Solomon, D. L. (2000). Toward a post-modern agenda in instructional technology. *Educational Technology Research and Development, 48*(4), 5-20.

Spector, P.E. (1994). Using self-report questionnaires in OB research: A comment on the use of a controversial method. *Journal of Organizational Behavior, 15*(5), 385-392.

Spector, P. E. (2006). Method variance in organizational research: Truth or urban legend? *Organizational Research Methods, 9*(2), 221-232.

Suter, W. N. (2012). *Introduction to educational research: A critical thinking approach* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Applied Social Research Methods, No. 46. Thousand Oaks, CA: Sage.

Teddie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research*. Los Angeles: Sage.

Texas School Technology and Readiness (STaR). (2011). Retrieved October 17, 2014 from https://www.txstarchart.org/.

Urdan, T. C. (2001). *Statistics in plain English.* Mahwah, NJ: Lawrence Erlbaum Association.

Vannatta, R.A., & Fordham, N. (2004). Teacher dispositions as predictors of classroom technology use. *Journal of Research on Technology in Education, 36*(3), 253-271.

Watson, D., Pennebaker, J. W., & Folger, R. (1987). Beyond negative affectivity: Measuring stress and satisfaction in the workplace. *Journal of Organizational Behavior Management*, *8*(2), 141-158.

Westen, D., & Rosenthal, R. (2003). Quantifying construct validity: Two simple measures. *Journal of Personality and Social Psychology, 84*(3), 608–618.

Wetzel, K., Zambo, R., & Ryan, J. (2007). Contrasts in classroom technology use between beginning and experienced teachers. *International Journal of Technology in Teaching and Learning, 3*(1), 15-27.

Williams, L. J., & Anderson, S. E. (1994). An alternative approach to method effects by using latent-variable models: Applications in organizational behavior research. *Journal of Applied Psychology*, *79*(3), 323-331.