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Cognitive Style: A Meta-Analysis of The Instructional Implications for Various Integrated Computer Enhanced Learning Environments

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COGNITIVE STYLE: A META-ANALYSIS OF THE INSTRUCTIONAL IMPLICATIONS FOR VARIOUS INTEGRATED COMPUTER ENHANCED LEARNING ENVIRONMENTS

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An overview

It seems some students learn effectively no matter what instructional innovation is applied to the modern classroom. It also seems, despite the best efforts of educators, some students struggle. In recent times, teachers have turned their focus toward instructional technology and media as a tool for providing more equitable and consistent instruction for their students. In an attempt to improve learning for some, others may ultimately be excluded.

This dissertation is purposed to (1) examine the implications of instructional technologies among students who differ in how they process information and (2) then measure differences in performance between these students as the application of technology varies.

For the purpose of this research, information processing style is based on Witkin's (1950) bipolar view of field dependence/field independence. In short, field dependent thinkers are often socially oriented; they tend to thrive in highly structured classrooms with feedback from instructors. Field independent thinkers perform better in classrooms with less intervention and structure. Integrated technologies in classrooms may isolate individuals from the information needed by field dependent learners to create meaning.

As classrooms become more integrated with technology, the question of creating equitable access for field dependent learners emerges and frames the problem for this paper.

This meta-analytical study is based on an historical view of educational technology in the United States. Although most of the primary studies are from the US, this meta-analysis includes data from primary research conducted in the US, Europe, and Asia over the last 20 years. Results indicate that, even after the adjustment for statistical error, field dependent students do not perform equally when compared to field independent students in technologically enhanced formal learning environments. Results also indicate that as teachers integrate technology, field dependent student performance abates significantly. Overall implications and practical significance are discussed.

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CHAPTER ONE

THE PROBLEM

Between the mid nineteen eighties through the mid nineties, the personal computer became so user friendly that it was successfully marketed to the general population. Consequently, during this period, the computer became an integral part of the new business paradigm (Ceruzzi, 1999). Eventually, schools followed the lead of the private sector and began to consider the personal computer‘s implications on learning and the learner.

Initially, the use of computers in classrooms was sporadic, poorly defined and inconsistently applied to the formal and operant curricula. As the age of accountability emerged, Wolfe & Hall (2005) imply that ―NCLB authors, as well as various leaders in technology and education, [began to] recognize that the integration of educational technology should be based upon the needs of students and communities and embedded in educational goals" (p. 48). Following this trend, education has been under Pressure to improve instruction by using computers.

Research has found that, in certain contexts, computers have been used with successful results. In general, it is believed that greater computer integration and implementation offers specific advantages for learners. Wighting (2006) found that students identified with three distinct elements of computer usage. First, students reported that they had a strong need for affiliation with their community and second, students reported a need to be ―liked by their peers" (p. 377) and finally, students indicated that they needed to feel a sense of trust in the learning environment itself. In learning contexts such as this, student achievement and attitude toward learning have been found to be positively correlated with participating in integrated computer based learning-communities. Research like this has caused, perhaps prematurely, a leap to the conclusion that computers offered significant gains for educators with no significant disadvantages.

To better understand the role of technology in learning, consider earlier examples of similar reform. In the early nineteenth century, Smedley (1831) asserted, ―the use of new technologies now available in chalkboards will revolutionize education. It will replace teachers and make schools more efficient" (as cited in Nelson, Palosnky & McCarthy, 2006, p. 340). Perhaps a curious example on the surface, but this chalkboard technology emerged as a cornerstone of the twentieth century educational archetype. The mere presence of chalkboards in virtually any twentieth century American classroom reinforces this point. To varying degrees, chalkboards were replaced with a variety of other implements such as dry erase boards, overhead transparency projectors, document scanners and smart board technologies. Consider, what ultimate instructional impact did each of these technologies actually have?

Time has shown Smedley's prediction false. Teachers were not replaced by chalkboards and this technology, in and of itself, probably did not change formal education in a profound, measurable way. Further, it's not likely that replacing outmoded chalkboard technology with overhead transparencies had an appreciable impact on learning either. The key to understanding the relationship between technology and instruction is not to examine the technology specifically, but to understand how the technologies affect formal instruction as a process. Richards (2006) framed a dichotomous model of technological implementation that describes the instructional use of technology as emerging from a dialogical modality toward an integrated one. In other words, teachers use computer slide presentations to assist in dialog (dialogical) in the same way instructors used chalkboards. This dialogical modality simply uses a newer technology in place of a pre-existing one. So, rather than writing all of the lecture notes out on the chalkboard, as Smedley suggested in 1831, teachers could create slide presentations to accomplish the same task. Since the technology is occupying essentially the same function as the old technology, it is not logical to conclude the newer technology would have any appreciable impact on instruction. Richards also implies that as twenty first century educational technologies become more interconnected with instruction, the lines between computers and pedagogy will become less clearly defined, resulting in an application of technology that will allow learning to occur in completely different ways. This constitutes a vertical application of technology.

Where horizontal applications simply use emerging technologies for traditional purposes, vertical applications use newer technologies in completely different ways. Since teachers who use educational technology in vertical applications not only use it in new ways, they use it to access even higher cognitive levels of student performance. Learning contexts that use information and communication technologies (ICT) in this manner have been found to place higher cognitive loads on the learner, thereby reducing her capacity to learn as efficiently (Van Merriënboer & Sweller, 2005; Beers, Boshuizen, Kirschner, Gijselaers, & Westendorp, 2008). Because of the increased cognitive loads associated with vertical application, the technology will logically have a greater impact on learning, at least on a theoretical level, when compared to horizontal usage. The only real question is will the nature of that impact be in the best interests of the learners educators seek to serve?

In seeking to answer this question, one must consider more philosophical questions regarding the man-machine relationship. Science fiction of the twentieth century has created imagery that puts humanity and machines together in perpetual warfare in some instances while depicting a symbiotic Utopia in others. For some reason, the human being seems to have a need to romanticize his relationship with technology. American culture tends to personify it, aggrandize it and encapsulate it in our very hopes and fears.

Toffler‘s *Future Shock* (1970), for instance, had such a profound impact on America‘s view of technology that it is still discussed today. Based on absolutely no empirical data, Toffler makes a compelling argument about the role technology played in the seventies and projected future implications. Like Smedley before him, Toffler‘s predictions were only loosely accurate. Still, given the popular status of this book, it would seem there are many who agree with him. For educators however, this unscientific approach to technology is problematic, particularly given the costs incurred by schools as they attempt to build and maintain prerequisite infrastructures needed to employ contemporary educational technologies (Oppenheimer, 2003).

What seems clear is there is a strong political desire to continue with the application of modern technology in the field of education. While this researcher is certainly not opposed to taking advantage of every learning tool available, it is advisable to proceed under the council of research. Although using computers to enhance learning does offer many compelling potential benefits, sagacious educators will not lose sight of the implicit costs the research describes.

Statement of the Problem

If someone gave you directions to a place, would you prefer him to say something like: Take I-79 south to 279 west, then to 376 east? Or would you prefer to hear something more like: Take the parkway through the Ft. Pitt tunnel and across the river. Follow highway toward the state park? People tend to prefer one of these approaches over the other, while some prefer a map with no words. Show me, don't tell me! This is a simple example how people differ in their thinking style, or information processing style.

As researchers attempt to clarify terms, the interpretation of the data have been largely inconsistent and the cognitive implications of these technologies on the learner are ambiguous. At this point, researchers have examined the role information processing style plays in the cognitive aspects of computer enhanced learning environments however; what is unclear is the extent that the data are applicable to educational contexts that use technology differently than it was used in the original study. In addition, not only is information processing style, or cognitive style, a fixed human characteristic (Witkin et al., 1967), the classroom environment can be seen as becoming an increasingly fixed context (Richards, 2006). As fixed learners enter fixed classroom environments, ethical questions arise as the possibility of creating equitable instructional opportunities for all learners diminishes (Apple, 1992).

These two issues, immutable learner characteristics , or learner attributes less prone to change, coupled with fixed integrated learning environments, are a threat to equitable educational opportunities and conspire to frame the problem of this study. The problem this study faces is that, although research has been conducted in response to these questions of equity, it fails to clearly explain what is happening to different learners in these computer-enhanced learning contexts. By examining many different studies and comparing what we already know about this topic, this dissertation will examine this problem and attempt to provide some framework to better explain, not only what is really happening to people who vary in how they think, but how we might improve instruction for everyone. Therefore, a meta-analytical approach will be employed in this study to address the problem posed by the fixed characteristic of cognitive style in the fixed integrated learning environment.

Purpose

The topic of educational technology has been discussed in the literature for decades. Consistently and effectively harnessing the instructional potential technology offers has proven an elusive goal. Even understanding the cognitive processes and outcomes this technology presents has proven difficult. Hashemzadeh & Wilson contend that both qualitative and quantitative analyses are key in more completely understanding effect technology is having on learning (2007). If the field of education truly aspires to improve instruction, and views modern digital technology as a vehicle to that improvement, then the first task is to understand the discrete learning implications these technologies have on that process.

With each study that is completed, more is understood about how learning occurs in educational contexts that employ digital technologies. The purpose of this study is to examine systematically what existing research studies show about how people with different information processing styles are affected by educational technologies used in modern classrooms. Does the person who needs landmarks to find his way have a difficult time navigating the classroom that uses computers in a way that doesn't supply this sort of information? Do these classrooms give the people who do well with less of this descriptive information an easier time? Variations of these questions have been addressed in the literature, but a clear answer has not emerged. This study is ultimately purposed at clarifying these questions.

Definitions of Terms

The following is a list of terms used by this study.

Blended classroom environment: Theoretical definition: ―Blended learning is an application of computer-assisted instruction combined with traditional classroom methods" (Troha, 2002, p. 34). Operational definition: An integrated learning environment that couples instruction, (e.g. direct or indirect), with any sort of computer application (e.g. Presentation software, word processor, web browsing, wiki, etc.) where that technology is used by either the student, the teacher during the instructional process. This excludes the use of this technology for teacher record keeping and other non-instructional purposes.

Computer assisted instruction (CAI): Theoretical definition: This term refers to any use of any computer technology in the classroom (Wolfe & Hall, 2002). Operational definition: This term is used to describe the most general application of technology for instructional purposes. All instructional applications of computers (e.g. word processors, presentation, online communication, etc.) are essentially described by this term.

Cognitive style: A theoretical term that describes the way or mode an individual uses to process information. This term is often incorrectly used synonym for learning style. Learning style is the process that people apply raw sensory input to experience (Henry, 2008). While a learner can choose the approach learning to some extent, how that student processes raw sensory information (e.g. visual or tactile information) is very much fixed at onset of adolescence (Witkin, Goodenough, & Karp 1967).

Computer based instruction (CBI): Dialogical application of technology: The use of computer technology in a didactic manner. Usually, this application of technology is oral or dialog based, hence the term dialogical (Richards, 2006). Dialogical use also tends to be parallel to previously used technology. For example, the use of chalk-boards were replaced by white boards and then smart boards, but still ultimately used for the same instructional purposes.

Computer enhanced contexts: These are formal learning environments that use computer technology to any extent. This term is a non-specific reference to any sort of computer technology (e.g. presentation software, computer based drill and practice, web based discussions, etc.) in a classroom.

Dialogical approach to technology: This term is essentially an antonym of a integrated approach to instructional technology. The dialogical approach is added to accentuate a traditional (i.e. talking to students) classroom modality, and used as a lecture aide as a means to disseminate knowledge to students (Richards, 2006).

Information processing style: Synonymous with cognitive style.

Information and communication technology (ICT): Information and communication technologies are devices that allow people to manipulate data digitally, thus moving it with relative ease and access. This includes not only computers, but devices that expand, connect, and enhance their use. (Richards, 2006)

Implementation: A key facet in the human-computer learning process, the level of technological implementation refers to the degree to which computer technology affects learners and is a function of the volume, or amount the technology is used (Rakes, Fields & Cox, 2006).

Integrated approach to technology: This term is essentially an antonym of a dialogical approach to instructional technology. While the dialogical approach is added to accentuate a traditional classroom modality, the integrated approach is inextricably connected to the curriculum to the extent that they are indistinguishable as separate components or modules in the classroom (Richards, 2006).

Integrated online learning community: This term is a synthesis between the synergistic learning relationships among students and teachers, both formal and informal (Yan, 2008), in a way that has become such an inherent part of the leaning process that it is indivisible from the technology that drives it (Richards, 2006).

Pedagogical agents: The use of digital characters or avatars as a way of reducing cognitive load and improving learning in a virtual learning environment. (Clark & Choi, 2007).

Virtual learning environment: In a blended learning environment, the virtual environment is the component of instruction that is delivered electronically. This may be web based or delivered locally through an application (e.g. an audio clip on a disc) or series of applications (e.g. a video clip embedded within presentation software).

Web based technologies (WBT): This technology allows information (e.g. pictures, sounds, words, etc) to be delivered from a central computer remotely to an end user's web browser using the hypertext protocol (http).

Hypotheses

This study is concerned with the extent to which cognitive style is involved in the students' ability to successfully engage the learning task in formalized educational contexts. Many studies have been completed that examine the relationships between instructional technologies and students' cognitive styles (e.g. Toyama, & Ichihara, 2008; Schellens, van Keer, Valcke, & De Wever, 2007; Nachmias, & Shany, 2002) with results varying greatly, a fact that is not uncommon in the social sciences (Glass, 1976). One plausible explanation of this particular variation may be that predictor variables are not accounted for in the study's methodology. One example of these variables is the way teachers are using the technology in these contexts, or level of integration (Richards, 2006). This contextual variation may be a significant predictor variable and can partially explain why different studies are finding conclusions that cannot be explained by normal variations in sample population. In addition to how the technology is used, research suggests the degree to which technologies are implemented and the pedagogical basis (e.g. behavioral theory) may also be significant predictor variables (Rakes, Fields & Cox, 2006).

There is a significant correlation between a teacher's use of authentic instructional techniques and their concurrent use of the personal computer. Even more simply stated, as many teachers scramble to integrate technology in their normal classroom prescriptions, unintended and perhaps undesirable results in performance are more likely to be observed (e.g. Student withdraw, behavior problems, poor performance, confusion, frustration, etc.). As those teachers develop technological acumen, that theoretical level of technological integration increases, so does the likelihood of indirect instructional methodologies (Rakes, Fields, & Cox, 2006). Although this technology will presumably have some effect on student learning, the question is will it work to improve that instruction for the student?

Assuming Witkin‘s original hypothesis is correct, a person‘s cognitive style represents the root level of processing capacity for sensory information (1950) and it is resistant to change over time (Witkin, et al., 1967). It stands then, that a person who has a cognitive style that is incompatible with highly integrated, highly implemented, socially constructed context will find it significantly more difficult to perform when compared to those who do not. To test this notion, this study therefore puts forth the following null hypotheses:

1) A learner‘s cognitive style will have no significant relationship with their performance in integrated learning environments.
2) As the level of technological integration increases, the role cognitive style plays in student learning will have no significant relationship with the learner‘s performance in that context.

Theoretical Framework

Technology has become an increasingly significant component of the formalized learning process in the twenty-first century (Liaw, Huang, & Chen, 2007; Lundt, 2004). Since the 1983 report, *A nation at risk*, educators, both in basic education and university teacher preparation programs, have been trying to measure and improve student performance (Borek, 2008; Seed, 2008). Since this time, the computer has been perceived as a useful tool to this end. Because the computer is becoming inextricably linked with the learning and teaching processes, the theoretical impact that this technology is having on students poses a problem that deserves scrutiny and reflection.

As computer use began in schools, the practical implications (e.g. teacher training, infrastructure costs, physical space, etc.) of technological propagation were not clear however, theoretical effects of computer assisted instruction suggested historically that certain groups of students stood to gain more while others stood to be alienated from equal access to learning opportunities (Apple, 1992; Cooper, 2006). Indeed, these questions persist today.

Because of this potential bias, educational reform efforts have conspired to create a learning environment that is becoming more fixed. Research also indicates that certain human characteristics, such as locus of control, personality factors, learning styles, and cognitive styles are very much fixed at the onset of adulthood (McElroy, Hendrickson, Townsend, & DeMarie, 2007; Witkin, 1977; Witkin, et al. 1967). Thus, the fixed nature of the learning environment, coupled with the static nature of certain student characteristics, create the potential for significant problems in terms of equitable instruction.

It is this construct that defines a cognitively immutable classroom context. It becomes theoretically possible that student‘s cognitive style will play a more significant role in their ability to process information effectively as technology becomes increasingly embedded within the context, leading to higher cognitive loads, increased frustration and lower efficacy among students whose cognitive styles are incongruent with this context. This disparity, a fixed classroom context that is inherently exclusive to learners who exhibit certain cognitive styles, thus frames the second part of the problem of this study.

Method of the Study

The question of cognitive style has been examined to some extent in other studies (e.g. Nachmias, & Shany, 2002; Overbaugh & Lin, 2006; Henry, 2008) however; integration depth, consistency in the terminology, measurement of the effect (impact of the technology on student performance and perception) and sample populations vary too widely to arrive at any clear conclusions. Given these shortcomings, a logical next step in the research process it to perform a meta-analysis on relevant studies that examine the role a learner‘s cognitive style plays in the process of learning using the level of implementation, degree of technological integration, and theoretical application as additional defining characteristics. Essentially, if the environment has low technological implementation and is delivered in a more disintegrated and behavioral way, one would expect the effect of cognitive style would be far less relevant. Thus, by controlling for the level of integration, the true effect of cognitive style, or lack thereof, can be more closely measured. Therefore, a meta-analytical approach will be employed in this study to address the problem posed by the fixed characteristic of cognitive style in the fixed integrated learning environment.

Since certain people are drawn to certain occupations and research on both sides of the Huber (1983)-Robey (1983) argument support the conclusion that this trend is related to cognitive style, logic suggests that students‘ selection of a major, essentially a derived from occupation, would similarly be related to cognitive style. In addition, research suggests the degree to which technology is integrated into the learning context can be a significant variable effecting student performance (Hodge, Tabrizi, Farwell, and Wuensch, 2007).

To truly examine the role cognitive style plays in students‘ performance and perceptions in integrated learning environments, this researcher contends that this relationship must be macroscopically examined. Although previous research examined certain facets of this issue, it was done in a limited vocational context (e.g. Barak et al., 2006; McElroy et al., 2007) with varying degrees of integration, implementation and theoretical bases. One of the key strengths of the meta-analytical process is it allows the researcher to quantitatively compare data from a large number of studies on a subject. At the risk of oversimplification, by using each study essentially as a single case, the researcher can measure the effect of phenomena, cognitive style and level of technological integration in this instance, over several cases to get a more complete picture of what is actually occurring. This macroscopic effect is very useful when one doesn‘t fully understand the phenomenon but the nature of the problem doesn‘t easily lend itself to qualitative study. In this way, meta-analyses can be used to effectively guide future research of a problem that is not clearly understood (Glass, McGaw, & Smith, 1981).

Questions Addressed in this Study

This study will use a meta-analytic methodology to answer the following research questions.

Among various computer enhanced learning environments:

1) How does the student's cognitive style influence their academic performance in computer enhanced learning contexts?

2) As the levels of integration and implementation increase, what relationship, if any, exists between field dependence and student performance?

Significance of the Study

The discussion about cognitive style has been evolved in the literature over the last four decades (Witkin, 1977; Witkin et al., 1967). In that time, many debates about the relationships among cognitive style, choice, attitude, learning, and performance have developed. These relationships have a particular significance for educators as they offer an opportunity to enhance learning for students while simultaneously threaten to potentially alienate others. Huber (1983) contends that cognitive style research is incapable of improving information system design and only becomes a significant in predicting occupation or vocational interests are considered, therefore considering cognitive style in the development of online learning environments might be fruitless. Witkin‘s (1977) view of cognitive style is congruent with Huber‘s view of the relationship between cognitive style and occupation, however the role cognitive style plays ―in designing a workable partnership between human beings and machines" holds significant promise (Robey, 1983, p. 581).

Since the desktop revolution in the mid nineteen eighties, computers have become increasingly more popular in our society as well as our schools (Ceruzzi, 1999). Since then, legislators, educators, and citizens have looked to emerging technologies to address perceived shortcomings of the American educational system. Critics argue that the glitz and lure of the technology in the early desktop era was unhealthy (Healey, 1998), unproductive and held little valid educational benefit (Oppenheimer, 1997). Engaging bored students in a faster paced society, for better or worse, has emerged as the challenge of the twenty-first century educators.

During the early twenty-first century, attitudes about educational technology have been more influenced by empirical data. More contemporary research indicates that using technology has improved student attitudes toward learning, and theoretically their concurrent academic performance, in certain contexts (e.g. Taylor & Duran, 2006; Nguyen, Hsieh, & Allen, 2006). Even more important is the idea that successful use of educational technology is seldom haphazard. In fact, the best implementation of computers for instruction tend to be those projects that are guided by research that addresses specifically how and why technology will improve learning in the proposed situation (Gülbahar, 2007).

This places the question of cognitive style back into the center of the discussion of human-computer interaction. To understand this relationship is to better understand how to use technology effectively to improve instruction for all and avoid widening existing achievement gaps or even creating new ones.

Summary

The goal of education should be to help students learn. Students, like all humans, have characteristics that vary from individual to individual. The way people process their environment is one of those characteristics and should be considered when educators prepare to carry out instruction. The tools used in that process are also important and should be considered carefully. Logically, any tool used to facilitate this process should help more students learn than it alienates. The microcomputer has become probably the most discussed single educational tool in recent educational history. Although some may choose to personify or even vilify computer technology, this research is conducted under the assumption that it, like any tool, is neutral. It is the sage of the educator, guided by quality research, which will determine the end result this technology will have on real students in real classrooms. It is this researcher‘s hope that this project will serve as some trifle in that research mosaic.

Chapter two will formally review the literature on this subject by first examining the history of micro computing from an educational perspective. Subsequently, the chapter will examine the schools of thought on implementing those technologies in formal learning contexts and the relationship that integration has with cognitive style research. Finally, chapter two explores the variations in measuring the relationship between cognitive style and educational technology that exist in the literature.

CHAPTER TWO

REVIEW OF THE LITERATURE

This chapter reviews the development of technology from an historical perspective. Additionally, the curricular application of digital technology, the cognitive implications of its use historically on learners and the curricular implications of these technologies will be addressed in this chapter.

Computer Assisted Instruction (CAI): An Historical Perspective

Depending on how the term computer is defined, the earliest rational examples of this technology date back to the nineteen fifties. These computers were expensive, cumbersome and relatively weak in terms of their processing power. Because of these factors, the computer had little impact on Western culture at this point in history. With the notable exception of the universities that developed the technology and the applied scientists who used it, most Americans of this era were scarcely aware of the existence of computers outside of the realm of science fiction.

It wasn‘t until the 1980‘s, according to Ceruzzi, that the personal computer became popular as a result of several converging technologies. What began years earlier as cryptic, expensive, and complicated computer systems designed for and by members of the computer science community, became polished, affordable, usable personal computers for the masses. This was primarily due to 1) the substantial cost reductions that were the result of improvements in circuit design and better methods of producing microchips and 2) significant usability improvements in the user interface (1999). These points coupled with the rapidly diminishing size and power requirements of computer components created affordable and portable devices for consumers. Essentially, computers became affordable to own and easier to use.

More affordable hardware coupled with usability improvements increased sales that increased the competition among microprocessor companies as well as secondary markets created by these processors such as drive media, monitors, peripherals and consumables such as paper and ink. As prices of these technologies surpassed break-even costs, the industrial leaders had access to a promising productivity tool. Business leaders looked at changing their practices to take advantage of productivity potential of the personal computer.

These processes followed competition inspired by “SUN Microsystems . . . [that] continued the long tradition of effecting a transfer of technology from a publicly funded university research project to a profit-making company” (Ceruzzi, 1999, p. 281). That process, according to Ceruzzi, allowed a “paradigm of personal computing based on inexpensive microprocessors” (p. 243) to become the basis for the reform that would both infiltrate the home and dominate the business world from that point on. Ultimately, what began as crude electronic tools used by people with significant technological acumen, became a technology that could be harnessed to improve productivity, both industrial and personal, at a time when American industry and education were receiving significant political pressure to reform their practices to facilitate competition with foreign counterparts (Goodwin, 1988; Yoshida, 1989). The reform movement in industry led to a gradual business implementation of digital technologies and those successes, ultimately, became the basis for the digital thrust in education designed to improve instruction and learning.

The challenge in the nineteen eighties to improve industrial quality was met by an attempt to employ the Deming Total Quality Management (TQM) Method. Deming‘s TQM was first applied in the American industrial context. By the early 1990‘s, schools tried to package these same concepts to educational settings (Sergiovanni, 1999). By layering Deming's ideas about how to efficiently manage an institution with the use of budding digital technologies, whose functions are aimed at increasing productivity, organizations redesigned they way they went about their business, first in industry, then in education. Productivity, measured by profit in industry and quantified by learning indicators in education, became the focus of the pre-millennium institution in America. The qualitative impact of this change in focus, particlarly in education, is harshly debated, particularly since the reauthorization of the Elementary and Secondary Education act of 2001 commonly referred to as No Child Left Behind (NCLB). In spite of this debate, these changes share a common genesis in the western application of Deming‘s TQM theory as well as the rapid proliferation of personal computers.

Although some may not see an immediate relationship between these reform movements in industry and education, Stensaasen (1994) discusses that the potential productive gains Deming's Quality Management theory offered to industry in the 1980‘s were seen by many as offering similar potential gains in the field of education. Until recently, these gains were virtually unchallenged by mainstream research as a vehicle to improve instruction on nearly every level (D'Angelo & Wooley, 2007; Hashemzadeh & Wilson, 2007; Klemm, 2007; Panastasiou, Zembylas, & Vrasidas, 2003). Even the contemporary scholar has not yet discounted Deming‘s theories potential to improve instruction, or at least some scholars‘ perceptions of it.

Computer Assisted Instruction (CAI)

Since the early 1980‘s, digital technology, specifically computer aided instruction (CAI), has become a profound social phenomenon and a major focal point in American education. Since that time CAI, or any instructional application of information and communications technology (ICT), has evolved significantly. This evolution changed the terminology and made understanding the implications of educational technology difficult for researchers and consumers of research (Häkkinen, 2002). For instance, two classrooms might use the same technology for instruction (e.g. word processors). One class might use it as a tool to organized pieces of information such as pictures and text the students gathered for a project. Another classroom might use it as a means of presenting material to students didactically. The cognitive implications in of each these contexts are hugely different, but research seldom reports these differences, a key problem noted in chapter one. To be clear, it must be recognized that ―media [including modern digital technology] are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (Clark, 1983, p. 445). This level of integration, which constitutes a change in the application of the technology and not simply a change in the technology itself, is not reflected in the current terminology, and constitutes a broad reaching problem in understanding the role educational technology plays in learning. In essence, while the mere presence of technology in classrooms does not improve learning, more effective applications (e.g. Aivazidis, Lazaridou, & Hellden, 2006; Nguyen, Hsieh, & Allen, 2006) can improve learning or aspects of the process.

Criticisms of applied educational technology abound and have persevered for well over a decade (e.g. Healey, 1998; Bayrak, Kanli, & Kandıl 2007). Although some may argue that CAI does not, in and of itself, constitute a credible threat to many students' propensity to learn, some aspects of this application of educational technology create issues that may interfere with the learning process, potentially broadening existing achievement gaps, perhaps regardless of level of integration. In any event, understanding implications of educational technology begins with a clear of understanding of how it works and how it can be actually used in the classroom, a criticism becoming more common among empirical educational research studies (Brodie, 2008).

There are studies on both sides of this issue and much of this research indicates that students learn best when they are using or experiencing content in digitally delivered ways (Lundt, 2004; Nguyen, Hsieh, & Allen, 2006). Some studies indicate that, not only do students learn more efficiently, they learn more effectively in profound ways that would not be possible without using these technologies (Liaw, Huang, & Chen, 2007). Thus, these technologies can, in at least certain contexts, be seen as effective means of improving instruction, making it impractical to even consider discarding the use of this technology entirely.

Critics then began to explore the aspects of applied educational technologies that do not lend itself readily to digital convergence. For instance, research indicates many learners, particularly those who are most in need of intervention, can be placed at a disadvantage because of characteristics that are not easily changed such as socio-cultural factors, (Overbaugh, & Lin, 2007; Solomon, 2006; Mihalca, & Miclea, 2006) learning styles, (Eom, Wen, & Ashill, 2006) or gender bias (Cooper, 2006). This state of learning disadvantage is possibly magnified by considering characteristics that have historically been thought of as rigidly fixed such as cognitive style (Witkin, 1977) and subsequent classical research on a student‘s locus of control (Marx, Howard, & Winne, 1985). These disadvantages, which stem from a failure not only to define technology clearly, but to distinguish between application of technology and other methodological differences among educators. These differences can degrade student resilience and are seen by some as systematically excluding many types of learners from equitable access to the education.

As technology use increased in through 1990‘s, criticism became more focused on ethical aspects of the problem. It was this shift in criticism that is the foundation of the modern social arguments regarding the use of educational technology. The argument is not the presence of technology, but the way that technology is used and in the socio-political ramifications of that usage. Before clear decisions can be made regarding the social and ethical questions on this topic, the field need first define technology.

Schools Grapple with Defining Technology

Prior to the No Child Left Behind (NCLB) era, ―the term [technology] initially meant using [computer] technology in the classroom" (Wolfe & Hall, p. 48). This could include all sorts of nondescript activity including, electronic communications, multimedia resources, productivity software, electronic criterion referenced assessment, content driven drill and practice applications or virtually any other application of computer technology that one could imagine. Clearly, the need for concise language emerged and discussion began about how, when, and where educators should use digital technologies. ―NCLB authors, as well as various leaders in technology and education, [began to] recognize that the integration of educational technology should be based upon the needs of students and communities and embedded in educational goals" (Wolfe & Hall, p. 48).

Defining technology also requires a valid rationale. If schools were to expend the resources to acquire hardware, software and human resources, there needs to be some justification to offer to underwriters, politicians and those charged with oversight. Deming's philosophies were the basis for this rationale. Stensaasen (1994) suggests that Deming's management method became one of several educational foundations for reform because of the hint of productivity boosts associated with the management method. These potential gains may be realized ―since educational institutions serve socializing purposes in society [thus], they ought to practise total quality leadership so that students may acquire the sort of competence that is needed at present in society at large" (p. 582).

Deming's base, according to Kerridge and Kerridge, is designed to effectively confront the deficient business practices organizations were struggling with in this era. If the business to education associative theories hold true, then what works for business institutional productivity augmentation ought to hold true for education. Kerridge and Kerridge identify several factors that are directly addressed by the TQM. Confusion, involving student, administrator, parent and teacher responsibilities, for instance, can be reduced, costs can be abrogated, conflicts can be resolved, industrial, or institutional chaos can be virtually eliminated and the processes of meeting production goals can be simplified, allowing businesses to maintain high levels of efficiency (1996). If one accepts the premise that boosting institutional efficiency enhances productivity, and if sufficient parallelism exists between businesses and schools from an institutional standpoint, then one must concede that to boost efficiency would boost theoretically learning. Computer assisted instruction, it would then seem, is the pooling of digital resources to bring about this boost in efficiency.

Justifying Technology: Applying the TQM to Schools Through Technology

The next step in logic is to examine the extent to which educational institutions are suffering from similar challenges faced by businesses and how parallel thought may be employed to increase efficiency in schools. ―We know that many large and small firms have adopted the TQM philosophy as a normal way of doing business. We also know there are school systems using it to improve the educational process" (Netherton, 1993, p. 4). During the early 1990‘s, some initiated the argument that efficiency is not a valid base for reform efforts for institutions of learning. This postulate, according to Kalyuga (2007), ignores the assertion that knowledge acquisition, and more arguably knowledge construction, the gateway to a more deep and profound level of understanding, occurs independent of instruction, regardless of the quality of that instruction when students find themselves in a motivated state of mind. Simply put, students can learn deeply in spite of poor instruction, poor funding and even poor social conditions; however, the process can be made more efficient, thus making it more effective.

These students who learn in spite of all other variables, are the exception. The groups of students who fail to independently overcome socio-economic barriers, inequalities based on gender bias, race, or language proficiency, for instance, are seen as lagging significantly behind (Guo, Dobson, & Petrina, 2008). Supporters of CAI argue that these resources and methodologies can improve instruction and learning experiences among these students because schools are more effective when learning happens efficiently. ―The whole point of investing considerable human and financial resources into the design and development of sophisticated high-tech interactive e-learning environments is to achieve returns in terms of efficiency: Learning faster and without mental stress” (Kalyuga, p. 388). It was this notion of effective and equitable instruction that made Deming's TQM appealing to those looking to improve the educational system and segued into the digital reform pushed by the vehicle of educational efficiency. This also provided the needed political motivation and justification for the expenditures of resources.

Essentially, schools first struggled to define and understand emerging educational technologies. Ultimately, these technologies became a tool to achieve a more effective, efficient and equitable learning environment for students. TQM was simply a bridge between the technology and the desire to improve learning. The following section will discuss the philosophical motivations for this desire for educational change.

Gemeinschaft and Gesellschaft

As the discussion focuses on improving learning, efficient operation and productive instruction, a philosophical question of purpose arises. Although businesses may exist to make profit and product, schools produce certain intangible things. Dewey's (1936) vision of the school is a social institution whose function is to bring about a change more centered on what he described as the ―true American ideals” (p. 328) seems to imply schools are more than simply factories that produce knowledge packaged for efficient consumption. The challenge that emerges is using technology to create this efficient learning environment while being cognizant of the need for human interaction.

Tonnies (1887) described social foundations of communities as functioning on a theoretical continuum that ranges from a simple closely bound co-interdependent group

(Gemeinschaft) to a loosely affiliated group (Gesellschaft) held together only by external rules and driven by self-interest (Heberle, 1937). The foundation of Tonnies' argument, from a macro-historical sense, whenever individual needs exceed the social ties that bind people in a society together, the result is generally catastrophic. These emergent uses for computers by schools have opened an ongoing debate on the appropriate use of computer-aided instruction in the 21st century classroom and the social impact that this technological infusion has on the student and the learning process. At the base of these questions is the effect these technologies have on the way students relate to one another as human beings on Tonnies' continuum. The research that follows will examine how these technologies emerged in the classroom and the cognitive implications they brought to learners.

TQM: Equity Through Computer-Assisted Instruction

The implied benefits of CAI, particularly in delivering equitable instruction to all students, are significant as schools attempt to respond to standards driven reform. In fact, this level of federal intervention is revolutionary to American education. The history of computer-aided instruction is as much a part of this aspect of the reform process as is the technology itself, and, as such, deserves to be considered as a function of the curricular, pedagogical and social processes.

Aside from productivity gains that were implied by research of this era, technology was thought to offer a level of collaborative instruction that is not available using traditional learning methodologies. Soon after the first wave of digital technologies spread through schools, a significant number of theorists began to find correlations between computer-augmented instructional techniques and student's propensity to collaborate (Maushak, Schlosser, Lloyd, and Simonson, 1998). This collaborative learning can be used to effectively teach students that would otherwise be left behind. For example, even in the light of standards based reform policy, many of the targeted students are not being reached due to what are described by Darling-Hammond (2004) as ―failures in political, legal, bureaucratic, professional or market accountabilities … [and the] policies that use schools' average scores for allocating sanctions have been found to result in several unintended negative consequences" (p. 1057) such as excluding certain groups from proportional success. It is theorized that CAI can, in some instances, be utilized in such a way as to address these shortcomings and potentially even close the performance gaps of these students (Beglau, 2005).

Other research Schellens, et al., 2007; Winters, & Azevedo, 2005) imply that this collaboration can improve learning not only from a standpoint of efficiency, but also from the standpoint of depth and quality among these learners (e.g. knowledge construction, task based learning, convergence of verbal process, narrowing knowledge deficits, etc). Darling-Hammond (2004) asserts that ―low-scoring students [are designated] for special education placements so that their scores won't 'count' in school reports, retaining students in grade so that their relative standing will look better on 'grade-equivalent' scores, excluding low-scoring students from admission to 'open enrollment' schools, and encouraging such students to leave schools or drop out" (p. 1058). Many researchers (e.g. Beglau, 2005; Valadez, 2007) postulated that CAI models could engage these learners in a way that can overcome these issues.

In the same manner, Marttunen and Laurinen (2007) analyzed the relationship between structured online real time communication and student's capacity to engage in reflective learning and metacognitive practices and the subsequent impact these practices had on their learning. Specifically, these researchers found ―the sources of the students' [performance and learning increases] came from both the collaborative work and the texts. This means that collaborative knowledge work stimulated students to recall their earlier knowledge acquired from the texts" and this collaboration was organized and driven by the use of digital technologies (p.124). The implication of this research is that this methodology can be used to address the problems that Darling-Hammond (2004) describes as failures in political, legal, bureaucratic, professional, or market accountabilities that occur in the operant level of instruction.

With bleeding edge digital educational reform focusing on the subjects of math and science, there are several studies that examine how technologies impact student learning in this content. Even from a context of collaboration, there are apparent gains to be recognized through the use to computer-aided instruction. Khalid, Alias, Razally, and Suradi (2007) focused on the extent to which multimedia collaborative course work would help students acquire algebra skills from the Hermann whole brain perspective across the cognitive, affective, and psychomotor domains. Using pretest and post-test, comparisons, Khalid et al. found the experimental group showed better learning across the domains, indicating collaborative e-learning has a more significant impact on the process of knowledge acquisition in math that traditional approaches of instruction do. One of the limitations in this study is the findings are not necessarily externally valid to other subjects. For example, although data analyzed by Khalid et al. support the idea that technology improved learning for students in mathematics, this conclusion is not necessarily true for other subjects, particularly in the instances of the social sciences

(Rutherford and Lloyd, 2001) and literature (Torlaković, & Deugo, 2004). To see the extent that technology may impact other kinds of content acquisition, the idea of equitable instruction need be examined beyond this research.

To this end, researchers from Tunisia examined the kinetic gains digital agents offer learners collaborating to achieve better results, independent of subject area. Early results (Neji & Ammar, 2007) imply that by creating digital agents that are programmed to emulate facial expressions indicative of certain emotions, improve learners' overall success rate and the inclusion of these affective attributes advance cooperative e-learning significantly and consequently, close achievement gaps. Using responsive digital characters to direct student response has been found to encourage participation in the process and create a more positive perception of the process, positively impacting student resilience and efficacy.

Learning systems built upon computer aided, mediated and delivered content positively impact the process of learning in terms of cognitive, affective and psychomotor domains (Kinshuk, Sampson, Isaías, Spector, & Schrum, 2007; Taylor, & Duran, 2006). In order to achieve goals in these domains, schools must first provide access to quality digital resources, provide adequate experience levels for both teachers and learners and deliver the resources in a manner that can be utilized by the students. Some degree of skill based homogeneity and size limitation are also prerequisite to achieving goals in these three domains (Wan, Fang, & Neufeld, 2007). Thus, an efficient institution, using a school based reform approach, might serve as a more stable platform from which to launch a digital initiative when compared with a more hierarchically aligned institution might when the ultimate goal is to provide more efficient access to improved learning in the cognitive, affective or psychomotor domains. Wan, Fang, and Neufeld's research represents an important cornerstone in the logic that holds this concept together. Efficient learning can be achieved through the use of digital technologies employed to aide instruction. These approaches result, under certain instances, in student collaboration that improves learning.

According to a 2006 meta-analysis, Timmerman and Kruepke found that, particularly in the social sciences, there is a convergence in learning among students who receive CAI as a supplement to more traditional learning and teaching approaches. The implication is all learners become more effective when these technologies are used in classrooms. This improved learning experience is achieved by raising student interest through synergistic learning and stands, not only as one of the strongest arguments in favor of CAI methodologies, but also as the segue to the impact digital technology has on the motivation of the learner.

Formal institutions of learning have a strong history of using technology to motivate students to learn under the assumption that motivated students are more likely to engage content in meaningful ways. Since the 1990‘s, according to Reed and Spuck (1996), schools have been successfully ―merging of computer mediated communications (CMC) and hypermedia” (p. 554) to develop a foundation for synergistic learning and emergent knowledge construction. Similarly, English teachers have used this approach to teach literature by allowing students to first download materials to read and then use e-mail to receive direction and critique of the writing process in a controlled and private manner. Because of the limitations of this study, Read and Spuck concede that a meta-analysis is impossible in this context, but would be a logical next step in isolating the extent to which the blending of computer-mediated communication with hypermedia impacts student's motivation to learn.

It was this thinking that established a foundation for Darabi, Nelson and Paad (2007) to examine relationships between students motivation to learn and CAI “by explaining [the] underlying factors of learners‘ behavioral, emotional, interpersonal, and cognitive involvement in learning tasks”(p. 39). The three instructional strategies that served as a basis for this study were 1) process oriented methodology; where students were given information describing how and why the process works as it does, 2) product oriented methodology; where students examined problems in a sequential format, but had no discussion concerning context, or why the problem was relevant, and 3) conventional problem solving; where students approached the problems with no discussion about context of problem or what exactly how the process works. The author's hypothesis made the basic contention that “learners using worked example instructional strategies would show greater involvement than the learners using the conventional problem solving strategy” was upheld by the data (p. 46). This suggests, all other things remaining equal, technology could be used to increase learners‘ motivation and their subsequent engagement with the learning task if these concepts were a part of the original course development. This finding also implies that if specific course outcomes are not an inherent part of the applied technology (i.e. haphazard application of technology), increased learning would not be as likely.

In essence, CAI, from a standpoint of quality, efficiency and productive learning experiences, offers advantages in learning that are simply not possibly to achieve effectively using methodologies that exclude digital technologies. It is this efficient and productive environment that some contend will close achievement gaps. Stemming from Deming's TQM, technology has been shown to effectively guide learning in a way that is more efficient when compared to traditional methodologies, regardless of the theoretical approach or educational context. Similarly, efficient learning environments that create collaborative structures in the classroom yield learning experiences that result in broader and deeper learning experiences for students. Finally, collaborative environments have been shown to conspire to help students formulate questions about the context of the problems to be solved at the learning task, resulting in high intrinsic motivation to learn and subsequent increases in learning. CAI effectively improves instruction when it can be used in a way that makes instruction more effective, creates synergy and improves students' self-efficacy.

Two Schools of Thought: Instructional Applications of Information and Communication Technologies (ICT)

Identifying the instructional and cognitive implications of using ICT has been an enigmatic process for educational researchers. It has been difficult for scholars to define –exactly what ICT curriculum integration comprises, as well as the resultant difficulties of defining a research methodology based on such an ill-defined construct. Hence, theoretical and methodological issues have hampered the study of ICT curriculum integration" (Proctor, Watson, and Finger, 2003, p. 69). In clarifying the vague definitions of ICT and its subsequent application to the learner's cognitive process, the resulting blended learning environment, as defined through a synthesis of research (Driscoll, 2002; Troha, 2002; Findley, 2005; Liu and Velasquez-Bryant, 2003), can be dichotomized as either a dialogical add-on learning environment or an integrated context.

This blended learning environment, conceivably the midpoint on this dichotomy, ―seeks the optimum blend of self-study, teacher-led events and group collaboration, each deployed in a blend of asynchronous or synchronous modes, appropriate for the learning outcomes"(Downing & Chim, p. 268).

The Add-on Environment

ICT implementation is considered an add-on when the underlying curriculum is generally unmodified as the technology is merged with it. Simply stated, Ms. Jones who has taught particular science curriculum for years has a sudden access to a computer lab. She takes advantage of this resource by taking her students to the lab to do a WebQuest on the earthworm, a unit in that curriculum. This WebQuest is simply merged into the pre-existing curriculum, this constituting an add-on environment. According to Cirssan, Lerman, and Winbourne, (2007), there are essentially two general factors that influence how ICT is implemented from the add-on perspective. First, contextual factors, consisting of access to hardware or software, frequency and quality of professional development opportunities, ―departmental ethos," essentially the institutional goals, and teacher's skills (p. 28) all play roles in the learners successful experience with ICT as an add-on. For example, teachers were more likely to use ICT in math curriculum with middle school students as opposed to a high school student‗s because of the implications of testing accountability concerns among the older students (Cirssan et al.). This choice in implementation is a result of department's disposition regarding the relative importance of using technology over test preparation. Similarly, Rutherford and Lloyd (2001) describe this application of ICT among undergraduate students enrolled in a university world geography course. Students in the experimental group were given a computer supplement once a week in an attempt to improve their geographical knowledge and self-efficacy. These are examples of an add-on approach because the methodology and ICT are completely modular. Since the application of the technology is modular, it can either be employed or omitted depending on the context. This allows a focus on what is the most critical issue in the perception of the educator, department or institution.

Secondary to the contextual factors are the personal factors related to the teacher's view of their content. A teacher's technological efficacy is ultimately related to; 1) using relevant software, 2) adopting recommendations from national and state level organizations regarding the use of ICT, 3) considering their own personal learning experiences with ICT, and 4) developing their own ―personal pedagogical construct" (Cirssan et al., p. 33), which is comprised of the teachers perception of the learner's cognitive gains from using ICT. These personal factors ―were found to be of paramount importance in their uptake and incorporation of ICT" (Cirssan et al., p. 34).

Both contextual and personal factors influence teachers' propensity to employ ICTs as curricular add-ons. Cirssan's research is a basis for further analysis and suggests that, when adopting an add-on approach to ICT integration, the institutional context along with the instructors personal views significantly influence the propensity for the technology implementation to be successful.

When ICTs are used as add-ons in the classroom, they tend to be a function of either contextual or personal factors, not necessarily directly related to the student response or assessments. Web quests are an example of using an ICT from an add-on perspective. A web quest is an inquiry based learning module designed to help learners extend an experience started in a traditional classroom setting (Ikpeze and Boyd, 2007).

Since these modules are add-ons, they can be used to supplement any curriculum without modifying its essence. ―WebQuests can be used not only for content learning but also to conduct research in an authentic, problem-solving environment" (Dodge, 1997 as cited in Ikpeze and Boyd, p. 645, 2007). This add-on approach provides a cognitive gain for the learner. Because of the added learning dimension the web quest offers, the chance for the student to engage the learning task increases. The effectiveness of web quests is a function of the context and personal factors described by Cirssan et al., Ikpeze and Boyd (2007). The authors find web quests ―and other information and communication technologies (ICTs) have the potential to revolutionize teaching and learning through purposeful integration of technology for thoughtful and critical literacy" assuming they are used in the proper contexts (p. 644).

Using ICTs to Build Integrated Contexts

A learning center is based on the idea of ―distributed knowledge" (p. 519) characterized by students who become, almost exclusively as a result of the community itself, self-reliant through collective solidarity (Riel & Fulton, 2001). Students in learning-communities are more likely to deeply engage the learning task resulting in higher efficacy because they can rely on the support of others to help them solve problems that would be more difficult to solve alone. This communication among students leads to a higher propensity to engage in self-reflective learning brought on by feedback that has ―a critical role in the formative learning that occurs in students‘ written work" (Wosley, 2008, p. 312).

From the perspective of some, learning-communities have been found to offer cognitive advantages, creating them in a traditional sense, pose challenges that offset those advantages. For instance, logistic constraints (e.g. scheduling), coupled with contextual challenges (e.g. conflicting educational views and methods), pose challenges to creating traditional learning-communities. Using ICTs to create integrated communities reduce these challenges and allows students to reap the benefits of feedback, collective problem solving and self-regulated learning -- essentially defined as synergy. This synergy increases in proportion to the teachers' use of learning-communities, particularly those that are built upon ICTs (Carneiro, 2006). In addition, building the learning community is often seen as the significant challenge. Overcoming the costs of hardware, acquiring software and developing meaningful in-service training experiences for teachers, for instance is not the most significant barrier, however. ―The real challenge in implementing collaborative technology ... is more a cultural than a technical one" (Chong, 2008, p. 190).

This joining of the masses can be accomplished by using ICT to connect isolated supplementary or complementary classes of learners. For example, a literature teacher in Ohio covering *A Tale of Two Cities* might create a complementary learning community with a history teacher in Florida covering the French Revolution. Questions about interpreting the literature could be posted electronically and a professor from a university might offer further insight to the original problem posed by the teacher. The resulting experience offers potential gains to both groups of students in ways not readily accessible without this digital learning community. This perspective certainly incorporates Finley's (2007) focused view of distance learning, but given the traditional classroom experience, allows for a more broad mixture of ICT and curricular applications.

Using ICT to create integrated contexts has a two-fold benefit. First, as with all learning-communities, students reap the benefits of synergistic collaboration among their peers and instructors. The process of feedback and peer problem solving improve students' likelihood of resilience and efficacy through peer review or peer tutoring that can occur among a group larger than any single classroom. —Students‘ retention increases when their learning environment allows them to see and hear their instructor, interact with instructor and others, and directly view educational information such as notes written on a blackboard" (Hodge, et al., 2007, p. 106).

The second benefit integrated communities offer students is the expertise of the larger community through the use of ICT's. For example, by using Internet based field experiences would allow learners to see how a graphic designer makes a logo for a product. An interested student could connect with a virtual mentor in that field and find out more about that vocation. Similarly, biology students could talk to scientists from zoos or research labs anywhere in the world, adding a learning nuance not achievable in other ways (Riel and Fulton, 2001) .

In addition to using ICT based learning-communities in academic settings, there are also non-academic implications. The use of Blogs has been documented in music and art classes and has allowed learning-communities to flourish (Chong, 2006, as cited in Chong, 2008). The term Blogs, according to Farmer, Yue, and Brooks (2008), contracted from web logs, and they –are essentially online journals where an author (or authors) publishes a series of [ideas]... which readers are invited to comment" (p. 123). The gains are consistent with those seen in academic subjects like biology or history, but allowed students studying music to collectively problem solve through synergy (Chong, 2008).

Like implementing any significant change in education, nudging the school culture to accept and immerse itself in this sort of learning takes time and enduring, consistent effort.

After a review of the literature on this topic, it seems clear that there has been documented evidence that integrated contexts have benefits for students and can generally improve their learning, while reducing barriers to instruction in some contexts. Aside from the context, there are, however, certain student characteristics like the student‘s cognitive style, may emerge to become a problematic variable to address in these increasingly integrated environments.

Cognitive Style

The cognitive revolution changed the way psychologists and educators think about human information processing. Ultimately, the operations of human behavior that Skinner‘s model failed to explain to the satisfaction on many scholars, like language acquisition and usage for instance, ushered in this change from behavior models to cognitive ones. As a curious effect of the development of computer technology, science began so see the human brain in parallel with computer processors created in the fifties (Hill, 1997).

The concept of cognitive style was an outgrowth of this cognitive revolution. Cognitive style emerged from research on psychological types done by Jung and originally published in the early 1920‘s (Jung, 1971). Through the 1950‘s, the Skinnerian behavior model dominated psychology. Skinner‘s (1957) functional analysis of spoken language was criticized by Chomsky (1959) who contended that Skinner‘s view was too narrow to adequately explain the phenomenon of language acquisition, thus challenging the foundations of the rapidly aging behavioral model. Neisser (1967) ultimately explored the cognitive implications of language and, this exploration is generally agreed as the catalyst of the cognitive revolution.

With the cognitive theory accepted by eminent scholars as the best available model to explain human behavior and learning processes, the context allowed Witkin‘s work on cognitive style, based largely in Jung‘s typology research, to emerge. Witkin‘s (1950) initial view of the mind was based partly on an information processing view, essentially a branch of cognitive psychology that views human thinking in terms of computer processor functions, and partly on the idea the that people are predisposed to process sensory information (e.g. sounds, written words, pictures, or smells) in fixed ways. His initial work dealt with visual information and he theorized that people tended to process it differently. Eventually, Witkin et al., (1967) postulated that as the individual entered adolescence, this propensity to process information tended to become fixed throughout adulthood. This fixed mode of human information processing is what Witkin described as one‘s cognitive style.

The Theory of Cognitive Style

Cognitive theory can be described as a model for understanding how human beings think, or process information. This model is built on a computer metaphor regarding how the mind processes that information. Just as a computer has several layers for processing data, so does the human brain. As raw data enters the processor, it is handled as binary data and processed in chunks. Although a computer can be upgraded (i.e. new software can be added to extend function and give the end user more options to complete tasks), the way the processor actually handles the raw data never changes. In this cognitive metaphor, cognitive style is the processor type while other psychological characteristics represent additional hardware or software that extend functionality. These higher-level human processes (e.g. personality type, locus of control, learning style, etc) are still dependent on low level processing, or cognitive style, because sensory data must first be processed at this level.

Jung described the human personality as having a fixed style for processing environmental information and this style forms the foundation for human choice (1971). Witkin‘s theory of cognitive style (1950), based partially on the assumption that cognitive processes are a component of personality, and evolved to include Jung‘s description of personality typologies, retaining Jung‘s theoretical construct of immutability.

Witkin‘s model is constructed upon a bipolar, singular dimension that is based on an individual‘s reliance on the context he refers to as field dependence. These individuals process information from their environment as a means to extract specific meaning, or to understand and interpret their context. At the other end of the model are field independent people who are less reliant on contextual matters to build meaning.

To state this notion more simply, field dependent individuals are whole-to-parts thinkers. They prefer the big picture and are confused and frustrated without these fine details. Field independent thinkers can be described as parts-to-whole thinkers who are more likely to see contextual details as secondary or ever superfluous.

The Fixed Nature of the Learner

When one examines educational problematic learner attributes, several characteristics emerge to complicate the issue of examining the discrete cognitive implications of applying technology in formal educational settings. In recent studies, perceived performance gaps among students along the lines of socio-cultural characteristics (e.g. race, gender, or socioeconomic status), have been found to be converging in some instances (Finn & Inman, 2004). If these gaps in learning are showing signs of improvement, it is logical to conclude that educators should begin to focus on other characteristics where gaps are still pervasive. This is particularly true of characteristics resistant to change such as cognitive style, locus of control, and personality style, (Witkin, 1977). These differences among learners currently pose at least as great a threat to creating theoretical equity in learning opportunities as demographic characteristics in current educational settings.

Of all these more unvarying characteristics, cognitive style in particular, is quite fixed from the emergence of adulthood (Witkin, et al., 1967) and therefore should be examined very carefully in reference to the context of the learning and the learner. It should be noted that some experts contend that CAI may have significant negative implications among pre-adolescent learners due to developing brain physiology (Dorman, 1997; Helaey, 1998). Although these arguments are potentially alarming, research (e.g. Chang, Mullen, & Stuve, 2005; Passey, 2007) has not conclusively found any significant negative physiological correlations due to exposure to technology among this group of people.

It is this researcher‘s contention that, beyond the point of adolescence, if the learner‘s cognitive style and their learning context are not congruent, then the students‘ engagement will decrease while frustration levels would increase. This would likely lead to decreased self-efficacy, resilience development of a more externalized locus of control, resulting in subsequent poor academic achievement. This fixed nature of a learner‘s cognitive style frames the first part of the problem of this study.

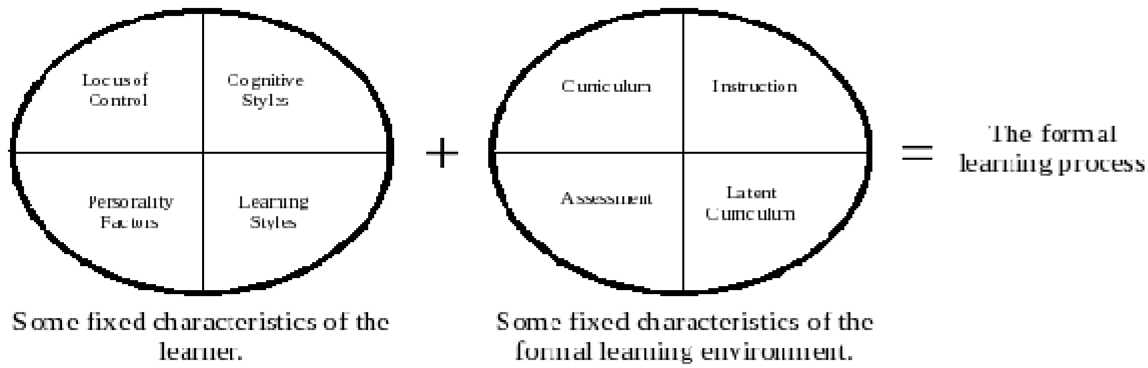

Figure 1. A representation of some examples of a learner‘s static characteristics and the theoretical context of formal instruction.

When the Fixed Learner Enters a Fixed Context

If learning could be reduced to an equation, then it might be described in terms of key variables. It can be said that learning is equal to the sum of the parts of the learner and sum of the parts of the learning environment, or context as illustrated in Figure 1. If the parts of the learner were constructed of a group of characteristics, then the context would be comprised perhaps of the things that make up the learning environment. As discussed, the fixed nature of the learner could lead to certain negative implications such as lower resilience and efficacy. Learning-communities can create synergy resulting in improvements in cognitive engagement, increased self-efficacy and heightened resilience for learners (Richards, 2006) however; these communities can also create a fixed context for learning.

Traditionally, the learning environment was as flexible as the instructor chose to make it. As introduced in chapter one, using technology to build integrated learning-communities has a distinctly different impact on instruction and cognitive processes than what Richards (2006) describes as the ―dialogical" approach, essentially technology added-on in a modular fashion to a traditional dialog based curriculum (p. 240). In this dialogical modality, the nature of the technology is such that learners may avoid potential cognitive overload (Igo, Kiewra, Zumbrunn, & Kirschbaum, 2007) by relying on visual and auditory information acquisition, nullifying some of the cognitive demands of the technology. This context might look like a teacher who is using presentation software as a lecture aid. The student is not forced to cognitively engage the task through the use of technology when he has simultaneous access to verbal and nonverbal cues from the teacher. As curriculum moves away from dialogical applications and more towards integrated approaches, the availability of additional cues becomes scarce and students will have fewer opportunities to connect cognitively with the content without using the technology as their primary means of information acquisition. This occurs at the same time ancillary information distracts the student from the task of learning, increasing cognitive load and decreasing learning efficiency (Beers et al., 2008).

The Bipolar View of Cognitive Style

Witkin's view of cognitive style can best be described as a bipolar modality. His longitudinal study (1977) followed a relatively large sample population (n=1548) as they entered college as freshmen through graduate/professional school and concluded that these individuals demonstrated a proclivity toward certain styles based upon how they processed information. By using the Group Embedded Figures Test as a tool, Witkin found that these students stratified themselves in predictable ways based on these fixed modalities for processing raw sensory information. This confirmed Witkin's previous assertion that cognitive style is a fixed human characteristic (1967) and distinguishes his view of cognitive style from other research that suggests that people choose how they process information (e.g. Messick, 1997). This rather fixed nature that frames the basis of Witkin‘s view and is shared by other scholars in this field (Janassen & Grabowski, 1993; Marx, Howard, & Winne, 1987).

The bipolar model places individuals on a continuum ranging from the field dependent (FD) to the field independent (FI). As individuals move toward field dependence, they are more likely to require contextual information and interpersonal relationships to help them make sense of raw sensory inputs (e.g. pictures, sounds, etc). Individuals who are more field independent are less likely to require these external cues to make sense of the same information. This perspective isolates cognitive style from other factors in the affective domain and scholars argue that it assesses only a small part of the entire phenomenon (Riding & Cheema, 1991). This perceived limitation of the bipolar model has motivated other researchers to develop other ways of examining cognitive style.

The Multi-Dimensional View of Cognitive Style

Zhang and Sternberg (2005) view information processing style, or more globally, human style research, in a multi-modal fashion. The argument is that human information processing cannot be easily separated from the affective domain because information processing, an inherently cognitive process itself, is significantly influenced by how one‘s personality engages the context (i.e. psychological implications) and how one interacts with other people (i.e. socio-cultural implications). Therefore, cognitive style, while an independent human characteristic in itself, is perceived as a function of both psychological and cultural characteristics.

Riding, & Cheema's, multi-dimensional design places individuals on a two dimensional scale that measures the traditional view of FD-FI (wholist-analytic dimension) while also assessing the individual's tendency to view things as either pictures or words (verbalizer-imager dimension). Riding & Cheema's multi-dimensional approach to assessing cognitive style is appealing because it offers some additional measurement of the affective domain without becoming cumbersome, however; since collecting this data is reliant on self-reporting, skeptics challenge this model's external validity. This model, while somewhat more comprehensive than the bipolar model, still doesn't examine all of the aspects of five-factor model of personality model, sometimes referred to as the big five personality traits. This drive, to develop a more comprehensive tool, that was able to measure cognitive style in a way to reflect these personality traits (e.g. agreeableness, conscientiousness, extraversion, neuroticism, and openness to experience).

The Myers-Briggs Type Indicator (MBTI), essentially based on Jung's (1971) work regarding personality traits he developed in the 1920's, has become a widely accepted method for measuring cognitive style in conjunction with several other personality characteristics, including the big five. Even though the purpose of expanding how one measures and defines cognitive style has a certain appeal for the researcher, attempting to integrate these kinds of human characteristics in a singular instrument has been a challenge.

Although certainly more comprehensive than other indexes, the MBTI has generated concerns by critics who suggest that the it lacks construct validity (Osterlind, Miao, Sheng,& Chia, 2004) because the MBTI fails to demonstrate cultural flexibility.

The MBTI is problematic in that it does fail to consistently ~~-p~~predict cognitive variables and more studies examining the incremental validity of the MBTI will further our understanding of the concrete significance of scores on this popular instrument" implying that this measure is far from satisfying critics demand for reliable and valid means of measuring cognitive style and personality traits (Edwards, Lanning, & Hooker, p. 446, 2002).

Cognitive Style and Learning Style

What is the difference between thinking and learning? Existential questions about the nature of thinking notwithstanding, thinking in its simplest terms, can be seen as a means in itself; while learning might be viewed as a means to an end, weather intrinsic or extrinsic. From a cognitive perspective, if thinking is the act of processing information, then learning is the use of that processing power for some purpose (e.g. understanding a process or applying old information to a new context). Using the classic computer metaphor, computers take raw input, like pressing the keys A-M-D on a keyboard, which happens to be the brand name of a computer processor. The computer processes that information then outputs those letters into your word processing document. Although this might constitute thinking in a general sense, it certainly doesn‘t qualify as even rudimentary learning because the computer wasn‘t changed in any way by that experience. If you, acting as a facilitator of learning added the word AMD into the word processor‘s custom dictionary, the computer has effectively learned that AMD is a word in its model of the English language. Admittedly, this is a shallow example of learning, but it illustrates that there is a clear difference between thinking (cognitive style) and learning (learning style). It is in this difference that style research draws a definitive line.

Learning style is very easily confused with cognitive style because both terms refer to an approach for dealing with sensory input. There are some key characteristics that separate cognitive style from learning style. First, learning style is seen as process of adapting new information to new contexts. Learning style is also seen as a hemispheric brain operation (Lin, 2007). So, based on the theory that each hemisphere of the brain controls certain function, humans have a dominant hemisphere of the brain. That dominance drives their preference for adapting and assimilating new information. This theory attempts to explain why some people might learn orally, for instance, while others learn best kinesthetically. In both cases, the auditory learner and the kinesthetic one, the learner must first sense the input and then process it before learning can begin. This first stage of information processing is their cognitive style and this second stage where the information is applied, auditory or kinesthetic in this case, is learning style.

Learning style specifically deals with which sensory input that the learner prefers to experience (Henry, 2008). The key concept is that learning style is seen as a preference while cognitive style is seen as generally fixed (Witkin et al., 1967). Henry‘s conclusion is that a person who has an auditory learning style may be able to learn kinesthetically while Witkin‘s view suggests a person who is in a context incongruent with his cognitive style may not have the capacity to change. The implications for cognitive style‘s immutable tendency in the individual has more significant applied implications, therefore merit further research.

Cognitive Style and Intelligence

Cognitive ability, or intelligence, is so misused in lay conversation, that the meaning has become synonymous with words like smart, bright, or even genius. General definitions of intelligence vary widely and defining it meaningfully has been traditionally elusive (Burt, 1945). Valid measurement of intelligence is very difficult to do without considering how language variations, learning style, personality, cognitive style, and cultural context affect the subject‘s context. The classic styles assessments have all consistently considered these variations (Curry, 1983; Miller, 1987; Riding & Cheema) because ‗to varying degrees, an intellectual style is cognitive, physiological, psychological, and sociological" (Zhang & Sternberg, 2005, p. 2). Thus a measurement of this phenomenon must consider these points.

To understand how cognitive style and cognitive ability are related, one must first measure them independent of the other. This is difficult to do effectively because cognitive style itself deals with one‘s fundamental information processing schema while cognitive ability is influenced by so many factors. Kirton‘s view of cognitive style allows for more accurate measurement of this characteristic by carefully considering this variable along with the other individual variables. By doing this, Kirton contends that it is possible to reliably measure cognitive style independent of cognitive ability (Kirton, 1976; Kirton, Bailey, & Glendinning, 1991). First the individual must process raw sensory data. Next, that individual‘s intellectual style focuses their processing sensory input in the affective domain based on their personality style. Finally the individual‘s preferred learning style, a function of hemispheric orientation, determines how they apply that data to changing contexts. Measuring cognitive style independently of other extraneous factors is critical if one hopes to examine its impact on performance and contextual perceptions.

Cognitive Style and CAI

An examination of the literature suggests that the learner‘s cognitive style should have a significant effect on the learner‘s performance and perceptions of the learning context. There is an historical trend in the research that suggests cognitive style plays significant roles in students‘ self efficacy and perceptions of their environment in basic education (Mann & Murphy, 1981; Marx, Howard & Winnie, 1987; Toyama, & Ichihara, 2008) as well as in higher educational contexts (Fearing & Riley, 2005).

This study is concerned with the extent that these implications regarding cognitive style translate to the application of CAI. Nachmias & Shany (2002) found significant correlations among the learner‘s cognitive style and their performance and perceptions of the learning environment in high school students. This study‘s findings were based in what the authors describe as a virtual environment, which indicates a lack of traditional classroom contact that would be a part of a blended learning environment. Atasoy, Güyer, & Atasoy (2008) found correlations between the students‘ cognitive style and their perception and performance among college freshmen.

Curiously, not all research supports this hypothesis. Barak et al. (2006) found weak correlations between the learners perceptions and performance and their cognitive styles among undergraduate students. In similar fashion, McElroy et al. (2007) failed to conclusively link cognitive style to Internet usage patterns among graduate and undergraduate students. Both of these studies cited characteristics in the affective domain to be more significant than cognitive style among their sample populations. One possible explanation of the difference might be that the sample populations differed in ways that disrupt effective measurement of cognitive style. Another potential explanation of the difference might be explained by the varying methods of defining and measuring cognitive style. Yet another explanation might be the presence of unknown or uncontrolled variables (e.g. cognitive ability) in the studies. Future research on this topic should consider each of these possibilities to better understand the role cognitive style actually plays in the context of CAI.

Level of Technological Implementation: Explaining Variation in Measurement

There have been several studies focusing on the relationship between cognitive style and students' classroom performance. As described in the previous section of this chapter, study results have been inconsistent beyond what can be explained by statistical error and sample bias. While some studies (e.g. Nachmias & Shany 2002; Atasoy, Güyer, & Atasoy, 2008) suggest there is a significant relationship between these variables, other studies (e.g. Barak et al. 2006; McElroy et al., 2007) imply cognitive style plays no significant role in a student's propensity to be successful in a technology-enhanced classroom.

Proctor, Watson, & Finger (2003) suggest that two significant challenges emerge when one attempts to study this particular problem in a controlled way. First, defining technology poses a significant challenge. Additionally, what compounds this challenge is measuring the degree to which a teacher implements that technology in the classroom. This, according to Rakes, Fields, & Cox (2006), is referred to as level of technological implementation (LoTI) and was originally conceptualized through a series of studies completed in the 1990's (Moersch, 1997; Moersch, 1995). This variation in how computers are used in each classroom is not only potentially a significant variable in the relationship between cognitive style and student success, but it is seldom controlled for.

To better understand this relationship between LoTI and student learning, two distinct variables emerge. First, one must be cognoscente of how teachers are using the technology (i.e. the level of integration). Attempting to measure the impact of technology in the classroom, a notion that is loosely defined to begin with, without considering the way that the teacher is using that technology could explain the inconsistent study results. In addition to the level of integration, relevant student characteristics must be considered if one is to gain an accurate picture of what is actually occurring. For example, if a medical drug trial attempted to study the impact that a new self-administered over-the-counter pain reliever had on headaches without controlling for specific, relevant patient characteristics (e.g. weight, age, pre-existing conditions, and lifestyle), the results would probably be just as inconsistent. In the same manner, student characteristics should be considered when implementing a treatment or methodology in the classroom. These characteristics are even more significant if they are fixed, as is the case with cognitive style (Witkin, 1977).

The problem of defining technology has been discussed in the literature and reported at the beginning of this chapter. Although many of the studies done since 2000 consider technology to be some application of computer assisted instruction, it is not consistent how those computers are used in the classrooms these studies are focused. One study may define computer use as delivering content once a week in an open lab setting as an extension of a lecture (e.g. Rutherford & Lloyd) while other authors will define it as an integrated constructivist learning application (e.g. Barak et al.). By using any one of these studies, both of which are valid given their operational definitions and contexts, one would draw inconsistent conclusions about the impact technology has on learning. By using a meta-analysis, some of these inconsistencies can be controlled because this methodology by design compares data from a large number of independent studies. Given the number of studies included in a typical meta-analysis, these inconsistencies are reduced into one single data set and bias is reduced because no single study's shortcomings (e.g. sampling bias, overgeneralization, geographical limitations, etc.) may have any significant impact on the overall data set. As long as the selection criteria are valid and clearly explained in the methodology, Glass, et al. suggest that this type of study bias can be successfully adjusted for. Thus, meta-analysis can be an effective tool in adding clarity to issues such as these.

The second problem, quantifying the level of implementation, is more difficult to control. If integration is a continuous variable from no implementation (i.e. a classroom with no computer technology used at all) to full integration (i.e. a classroom where students are forced to cognitively engage content primarily through computer technology), then classrooms at different points on this scale would invariably have different outcomes in terms of the interaction between cognitive style and student performance. Understanding contexts with no implementation is straightforward and, because computers would not be present in this context, irrelevant for the purposes of this study. As classrooms move more toward integration, the subsequent interaction between a student's performance and cognitive style may become more significant.

Defining Integration Theoretically

Fully integrated contexts are only slightly more difficult to understand than those with no integration as they occur at the point of saturating both students and instructors in a setting where the instruction is completely reliant on ICT. ―Integration means that instructors move from initial adoption and one-time demonstrations [of technology], to implementing technology as [an inextricable] part and parcel of instruction” (Weston, 2005, p. 101). Based upon this construct, full integration occurs as the teacher develops an implementation that is not only frequent, but an indigenous part of the coursework. Understanding the implications of this integration may not be simply a question of counting the frequency of usage or adding the cumulative time spent using the computer for classroom tasks because these things are not necessarily a measure of cognitive engagement. Meaningful interpretation of this phenomenon will require the researcher to examine how the student in that enviornment uses technology.

As suggested at the beginning of this chapter, an historical examination of micro computing suggests that these issue emerged in the late nineteen nineties as schools began to invest in high speed Internet connectivity. During this period, Ertmer, Addison, Lane, Ross, & Woods‘ early work on this topic suggest that the problem of integration can be understood by first examining the impediments of implementation (1999). The internal barriers proposed in this model, much of which was built upon study of institutional change facilitation, include ―first-order” infrastructure barriers (e.g. hardware, software, networking, bandwidth, etc.). These challenges clearly have an impact on a teacher‘s propensity to use and integrate instructional technology. Overcoming these hardware barriers does not pose the most significant challenge to integration, however. The real difficulty arises in ―confronting second-order barriers [because this] requires challenging one‘s beliefs systems and the institutional routines of one‘s practice” (Brickner as cited in Ertmer et al., 1999, p. 55). These first (internal) and second (external) layer barriers have served as a basis for subsequent researchers to construct more sophisticated methods of quantifying the LoTI. The teacher‘s decision to reconcile these second layer barriers has so much to do with what that teacher is trying to accomplish in the classroom. Implementation of skill oriented objectives may be easier to accomplish than implementing technology to accomplish higher order thinking (Malmsköld, Örtengren, Carlson, & Nylen, 2007). Using technology to facilitate higher order thinking through the application of constructivist and social constructivist theory may be far more complex a task for educators to accomplish.

Using computer technology to achieve higher level taxonomical thinking (i.e. analysis, synthesis & evaluation) can be accomplished by considering the learning preferences of the contemporary student. This generation of student responds well to learning-communities, social learning, and collaboration (Hodge, Tabrizi, Farwell, & Wuensch, 2007). As Ertmer et al. suggest, redesigning curricula to accommodate this type of learning constitutes a second order barrier and is more difficult to accomplish, but recent research suggests it is more beneficial for learning in general (Ikpeze & Boyd, 2007; Farmer, Yue, & Brooks, 2008; Elgort, Smith, & Toland, 2008). Logic suggests, assuming first order barriers have been resolved; it is the teacher who elects to invest the time and energy in this integrated technology that improved the probability of success. Fullan describes the need for inspiration on the part of those who would implement an institutional change (2007). Effective integration would theoretically occur when educators use technology in this way. If there is a measurable relationship between student cognitive style and computer assisted learning, it should present itself in the highly integrated environments that emerge from these inspired educators.

Ertmer and her colleagues‘ model of integration can be extended by looking beyond the impediments to integrating technology and identifying how teachers or professors ―achieve specified goals in particular environments" (Tselios, Avouris, & Komis, 2008, p. 56). By focusing on the application of the courseware and the methodology driving the courseware, researchers can meaningfully understand variations in applications in a consistent way. Tselios, Avouris, & Komis suggest three themes emerge to create this model.

Primary Courseware

Primary courseware focuses on applying behavioral theory to the instructional use of ICT. Teachers who use technology in this way have the student access information through ICT for the purpose of gaining access to knowledge. This application constitutes the most limited level of integration because the cognitive engagement is limited to the student accessing and recalling information at very low cognitive loads (Ozcelik & Yildirim, 2005; Igo, et al., 2007; Kalyuga, 2007).

Because the load is low, the student may gain the knowledge without the technology, outside of first-order barriers like hardware malfunction, playing a significant role in the learning process. Examples of this application of instructional ICT are drill and practice software, vocabulary exercises or reference activities where information is disseminated through the use of computer technology. From a cognitive standpoint, the information is processed in the same way it would be if that student accessed the same information in a textbook.

Secondary Courseware

Secondary courseware focuses on applying constructivist theory to the instructional use of computers. This particular application of ICT presents a new set of challenges for both the educator as well as the student because the cognitive demands increase when compared to primary courseware. Constructivist theory places ICT in the role of facilitating learning through exploratory modes of instruction. While this application increases student engagement and learning theoretically, it also creates increased cognitive load and the potential for cognitive failure that do not exist in primary courseware. As true with any application of constructive theory, these cognitive challenges may be either content related or skill based. The additional caveat with secondary courseware is that the skill deficiency may be classical (e.g. literacy, cultural) or based in computer usage acumen (e.g. word processing skill). Since primary courseware does not rely on constructing knowledge, content information processing is the only potential source of cognitive failure. Secondary courseware adds the challenge of constructing knowledge with a reliance on computer skills to accomplish that goal. As the educator's propensity to employ constructivist theory in the classroom increases, so does the likelihood that ICT will be used for instruction and, theoretically, the level of integration increases (Rakes, Fields, & Cox, 2006). As a result, the likelihood that a cognitive failure will emerge in secondary courseware is greater than in primary courseware.

Tertiary Courseware

Tertiary courseware applies social-constructive theory to instructional ICT. It can be argued that social learning opportunities offer the very best improvements in the computer-enhanced environments (Kramer, Walker, & Brill, 2007). Tertiary courseware is more integrated than either primary or secondary courseware because, in order to engage the content, the student must: 1) Engage the content material cognitively; 2) connect socially with peers; 3) construct knowledge independently; and finally 4) re-construct knowledge from the previous step socially while relying on their skills with ICT at each of these four steps.

The limitation of this approach is that it creates four distinct opportunities for cognitive fault and simultaneously requires the greatest level of ICT usage in order to achieve successful cognitive engagement. Social failure (i.e. student inability to connect with other learners) combined with social construction difficulties (i.e. using social interactions to solve a problem) are inherently linked to the successful usage of ICT, thus, tertiary applications are the most integrated. The hope has been that this approach would encourage the sort of teacher-student relationship that might enhance identity development in risk groups like African American males and students whose families are struggling with poverty. Research has failed to show conclusive evidence that these otherwise marginalized groups are more likely to be socially integrated into these learning-communities (Webb, 2006). Although some research suggests learning gaps are growing (Cooper, 2006; Allen, 2008), the specific reason for this achievement gap (e.g. cultural, social, technological, etc.) is not as clear (Hew, & Brush, 2007). Given this argument, the likelihood that these students would struggle with the content is theoretically greatest when compared to either primary or secondary approaches.

Summary

The historical use of computers in the field of education shares its roots with Western business firms. Competition from Eastern businesses and perceptions that Eastern educational institutions were outperforming American institutions drove educational policy towards computer-assisted instruction in various forms. In hopes of improving measured student performance, formal learning institutions were motivated to move away from dialogical applications of CAI toward more integrated. This integration of technology created an environment that is both fixed and potentially inequitable for learners who were not able to cognitively function on as effectively in this context. This research will examine the question of this integrated context as the learner, with an immutable cognitive style, reports to that learning task.

Chapter three describes the process that was followed in measuring the effect this technological application has on student with regard to their cognitive style. It will include a formal review of the meta-analytical process, a critical evaluation of different meta-analytical techniques, the coding procedures, equations, and hypotheses.

CHAPTER THREE

METHOD

Chapter two reviews cognitive style research and its implications for human learning. This researcher raises questions about the impact information and communication technology (ICT) has on learners, particularly in regard to the way those students process information. Since the Internet became widely available in America, educational application of ICT has evolved significantly. This evolution occurred so quickly and haphazardly that the result was a lack of standard, concise terminology, also discussed in chapter two, and has made it difficult for consumers of research to understand the practical implications of the myriad of studies conducted on this topic since 1984, i.e. the emergence of the desktop computer among American households.

Researchers in instances where a problem or phenomenon is poorly understood have successfully used qualitative analysis, or a qualitative component or a larger study, to delve more deeply into an issue with the goal of gaining clearer understanding of the problem (Jasmine, & Weiner, 2007; Hatzios, & Lariscy, 2008). However, the problem of the equitable application of educational theory, particularly in regard to instructional technology, is not so easily analyzed qualitatively because of the predictor variables that are related to a person‘s propensity to engage the learning task, and the subsequent threat these factors pose to external validity.

Properly sampled quantitative studies are more likely to have a greater external validity, but only marginally due to widely varying contextual variations and application (Szabo, & Montgomerie,1992; Kukulska-Hulme, 2007), variable isolation, and poorly constructed definitions of key terminology as discussed in chapters one and two. This challenge to analyze the relationship between cognitive style and computer enhanced instruction becomes more challenging due to varying levels of integration, (i.e. how the computers are actually used in each classroom context) implementation, (i.e. the amount technology used in the classroom) teacher skills and attitudes, student skill and attitudes, and the school‘s ability to respond institutionally to change, at the very least. Given the number of possible combinations of these characteristics, all of which have been found to have a significant effect on student learning, neither qualitative nor quantitative analysis offers the breadth required to gain any real perspective on the role a student‘s cognitive style plays in how that student learns in various applications of CAI. Thus, qualitative, qualitative, nor mixed-methodological analyses would be an appropriate method for this study‘s questions.

A meta-analysis offers a methodological middle ground for researchers. With a scope broad enough to maintain acceptable external validity, meta-analytical research can address questions that deal with the range of variables implied in this study‘s research questions. At the same time, the meta-analysis can offer this researcher the opportunity to examine technology‘s impact on learning using groups of sample populations and in contexts varying in levels of integration, application and theoretical constructs. Given this, a meta-analysis presents the single best opportunity to answer this study‘s questions.

This chapter seeks to: 1) Make a compelling argument in favor of meta-analysis as a research methodology; 2) address common criticism of meta-analytical research; 3) and describe the process that this study will undertake to control for these methodological limitations. As is common in this methodology, the procedure for identifying and selecting studies incorporated in this meta-analysis, the procedure used to code the studies, followed by the equations used to calculate effect size in this study will be reported in this chapter.

Theory Into Practice

Wolf (2005) suggests that data should be used as a basis for determining the extent that technology has been implemented in the classroom context. This implies that both student performance and contextual issues are paramount indicators of implementation levels. Consequently, the State Educational Technology Directors Association (SETDA) has developed the Profiling Educational Technology Integration (PETI) assessment suite. These tools focus on both student and context aspects of the implementation process.

Since this particular study is meta-analytic, collecting data of this kind will not be possible. Understanding the level of implementation, however; is a critical factor if one is to more closely examine the interaction between a student‘s cognitive style and their successful engagement with the computer mediated content. Thus, the relevant characteristics relating to LoTI that emerge in the literature are as follows: 1) The theoretical perspective that the course is based upon (Tselios, Avouris, & Komis). As the basis of the course work moves from a foundation in behaviorism through constructivism and eventually toward social constructivism, theoretical levels of technological integration (tLoTI) increase. 2) The role the technology plays in the process of learning (Malmsköld, Örtengren, Carlson, & Nylen, 2007). As students are asked to use technology to delve more deeply into content, the subsequent cognitive loads increase. Consequently, the tLoTI would also increase. 3) The time students spend using technology to engage the task (Adams, 2006). Assuming that both the theoretical basis for the coursework and the role technology plays in learning are aimed at integrating technology into coursework, the assumption is that the more time students spend using ICT for these purposes, the more tLoTI would increase. These three attributes create the tLoTI profile. Therefore, the studies included in this meta-analysis will be assessed for their respective level of implementation based on the characteristics described in the literature.

Meta-Analysis as a Research Methodology

Meta-analysis is generally defined as a research study that uses data from pre-existing studies to answer the research questions. Initially proposed as more of a research ideology, meta-analyses have evolved into a rather common research perspective (Glass et al). Theoretically, the meta-analytical researcher takes statistical data and generates an adjusted statistic that allows several similar studies to be compared mathematically while preserving relative scale that might be a function of sample size, variations in population, sampling error, etc.

Meta-analyses are not exempt from methodological limitations. As this research method has evolved, several distinct meta-analytical approaches have been developed, each with respective strengths and limitations. What follows is a discussion of the most common approaches to meta-analytical research with the respective strengths and limitations of each. This will be concluded by a discussion concerning the approach used in this meta-analysis.

Critical Evaluation of Meta-Analytical Study

What Exactly Is a Meta-Analysis?

Like all other empirical methods of research, meta-analysis is purposed to answer a question or questions on a topic. Glass (1976) identifies three distinct kinds of research, each designed to use data to ultimately predict phenomena or design models that explain them. In education Glass notes, this is particularly challenging for the empirical study due to the variety of variables that are difficult to control for (e.g. contexts, social characteristics, etc). Nonetheless, empirical research on the general topic of education may be primary, secondary or meta-analytic.

Primary studies are those that collect data directly to answer a particular question. For instance, Rutherford, & Lloyd (2001) sought to examine the treatment effect of computer -assisted instruction among college students enrolled in a world geography course at university. Differences between the control and experimental group suggest that the treatment (computer assisted-instruction) had no significant effect on the dependent variable (learning) in this experiment. It would hasty to assume these results have high external validity without considering independent variables in Rutherford and Lloyd‘s study (e.g. variations is treatment group, individual characteristics not controlled for, level of application, etc). These independent variables are notoriously difficult to control, particularly when random or random-stratified sampling is not practical as is typically the case in educational and social contexts. Glass (1976) contends that the social sciences are very different from the traditional science in this way. He argues ―where ten studies might to resolve a matter in biology, ten studies of computer assisted instruction or reading may fail to show the same pattern of results twice" (p. 3). This is presumably the result of limitations such as the ethical constraints that keep social scientists from designing experiments that effectively isolate predictor variables from criterion variables.

If social scientists are to use the same tools as traditional sciences to predict and explain phenomena, there must be some adjustment for the problem, for lack of a better word, posed by ethics. Secondary analysis provides an option. In these analyses, researchers take pre-existing data sets and analyze them using improved technologies. Secondary analysis will require complete data from the original study to be available. Glass suggests that this is problematic in that data is usually not available indefinitely and, in many cases, is incomplete or missing unless the original study intended to revisit that data as a part of the initial research design (e.g. longitudinal studies).

Meta-analysis differs from primary and secondary analyses in that they focus on –the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings” (Glass, 1976, p. 3). While primary and secondary research can be seen as a technique, Glass, McGaw and Smith contend that meta-analysis should be seen as a perspective that uses a variety of techniques to arrive at a conclusion (1981). A concise definition of the meta-analytical approach should include the three characteristics that differentiate this kind of analysis form primary and secondary techniques. Meta-analyses are as follows: 1) Quantitative (i.e. meta-analyses are not suitable to examine qualitative research); 2) not restricted to studies that have arbitrary exclusion criteria, allowing the researcher to generalize about a given phenomenon (i.e. the researcher is permitted to use data that would likely not be included in a secondary analysis); 3) are designed to form general impressions about a topic that reports varying results in the research. These three characteristics allow the researcher to integrate several related, but different, studies to draw generalizations on the topic in a way that strictly follows scientific convention (Kavale, 2001). This rationale for this integration is to help explain aberrant variations in statistical data that occurs as a result of the researcher's challenge of variable isolation that may be present in both primary and secondary analyses.

Glass (1976) contends that the sheer amount of research in existence created the need for and driven the evolution of meta-analytical research. The age of information, because it inundates the scholar with almost too much to thoughtfully consider, presents the researcher with the new challenge of assimilating these copious amounts of knowledge and then synthesizing new knowledge from the primary and secondary research base. This growing research base, particularly in the topic of computer enhanced instruction, is in many cases paradoxical because of the varying characteristics of studies and the inability of the researcher to control these variations. Glass, McGaw, and Smith, (1981) maintain that the problem of creating replicable studies is the foundation scientific research, however; given the variations in findings among educational studies, reliability emerges as yet another challenge for the social scientist. Consequently, meta-analytical research is becoming an increasingly valuable tool as the literature base grows because the researcher requires ―methods for the orderly summarization of studies so that knowledge can be extracted from the myriad of individual researches," and more reliable knowledge can be gleaned (Glass, 1976, p. 4). The meta-analysis is, in its simplest form, is a tool that offers an opportunity for researchers to make sense of information that would otherwise be unmanageable. There are several approaches to meta-analysis. In what follows, the most popular types of meta-analysis will be discussed in turn with a cursory discussion of relative strengths and needs.

Glassian Meta-Analysis (GMA)

Although many credit Glass as the originator of the meta-analysis, the techniques that evolved into modern meta-analytical methods emerged before Glass first coined the term (e.g. Underwood, 1957; Light & Smith, 1971; Jackson, 1978 as cited in Glass, McGaw, & Smith, 1981). Because this perception persists, some see the Glassian meta-analysis (GMA) as the classical approach. The purpose of this approach is to synthesize the research in a very particular area (Bangert-Drowns, 1986). Of the different approaches to meta-analysis, the GMA is relatively straightforward. Studies are selected and the data combined by calculating what Glass describes as the effect size (Δ), which is defined as the differences between the means of the experimental group and the control group divided by the control group's standard deviation (i.e. $\Delta=M_x-M_c/\sigma_c$) and that data can be used to answer research questions and respond to hypotheses. The advantages of the GMA are as follows: 1) It allows the researcher to gain a macro-perspective of the study problem (i.e. the researcher can look at the treatment effect in many contexts; 2) it allows low exclusion critieria, thus incorporates studies that would not typically be included in most other primary or secondary analyses, such as dissertations, unpublished studies or non-peer reviewed research reports; and 3) because the researcher can control the coding process, external validity, construct validity and reliability can be increased(Glass, McGaw, & Smith, 1981).

There are limitations of the GMA approach. Because a meta-analysis requires the researcher to collect several independent studies from a variety of sources, one concludes that any extrapolation from that data would be meaningless because the studies are inherently different (e.g. different authors, different sample population, different definitions, etc). This ―apples and oranges problem” is best rebutted by considering the underlying rationale for conducting a meta-analysis is to understand a problem more globally (Glass, McGaw, & Smith, 1981, p. 218). Upon review, it makes little sense to compile several identical studies because, assuming the studies have internal and external validity, and had sound methodological bases, those studies would all come to the same conclusion about the phenomenon in question (e.g. computer enhanced instruction). ―Gene Glass has impatiently dismissed such criticisms by saying it is a good thing to mix apples and oranges when we are trying to generalize about fruit” (Hunt, 1997, p. 61). Therefore, it would be the goal of a well-designed meta-analysis to include studies that are inherently different so that these findings could be compiled together in a coherent manner, facilitating a deeper understanding of the initial problem.

Selection Bias

Selection bias is another problem for the GMA and the meta-analytic perspective generally speaking. This problem occurs when the researcher, either intentionally or arbitrarily, excludes studies in such a way as to skew the study results. The problem can manifest itself in two distinct ways in meta-analytic study. If selection criteria are biased towards non-significance (i.e. studies that are more less likely to find measurable differences between control and treatment groups), the result of a Type I (α) error, where the researcher tends to reject the null hypothesis when it is not prudent to do so, is greater. Conservitively planned studies, for example, are more likely to be biased in this way and the meta-analyst who disproportionaltly selects these studies is at risk for this type of error. Conversely, if selection criteria are biased towards significance (i.e. studies that are more likely to find measurable differences between control and treatment groups) the risk is a greater likelihood of committing a Type II (β) error, failing to reject the null hypothesis when it should be. Studies that have very liberal inclusion criteria are subject to Type II error.

In the case of this meta-analysis, errors toward non-significance (Type II) represent the more conservative choice and therefore are preferential to Type I errors. Type I error, may reuslt from selection bias and will be controlled methodologically by transparently reporting the exclusionary criteria, data acquisition process (i.e. how included studies were located), coding procedure and effect size equations. Although these steps will not eliminate selection bias from occurring, it will reveal potential bias to the consumer of the research and make the study more replicable (Kulik & Kulik, 1989).

Using data from poorly designed or poorly executed studies another point of contention for the critic of meta-analysis. Consequently, the temptation for the researcher is to use only studies published in peer reviewed journals; however; this will result in many potentially relevant studies from being arbitrarily excluded, resulting in biased data (i.e. the classical file drawer problem). Although this limitation can be overcome mathematically, Glass, McGaw, & Smith (1981) suggest that the research is better served by including these studies because, while overtly fallacious research has no place in a well designed meta-analysis, ―it hardly follows that after a less-than-perfect study has been done, its findings should not be considered" (p. 220). In the case of this study, to better control selection bias, this researcher will avoid unnecessarily conservative exclusion criteria.

The File Drawer Problem

Aside from selection bias, publication bias, often referred to as the ―file drawer problem," (Rosenthal, 1991, p. 128) occurs when editors favor studies with significant findings over studies that fail to reject the null hypothesis (Rosenthal, 1979; 1991). Although this might be a problem in research in general, the question of the applicability in educational technology research is not definitive. Leping, Aberasturi, Axtell, and Richmond (2007) reviewed all studies published in the *International Journal of Information Technology in Education* over a six year period and the independent *t*-test, $t(23) = 0.843$, $p = .408$, identified no significant relationship between the likelihood of a study's publication and their reporting significant findings.

This suggests that educational research on this topic may be less susceptible to publication bias. The authors argue that the field of education is not driven by the same kinds of pressures to produce results significant research findings. Journals that have educators as an audience are more likely to satisfy their readers with both qualitative research (which is not designed to find statistical significance at all) and quantitative research that does not report a statistically significant result because educators can find relevance in this sort of research. Although this argument does not hold true in all fields, education may be less susceptible to Rosenthal's file drawer problem.

Controlling the File Drawer Problem Through Inclusion

Meta-analytic process had developed procedures for controlling this problem of sampling bias. In chapter three, the procedure for identifying included studies was described. One of the best ways to control the problem of publication bias is to avoid limiting selected research to the studies published in traditional academic peer-reviewed journals. While some meta-analytic approaches encourage the researcher to have very stringent inclusion criteria as a means in increasing validity, this process also introduces bias. This study aims to have as few exclusionary criteria as possible as a means of controlling this source of bias. Although a complete description of these criteria are discussed in chapter three, a brief review of the criteria for exclusion in this study are as follows: 1) The age or the subject population must exceed adolescence; 2) each primary study must include the statistical data to perform the necessary effect size calculations; 3) the cognitive style assessment must be either the Group embedded figures test, or a derivative; and 4) the data in the primary study must have been collected no earlier than 1985. These four criteria constitute the fewest limitations for including studies necessary to maintain acceptable levels of internal validity for this meta-analysis and therefore represent the first step in controlling publication bias.

Calculating the Failsafe N Statistic

Cooper (1979) contends that, no matter how diligent the efforts of the researcher, an inherent limitation of all meta-analyses is that gaps will exist in the review for included studies. The Failsafe *N* statistic is a calculation for determining ―how many studies totaling a null hypothesis confirmation would be needed to reverse the conclusion that a relationship exists" (p. 134). This is calculated by adding the square of the sum of known effect sizes divided by a constant of 1.645 (for the α .05 level) and then subtracting the number of studies.

$$N_{fs.05} = \left(\frac{Z_{s1} + Z_{s2} + \cdots Z_{sn}}{1.645}\right)^2 - (N_s),$$

A more generalized method for calculating the failsafe statistic (K_0) using mean effect size data can be calculated by first finding the product between the number of effect sizes (K) and quotient of the weighted (Δ_k) and criterion (Δ_c) effect sizes minus one (Lipsey & Wilson, 2001). This more simplistic method will be used to calculate the failsafe N for this meta-analysis.

$$K_0 = K\left[\frac{\Delta_k}{\Delta_c} - 1\right],$$

Study Effect Meta-analysis (SEM)

The main purpose of the SEM is to identify the effectiveness of a particular treatment (Bangert-Drowns, 1986). The SEM, while still meta-analytical, is different from the Glassian approach in two distinct ways. The SEM has different methods of including studies and analyzing effect size comparisons. First, according to Bangert-Drowns (1986), because the inclusion criteria are more stringent, studies with suspect methodologies, questionable samples, or dubious assessment tools are easily excluded by the researcher. Although conservative inclusion criteria theoretically strengthen the study‘s validity, it increases the likelihood of reviewer bias, nullifying the gain to some extent. The second defining characteristic of the SEM is, since effect size is calculated for each study included in the database, the data set‘s integrity is better maintained because each study would have equal weight. This advantage comes with the cost of further bias given studies with smaller sample populations, which are more likely to show statistical significance, have the same weight as those studies with larger sample populations, comparatively less likely to show statistical significance. This magnifies the power of the smaller studies leading to a greater likelihood of both Type I (α) and Type II (β) error, which are compounded by bias if the researcher is too conservative in developing exclusionary criteria (Wilson and Shadish, 2006 as cited in Bösch, Steinkamp, and Boller, 2006).

Combined Probability Method (CPM)

The purpose of this method is to estimate the effect of a given treatment and confirm the validity of that estimation (Bangert-Drowns, 1986). CPM is a less popular approach to meta-analytical research but one that affords the researcher with certain advantages. As is typical with most meta-analyses, studies are identified and effect sizes are calculated, then averaged to generate a single overall effect measurement. (Bangert-Drowns). This allows the researcher to glean a clear, singular picture or a cumbersome data set.

CPM is not without limitations. Given the goal of this approach is to create broad brush strokes, it lacks the ability to produce data with high specificity. Bangert-Drowns (1986) argues, ―what is most conspicuously absent from this form of Meta-Analysis is rigorous attention to differences in study features" (p. 394). In addition, this method is susceptible to bias because the ―decisions regarding the inclusion or exclusion of methodologically inferior studies are left to the reviewers discretion" and are therefore much more likely to produce loosely generalizable data. (Bangert-Drowns, p. 394).

Although there are other approaches to the meta-analytic perspective, these three, the Glassian, the SEM and the CPM, are the most commonly relevant to the questions posed by this research project. The challenge is to select the approach that offers the research the best opportunity to answer the research questions while interjecting the least amount of error.

The CPM, while appropriate for a very broad perspective, lacks the specificity to perhaps identify small differences between field dependent (FD) and field independent (FI) learners in computer-enhanced contexts. In addition, the risk of interjecting bias outweighs the comparative advantage of simplicity.

The SEM offers an alluring flexibility to the researcher regarding the selection of studies. The stringent inclusion criteria are enticing to the researcher aiming to increase validity by eliminating poorly implemented studies from contention. The problem with this approach is the risk of researcher bias contaminating the pool through exclusion exceeds the risk of poor studies skewing the data. Glass , McGaw and Smith conclude, “the researcher does not want to perform a study a study deficient in some aspect of measurement or analysis, but it hardly follows that after a less than perfect has been done, its findings should not be considered” (p. 220).

The Glassian approach offers this researcher the best single opportunity to respond to the hypotheses set forth by this meta-analysis. Since the GMA compels the researcher to be more inclusive regarding studies, the problem constituted by small samples in certain studies may skew data and compromise internal, external and construct validities. In addition, using only the standard deviation from the control group potentially introduces more error (Cook & Campbell, 1979). To attempt to adjust for this problem, two measures will be undertaken as a part of this study‘s methodology. First, an adjusted equation will be used for studies that have sample sizes of less than 20 participants. In addition, rather than simply using the control groups standard deviation in the denominator of the effect size equation, using the standard pooled variance will produce less error (Cohen, 1998). These procedures have been used in other meta-analyses (e.g. Preston, 2008) and this equation, along with other relevant effect size equations, will be fully described in the following sections.

Identifying Included Studies

Although research indicates the level of technological implementation is a key variable, this characteristic will not be considered a basis for exclusion as to facilitate examination of the effect of this variable on student learning. Research also indicates that findings from older studies may not be as useful in understanding the learning implications of technology. It is the view of this researcher that, although technology has evolved, findings from studies completed anytime after the desktop revolution in 1984 will contain information that will add credence to this database.

Many meta-analyses limit target research studies to reports published with the last ten years (e.g. Liao, Chang, & Chen, 2007; Tenenbaum, & Ruck, 2007; Levine, Fallahi, Nicoll-Senft, Tessier, Watson, & Wood, 2008). This particular study is also aimed at examining the role information technology plays in education; therefore, older studies have been excluded because of relevance and because change regarding ICT is perceived as being so significant, older studies should be excluded because of relevance. Glass, McGaw, & Smith suggest excluding studies for reasons such as this is not only undesirable; it may skew the database, increasing the likelihood of researcher bias (1981) and increasing the likelihood of Type II error. For the purposes of this study, the risk of older studies skewing the data is less relevant than the danger of bias skew, therefore, there will be no arbitrary exclusion based upon year of publication as long as the study topic is relevant to the study questions.

Given these broad goals, the process of synthesizing research demands that the process for selecting studies should be described. Based on recommendations from Lipsey & Wilson (2001), the following criteria will serve as basis for study inclusion in this meta-analysis.

Study Eligibility Criteria

Distinguishing Features

This meta-analysis is concerned with finding the overall effect of various applications of educational technology on learners‘ relative field dependence as defined in chapter two. To ascertain the treatment effect (i.e. various educational technology), the studies selected must address some form of this treatment, then report and measure it in a rational way.

This research study focuses on the effect a student‘s cognitive style has in formal learning contexts that use digital technology. Therefore, both psychological (cognitive style) and educational (instructional technology) features are involved. Because of this, several study characteristics emerge as critical and should be a considered as a key in determining if a particular study is appropriate for this meta-analysis. The main study effect (the impact of the treatment on field dependent learners) must be present in the research report to me considered. The level of integration (i.e. how the technology is applied), the theoretical basis for application and, the level of application (i.e. the quality of application) comprise the secondary effect of interest in this study and should optimally be present, but are not inherently required to respond to the main question.

Research Respondents

This study's target psychological characteristic is cognitive style. Since the research suggests that this human characteristic crystallizes at adolescence (Witkin, Goodenough, & Karp, 1967), the learning context (e.g. high school, undergraduate university, technical schools, etc.) therefore becomes less significant so long as it includes students beyond the point of cognitive crystallization. Therefore, this meta-analysis will target any relevant study performed in formal instructional contexts with students who are at least adolescent and conforms to previous inclusion criteria.

Key Variables

For this particular study, the most important variable is the statistical data reported in the original report. Meta-analyses are methodologically limited to studies that report specific data in order to calculate effect size (Δ). Because of this limitation, only studies that report data needed to calculate effect size would be included. This meta-analysis will target any relevant study that reports this data and conforms to previous inclusion criteria.

Research Methods

Direct measurement of human thinking is not possible given the technology available to us presently. Indirectly measuring indicators of thinking vary greatly and social scientists concede that all research methodology have inherent limitations. Given that one cannot control a student's proclivity toward field dependence, methods that incorporate control and treatment groups do not lend themselves to studying the performance of two groups in a formal learning context. Traditional experimental designs are preferred in science and are sometimes seen sin social science as well. Theoretically, a traditional research design would be more valid, however it is unlikely that there are enough traditional research studies available and the threat to validity is not so significant that it compromises the integrity of the data. Quasi-experimental designs, for example, are common in social science and will be included in this study assuming previous criteria are met. This meta-analysis will target any relevant study that employs a research design that: 1) Measures FD-FI of the participants using a valid measurement tool, 2) measures some aspect of performance as it relates to a formal learning context that uses some modality of educational technology; and 3) compares those measurements and a clearly defined, statistically appropriate fashion. Studies that use any method that accomplishes these goals shall be considered providing they also conform to previous inclusion criteria.

Publication Type

Publication sources, particularly those that employ a stringent peer-review process are often cited as a means for gauging the validity of studies (Ramos-Álvarez, Moreno-Fernáde, Valdés-Conroy, & Catena, 2008). The goal of a meta-analysis is to combine as much data as realistically possible into a singular synthesized construct that will be used to respond to the research questions. Although peer-reviewed studies are typically well executed and reported, there are many studies that are completed that are not peer reviewed, either because they were published in some alternate format (e.g. web published, self-published, etc) or not formally published at all. These studies may include data that might be significant, therefore should be included. To omit these studies because they are not peer reviewed creates a particular bias for the meta-analytic researcher referred to as ―the file drawer" problem because the data remains out of the public view and is not typically included in the scholarly knowledge base (Muncer, Taylor, & Craigie, 2002, p. 277). This is compounded by –the possibility that the journals are filled with the five per cent of studies that show Type I errors while the file drawers back at the lab are filled with 95 per cent of these studies that show nonsignificant results" (Rosenthal, 1979, as cited in Muncer, Taylor, & Craigie, p. 277). Therefore, by including these alternate studies when possible, the meta-analysis is uniquely designed to better address this particular problem. Therefore, any study that presents a valid data set and conforms to the previous criteria will be considered for this meta-analysis.

Coding Procedure

Coding is an important aspect of a meta-analysis, particularly when one considers how large the data sets can be. For this study, several study characteristics will be coded. Each study will be assigned a sequential study number for identification. Aside from basic bibliographical data (e.g. author, date, publication source, title, etc.), relevant statistical information will be recorded.

Statistical Measurements

SD and *M* for both control and treatment groups will be coded. F-scores will also be coded when appropriate as well as the direction of significance. T-scores will be recorded when applicable as well. The study‘s overall statistical significance will be coded (0, non-significant; 1 significant).

Study Exclusion Characteristics

The next step in the process of meta-analysis is to select the studies that will be excluded from the database. In the perfect scenario, one might contend that every study located should be included. Reality makes this impossible. Studies vary significantly, report findings in different ways and reflect the interests and concerns of the original authors, which may be different than the intentions of the meta-analyst. This necessitates excluding at least some of the research from being included in the meta-analytical database. To make this process as regimented as possible, criteria should be set up that clearly define which studies will not be included and on what basis (Lipsey & Wilson, 2001).

Since cognitive style is a psychological characteristic that is unlikely to change due to external factors (Witkin,1950; Jung, 1971) this researcher will assume that environmental and demographic factors such as socio-economic status, race, gender, and geographic location are not significant predictor variables in this meta-analysis, thus need not be considered as exclusionary criteria. The level of instruction (grade level or year in college) is also not a significant predictor variable in this instance because, once the brain has reached maturation, there is no indication that a change in field dependence would be likely for the duration of most research studies, making exclusion unnecessary.

Age of Participants

Essentially, this study is focused on examining the relationship between a student‘s field dependence and her performance in computer-enhanced contexts. This relationship should be proportional regardless of the age of the learner, assuming the student has reached adolescence. Since this meta-analysis will exclude studies that sample pre-adolescent students, there is no advantage in considering the level of instruction. Therefore, studies that are performed on students who are not in at least grade seven, or an equivalent level, will be excluded.

Statistical Measurements

Given the wide range of publication sources, the reported data varies greatly. In some cases, only the minimal data is reported if statistical significance is found (e.g. coefficient of correlation and significance). In other sources, presumably where space is not as much a factor or perhaps where the audiences are consumers of such information, more exhaustive data are reported (e.g. F ratio from and ANOVA, significance, along with full descriptive statistics including means and standard deviations).

As discussed, this study will implement a meta-analytical methodology and is contingent upon calculating effect size (Δ). Any potential study that fails to report adequate statistics (e.g. means, standard deviations, F-Ratios, etc.) to make this calculation will also be excluded.

Cognitive Style Assessment

Conceptually, cognitive style is defined in this study as an inherently cognitive process and only indirectly related to personality. In chapter two, I discussed the similarities and differences between cognitive style and other similar human style research as well as the inconsistent application of these terms in the literature. This variation in defining cognitive style presents a problem in selecting studies for meta-analysis because the measure itself may vary from study to study. Therefore, studies that operationally define cognitive style in alternate ways or measure it in a way that is radically different from Witkin‘s field dependence model (1950) shall be excluded.

Publication Date

Finally, there has been much discussion on the rapid evolution of technology in general. Some scholars posit that the technology has changed so much, that comparing research done in the eighties has little contemporary relevance (Häkkinen, 2002). Cognitively, human thinking has clearly not changed since the mid nineteen eighties. The major difference between the contemporary computer and personal computers of antiquity (i.e. personal computers made in the late seventies and early eighties) is the development of graphical user interfaces (Ceruzzi, 1999). This interface allowed lay people to use this technology, thus increasing demand and subsequently production of these computers. Nineteen eighty-four became the landmark year for this evolution of computers and this innovation would logically have a cognitive effect on how individuals interfaced with a computer. The changes that have occurred since this innovation (e.g. faster processors, increased storage capacity, interconnectivity) have not significantly changed the way humans interact with computers in so far as this study‘s research questions are concerned. Therefore, any study completed prior to 1984 shall be excluded from this meta-analysis.

Measuring the Theoretical Level of Technological Integration (tLoTI)

Several factors contribute to a student‘s cognitive engagement in classrooms that use ICT for learning purposes. As described in chapter two, the literature suggests several themes conspire to create the level of technological integration. The subsequent cognitive load a student will experience at the learning task would theoretically be a function of this level of integration (Ozcelik, & Yildirim, 2005; Igo, et al., 2007). The studies selected for this meta-analysis should be ranked according to their level of technological implementation because, as discussed previously, research indicates courses that are more integrated will place higher loads on students. Given this likelihood, if there is a strong correlation between cognitive style and performance in highly integrated environments, it should be more apparent in courses that have higher $_{t}$LoTI scores.

$_{t}$LoTI Raters

In order to control bias in the tLoTI measurement, three individuals who specialize in educational technology will code each primary study. In addition to this researcher, the other two educators who coded these studies will review the method section of the research report to ascertain the degree in integration in each of the three dimensions of the tLoTI variable. This researcher will provide an explanation of the process, describe the use of the coding form and provide a practice study for the other raters to complete prior to commencing the formal coding process.

The $_{t}$LoTI measurement used in the final analysis will be the mean average of these three scores. Each rater‘s scores for each study will be reported in chapter four along with the mean and standard deviation for each primary study‘s $_{t}$LoTI rating.

Instrument Design

As discussed, the three relevant characteristics that one must examine to determine the theoretical level of technological integration ($_{t}$LoTI) are the following: 1) The theoretical perspective that the course is based upon (Tselios, Avouris, & Komis); 2) the role the technology plays in the process of learning, or the level of implementation (Malmsköld, Örtengren, Carlson, & Nylen, 2007) and 3) the level of integration, or the time students spend using technology to engage the task (Adams, 2006). These three concepts shall become the basis for the instrument that will be used to quantify the $_{t}$LoTI for the purposes of this study.

Research suggests that as each of these dimensions become more prominent in classroom contexts, the level of integration ought to increase. Therefore, each of the three dimensions will be considered and ranked. Authors provide this information in their descriptions of the method used. These descriptors will be noted, coded, and used to assess each study. Each included study will receive a score on a scale from one through twenty-seven. Higher scores correspond with greater ICT integration.

Measurement One: Theoretical Basis for Coursework

In the method section of the selected study, the rater will identify key tasks the students will be performing in the coursework and how the key variables will be isolated and tested. This dimension has four possibilities: 1) No theoretical basis indicated; 2) behaviorist basis; 3) constructivist basis; or 4) social constructivist basis. Behavioral theory is indicated by computer-based activities designed to foster knowledge and understanding of key concepts, vocabulary of skills needed for more advanced subsequent study. Constructivist theory is implied by the use of terms that state students will use ICT to solve abstract problems or complete more authentic tasks. Courses based in social constructive theory will solve similar problems, but will require students to use ICT for collective collaboration as a means to solve the problems presented by the task.

To quantify the theoretical perspective measurement, the rater will consider the basis for the coursework described in that study. To code the study, the rater will review the method as the author describes, extrapolate key tasks reported, and code as follows: I) No basis = 0; II) behavioral theory = 1; III) constructive theory = 2; IV) social constructivism = 3.

Measurement Two: The Role of Technology in the Classroom

The role technology plays in the contexts of the selected study is also identified by an analysis of the method. This dimension has four possibilities: 1) No role stated (coded 0) ; 2) level 1, (coded 1); 3) level 2, (coded 2); or 4) level 3, (coded 3).

Level 1 is indicated by computer-based activities designed to foster knowledge and understanding of key concepts, vocabulary of skills needed for more advanced subsequent study. Level 2 is implied by the use of terms that state students will use ICT to solve abstract problems or complete more authentic tasks. Courses designed at Level 3 theory will solve similar problems, but will require students to use ICT for collective collaboration. This type of integration yields what is currently considered to be the apex of ICT integration (Richards).

This second measurement is included to add some level of redundancy to increase the probability that the correct relationship between the theoretical basis of the courseware and the course implementation are analyzed. Thus, if measurement one is reported as social constructivism, measurement two should be scored level 3.

Measurement Three: Student Engagement Time

Understanding the degree to which ICT is actually integrated into coursework is predicated upon analyzing: 1) The basis for the overarching learning objective and; 2) How the ICT is being used by the teacher in that context. These two concepts are isolated by the first two measurements. The third significant factor is the time students spend engaged with the technology. Time is not, in itself, a significant factor because coursework can be arranged so that cognitive engagement through ICT is low or non-existent. In a primary application of courseware, students may be required to access vocabulary words. Students might print a list of words, memorize them and complete an assessment with virtually no cognitive engagement through any ICT. If a student spends more time engaged in this context, there is no reason to conclude that it should have any significant effect on performance.

If the courseware is integrated to higher levels, students would be forced to a higher engagement level, thus the time spent in this context becomes more significant. Because of this relationship, one must consider the time aspect of this scenario as a component of integration. To keep relative significance in perspective, student engagement time variable (measurement 3) will be multiplied by the sum of the first two variables (Measurements 1 & 2). This will improve the validity of the result by making time only significant if it is being spent in a context that presents higher cognitive loads through ICT based coursework.

The rationale for this quantification, as discussed at length in chapter two, is that as coursework moves from behavioral theory to social constructivism, cognitive load increases. The more time students spend at high levels of cognitive load, the more potential for cognitive failure, the greater the depreciation of self-efficacy, and ultimately, the lower performance one might predict for that student. A course that requires students to use ICT to problem-solve creatively and collaboratively is more significant, from a cognitive perspective, than an environment that uses the ICT to reinforce simple tasks. It is hypothesized by this author that differences in performance, as it pertains to cognitive style, are more likely to be present as the cognitive load increases. Therefore, by stratifying the studies by tLoTI, it will be possible to examine the relationship between cognitive style, performance and the level of ICT integration in coursework.

Three ICT experts will score each study included in this meta-analysis using an instrument designed through the application of this research. The instrument, the theoretical level of technology integration coding form, is included in Appendix A. Mean scores will be calculated for each study and used as a measure of tLoTI.

Effect Size Equations

The primary studies' data selected for this meta-analysis must be converted into a standard measurement to facilitate meaningful comparison. The standard procedure for this begins with calculating effect size (Δ). This calculation may be accomplished in a variety of ways depending on several factors such as the nature of the primary study, the specific kinds of tests run in that study, and the way the data were reported by the author.

In this study, the Cohen's *d* statistic, which is calculated by taking the differences between the means of the treatment group ($\bar{x}_t$) and the control group ($\bar{x}_c$) divided by the standard pooled variation (S_p), will be used as a means of calculating the effect size. This will be used to control the intra-studies variance (i.e. the differences between the studies) as well as a means for controlling for data skew due to small sample sizes. When the data allows, this method will be used to calculate delta. The equations for these calculations are as follows:

$$\Delta = \frac{\overline{X_T} - \overline{X_C}}{s_p} \qquad s_p = \sqrt{\frac{(n_T - 1)s_T^2 + (n_C - 1)s_C^2}{(n_T - 1) + (n_C - 1)}}$$

Cohen's *d* is preferable when there are likely to be instances where the traditional delta calculation might become statistically problematic. For instance, an examination of the Glassian delta calculation reveals what appears to be a disregard for the total sample population (N). This could give studies with very small sample sizes more statistical power, skewing results and increasing the likelihood of the researcher making a Type I (α) (i.e. rejecting the null hypothesis when it is true) or Type II (β) errors (i.e. failing to reject the null hypothesis when it is false). As discussed earlier, Glass offers an alternative for standard pooling of data, Lipsey and Wilson (2001) offer an even simpler solution of using standardized mean differences. Using this method, the researcher can control for variations in sample size among the selected studies by first calculating delta as already described. The effect size adjusted for small sample sizes (Δ^1), would then be equal to the product of the effect size (Δ) multiplied by one minus the quotient of three divided by four times the sample size (N) minus the original sample size (N). This

$$\Delta^1 = 1 - \frac{3}{4N-9}\Delta$$

calculation will be used with studies with relatively small sample size (e.g. where $N < 20$) and is represented in the following equation:

Lipsey and Wilson (2001) also provide equations that can be used to calculate Delta in circumstances that are not addressed by the traditional Glassian Delta calculation. In many of the more contemporary comparative analyses, t-tests are administered on data sets. In these instances, Delta is calculated by finding product of the t-value and the square root of the sums of both the control and treatment groups divided by the product of the control group and treatment groups. In these cases, the following equation will find Delta.

Similarly, in the case of a one-way Analysis of Variance (ANOVA), F-scores will be applied to the other descriptive statistics to calculate delta as follows.

$$\Delta = \sqrt{\frac{N_t - N_c}{N_t N_c}}$$

Directionality of the F-score will be preserved by adding a positive sign if the treatment group had better performance than the control group. Conversely, a negative sign will be coded if the treatment group (FD students) performed poorly compared to the control (FI students).

Meta-analysis Software

To calculate effect size, Wilson's effect size determination program (2001) was used. This software calculates the effect size using Cohen's calculation described earlier in this chapter. These effect sizes will be recorded for each study and be analyzed using the Statistical Package for the Social Sciences (SPSS) using the Meta-analysis macros for SAS, SPSS, and Stata (Wilson, 2001). These macros are designed to generate meta-analytical dependent statistics as well as apply modeling to allow for variance.

Measuring Homogeneity Among the Primary Studies

Meta-analyses are a comparison of many studies on a related topic of interest. Since each study has inherent differences in methods, populations, and data, variation among those data are inevitable. Meta-analyses whose data vary greatly between the included primary studies are seen as lacking homogeneity and additional corrections are required to generate and interpret those data in a meaningful way (Huedo-Medina, Sánchez-Meca, Marín-Martínez, & Botella, 2006).

In order to determine the total degree of variation, this study uses a Q-statistic. The formula for Q is: $Q = \Sigma\, w_i(\Delta_i - \Delta)^2$, where w_i is the individual weight of the effect size, Δ_i is the individual effect size and Δ is the mean effect size over the total number of studies. ―If *Q* exceeds the critical value for a chi-square with *k*-1 [where k is the number of studies] degrees of freedom, then the null hypothesis of homogeneity is rejected" (Lipsey & Wilson, p. 116, 2001) and the researcher must conclude that the differences in effect size data between the primary studies is greater than what would be expected by normal sampling error.

After the primary studies are identified, the differences between them will be measured by calculating the Q-statistic in this way. The results of this statistical measurement will assist this researcher in deciding how to proceed with the analysis of these data.

Research Hypothesis and Statistical Analysis

In the section that follows, the study hypotheses will be framed. This will be succeeded by a brief review of the research questions and an analysis of how these questions will be addressed in this study. This will be concluded with a summary of this chapter.

Research Hypotheses

This study is concerned with the role a student‘s cognitive style plays in their performance in an integrated online learning environment. As defined in chapter one, computer enhanced instruction is creating formal learning contexts that have significantly higher levels of integration. This altered context may place field dependent learners at a relative disadvantage when compared to their field independent counterparts. Based on this argument, this study puts forth the following hypotheses:

1) A learner‘s cognitive style will have no significant relationship with their performance in integrated learning environments.

2) As the level of technological integration increases, the role cognitive style plays in student learning will have no significant relationship with the learner‘s performance in that context.

Statistical Analysis

This meta-analysis will address two questions. Each question must be answered through a statistical procedure. In this section, the procedure to answering each question will be explained.

For question one, regarding the relationship between the students‘ cognitive style and their academic performance in computer enhanced learning contexts, the researcher will calculate the effect size (Δ) by following the procedures described earlier in this chapter. Correlation tests will be administered to ascertain the significance of the relationships between the effect size (Δ), and then reported in chapter four. From an analysis of this data, the researcher will glean a response to this question and report the implications in chapter five.

Question two: ―As the levels of integration and implementation increase, does cognitive style have a greater influence on that student‘s performance?" The study responds tot this question calculating the correlation between Δ and the theoretical level of implementation ($_t$LoTI), which was ascertained by collecting information in the relevant study‘s report of methodology. The entire process is described earlier in chapter three. In short, there are three possible outcomes for this data. The relationship will be positive; the FD students‘ performance increased with the level of integration increased, negative; the FD students‘ performance decreased with the level of integration increased; or neutral; there was no relationship between FD the students‘ performance and level of integration. Results will be reported in chapter four and the implications will be reported in chapter five.

Summary

The procedure for this meta-analysis has been described in this chapter. The methods used to address the limitations inherent to all meta-analyses are described. A clear description of the process by which studies were identified is described as well as a discussion about the coding procedure and effect side equations. This chapter concludes with a discussion of how the study shall respond to the hypotheses and research questions.

CHAPTER FOUR

DATA ANALYSIS

As described in chapter one, the purpose of this meta-analysis is to examine relationships between students performance in various computer enhanced learning environments and the students' tendency toward field dependence. This chapter commences with a brief review of the meta-analytic and the data collection processes. This review is followed by a description of the primary studies included in this analysis. This chapter concludes with a presentation and analysis of the data.

Review of Meta-Analysis

As described in chapter three, a meta-analysis is generally defined as a research synthesis that uses data from pre-existing studies to answer research questions. While primary and secondary research can be seen as a technique, Glass, McGaw, and Smith contend that meta-analysis should be seen as a perspective that uses a variety of techniques to arrive at a conclusion (1981). A meta-analytic perspective has been applied to this particular study as a means of better understanding how students' performance with educational technology differs in regard to their relative field dependence.

Also as stated in chapter three, meta-analyses generally share the following characteristics: 1) They must be based on quantitative data (i.e. meta-analyses are not designed to examine qualitative data); 2) they endeavor to consider as many studies as possible, avoiding arbitrary exclusion criteria (i.e. the researcher is permitted to use data that would likely not be included in a typical secondary analysis); and 3) meta-analyses are designed to form general impressions about a topic that has been reported with varying or inconclusive results in the research. Because of these characteristics, a meta-analytical perspective was adopted as it emerges as the most appropriate approach given the natures of the problem and data that were described in chapter one.

Review of Data Collection Process

To locate appropriate studies for this meta-analysis, a review of relevant literature began in electronic databases including Academic Search Complete, Communication & Mass Media Complete, Computers & Applied Sciences Complete, Education Research Complete, Education Resource Information Center, Library, Information Science & Technology Abstracts, PsycARTICLES, Psychology and Behavioral Sciences Collection, PyscINFO, Proquest dissertation and theses, Teacher Reference Center, etc. A Complete listing of the databases can be found in Appendix C. Search terms included ―cognitive style‘ and technology,” ―field dependent‘ and computers,” ―GEFT and computer instruction,” ―cognitive style and ICT,” ―cognitive style and WBT” and variations of these terms. Identified studies were coded into a database and examined more closely to ascertain the degree to which the studies met the inclusion criteria of this meta-analysis.

Study Characteristics

Preliminary results yielded a total of 67 primary studies (n=3227) identified and reviewed for this meta-analysis. Forty-two of those studies (62.7% of the total studies identified) were excluded, primarily due to incomplete or inadequate statistical reporting. The remaining studies comprise the database of this meta-analysis and are listed in Table 1. These 25 studies produced 26 effect sizes and include 723 field dependent subjects and 851 field independent subjects for a population totaling 1,574 in both basic (K-12) and higher education. Almost all of the studies‘ (96%) individual data sets suggest that field independent students outperform field dependent students (Table 1). What is perhaps more interesting is that approximately one third of the studies included (*N* = 9) failed to find significance differences between field dependent and field independent students' performances (Table 2). Given this rather large discrepancy in significant findings, further analysis of this question is warranted and this study is partially purposed to examine this particular aberration in data.

Table 1
Included Primary Studies With Year, Significance, and Performance Direction

Study ID	Author	Year	Significant findings	Favors
10	Angeli & Valanides (A)	2004	Yes	FI
21	Angeli & Valanides (B)	2004	Yes	FI
73	Angeli, Valanides, Kirschner	2009	Yes	FI
74	Archer	2005	No	FI
26	Atasoy, Guyer, & Atasoy	2008	Yes	FI
63	Daniels	1996	No	FI
75	Daniels & Moore	2000	No	FI
51	Davidson	2000	Yes	FI
48	Edmiston	2001	Yes	FI
64	Kessler	1995	Yes	FI
79	Khine	1996	Yes	FI
15	Kim	2001	Yes	FI
27	Leader & Klein	1996	Yes	FI
29	Liu & Reed	1994	No	FI
28	Luk	1998	Yes	FI
61	Molina	1997	No	FI
5	Palmquist & Kim	2000	Yes	FI
78	Post	1987	Yes	FI
57	Shih	1998	No	FI
31	Somyürek & Yalin	2007	No	FI
46	Tang	2003	No	FD
25	Umar & Maswan	2007	Yes	FI
52	Umar	1999	Yes	FI
41	Wang, A.	2008	No	FI
1	Wang, T	2007	Yes	FI
18	Weller, & Repman, & Rooze	1994	Yes	FI

Table 2
Statistical Significance and Non-Significance

	Number	Percentage
Significant findings	16	65.38%
Non-significant	9	34.62%
Total	25	100.00%

In addition, approximately two-thirds (*N* =16) of the selected research reports were conducted in undergraduate university classrooms and the remainder (*N* = 9) took place in basic educational contexts (i.e. K-12). Although there were several studies initially identified that took place in graduate programs, those studies were ultimately excluded because they failed to meet inclusion criteria described in chapter three. More than half (62%) of the included studies were published within the last ten years (*N* = 15) and only three (12%) were published prior to 1995. Most of the included studies were conducted in the United States (72 %) with the remaining taking place in either Europe or Asia (Table 3).

Table 3
Countries and Mean Effect Sizes

	Count	Percentage	Criterion Δ
US	18	72.00%	-0.72
West Europe	3	12.00%	-0.26
Asia	4	16.00%	-1.01
Total Included	25	100.00%	-0.7

Table 4 illustrates that nearly half of the studies included for analysis were originally published in academic journals (*N* = 12) while the remaining data came from either dissertations (*N* = 9) or ERIC documents (*N* = 4). Finally, Tables 5 and 6 depict the duration and focus of the primary studies. The vast majority of the research studies were single observations (*N* = 14) and focused on the use of web-based technology (WBT) (*N* = 13).

Table 4
Publication Types

Publication	Number	Pecentage
Dissertations	9	36.00%
Journal Articles	12	48.00%
ERIC Documents	4	16.00%
Total	25	100.00%

Table 5
Primary Study Duration

Duration	Number	Percentage
One observation	13	57.69%
< 1 week	2	7.69%
1-9 weeks	6	23.08%
9-18 weeks	1	3.85%
Full semester	2	7.69%
Total	25	100.00%

Table 6
Primary Study Focus

Focus of Study	Number	Percentage
WBT/Hypermedia	13	50.00%
Assessment	1	3.85%
Blended	3	11.54%
Distance ed.	1	3.85%
Games	1	3.85%
Simulations	5	23.08%
Unspecified	1	3.85%
Total	25	100.00%

Study Effect Size Data

As reviewed in chapter three, a meta-analysis is based on summarizing the data from several studies into one measure that is more comparable (Glass, 1976) than the series of independent measures taken from primary studies. To calculate this measurement, essentially the differences between the two groups' performances are measured (i.e. the mean score of group one from the mean score of Group 2) and then divided by the variation between the groups (Standard pooled variance or S_p). The standard pooled variance accounts for differences between the two groups that might skew the result. The researcher first subtracts one from the number in each group (i.e. degrees of freedom) and multiplies that by the square of the standard deviation of that

$$\Delta = \frac{\overline{X_T} - \overline{X_C}}{s_P} \qquad s_P = \sqrt{\frac{(n_T - 1)s_T^2 + (n_C - 1)s_C^2}{(n_T - 1) + (n_C - 1)}}$$

group. The results for each group are added together and divided by the sum of the degrees of freedom for each group. Although a thorough explanation of this calculation is described in chapter three, this comparable measure is referred to as an effect size (Δ) and is calculated in this study, where the data allow, as depicted below.

In situations where the data (i.e. mean and standard deviation statistics for both groups) are not completely reported in the primary study, alternate calculations are sometimes implemented. The reader should be reminded however; alternate methods of calculating effect size (Δ) introduce additional error and make accurately generating some dependent statistics impossible. Thus, alternate procedures are generally less preferable than using group means and standard deviations to generate effect size statistic data (Lipsey &Wilson, 2001).

Analysis of Research Question One

How does the student's cognitive style influence their academic performance in computer enhanced learning contexts? To answer this question, Table 7 displays the total of 25 studies and 26 effect sizes that were meta-analyzed. Table 8 displays sample sizes (n), correlation coefficients (r), standard pooled variation (S_p), variances (V), inverse variances (V_i), and, effect sizes (Δ). The criterion (i.e. the unweighted effect size that is not adjusted for overall variance) mean effect-size is for this study is -.70 (Table 8). This indicates that field dependent students' performance is lower than field independent students' performance in computer enhanced educational contexts.

Table 7

Meta-Analytic Results Distribution Description

N	Min ES (Δ)		Max ES (Δ)		Weighted SD	
26	-3.500		.160		1.444	
	Fixed & Random Effects Model					
	Mean ES (Δ)	-95%CI	+95%CI	SE	Z	P
Fixed	-1.6776	-1.6943	-1.6609	.0085	-196.8249	.0000
Random	-.6679	-1.3064	-.0294	.3258	-2.0502	.0403
	Random Effects Variance Component					
	V = 2.514031*					
	Homogeneity of Variance Analysis					
	Q	Df	P			
	28705.8343	25.0000	.0000			

*. Random effects v estimated via non-iterative method of moments.

Table 8

Primary Studies with Key Statistical Measurements

ID	Name	N	R	S_p	V	V_i	ES (Δ)
10	Angeli & Valanides (A)	43	-0.56	0.699820	1.399640	0.714469	-1.36
21	Angeli & Valanides (B)	43	-0.08	0.612990	1.225980	0.815674	-0.16
73	Angeli, Valanides, Kirschner	65	-0.61	0.565410	1.130820	0.884314	-1.52
74	Archer	63	-0.26	3.249200	6.498400	0.153884	-0.53
26	Atasoy, Guyer, & Atasoy	53	-0.2	17.817000	35.634000	0.028063	-0.42
63	Daniels	82	-0.08	1.916300	3.832600	0.260919	-0.17
75	Daniels & Moore	42	-0.13	1.226400	2.452800	0.407697	-0.26
51	Davidson	59	-0.55	3.753600	7.507200	0.133205	-1.32
48	Edmiston	29	-0.47	18.761200	37.522400	0.026651	-1.06
64	Kessler	48	-0.44	0.951079	1.902158	0.525719	-0.99
79	Khine	70	-0.55	2.285400	4.570800	0.218780	-1.31
15	Kim	44	0.03	64.575300	129.150600	0.007743	-0.63
27	Leader & Klein	75	-0.04	3.559340	7.118680	0.140475	-0.83
29	Liu & Reed	32	-0.11	19.280300	38.560600	0.025933	-0.04
28	Luk	51	0.27	11.731000	23.462000	0.042622	-0.39
61	Molina	31	-0.2	0.675190	1.350380	0.740532	-0.41
5	Palmquist & Kim	48	-0.31	64.575300	129.150600	0.007743	-0.66
78	Post	58	-0.43	3.275640	6.551280	0.152642	-0.96
57	Shih	74	-0.01	1.000000	2.000000	0.500000	-0.02
31	Somyürek & Yalin	54	-0.16	19.610000	39.220000	0.025497	-0.32
46	Tang	30	0.08	1.881800	3.763600	0.265703	0.16
52	Umar	75	-0.29	43.530000	87.060000	0.011486	-0.61
25	Umar & Maswan	141	-0.87	1.010000	2.020000	0.495050	-3.5
41	Wang, A.	54	-0.11	0.135830	0.271660	3.681072	-0.22
1	Wang, T.	182	-0.02	17.993000	35.986000	0.027789	-0.41
18	Weller & Repman & Rooze	28	0.07	11.955000	23.910000	0.041824	-0.14
	Average	60.54	-0.23	12.18	24.36	0.4	-0.7

Determining the significance of this effect size requires analyzing the homogeneity of the sample, calculating a *Q*-statistic, and the subsequent selection of the appropriate model of analysis. This process will be discussed in the following section.

Homogeneity Analysis and Practical Significance

Once the mean study effect size has been calculated, the meta-analyst must determine if that effect size has any statistical significance. As discussed in chapter three, the practical significance is determined through the process of fitting an effects model. Selecting the proper model is contingent upon several factors. Of these factors, the Q-statistic represents the beginning of this process. In this sample, Table 7 shows the value of *Q* (28705.8343) exceeds the critical value (3.84 if $p = .05$), indicating that the heterogeneity within the sample is significant ($p < .001$). In simpler terms, the differences among the criterion (i.e. unweighted) effect sizes are greater that can be explained by sampling error. ―In a homogenous distribution, an individual effect size differs from the population mean only by sampling error," thus this sample, by failing the test of homogeneity, requires further analysis (Lipsey & Wilson, p. 115).

To complete the analysis, the meta-analyst next selects an effects model. If the data are homogeneous, a fixed-effects model can be applied to determine the practical significance of the effect size (Δ) because the fixed model assumes that the only difference between the sample and broader population is the random error that occurred in the sampling process of the primary studies (Hedges, & Vevea, 1998). Since the analysis of *Q* prompts this researcher to reject this assumption, an alternate method of analyzing the significance of the effect size is warranted.

Applying a Random Effects Model to the Effect Size Data

With data sets that are not homogeneous, the meta-analyst has the option of fitting a random-effects model. This is appropriate not only when the *Q* suggests heterogeneity exists among the data, but also when the researcher has a theoretical basis from which to assume a fixed effect model is not applicable. In the case of this study, both reasons are true. As previously discussed, the *Q*-statistic does suggest that there are significant variations in the data. In addition, this study postulates that there is an inherent difference among these implementations of educational technology, which implies that the difference in performance of the students sampled may be partially and significantly influenced by the way technology use varies among these studies. This theoretical construct prompts the researcher to expect significant variation and it is advisable to select the more conservative option of applying a random-effects model to the data independent of the analysis of *Q*.

Application of the random-effects model (Table 7) yields a weighted effect size of -.6679, which is significant at the .05 level (p = .0403) and null hypothesis one, indicating that a learner‘s cognitive style will have no significant relationship with their performance in technologically enhanced learning environments, is rejected. The data indicate that, even after the adjustment for statistical error and variance, field dependent students do not perform equally when compared to field independent students in formal learning contexts that are enhanced with technology.

Analysis of Research Question Two

As the levels of integration and implementation increase, what relationship, if any, exists between field dependence and student performance? To answer this question, effect size data (Δ), produced in the first part of this study, which represents the difference in performance between field dependent and field independent students, will be related, then compared to the level of integration ($_t$LoTI), which can be seen in simple terms as a measure of technological magnitude. In order to accomplish this, it is first necessary to measure discriminately the level of integration. This study attempts to do this using $_t$LoTI data. Although a more complete discussion of the measurement $_t$LoTI can be found in chapter three, this next section will describe how these data were collected and subsequent measurements calculated.

Theoretical Level of Technological Integration (tLoTI) Data

Aside from effect size statistics, this study‘s second question required an additional measurement of technological magnitude. In other words, part of this study is concerned with the additional load the technology is placing on the task from the perspective of the learner and if that load changes as field dependence varies. It is not particularly meaningful to measure the student‘s performance at a task without at least considering the nature of the task itself and the effect the relative ease or difficulty that task might have on the performance measured by the assessment. When a colleague says that they ―use a computer to teach," has little real meaning because, as articulated in chapter two, computer usage can mean virtually anything. Measuring technology‘s effect on learning rests on successfully identifying, and describing what the educator will be doing with the technology.

If the reader recalls, also in chapter two, the conceptual evolution of educational technology was explored. Chapter two makes a concise argument that there is very little clarity regarding how educational technology is defined. Further, there is still some question as to how application of that technology should be measured or compared. Scholars (e.g. Clark, 1983; Häkkinen, 2002; Wozney, Venkatesh, & Abrami, 2006; Klemm, 2007) have argued that the technology itself is unlikely to change learning or instruction, and empirical research (e.g. Rutherford & Lloyd, 2001; Rau, Gao, Wu, 2008) in the field has upheld this point of view. In fact, even in studies (e.g. Basturk, 2005) that do find statistical significance between control and treatment groups' performance in computer-enhanced contexts, the difference, so this study hypothesizes, can be partially accounted for by examining the way the technology is applied. Thus one fundamental problem in this study is that asking a meaningful question regarding the effectiveness of educational technology is predicated upon the ability to define it and, subsequently, understand its application.

Table 9

Theoretical Level of Technological Integration Ratings

Study ID	Author	Year	N	Rater 1	Rater 2	Rater 3	Mean	SD
10	Angeli & Valanides (A)	2004	43	12	10	8	10	2
21	Angeli & Valanides (B)	2004	43	12	10	8	10	2
73	Angeli, Valanides, Kirschner	2009	65	12	10	10	10.67	1.15
74	Archer	2005	63	12	12	6	10	3.46
26	Atasoy, Guyer, & Atasoy	2008	53	8	9	12	9.67	2.08
63	Daniels	1996	42	8	9	12	9.67	2.08
75	Daniels & Moore	2000	82	2	15	8	8.33	6.51
51	Davidson	2000	59	12	6	12	10	3.46
48	Edmiston	2001	29	8	6	8	7.33	1.15
64	Kessler	1995	48	3	4	3	3.33	0.58
79	Khine	1996	70	6	6	6	6	0
15	Kim	2001	44	9	12	12	11	1.73
27	Leader & Klein	1996	75	6	3	8	5.67	2.52
29	Liu & Reed	1994	32	5	6	9	6.67	2.08
28	Luk	1998	51	6	12	8	8.67	3.06
61	Molina	1997	31	6	8	12	8.67	3.06
5	Palmquist & Kim	2000	48	12	6	15	11	4.58
78	Post	1987	58	6	10	10	8.67	2.31
57	Shih	1998	74	2	4	8	4.67	3.06
31	Somyürek & Yalin	2007	54	3	4	6	4.33	1.53
46	Tang	2003	30	2	4	4	3.33	1.15
25	Umar & Maswan	2007	141	18	12	15	15	3
52	Umar	1999	75	6	12	5	7.67	3.79
41	Wang, A.	2008	54	2	4	6	4	2
1	Wang, T	2007	182	4	6	8	6	2
18	Weller, & Repman, & Rooze	1994	28	6	14	12	10.67	4.16
Mean averages			60.54	7.23	8.23	8.88	8.12	2.48

Research on the topic (Rakes, Fields & Cox, 2006; Moersch, 2004) is now beginning to examine the problem of defining, not just what technology means, but understanding how it is used in classrooms. The second question of the project serves as a platform to continue this work on the discrete measurement of technological implementation and integration.

Due to the nature of this project, it is simply not possible to collect additional data regarding the level of implementation for each study in this database. Therefore, it was necessary to develop a theoretical extrapolation of Moersch's Level of Technological Implementation (LoTI) index. As described in chapter three, this synthesis produced the coding sheet (Appendix A) that was applied to each study and used by this researcher to calculate the theoretical LoTI, or $_t$LoTI. To help control bias, two additional educators with expertise in educational technology also coded each study in the database. The average $_t$LoTI scores, which ranged from 0 (representing no integration) to 18 (representing the highest level of integration), for each primary study were included in this meta-analysis. Table 9 reports the authors of the primary study, sample size (M = 61), the $_t$LoTI scores by each of the three experts, the mean $_t$LoTI scores and standard deviations (M = 8.12, 2.48).

$_t$LoTI and Effect Size Correlations

The $_t$LoTI scale ranges from zero, representing no integration, to eighteen, representing the highest theoretical level of integration. Results of $_t$LoTI data were correlated with effect size (Δ) data and non-parametric results ($r(24) = -.388$, $p = .05$) indicate a significant negative correlation between these variables (Table 10). To be diligent, this researcher analyzed these data parametrically as well. The Pearson product movement ($r(24) = -550$, $p = .004$) also indicates a significant negative correlation between the level of implementation ($_t$LoTI) and performance (Δ) for field dependent students. In a more practical sense, these data suggest that, as technology is more deeply integrated, field dependent students' performance fell significantly

Table 10

Non-Parametric Correlation Results

			Mean $_{t}$LoTI	ES (Δ)
Spearman's rho	Mean $_{t}$LoTI	Correlation Coefficient	1.000	-.388*
		Sig. (2-tailed)	.	.05
		N	26	26

*. Correlation is significant at the 0.05 level (2-tailed).

Table 11

Parametric Correlation Results

		Mean $_{t}$LoTI	ES (Δ)
Mean $_{t}$LoTI	Pearson Correlation	1	-.5
	Sig. (2-tailed)		.
	N	26	

*. Correlation is significant at the 0.05 level (2-tailed).

. This analysis of the relationship between of effect size (Δ) and $_{t}$LoTI is problematic in two ways. First, $_{t}$LoTI data, as described in chapter three, appear to this researcher to be interval and, aside from the cases whose ratings are highly varied among the raters, normally distributed. Realistically, there is no way to arrive at these conclusions an objective, scientific way. The $_{t}$LoTI measurement represents movement from behavioral to socially constructed applications of technology; from dialogical to integrated technology; and from no student usage toward infinite time usage. These three characteristics, (i.e. theoretical basis, integration level, and exposure time) comprise this data set. The assumption is that these data are continuous across intervals. For instance, it appears logical to conclude that 30 minutes of computer use is less than 60 minutes. Weather or not the 60 minute session represent a greater effect, either positive or negative, on mean field dependent student performance when compared to the 30 minute session is not as clear. Similarly, the study hypothesizes that behavioral applications of technology (e.g. drill and practice computer software) are less taxing on field dependent students than constructed or socially constructed applications of technology (e.g. simulations or blogs).

Objectively, this researcher need remain open to the possibility that data on any one of these three axes may be nominal or ordinal. This fact creates additional complications for statistical analysis because, according to Harwell (1988), the use of parametric statistics requires certain conditions to be met (e.g. normally distributed, interval data). Because of these questions, it was not clear if the $_t$LoTI data violated one or more of the basic assumptions. As a result, both parametric and non-parametric correlation tests were conducted. All analyses indicate a significant relationship between these variables and the subsequent analyses, both parametric and non-parametric, indicate that student performance falls as the level of integration increases.

The second problem with the analysis of the relationship between of effect size (Δ) and $_t$LoTI data is that there was a question about the variance within the $_t$LoTI variable itself, evidenced by distribution of standard deviations. Presumably, because some cases methodologies (e.g. studies 5 & 75 as listed in Table 9) were more difficult to describe for the raters, there were very high (more than two standard deviations) variations in those data.

Much of this study's validity hinges upon the researchers ability to measure, successfully and discretely, the differences in how technologies are used among these primary studies. The mean $_t$LoTI score represents the average level of computer implementation as evaluated by three independent assessors. The average standard deviation of the $_t$LoTI data is 2.48. Evidenced by high standard deviations, some of the primary studies presented particular challenge for the raters to measure reliably (e.g.

Daniels & Moore, 2000; Palmquist & Kim, 2000). Due diligence requires that this variation receive additional analysis.

To observe this factor more closely, a correlational analysis was completed with data sets excluding the cases with the highest levels of variance (i.e. cases that were greater than two standard deviations from the mean, or cases where SD > 4). The data still indicate a significant inverse correlation between effect size (Δ) and $_t$LoTI ($r(22) = -.506$, $p = .014$) as exhibited in Table 12 and the second null hypothesis suggesting that, as the level of technological integration increases, the role cognitive style plays in student learning will have no significant relationship with the learner's performance, is rejected.

Table 12

Non-Parametric Correlation Results Excluding Cases with Low Levels of Inter-rater Reliability

			ES	$_t$LoTI
Spearman's rho	Effect Size (Δ)	Correlation Coefficient	1.000	-.506*
		Sig. (2-tailed)	.	.014
		N	24	24

*. Correlation is significant at the 0.05 level (2-tailed).

Isolating the Significant Effect Within the Broad Spectrum of Integration

Since the rejection of the second hypothesis indicates there is a negative relationship between field dependent student performance and the level of integration, a new question regarding this correlation within the spectrum of technology integration emerges. In order to more effectively identify performance trends relative to the students' field dependence, $_t$LoTI data were re-coded into three levels based on the standard deviation to create a low level (Mean $_t$LoTI = 0 - 4.99), intermediate level (Mean $_t$LoTI = 5 -10.99), and a high level (Mean $_t$LoTI = 11 -18) of technological integration. These somewhat arbitrary categories were selected where data clustered at natural data break points as illustrated in Figure 2.

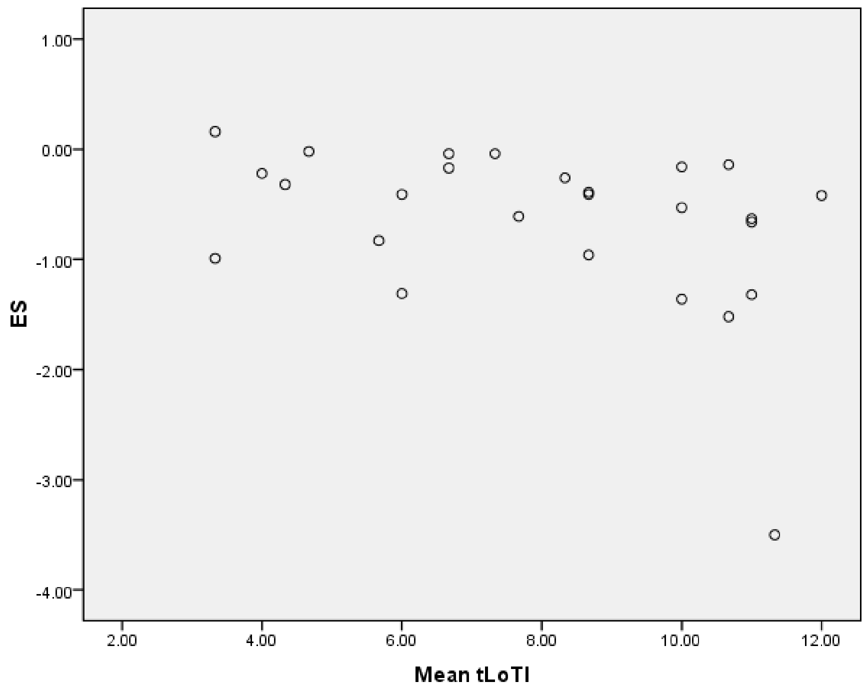

Figure 2. Scatter plot diagram of effect size (Δ) and $_{t}$LoTI with all studies included.

The re-coded $_{t}$LoTI data were compared to performance data using a one way ANOVA. Results of the one way Analysis of Variance (Table 13) indicate that there is a significant interaction between the level of integration and field dependent student performance ($F(2, 23) = 3.771$, $p = .038$). To ascertain the levels of significant interactions, the Fisher Least Significant Difference (LSD) post-hoc analysis reveals no significant interaction between performances at low (M = -.27, SD = .43) and intermediate (M = -.66, SD = .48) levels of integration. The post-hoc analysis does indicate signfificantly different performance between the lowest and highest levels (M = -1.59, SD = 1.64) as well as significant differences between the intermediate level and highest levels of integration (Table 14). More practically, field dependent performance is the same as field independent student performance at the lowest levels of integration. As the level of integration reaches the intermediate point, field dependent performance drops off slightly, although the difference is not statistically significant. Finally, as the level of integration increases to the highest levels, the gap between field dependent students' perfomance is largest and most significant compared to field independent students (Figure 3).

Table 13

Analysis of Variance between Δ and $_t$LoTI Levels

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.329	2	1.665	3.771	.038*
Within Groups	10.151	23	.441		
Total	13.480	25			

Table 14

Post Hoc Analysis among the Three Levels of Technology Integration
Dependent Variable: Effect Size (Δ)

	(I) $_t$LoTIlevel	(J) $_t$LoTIlevel	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	1.00	2.00	.38311	.33585	.266	-.3116	1.0779
		3.00	1.31867*	.48517	.012	.3150	2.3223
	2.00	1.00	-.38311	.33585	.266	-1.0779	.3116
		3.00	.93556*	.41430	.034	.0785	1.7926
	3.00	1.00	-1.31867*	.48517	.012	-2.3223	-.3150
		2.00	-.93556*	.41430	.034	-1.7926	-.0785

*. The mean difference is significant at the 0.05 level.

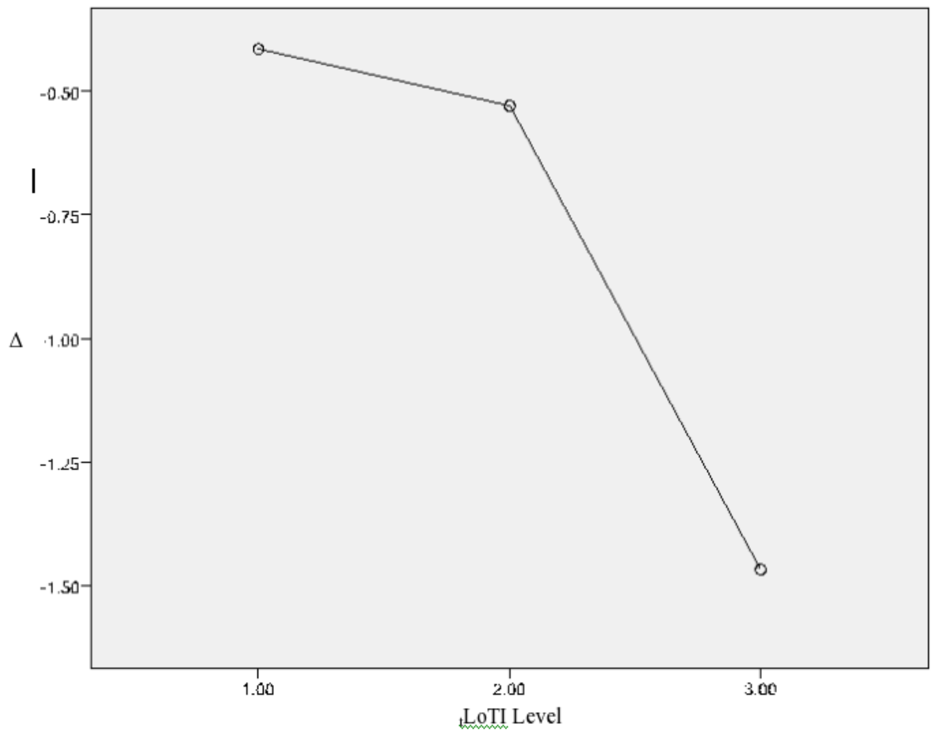

Figure 3. Line graph illustrating performance differences of field dependent students in low, intermediate and high levels of integration.

Summary

The purpose of this chapter was to first discover how the student's cognitive style influences their academic performance in computer enhanced learning contexts and then to examine what relationship, if any, exists between student performance and the level of integration.

Data suggest that field dependence and computer enhanced learning contexts are negatively correlated. Students who are field dependent struggle disproportionately compared to field independent students.

Data also suggest that student performance and the level of technological integration are negatively correlated. When the primary studies are grouped by their magnitude, or respective level of integration, overall student performance diminished as the magnitude increased. This indicates that classrooms that have higher levels of integration produce lower performance on the part of the students in these classrooms.

In addition, as the level of technological integration increases from moderate to higher levels, student performance falls significantly. The data show that mean performance is significantly lower at high levels of integration compared to mean performance at low levels of integration.

CHAPTER FIVE

CONCLUSION

As stated in chapter one, the problem posed in this study was that, although research has been conducted regarding performance differences between field dependent and field independent students in integrated contexts, that research fails clearly to explain what is happening to these different learners in these computer-enhanced learning contexts. Some studies, for instance, identified performance advantages for field independent students (e.g. Lau, & Yuen, 2009; Cameron, & Dwyer, 2005; Price, 2004) while other studies failed to identify significant differences between these groups (e.g. Hodges, Stackpole-Hodges, & Cox, 2008; Akdemir, & Koszalka, 2004; DeTure, 2004). This study is purposed at better understanding why these data are so seemingly contradictory.

In chapter two, the use of educatonal technology was examined historically and the foundation for the problem in this study, the effect of a fixed learning environment has on the learner as a result of immutable human characteristics like cognitive style, was introduced. Chapter two also introduced the notion that the role of integration, referred to in this study as the theoretical level of technological integration ($_t$LoTI), may play a significant role in formal learning situations.

In chapter three the research methodology that would be used to analyze the problem and respond to the questions posed by this study was described. This chapter also restated the research hypotheses and relevant statistical analyses.

In the chapter four, this researcher reviewed the method and described both the data and data collection processes. Subsequently, chapter four presented the analysis of the effect size data and $_t$LoTI data.

The purpose of chapter five is to interpret the data presented in chapter four and to draw conclusions from that data where possible. It will include discussions of both research questions, a discussion of both the overall and practical implications and shall conclude with the limitations and suggestions for future research.

Discussion of Research Question One

The first research question examined the extent to which a student's cognitive style influences his or her academic performance in computer enhanced learning contexts. This study pooled data from other primary studies and synthesized those data into an effect-size measurement as described in chapter three. Mean performance of students, grouped by their cognitive style, were compared by this effect size statistic and then analyzed for practical significance through a random-effects model as described in chapter four. Application of the random-effects model produced a weighted effect size of -.6679, which is significant at the .05 level ($p = .0403$) indicating that, field independent students significantly outperform field dependent students in classrooms enhanced with technology.

Extrapolating knowledge from this information is an intricate process because, at the core of any analysis of data such as these, there is the fundamental question of meaning. As described in chapter three, the cognitive styles of the subjects sampled in each of the primary studies included in this meta-analysis were measured using Witkin‘s (1950) Group Embedded Figures Test (GEFT). What these measurements actually mean has been a point of contention for quite some time. McKenna (1990) argues that there can be little doubt that there is a relationship between performance on a variety of embedded images tests and … [student] ability" (p. 434). McKenna's point is that most cognitive style tests are indirectly measuring intelligence concurrently with field dependence. Even more simply, McKenna contends that field dependent students score lower on intelligence tests than field independent students. If this argument is true, then to say that field dependent students perform poorly relative to field independent students could simply be attributable to the fact that they are not smart as their field independent counterparts. Kirton (1976) makes similar criticisms of embedded image based psychometric assessments like the GEFT, both of which have rather strong implications on this study's findings if they are correct.

In response to the criticisms of the GEFT, data suggest that student performance is normally distributed in most instances. For instance, Witkin (1977) contends that, while this apparent correlation between cognitive style and intelligence may be valid in certain, narrow contexts (e.g. mathematics), it is not true when one looks at broader measurements (e.g. general knowledge tests), particularly ones that are norm referenced. Moreover, as sample size increases, this propensity for student performance data to hinge on intelligence, however the reader opts to define and measure it, becomes less significant. This study is concerned with a broad range of measurements (i.e. many subjects, ages, grades, etc.) and is based on a rather large sample, this researcher is prompted to consider these criticisms as rather minor threats to the validity of this study.

In the end, if the reader accepts Witkin's argument concerning the viability of GEFT data, educators are faced with the realization that using technology without first considering the basis for that choice may have rather serious consequences for the field dependent learners. Consider that with the exception of one case in this database (Tang, 2003), field dependent learners consistently performed lower than field independent learners in classrooms that use technology. This basic perspective can be seen with just a passing glance at the study effect sizes (Table 15) as the negative effect size indicates lower mean performance for field dependents students.

Table 15
Primary Study Effect Sizes, Statistical Significance, and Direction of Results

Author	**ES**	**Significant findings**	**Results Favor**
Tang, H.	0.16	Yes	FD
Angeli C. & Valanides N. (B)	-0.02	Yes	FI
Archer, L	-0.14	Yes	FI
Atasoy, S., Guyer, T., & Atasoy B.	-0.16	Yes	FI
Davidson, Conda Irene	-0.26	Yes	FI
Edmiston, Linda L.	-0.32	Yes	FI
Khine, M	-0.41	Yes	FI
Leader L. & Klein J.	-0.42	Yes	FI
Liu, M. & Reed, M.	-0.53	Yes	FI
Luk, S.	-0.61	Yes	FI
Molina, Laurie E. S.	-0.63	Yes	FI
Palmquist, R, & Kim, K.	-0.66	Yes	FI
Post, P.	-0.83	Yes	FI
Umar, I & Maswan, S	-1.06	Yes	FI
Wang, A.	-1.32	Yes	FI
Wang, T	-1.52	Yes	FI
Angeli, Valanides, Kirschner	-0.04	No	FI
Daniels & Moore	-0.17	No	FI
Daniels, Harold Lee	-0.22	No	FI
Kessler, Rohn	-0.39	No	FI
Shih, Ching-Chun	-0.96	No	FI
Somyürek, S., & Yalin, H.	-0.99	No	FI
Umar, Irfan Naufal	-1.31	No	FI
Weller, H., & Repman, J, & Rooze, G.	-3.5	No	FI

A more specific analysis of these data requires an interpretation of the study's weighted effect size as presented in chapter four (Table 7). There are multiple approaches in understanding the meaning of effect size data. Glass (1981) cautions against the assignment of arbitrary or nominal labels for effect size analyses. ―After decades of confusion, researchers are finally ceasing to speak of regions of the correlation coefficient scale as low, medium and high. The same error should not be repeated in the case of the effect-size metric" (p. 104). A preferred way of analyzing this effect is to consider how that effect size translates into an impact on the subjects, given the fact that many researchers see effect size analysis as content specific and highly interpretive (Vasquez, Gangstead, Kay, & Henson, 2000). In this case, analysis of the effect size (-.67) and average standard pooled variance (11.77) indicate that, in a course using highly integrated technology, field dependent students can be expected to learn roughly eight percent (11.77*.67) less as much as field independent students. In a more practical sense, if there is a collection of 100 vocabulary words to learn using integrated technology, while the average field independent student learns a mean of 75 of them, the average field dependent student learns only a mean of 67 words. On a typical grade scale, this would result in nearly an entire grade level difference (i.e. the field dependent student earns a D to the field independent student's C). Also consider the total loss in growth over a semester or an entire year if the field dependent student loses ground at this rate.

Although this is a crude example, it does illustrate how dramatic the cumulative effect over an undergraduate career of the field dependent student could be, for instance. In simplest terms, although field dependent students can learn in these integrated classrooms, they do so at a significant proportional disadvantage.

Discussion of Research Question Two

The second research question of this study examined the relationship between student performance and the levels of integration and implementation. To answer this question, effect size data were related, and then compared with measurements of technology integration. Data presented in Chapter four indicate that the relationship ($r(24) = -.388$, p = .05) between field dependent students‘ performances (Δ) and technology integration ($_{t}$LoTI) are significantly inversely correlated (Table 11). This suggests that as teachers increase their levels of integration, field dependent students are more likely to experience disproportional levels of difficulty.

The comparison of means suggests three distinct points. First, the results from the ANOVA ($F(2, 23) = 3.771$, $p = .038$) reinforces findings from relational analyses that show a negative relationship between the two variables. Secondly, post-hoc analysis suggests that the differences in mean scores between low (M = -.27, SD = .43) and intermediate (M = -.66, SD = .48) levels of technological integration are not significant. Finally, the post-hoc analysis suggests that the highest levels of integration are most problematic for the field dependent learner. Dabbagh (2007) suggests that there are the key human characteristics that are consistent with field dependency (e.g. social orientation and external locus of control). The analysis of the data in this study indicates that these human characteristics appear to be somewhat at odds with pedagogy centered upon educational technology. Given this point of view, it seems plausible that students‘ performance should suffer in these contexts, but remained largely unidentified by research. This trend remains hidden until the connection is made between performance, technology, and level of integration. The post-hoc analysis of these data also suggests that (Figure 4), as the level of integration reaches the highest levels, the performance falls significantly for field dependent learners.

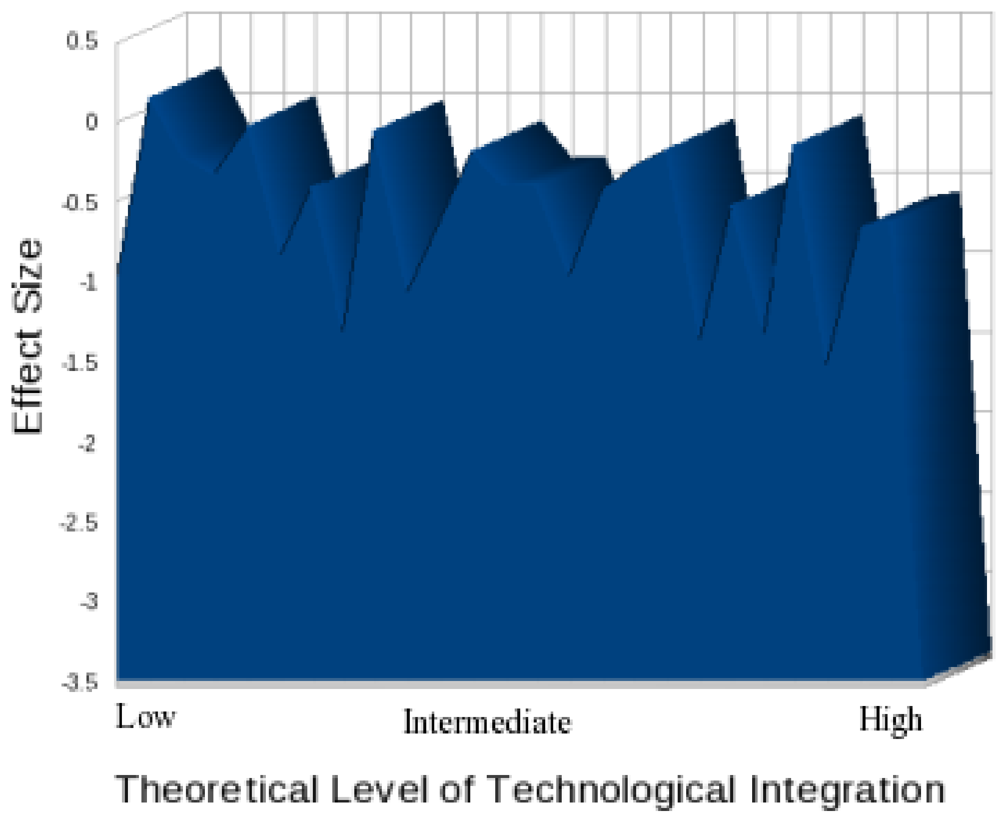

Figure 4. Graph illustrating the relationship between effect size and level of integration.

Overall Implications

The general impression about these data is that student performance, particularly students who are more field dependent, tends to be inversely correlated with technological integration. This means that ass field dependent learners are exposed to increasingly higher levels of technological integration, performance is more likely to abate significantly. Interestingly, this tendency seems to be less likely as the integration moves from lower levels of integration (i.e. $_{t}$LoTI < 4) toward the more moderate levels of integration (i.e. $_{t}$LoTI < 11). Hite (2004) suggests that this may be partially due to the field dependent learners‘ ability more effectively to use social interaction as a learning support tool. Hite's observation does seem to correspond somewhat with the data reported in this study, given that applications of educational technology that use social constructivism as a theoretical basis for the implementation will score a higher ${}_{t}$LoTI measurement. Classes such as these might entail the use of socially constructed learning activities as a supplement to highly integrated contexts (e.g. distance learning) with field dependent students may merit exploration on the part of educators. For instance, the use of real time video chat, may very well diminish the measured effect of these learning contexts for field dependent students.

Practical Implications

If the reader recalls, this study is based in an historical view of applied educational technology. In chapter two, this dissertation examined recent educational reform. Those movements derived from the political ramifications of the *A nation at risk* (National Commission on Excellence in Education, 1983) report, initiated the need for accountability and improvement in schools. Technology, an integral part of this commission's recommendations, has been by many seen as a tool for improvement, in spite of the fact that the term still eludes concise description. Analysis of these data suggests that allowing for appropriate application of this technology is a critical pre-requisite step. The practical value of this step will be discussed in the following section.

Recommendations for Practice

At first sight, educators may be initially isolated from the real-world application of this study's findings. After all, a research report describing the results strictly in terms of field dependent performance lag might seem a bit pedantic to a high school science teacher, for example. The reader should consider who these field dependent students tend to be in the larger scheme.

Certain groups of people tend to be more likely to develop higher degrees of field dependence than other groups. African-American people, for instance, are more likely to develop higher levels of field dependency (Hall, 2003). Similarly, Witkin's original research (1950) indicates that females have more difficulty and score significantly lower on Group Embedded Figures Tests (GEFT) tests than males do. Recent research confirms that these trends are still occurring, at least in Western cultures (Guillot, Champely, Batier, Thiriet, & Collet, 2007). This indicates that both African-Americans and women are much more likely to be field dependent.

So, from the perspective of the practitioner, this means that in highly technologically integrated learning classrooms, African-American and female students are struggling to learn when compared to other students. Consequently, classrooms that are dominated by these students may not lend themselves to higher levels of integrated technology. Finally, if choice is made to apply educational technology, lower levels of integration are less likely to contribute to higher attrition among these students.

Glass (1981) also makes the point that the interpretation and application of the effect size should not be considered independent of the cost of the benefit. For example, if this study found that there was a treatment effect of integrated technology of -.01 for field dependent students and a variance of four, the question of cost would be the marginal gain of the treatment for field independent students minus the loss of the field dependent students (.04 of a semester's learning). In this hypothetical case, it becomes more an argument about the cost in integrating technology (e.g. teacher training, hardware, software, technology support, etc) in the face of a treatment effect of less than a half percent a year's growth benefit.

Since the data of this meta-analysis suggest the cost of integrating technology is significant for field dependent students, the question now becomes if that if the benefit to cost ratio is significant enough to persuade policy makers to endure the expense of changing the schooling process in a way that reduces this effect on field dependent learners. Although this question exceeds the scope of this study, it is logical to postulate that educational technology may be a viable avenue to help field independent students excel. The self-sufficient nature of this learner may lend itself to distance learning experiences that alienate, isolate, and frustrate field dependent students, therefore should probably not be abandoned as a viable instructional strategy. Analyses of these data also suggest that educators may wish to consider a careful examination of specific characteristics when planning to implement technology into existing curricula or building new curricula around educational technology.

Limitations

The argument has been made that measuring cognitive style independently of cognitive ability is difficult (Kirton, Bailey, & Glendinning, 1991), but critical if one hopes to truly understand how using computer technology affects the learning process among students. Since this study is meta-analytical, this researcher did not have an opportunity to measure the cognitive style of the participants, therefore any implications gleaned from analysis of this data may not completely reflect this important caveat. To make the comparisons more direct, primary studies selected for this meta-analysis measured cognitive style using Witkin's (1950) model, or derivatives. Although other researchers (e.g. Slemmer, 2002) have successfully synthesized data on this topic without concern for the type of cognitive style assessment used, this study was developed with a more conservative approach to this particular problem.

Limitations in Calculating the Theoretical Level of Technological Integration ($_t$LoTI)

The concept of educational technology is certainly nothing new; however considering the various effects of its application offers promising new opportunities for researchers and theoreticians. The way educational technology is used in the classroom plays a critical role in student performance (Rakes, Fields, & Cox, 2006; Moersch, 2004). The data presented in this meta-analysis suggest that increases in $_t$LoTI are related to disproportionately low performance for field dependent learners. Although this conclusion is based on significant results from robust statistical models, the data are not beyond scrutiny themselves.

As described in chapter three, the $_t$LoTI data were calculated through an analysis of the primary study's methodology. In some cases, information regarding how the technology was used is clear while in others, it is quite ambiguous. In order to control bias in these data, three experts scored each primary study using the coding form developed for this analysis (see appendix A). The $_t$LoTI data were calculated from the mean of those data and, although this process did limit bias to some degree, the question of accuracy cannot be escaped.

A far better solution would have been to collect the LoTI data concurrently with cognitive style and performance data. Since this study was meta-analytic, this option was not available, but should be considered for any future research on this topic.

Failsafe N Calculation

As introduced in chapter three, publication-bias is defined as the journal editor‘s propensity to publish studies that find statistical significance over those that do not. When the meta-analyst collects primary studies, there is a greater probability of locating studies with significant findings due to this bias. The failsafe N calculation represents the number of studies with non-significant findings it would take to change the results of the meta-analysis from significance to non-significance or vice versa. This statistic is calculated with the procedures and equations provided in chapter three.

Using this method, two additional studies with non-significant results would change the findings of significance in this meta-analysis. Some (e.g. McDaniel, Rothotein, & Whetz, 2006) contend that a very conservative failsafe statistic, if multiplied by five then increased by ten, should be less than the number of included primary studies. This ratio ―would indicate that the meta-analytic results were robust to the threat of publication bias" (p. 940). Chapter three framed a discussion regarding education‘s resistance to publication bias. Given the ways educational research differs from other fields, this ratio might be unnecessarily conservative. Lipsey and Wilson (2001) suggest that more practical application of this statistic involves examining the differences between the criterion effect size and the weighted effect size, which, in the case of this study, are relatively close together. Given that a fairly systematic and thorough search for relevant research yielded only 25 primary studies at the time of publication, the likelihood that more than two educational studies showing statistical non-significance are sitting ―in the file drawer" is relatively low in the estimation of this researcher; however the reader can attribute to this whatever significance would seem most appropriate. Coupling the results of the failsafe calculation with the absence of extensive exclusion criteria, this researcher has confidence that appropriate steps have been taken to improve the internal validity of this meta-analysis.

Suggestions for Future Research

Since a major limitation of this study is the way in which the level of technological implementation was calculated, future research could seek to reduce the impact of this problem. Given the present availability of technology, web based portals could be used to collect relevant data (e.g. demographic, cognitive style, learning style, performance, and LoTI) from any number of classes and locations simultaneously. With more accurate measurements of LoTI and much larger sample sizes, a better understanding of the implications of various educational technologies applications is possible.

A simulation could be constructed that tested an individual‘s ability to understand what is actually happening in a virtual environment. The test might determine if the subject could differentiate between web pages that were being viewed locally or remotely, for example. This simulation could be used to acquire data that could first be compared to existing student performance data on this subject and ultimately aid in constructing a model that could then predict, using nothing more than cognitive style data, an individual‘s propensity to learn successfully in various computer-enhanced learning contexts.

Much of the research analyzed for this meta-analysis focused on the topic of web-based instruction. Although measuring this application of educational technology is relatively straight forward, it is not necessarily indicative of what is most often used in the classroom today. Research should be conducted, at university as well as basic education, to determine which educational technologies are being applied, the extent of that application, and the theoretical basis that drives those applications. Any knowledge on these topics will help understand more completely what the research actually means in a practical way.

Finally, although the data do seem to indicate that certain applications of educational technology are not suited to certain kinds of learners. This study is not purposed to explain why exactly this appears to be the case. Certainly, there are theoretical models that can be applied to this problem. For instance, researchers are drawing connections between cognitive load hypothesis and the non-verbal cues used by learners to understand what is happening in the classroom (La France, Heisel, & Beatty, 2007). This notion of cognitive load hypothesis suggests the additional, quite provocative possibility that the performance disadvantage for field dependent students implied in these data may be contextual and not necessarily a function of the technology itself. In simpler terms, Van Merriënboer, & Sweller, (2005) find that certain aspects of the learning context can increase the cognitive load students feel, thus increasing frustration levels and contributing to poor academic performance. These factors are referred to as extrinsic loads as they exist externally to the learning task itself. Certainly, particularly for field dependent students, technology can increase these extrinsic loads. If these assumptions are correct, then any increase in extrinsic load may be contributing to the performance differences suggested in these data. Additional research in this area may help to further explain why certain groups of students are not responding to technological learning solutions.

Summary

This meta-analysis examined at a sample of research reports conducted over the last two decades in hopes of better understanding why certain students seem to perform well while others struggle to learn effectively using educational technology. The data suggest at least part of the problem is that educators need look to more qualitatively at how the technology is being integrated into curriculum and instruction.

Much of the data reviewed for this meta-analysis indicated that field independent students significantly outperformed their field dependent counterparts on criterion-referenced assessments (e.g. Cameron, & Dwyer, 2005). The data do not support the conclusion that the differences are a direct result of the educational technology. In fact, as previously discussed in this chapter, the use of technology is not a key factor in and of itself. Although the factors that are involved in learning are numerous, these data prompt educators to take a closer look at how we assess student learning and how we tailor instruction for those learners. This study provides evidence that certain kinds of learners are placed at a disadvantage because of the way they process information. More style research may lead to breakthroughs in how and why other kinds of students are performing well and allow educators to improve instruction for all learners.

Perhaps now, that the novelty of educational technology has subsided somewhat, educators will begin to really consider the costs of utilizing technology in the classroom. It may be advisable for the students who are benefiting from the use of these technologies to continue to receive these forms of instruction. This study provides evidence that cognitive style does play a significant role in learning when educational technology becomes an embedded part of the curriculum and instruction. For the students who do not fair well in these contexts, sagacious educators may well reconsider their pedagogies.

REFERENCES

References marked with an asterisks indicate studies that were included in the meta-analysis.

Adams, D. (2006). Wireless laptops in the classroom (and the Sesame Street syndrome). *Communications of the ACM(49)*9, 25-27.

Aivazidis, C., Lazaridou, M., & Hellden, G. (2006). A comparison between a traditional and an online environmental educational program. *Journal of Environmental Education, 37*(4), 45-54.

Akdemir, O., & Koszalka, T. (2008). Investigating the relationships among instructional strategies and learning styles in online environments. *Computers & Education, 50*(4), 1451-1461.

Allen, L. (2008). The technology implications of a nation at risk. *Phi Delta Kappan*, *89*(8), 608-610.

Allport, G.W. (1937) *Personality: A Psychological Interpretation*. Holt & Co. New York.

*Angeli, C., & Valanides, N. (2004). Examining the effects of text-only and text and-visual instructional materials on the achievement of field-dependent and field-independent learners during problem-solving with modeling software. *Educational Technology Research & Development, 52*(4), 23-36.

*Angeli, C., Valanides, N., & Kirschner, P. (2009). Field dependence & independence and instructional-design effects on learners‘ performance with a computer-modeling tool. *Computers in Human Behavior, 25*(6), 1355-1366.

Apple, M. (1992). Computers in schools: Salvation or social disaster?. *Education Digest*, *57*(6), 47.

*Archer, L. (2005). *The interactive effects of field dependence-independence and instructional aids on student achievement in web-based instructional systems* (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3139648)

*Atasoy, S., Guyer, T., & Atasoy, B. (2008). The effects of individual differences on learner's navigation in a courseware. *Turkish Online Journal of Educational Technology, 7*(2), 32-40.

Bangert-Drowns, R. (1986). Review of developments in meta-analytic method. *Psychological Bulletin, 99*(3), 388-399.

Barak, M., Lipson, A., & Lerman, S. (2006). Wireless laptops as means for promoting active learning in large lecture halls. *Journal of Research on Technology in Education*, *38*(3), 245-263.

Basturk, R. (2005). The effectiveness of computer-assisted instruction in teaching introductory statistics. *Journal of Educational Technology & Society 8*(2), p. 170-178.

Bayrak, B., Kanli, U., & Kandıl İngeç, Ş. (2007). To compare the effects of computer based learning and the laboratory based learning on students' achievement regarding electric circuits. *Turkish Online Journal of Educational Technology, 6*(2), 15-24.

Beers, P., Boshuizen, H., Kirschner, P., Gijselaers, W., & Westendorp, J. (2008). Cognitive load measurements and stimulated recall interviews for studying the effects of information and communications technology. *Educational Technology Research & Development, 56*(3), 309-328.

Beglau, M. (2005). Can technology narrow the Black-White achievement gap?. *T H E Journal, 32*(12), 13-17.

Borek, J. (2008). A nation at risk at 25. *Phi Delta Kappan, 89*(8), 572-574.

Brodie, J. (2008). Experts: Data often not in tune with real world. *Education Daily, 41*(93), 3.

Burt, C. (1945). Personality, a symposium. I. The assessment of personality. *British Journal of Educational Psychology*, 15, 107-121.

Bösch, H., Steinkamp, F., & Boller, E. (2006). In the eye of the beholder: Reply to Wilson and Shadish (2006) and Radin, Nelson, Dobyns, and Houtkooper (2006). *Psychological Bulletin, 132*(4), 533-537.

Cameron, B., & Dwyer, F. (2005). The effect of online gaming, cognition and feedback type in facilitating delayed achievement of different learning objectives. *Journal of Interactive Learning Research, 16*(3), 243-58.

Carneiro, R. (2006). Motivating school teachers to learn: Can ICT add value. *European Journal of Education, 41*(3/4), 415-435.

Ceruzzi, P. (1999). *A History of Modern Computing*. The MIT Press: Cambridge, Massachusetts, London.

Chang, Y., Mullen, L., & Stuve, M. (2005). Are PDAs pedagogically feasible for young children? Examining the age-appropriateness of handhelds in a kindergarten classroom. *T.H.E. Journal, 32*(8), 40-42.

Chomsky, N. (1959) ―Verbal behavior review." In *Language.* In Munger, M. (Ed.), *The history of psychology: Fundamental questions* (pp. 408-430). New York: Oxford University Press.

Clark, R. (1983). Reconsidering research on learning from media. *Review of Educational Research, 53*(4), 445-459.

Clark, R., & Choi, S. (2007). The questionable benefits of pedagogical agents: Response to Veletsianos. *Journal of Educational Computing Research*, *36*(4), 379-381.

Cohen, J. (1998). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings*. Boston, MA: Houghton Mifflin.

Cooper, H. M. (1979). Statistically combining independent studies: A meta-analysis of sex differences in conformity research. *Journal of Personality and Social Psychology, 37*(1), 131–146.

Cooper, J. (2006). The digital divide: The special case of gender. *Journal of Computer Assisted Learning, 22*(5), 320-334.

Crisan, C., Lerman, S., & Winbourne, P. (2007). Mathematics and ICT: A framework for conceptualising secondary school mathematics teachers' classroom practices. *Technology, Pedagogy & Education*, *16*(1), 21-39.

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

Curry, L. (1983). *An organization of learning styles theory and constructs*. Retrieved from ERIC database. (ED235185)

Dabbagh, N. (2007). The online learner: Characteristics and pedagogical implications. *Contemporary Issues in Technology & Teacher Education*, *7*(3), 217-226.

D'Angelo, J., & Wooley, S. (2007). Technology in the classroom: Friend or foe. *Education*, *127*(4), 462-471.

*Daniels, H. L., & Moore, D. (2000). Interaction of cognitive style and learner control in a hypermedia environment. *International Journal Of Instructional Media, 27*(4), 369-383.

*Daniels, H. L. (1996). *Interaction of cognitive style and learner control of presentation mode in a hypermedia environment* (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 9704784)

*Davidson, C. (2000). *Comparative analysis of teaching methods and learning styles in a high school computer spreadsheet unit*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 9974620)

de Grauwe, A. (2005). Improving the quality of education through school-based management: Learning from international experiences. *International Review of Education*, *51*(4), 269-287.

DeTure, M. (2004). Cognitive style and self-efficacy: Predicting student success in online distance education. *American Journal of Distance Education, 18*(1), 21-38.

Dewey, J. (1936). Education and new social ideals. *Vital Speeches of the Day*, *2*(11), 327-328.

Dorman, S. (1997). Video and computer games: Effect on children and implications for health education. *Journal of School Health, 67*(4), 133.

Downing, K., & Chim, T. (2000). Reflectors as online extraverts? *Educational Studies, 30*(3), 265-276.

Driscoll, M. (2002). Blended learning -- Let's get beyond the hype. *e-learning*, *3*(3), 54-54.

*Edmiston, L. (2001). *Relationships among field dependence-independence, perceived computer competence and unit test score for a Northeastern Ohio College*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3015165)

Edwards, J., Lanning, K., & Hooker, K. (2002). The MBTI and social information processing: An incremental validity study. *Journal of Personality Assessment, 78*(3), 432-450.

Elgort, I., Smith, A., & Toland, J. (2008). Is wiki an effective platform for group course work? *Australasian Journal of Educational Technology*, *24*(2), 195-210. Retrieved March 28, 2008, from Education Research Complete database.

Eom, S., Wen, H., & Ashill, N. (2006). The determinants of students' perceived learning outcomes and satisfaction in university online education: An empirical investigation. *Decision Sciences Journal of Innovative Education, 4*(2), 215-235.

Ertmer, P., Addison, P., Lane, M., Ross, E., & Woods, D. (1999). Examining teachers' beliefs about the role of technology in the elementary classroom. *Journal of Research on Computing in Education, 32*(1), 54.

Farmer, B., Yue, A., & Brooks, C. (2008). Using blogging for higher order learning in large cohort university teaching: A case study. *Australasian Journal of Educational Technology*, *24*(2), 123-136.

Fearing A, Riley M. (2005). Graduate students' perceptions of online teaching and relationship to preferred learning styles. *MEDSURG Nursing, 14*(6), 383-389.

Finley, C. (2005). Instructional technology. *Distance Learning*, *2*(5), 35-37.

Finn, S., & Inman, J. (2004). Digital unity and digital divide: Surveying alumni to study effects of a campus laptop initiative. *Journal of Research on Technology in Education, 36*(3), 297-317.

Fullan, M. G. (2007). *Leading in a culture of change*. San Francisco: Jossey-Bass.

Glass, G. V. (1976). Primary, secondary, and meta-analysis of research. *Education Research, 5*(10), p. 3-8.

Glass, G. V., McGaw, B., & Smith, M. L., (1981). *Meta-analysis in social research.* Beverly Hills, CA: Sage publications.

Goodwin, I. (1988). Five years after 'a nation at risk' US schools still seek better grades. *Physics Today*, *41*(6), 50-52.

Guillot, A., Champely, S., Batier, C., Thiriet, P., & Collet, C. (2007). Relationship between spatial abilities, mental rotation and functional anatomy learning. *Advances in Health Sciences Education, 12*(4), 491-507.

Guo R., Dobson, T, & Petrina, S. (2008). Digital natives, digital immigrants: An analysis of age and ICT competency in teacher education. *Journal of Educational Computing Research, 38*(3), 235–254.

Gülbahar, Y. (2007). Technology planning: A roadmap to successful technology integration in schools. *Computers & Education, 49*(4), 943-956.

Hall, P. (2003). Developing research skills in African-American students: A case note. *Journal of Academic Librarianship, 29*(3), 182.

Häkkinen, P. (2002). Challenges for design of computer-based learning environments. *British Journal of Educational Technology, 33*(4), 461-469.

Harwell, M. (1988). Choosing between parametric and nonparametric tests. *Journal of Counseling & Development, 67*(1), 35.

Hashemzadeh, N., & Wilson, L. (2007). Teaching with the lights out: What do we really know about the impact of technology intensive instruction? *College Student Journal, 41*(3), 601-612.

Hatzios, A., & Lariscy, R. (2008). Perceptions of utility and importance of international public relations education among educators and practitioners. *Journalism & Mass Communication Educator, 63*(3), 241-258.

Healey, J. M. (1998). *Failure to connect: How computers affect our children's minds-for better and worse.* New York: Simon &Schuster.

Heberle, R. (1937). The sociology of Ferdinand Tönnies. *American Sociological Review 2*(1), 9-25.

Hecht, D., & Reiner, M. (2007). Field dependency and the sense of object-presence in haptic virtual environments. *CyberPsychology & Behavior, 10*(2), 243-251.

Hedges, L. V. & Vevea, J. L. (1998). Fixed- and random-effects models in meta-analysis. *Psychological Methods, 1*, 154-169.

Henry, P. (2008). Learning style and learner satisfaction in a course delivery context. *Proceedings of World Academy of Science: Engineering & Technology*, *28*, 410-413.

Hew, K., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: current knowledge gaps and recommendations for future research. *Educational Technology Research & Development*, *55*(3), 223-252.

Hill, W. (1997). *Learning: A Survey of Psychological Interpretations. (6th Ed.)* Boston: Allyn & Bacon.

Hite, C. (2004). Expository content area texts, cognitive style and gender: Their effects on reading comprehension. *Reading Research and Instruction, 43*(4), 41-74.

Hodge, E., Tabrizi, M., Farwell, M., & Wuensch, K. (2007). Virtual reality classrooms strategies for creating a social presence. *International Journal of Social Sciences*, *2*(2), 105-109.

Hodges, C., Stackpole-Hodges, C., & Cox, K. (2008). Self-efficacy, self-regulation, and cognitive style as predictors of achievement with podcast instruction. *Journal of Educational Computing Research, 38*(2), 139-153.

Huber, G. (1983). Cognitive style as a basis for MIS and DSS designs: Much ado about nothing? *Management Science 29*(5), 567-579.

Huedo-Medina, T., Sánchez-Meca, J., Marín-Martínez, F., & Botella, J. (2006). Assessing heterogeneity in meta-analysis: Q statistic or I^2 index? *Psychological Methods, 11*(2), 193-206.

Hunt, M. (1997). *How science takes stock: The story of meta-analysis*. New York: Russell Sage.

Igo, L., Kiewra, K., Zumbrunn, S., & Kirschbaum, A. (2007). How best to remove the snare from the pair: Construction and cognitive load hypotheses. *Journal of Experimental Education, 75*(2), 130-144.

Ikpeze, C., & Boyd, F. (2007). Web-based inquiry learning: Facilitating thoughtful literacy with WebQuests. *Reading Teacher*, *60*(7), 644-654.

Jasmine, J., & Weiner, W. (2007). The effects of writing workshop on abilities of first grade students to become confident and independent writers. *Early Childhood Education Journal, 35*(2), 131-139.

Jonassen, D. H., & Grabowski, B. L., (1993). *Handbook of Individual Differences, Learning, And Instruction.* Hillsdale, New Jersey: Lawrence Erlbaum Associates, Publishers.

Jung, C. (1971). *Psychological Types.* (Collected Works, Vol. 6). Princeton, NJ: Princeton University.

Kalyuga, S. (2007). Enhancing instructional efficiency of interactive e-learning environments: a cognitive load perspective. *Educational Psychology Review*, *19*(3), 387-399.

Kavale, K. (2001). Meta-analysis: A primer. *Exceptionality, 9*(4), 177-183.

Kerridge, D., & Kerridge, S. (1996). Dr. Deming's cure for a sick system. *Journal for Quality & Participation*, *19*(7), 24.

*Kessler, R. (1995). *Cognitive styles and concept mapping dimensions of hypermedia computer users*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 9528553)

*Khine, M. (1996). The interaction of cognitive styles with varying levels of feedback in multimedia presentation. *International Journal of Instructional Media, 23*(3), 229-37.

*Kim, K. (2001). Implications of user characteristics in information seeking on the World Wide Web. *International Journal of Human-Computer Interaction, 13*(3), 323-340.

Kirton, M. (1976). Adaptors and innovators: A description and measure. *Journal of Applied Psychology*, *61*(5), 622-629.

Kirton, M., Bailey, A., & Glendinning, W. (1991). Adaptors and innovators: Preference for educational procedures. *Journal of Psychology*, *125*(4), 445.

Klemm, W. (2007). Computer slide shows: A trap for bad teaching. College *Teaching, 55*(3), 121-124.

Kramer, B., Walker, A., & Brill, J. (2007). The underutilization of information and communication technology-assisted collaborative project-based learning among international educators: A Delphi study. *Educational Technology Research & Development*, *55*(5), 527-543.

Kukulska-Hulme, A. (2007). Mobile usability in educational contexts: What have we learnt? *International Review of Research in Open and Distance Learning, 8*(2), 1-16.

Kulik, J.A., & Kulik, C. (1989). Meta-analysis in education. *International Journal of Educational Research, 13*, 221-340.

La France, B., Heisel, A., & Beatty, M. (2007). A test of the cognitive load hypothesis: Investigating the impact of number of nonverbal cues coded and length of coding session on observer accuracy. *Communication Reports, 20*(1), 11-23.

Lau, W., & Yuen, A. (2009). Exploring the effects of gender and learning styles on computer programming performance: implications for programming pedagogy. *British Journal of Educational Technology, 40*(4), 696-712.

*Leader, L., & Klein, J. (1994). *The effects of search tool and cognitive style on performance in hypermedia database searches*. Retrieved from ERIC database. (ED373729)

Leping, L., Aberasturi, S., Axtell, K., & Richmond, A. (2007). An examination of publication bias in an international journal of information technology in education. *Computers in the Schools, 24*(1/2), 145-165.

Levine, L., Fallahi, C., Nicoll-Senft, J., Tessier, J., Watson, C., & Wood, R. (2008). Creating significant learning experiences across disciplines. *College Teaching, 56*(4), 247-254.

Liao, Y., Chang, H., & Chen, Y. (2007). Effects of computer applications on elementary school students' achievement: A meta-analysis of students in Taiwan. *Computers in the Schools, 24*(3/4), 43-64.

Liaw, S., Huang, H., & Chen, G. (2007). Surveying instructor and learner attitudes toward e-learning. *Computers & Education*, *49*(4), 1066-1080.

Lin, C. (2007). e-Learning strategies for aboriginal children in Taiwan. *International Journal of Learning*, *14*(6), 153-160.

Lipsey, M. W. & Wilson, D. B. (2001). *Practical meta-analysis.* Thousand Oaks, CA: Sage.

Liu, L., & Velasquez-Bryant, N. (2003). An information technology integration system and its life cycle: What is missing?. *Computers in the Schools*, *20*(1/2), 91-104.

*Liu, M., & Reed, W. (1994). The relationship between the learning strategies and learning styles in a hypermedia environment. *Computers in Human Behavior, 10(*4), 419-434.

*Luk, S. (1998). The relationship between cognitive style and academic achievement. *British Journal of Educational Technology, 29*(2), 137.

Lundt, J. (2004). A new paradigm for education. *Futurist*, *38*(6), 18-22.

Malmsköld, L., Örtengren, R., Carlson, B., & Nylen, P. (2007). Instructor based training versus computer based training—A comparative study. *Journal of Educational Technology Systems, 35*(4), 457-478.

Mann, J., Murphy, A., & Northwest Regional Educational Lab., (1981). *Early adolescent education: Literature synthesis and report*. Retrieved from ERIC database. (ED213509)

Marx, R., Howard, D., & Winne, P. (1987). Students' perception of instruction, cognitive style, and achievement. *Perceptual and Motor Skills, 65*(1), 123-134.

Maushak, N., Schlosser, C., Lloyd, T., Simonson, M., & Association for Educational Communications and Technology, W. (1998). *Proceedings of Selected Research and Development Presentations at the National Convention of the Association for Educational Communications and Technology (AECT) Sponsored by the Research and Theory Division (20th, St. Louis, Missouri, February 18-22, 1998).* Retrieved from ERIC Database. (ED423819)

McDaniel, M., Rothotein, H., & Whetz, D. (2006). Publication bias: A case study of four test vendors. *Personnel Psychology, 59*(4), 927-953.

McElroy, J., Hendrickson, A., Townsend, A., & DeMarie, S. (2007). Dispositional factors in Internet use: Personality versus cognitive style. *MIS Quarterly*, *31*(4), 809-820.

McKenna, F. (1990). Learning implications of field dependence--independence: Cognitive style versus cognitive ability. *Applied Cognitive Psychology, 4*(6), 425-437.

Messick, G. (1997). The nature of cognitive styles: Problems and promise in educational practice. *Educational psychologist, 19*(2), 59-74.

Mihalca, L., & Miclea, M. (2007). Current trends in educational technology research. *Cognitie, Creier, Comportament/Cognition, Brain, Behavior, 11*(1), 115-129.

Miller, A. (1987). Cognitive styles: An integrated model. *Educational Psychology*, *7*(4), 251-268.

Moersch, C. (1995). Levels of Technology Implementation (LoTi): A Framework for Measuring Classroom Technology Use. *Learning and Leading with Technology, 23*(3), 40-42.

Moersch, C. (1997). Computer efficiency: Measuring the instructional use of technology. *Learning and Leading with Technology, 24*(4), 52-56.

Moersch, C. (2004). Chapter 1: Levels of Technology Integration. (pp. 9-10). *International Society for Technology in Education*. Retrieved from Education Research Complete database.

*Molina, L. (1997). *The influence of field dependence/independence on high school students' problem-solving performance in a computer-based geographic learning activity*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 9801256)

Muncer, S., Taylor, S., & Craigie, M. (2002). Power dressing and meta-analysis: incorporating power analysis into meta-analysis. *Journal of Advanced Nursing, 38*(3), 274-280.

Nachmias, R., & Shany, N. (2002). Learning in virtual courses and its relationship to thinking styles. *Journal of Educational Computing Research*, 27(3), 315-329.

National Commission on Excellence in Education (1983). *A Nation at Risk: The Imperative for Educational Reform.* Washington, D.C.: U.S. Department of Education.

Neisser, U. (1967). Cognitive psychology. In Munger, M. (Ed.), *The history of psychology: Fundamental questions* (pp. 447-466). New York: Oxford University Press.

Nelson, J.L., Palonsky, S.B., McCarthy, M. R. (2006). *Critical issues in education: Dialogues and dialectics.* Boston: McGraw Hill.

Netherton, D. (1993). Total quality management. *Technology Teacher*, *53*(2), 4.

Nguyen, D., Hsieh, Y., & Allen, D. (2006). The impact of web-based assessment and practice on students' mathematics learning attitudes. *Journal of Computers in Mathematics & Science Teaching*, *25*(3), 251-279.

Oppenheimer T. (2003). *The flickering mind: The false promise of technology in the classroom and how learning can be saved*. New York: Random House.

Oppenheimer, T. (1997). The computer delusion. *Atlantic Monthly, 280*(1), 45-62.

Osterlind, S., Miao, D., Sheng, Y., & Chia, R. (2004). Adapting item format for cultural effects in translated tests: Cultural effects on construct validity of the chinese versions of the MBTI. *International Journal of Testing, 4*(1), 61-73.

Overbaugh, R., & Lin, S. (2006). Student characteristics, sense of community, and cognitive achievement in web-based and lab-based learning environments. *Journal of Research on Technology in Education, 39*(2), 205-223.

Ozcelik, E., & Yildirim, S. (2005). Factors influencing the use of cognitive tools in web-based learning environments. *Quarterly Review of Distance Education, 6*(4), 295-307.

*Palmquist, R., & Kim, K. (2000). Cognitive style and on-line database search experience as predictors of web search performance. *Journal of the American Society for Information Science, 51*(6), 558-66.

Papanastasiou, E., Zembylas, M., & Vrasidas, C. (2003). Can computer use hurt science achievement? The USA Results from PISA. *Journal of Science Education & Technology*, *12*(3),325-332.

Passey, D. (2006). Technology enhancing learning: Analysing uses of information and communication technologies by primary and secondary school pupils with learning frameworks. *Curriculum Journal, 17*(2),139-166.

Perchman, E. M. (1992). Child as meaning maker: The organizing theme for professional practice schools. In M. Levine (Ed.), *Professional practice schools* (pp. 25–62). New York: Teachers College Press.

*Post, P. (1987). The effect of field independence/field dependence on computer-assisted instruction achievement. *Journal of Industrial Teacher Education, 25*(1), 60-67.

Preston, J. (2008). *Student-centered versus teacher-centered mathematics instruction: A meta-analysis*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3289778)

Price, L. (2004). Individual differences in learning: Cognitive control, cognitive style, and learning style. *Educational Psychology, 24*(5), 681-698.

Proctor, R., Watson, G., & Finger, G. (2003). Measuring information and communication technology (ICT) curriculum integration. *Computers in the Schools*, *20*(4), 67-87.

Rakes, G., Fields, V., & Cox, K. (2006). The influence of teachers' technology use on instructional practices. *Journal of Research on Technology in Education, 38*(4), 409-424.

Ramos-Álvarez, M., Moreno-Fernáde, M., Valdés-Conroy, B., & Catena, A. (2008). Criteria of the peer review process for publication of experimental and quasi-experimental research in Psychology: A guide for creating research papers. *International Journal of Clinical Health & Psychology, 8*(3), 751-764.

Rau, P. L. P., Gao, Q., Wu, L.(2008). Using mobile communication technology in high school education: Motivation, pressure, and learning performance. *Computers & Education 50*(1), 1-22 .

Reichman, S. & Grasha, A. (1974) A rational approach to developing and assessing the construct validity of a study learning style scales investment. *Journal of Psychology, 87*(2), 213-223.

Richards, C. (2006). Towards an integrated framework for designing effective ICT-supported learning environments: The challenge to better link technology and pedagogy. *Technology, Pedagogy and Education*, *15*(2), 239-255.

Riding, R., & Cheema, I. (1991). Cognitive styles: An overview and integration. *Educational Psychology*, *11*(3), 193-215.

Riel, M., & Fulton, K. (2001). The role of technology in supporting learning-communities. *Phi Delta Kappan*, *82*(7), 518-523.

Rosenthal, R. (1979). The ‗File Drawer Problem' and tolerance for null results. *Psychological Bulletin, 86*(3), 638–641.

Rosenthal, R. (1991). *Meta-analytic procedures for social research*. Newbury Park CA: Sage.

Rutherford, D., & Lloyd, W. (2001). Assessing a computer-aided instructional strategy in a world geography course. *Journal of Geography in Higher Education*, *25*(3), 341-355.

Schellens, T., van Keer, H., Valcke, M., & De Wever, B. (2007). Learning in asynchronous discussion groups: a multilevel approach to study the influence of student, group and task characteristics. *Behaviour & Information Technology, 26*(1), 55-71.

Seed, A. (2008). Redirecting the teaching profession in the wake of a nation at risk and NCLB. *Phi Delta Kappan, 89*(8), 586-589.

Sergiovanni, T. (1999). *Building community in schools*. Josey-Bass Publishers: San Fransisco.

*Shih, C. (1998). *Relationships among student attitudes, motivation, learning styles, learning strategies, patterns of learning, and achievement: A formative evaluation of distance education via Web-based courses* (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 9911641)

Skinner, B. (1957). ―The Mand.” In *Verbal Behavior*. In Munger, M. (Ed.), *The History of Psychology: Fundamental Questions* (pp. 399-407). New York: Oxford University Press.

Skinner, D. (1997). Computers: good for education? *The Public Interest, 128*(1), 98-109.

Slemmer, D. L. (2002). *The effect of learning styles on student achievement in various hypertext, hypermedia, and technology-enhanced learning environments: A meta-analysis* (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. 3095975)

Solomon, N. (2006). The hollow media promise of digital technology. *Humanist, 66*(6), 39.

*Somyürek, S., & Yalin, H. (2007). The effects of advance organizers existence in computer aided instructional software on field dependent and field independent students' academic achievement. (Turkish). *Journal of Turkish Educational Sciences, 5*(4), 587-607.

State Educational Technology Directors Association (n.d.). *Profiling Educational Technology Integration (PETI): Resources for Assessing Readiness & Use*. Retrieved rom http://www.setda-peti.org/

Stensaasen, S. (1995). The application of Deming's theory of total quality. *Total Quality Management*, *6*(5), 579-592.

Szabo, M., & Montgomerie, T. (1992). Two decades of research on computer-managed instruction. *Journal of Research on Computing in Education, 25*(1), 113-133.

*Tang, H. (2003). *The interaction of cognitive style and learning environment on student performance, course satisfaction, and attitude toward computers*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3092453)

Taylor, J., & Duran, M. (2006). Teaching social studies with technology: New research on collaborative approaches. *History Teacher, 40*(1), 9-25.

Tenenbaum, H., & Ruck, M. (2007). Are Teachers' Expectations Different for Racial Minority Than for European American Students? A Meta-Analysis. *Journal of Educational Psychology, 99*(2), 253-273.

Toffler, A. (1970). *Future Shock*. New York: Random.

Toyama, M., & Ichihara, M. (2008). Test coping strategies and perceived academic competence in improved academic performance of junior high school students: Cognitive strategies. *Japanese Journal of Educational Psychology, 56*(1), 72-80.

Troha, F. (2002). The right mix -- A bulletproof model for designing blended learning. *e-learning*, *3*(6), 34-37.

Tselios, N., Avouris, N., & Komis, V. (2008). The effective combination of hybrid usability methods in evaluating educational applications of ICT: Issues and challenges. *Education & Information Technologies, 13*(1), 55-76.

*Umar, I., & Maswan, S. (2007). The effects of a web-based guided inquiry approach on students' achievement. *Journal of Computers, 2*(5), 38-43.

*Umar, I. N. (1999). *A study of the effects of cognitive styles and learning strategies among Malaysian pre-college students in a hypermedia environment*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 9957790)

Valadez, J., & Duran, R. (2007, February). Redefining the digital divide: beyond access to computers and the Internet. *High School Journal, 90*(3), 31-44.

Van Merriënboer, J., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review, 17*(2), 147-177.

*Wang, A. (2008). *The effects of varied instructional aids and field dependence-independence on learners' structural knowledge in a hypermedia environment*. (Doctoral dissertation). Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3292872).

*Wang, T. (2007). What strategies are effective for formative assessment in an e-learning environment?. *Journal of Computer Assisted Learning, 23*(3), 171-186.

Vasquez, L., Gangstead, S., & Henson, R. (2000). *Understanding and interpreting effect size measures in general linear model analyses*. Retrieved from ERIC database. (ED445081)

Webb, S. (2006) Can ICT reduce social exclusion? The case of an adults' English language learning programme. *British Educational Research Journal, 32*(3), 481-507.

*Weller, H., & Repman, J, & Rooze, G. (1994). The relationship of learning, behavior, and cognitive style in hypermedia-based instruction: Implications for design of HBI. *Computers in the Schools, 10*, 401-20. Retrieved from ERIC Database. (EJ499770)

Weston, T. (2005). Why faculty did—and did not—integrate instructional software in their undergraduate classrooms. *Innovative Higher Education, 30*(2), 99-115.

Wheeler, P., Hunton, J., & Bryant, S. (2004). Accounting information systems research opportunities using personality type theory and the Myers-Briggs type indicator. *Journal of Information Systems 18*(1), 1-19.

Wilson, D. B. (2001). *Effect-size determination program*. Retrieved, August, 11, 2009, from http://mason.gmu.edu/~dwilsonb/ma.html

Wilson, D. B. (2001). *Meta-analysis macros for SAS, SPSS, and Stata*. Retrieved, August, 11, 2009, from http://mason.gmu.edu/~dwilsonb/ma.html

Winters, F. & Azevedo, R. (2005) High-school students' regulation of learning during computer-based science inquiry. *Journal of Educational Computing Research, 33*(2),189 - 217.

Witkin, H. (1950). Individual differences in ease of perception of embedded figures. *Journal of Personality*, *19*, 1-15.

Witkin, H. (1977). Role of the field-dependent and field-independent cognitive styles in academic evolution: A longitudinal study. *Journal of Educational Psychology, 69*(3), 197-211.

Witkin, H., Goodenough, D., & Karp, S. (1967). Stability of cognitive style from childhood to young adulthood. *Journal of Personality and Social Psychology, 7*(3), 291-300.

Wolf, M. (2005). Assessing technology integration in schools. *T H E Journal, 32*(9), 12.

Wolf, M., & Hall, S. (2005). Fighting the good fight. *T H E Journal*, *32*(12), 48.

Wolsey, T. (2008). Efficacy of instructor feedback on written work in an online program. *International Journal on E-Learning*, *7*(2), 311-329.

Wozney, L., Venkatesh, V., & Abrami, P. (2006). Implementing computer technologies: Teachers' perceptions and practices. *Journal of Technology & Teacher Education, 14*(1), 173-207.

Yan, J. (2008). Social technology as a new medium in the classroom. *New England Journal of Higher Education*, *22*(4), 27-30.

Yoshida, K. (1989). Deming management philosophy: Does it work in the US as well as in Japan?. *Columbia Journal of World Business*, *24*(3), 10-17.

Zhang, L., & Sternberg, R. (2005). A threefold model of intellectual styles. *Educational Psychology Review*, *17*(1), 1-53. Retrieved from ERIC Database (EJ732425)

Appendices

APPENDIX A:

THEORETICAL LEVEL OF TECHNOLOGY INTEGRATION CODING FORM

TEMPLATE

	Theoretical foundation	**Integration**	**Frequency**	
The study uses technology to:	1 = Drill & practice or aide lecture. • I use Powerpoint® to present material. • I use a math program to help student learn multiplication tables.	1 = Dialogical/Modular. • Technology reinforces what I also teach in the classroom.	1 = Seldom. • My students rarely use technology for learning	
	2 = Construct learning • I use simulations to teach through individual experience. • Allow students to research independently for projects.	2 = Intermediate. • Technology introduces new material that **I also** discuss in class.	2 = Sometimes. • My students use technology for learning fairly often (2-3X/wk)	
	3 = Socially-Construct learning • I use blogs to allow students to critique others' writing. • Online/web group simulations.	3 = Integrated. • Technology introduces new material that **I never** discuss in class.	3 = Often. • My students use technology for learning almost daily.	
Circle the score that fits best. (0 for no use)	0 1 2 3	0 1 2 3	0 1 2 3	
Write the number you circled in the parentheses.	( ) +	( ) *	( )	Total
	Add these numbers together.		Multiply with the sum	

APPENDIX B:

META-ANALYTICAL EQUATIONS
EFFECT SIZE AND STANDARD POOLED VARIANCE

$$\Delta = \frac{\overline{X_T} - \overline{X_C}}{s_p} \qquad s_p = \sqrt{\frac{(n_T - 1)s_T^2 + (n_C - 1)s_C^2}{(n_T - 1) + (n_C - 1)}}$$

$$Q = \Sigma\, w_{\mathrm{i}}(\Delta_{\mathrm{i}} - \Delta)^2$$

FAILSAFE N CALCULATIONS

COOPER'S CALCULATION

$$N_{\mathrm{fs}.05} = \left(\frac{Z_{s1} + Z_{s2} + \cdots Z_{sn}}{1.645}\right)^2 - (N_s),$$

LIPSEY AND WILSON‘S CALCULATION

$$K_0 = K\left[\frac{\Delta_k}{\Delta_c} - 1\right],$$

APPENDIX C:

ALPHABETICAL LISTING OF DATABASES

Academic Search Complete

Academic Universe

Communication & Mass Media Complete

Computers & Applied Sciences Complete

Digital Dissertations

EDUCATION: A SAGE Full-Text Collection

Education Full Text

Education Research Complete

Education Resource Information Center (ERIC-EBSCO)

Education Resource Information Center (ERIC-Web)

Google Scholar

Humanities Full Text

JSTOR

Kraus Curriculum Development Library (kcdlonline)

Library, Information Science & Technology Abstracts

OMNIFILE FULLTEXT

Proquest dissertation and theses

PsycARTICLES

Psychology and Behavioral Sciences Collection

PsycINFO

ScienceDirect

Social Science Citation Index (SSCI) --Web of Science

SocINDEX with Full Text

Sociological Collection

Teacher Reference Center

Web of Science

WilsonWeb