THE EFFECTS OF SUPRALIMINAL BIPOLAR

PRIMES ON CAREER AND TECHNICAL

EDUCATORS' VIEWING TIME, PERCEIVED

CONFIDENCE, AND SELF-EFFICACY OF DESKTOP

VIRTUAL REALITY

By

MICHAEL SCOTT WILLIAMS

Bachelor of Business Administration in Management
Northeastern State University
Tahlequah, OK
2002

Master of Business Administration
Northeastern State University
Muskogee, OK
2003

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Dissertation Approved:

Dr. Lynna Ausburn
Dissertation Adviser

Dr. Mary Jo Self

Dr. Gary Conti

Dr. Mary Kutz

Dr. Floyd Ausburn

Dr. A. Gordon Emslie
Dean of the Graduate College

ACKNOWLEDGMENTS

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CHAPTER I

INTRODUCTION

Conceptual forms of virtual reality have existed since the 1920s. The technology was first introduced by the Link Corporation, which created a simulated training device for pilots called the Link Trainer. It basically consisted of an airplane cockpit set atop a pneumatic platform which was controlled by the pilot via a directional stick. The entire platform would shift in response to the pilot's control as the horizon line changed. Movie projectors would later be introduced to the device in order to provide a more realistic experience (Gladdis, 1997).

Virtual reality (VR) began to increase in popularity during the 1970s and 80s. This was due in large part to advances in computer technology. In the early 1970s Myron Krueger coined the term "artificial reality", which was later modified in the 1980s when Jaron Lanier conceived the term "virtual reality" (Siddens, 1999). However, there is no generally agreed upon definition of virtual reality. To further complicate matters, there are numerous types of VR that are being developed and experimented with. These include but are not limited to artificial reality, augmented reality, immersive reality, and telepresence. The different types of virtual reality provide varying experiences in relation to immersion, interactivity, and unencumbered navigation (Krueger, 1993; Pantelidis, 1993).

The various forms of virtual reality (VR) can be viewed as a collection of innovative ideas and instructional extensions based on the general purpose of providing the user with a realistic experience from which learning can derive. Therefore, a much broader definition for the technology was needed. Ausburn and Ausburn (2004) identified and fulfilled this need with their representative explanation:

> VR can range from simple environments presented on a desktop computer to fully immersive multi-sensory environments experienced through complex headgear and bodysuits. In all its manifestations, VR is basically a way of simulating or replicating an environment and giving the user a sense of 'being there', taking control, and personally interacting with that environment with his/her own body. (p. 34)

Because of substantially lower cost, training viability, and ease of use, VR formats that are not fully immersive have gained popularity. These VR formats have been identified as *desktop VR* (Ausburn & Ausburn, 2004; Hunt & Waller, 1999). They are generally accessed from a desktop or laptop computer and consist of a virtual reality movie that the user can control, explore, and navigate by using devices such as a mouse, scrolling ball, or glove. The VR movie can be generated with specific software packages and played in a viewer like Apple's QuickTime player, Flash, or Java. Web-based virtual world environments are made available through the use of virtual reality modeling language (VRML) or as VR movies played with Flash or Java. Similar to exploring an ordinary website, individuals can access an online virtual world or movie with three dimensional images surrounding their on-screen movement via an avatar, or personalized character who represents an individual within a virtual world (Ausburn & Ausburn, 2004).

As a learning tool, desktop virtual reality provides distinct opportunities across the educational spectrum (Dickey, 2005; Neel, 2006; Revenaugh, 2006; Shim, et al.,

2003; Smedley & Higgins, 2005; Vogel, Bowers, Meehan, Hoeft, & Bradley, 2004).

Secondary, post-secondary, and higher education can all use virtual reality to aid in the

learning process. With strong growth in distance education being provided via the

Internet and DVD, a viable pathway towards immersive learning and at-distance

duplication of real-world environments exists for desktop virtual reality. Even greater

opportunity for effective use of VR exists when considering those students in secondary

and post-secondary school systems who are being home schooled by their parents or a

privately hired instructor. VR can fill a gap in the educational opportunities available to

these students. Jancek (2001) asserted that:

> Virtual learning plays an important role in a home-schooled student's education.
> The traditional home-schooler does not have many of the educational
> opportunities as those in public or private schools. Students in public and private
> schools don't always have all the educational opportunities of their neighboring
> districts. Virtual learning levels the playing field and provides endless
> opportunities for homeschoolers. (p. 11)

An abundance of possibilities also exist for virtual reality as a training tool within

the vocational and technical education field (Ausburn & Ausburn, 2006; Park, Jang, &

Chai, 2006; Seth & Smith, 2004; Tiala, 2007). Introduction and familiarization with

complex and often dangerous locational environments is often necessary in occupational

preparation. Programs, courses, and training are provided in order to prepare future and

current engineers, technicians, first responders, and other personnel on new processes,

techniques, and skills. Technical skill development within professional occupations can

also derive from VR technology. The medical profession is one area that is seeing

measurable gains with VR over traditional methods when training surgeons and nurses

(Ahlberg, et al. 2007; Ganai, Donroe, St. Louis, Lewis, & Seymour, 2005; McClusky, et

al. 2004; Seymour, et al. 2002).

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Virtual reality is a multi-faceted tool that the literature indicates is capable of providing an increased sense of involvement and connectedness between learner and content. As education becomes more student-centered and exploratory activities become more important in course curricula, assistance through advanced technological applications might be expected to become more standard practice. Virtual reality, with its ability to immerse learners in an environment, experience it with multiple senses, and control the pacing and flow of exploration, may have the capability to transform the future of advanced instructional methodologies. Key to the introduction and adoption of this instructional innovation is likely to be continued research focused on practical development and adoption of the technology through demonstration of its specific positive effects on learning. The impetus for this study came from the proposition that VR is an innovation and that the adoption of this innovation in Career and Technical Education (CTE), particularly in its cost-effective desktop form, might be facilitated if a positive disposition toward the technology could be increased in CTE educators. The study was intended as a first step in testing this proposition. Despite its instructional benefits, VR, like other technology innovations, may not be adopted by some educators due to a variety of factors such as lack of training, instructional support and preparation time, technology literacy, presumed costs, and general understanding of the true potential that VR provides (Clark, Hosticka, Schriver, & Bedell, 2002; Geissler, Knott, Vazques, & Wright, 2004; Kuo & Levis, 2002; Spudic, 2001; Surry, 1997; Tiala, 2007). Thus, it could be argued that techniques that overcome this reluctance and facilitate the adoption of VR by educators would be desirable. This possibility provided the impetus for this study.

Theoretical and Conceptual Framework

The theoretical framework for this study derived from three primary areas: (a) diffusion of innovation theory, (b) priming theory of behavior influence, and (c) self-efficacy theory

Innovation Diffusion Theory

Rogers' diffusion of innovation theory characterized phenomena associated with the adoption of innovative products and practices. The theoretical foundation for research on innovation adoption has become well established. Rogers' 1962 first edition book, *Diffusion of Innovations*, brought about unification of relevant theory, thus enabling a cross-discipline research approach.

However, Rogers' theory was an extension of prior fundamental research. Foundational work can be traced back to the early 1900s with sociologists Gabriel Tarde and Georg Simmel (Rogers, 2003). The emergence of this line of inquiry continued to progress over the years with studies from differing perspectives. Socially-driven disciplines such as public health, family-planning, communications, marketing, geography, and education all researched innovation diffusion. According to Rogers (2003), "Early educational diffusion studies were almost all completed at one institution, Columbia University's Teachers College, and under the direction of one scholar, Dr. Paul Mort" (p. 61).

While Mort and others conducted well-regarded research in innovation diffusion, a broader and more generalized theory was needed. Rogers emerged as the most prominent scholar in the field, bringing a more holistic approach. Differing theories have since been developed, including Moore and his book *Crossing the Chasm: Marketing and*

Selling Disruptive Products to Mainstream Customers (2006) and Atkisson with his

"amoeba of culture" approach (2002) for example. However, Rogers is credited with

developing the broadened framework of innovation diffusion that can be applied across

many disciplines. Rogers (2003) explained that:

> Diffusion is the process in which an innovation is communicated through certain
> channels over time among the members of a social system…a kind of social
> change, defined as the process by which alteration occurs in the structure and
> function of a social system. (p. 5)

Five types of innovation adopters are identified within Rogers' theory: innovators,

early adopters, early majority, late majority, and laggards. Each adopter classification has

a specified rate of innovation adoption based on an existing predisposition or threshold.

Rogers (2003) illustrated the theoretical percentages of the adopter classifications in a

bell curve shown in Figure 1. The adoption curve is characterized by symmetry such that

innovators and early adopters constitute the same percentage of innovativeness as the

laggards, but on different ends of the curve. This represents those individuals who readily

INNOVATORS	EARLY	EARLY	LATE	LAGGARDS
2.5%	ADOPTERS	MAJORITY	MAJORITY	16%
	13.5%	34%	34%	
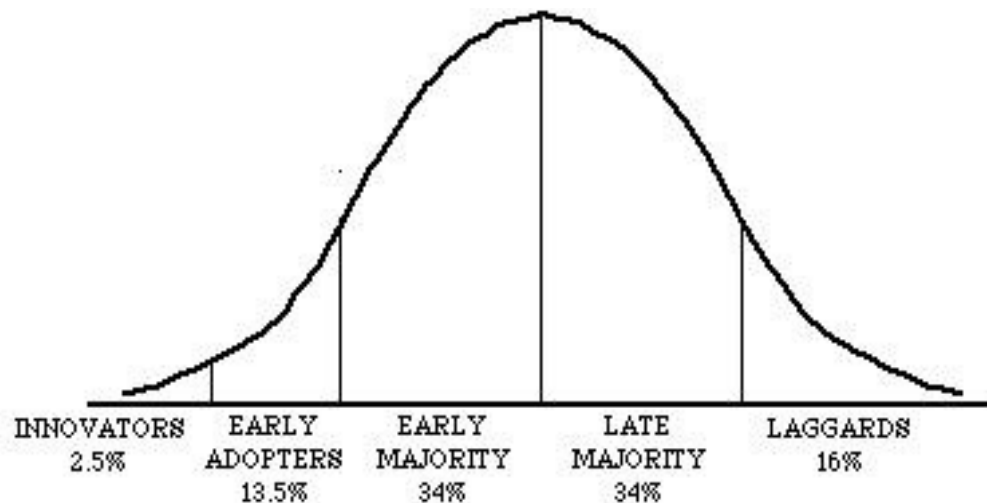
Figure 1. Rogers' Innovation Diffusion Bell Curve
Source: Rogers, E.M. (2003). *Diffusion of innovations*. New York: The Free Press.

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accept an innovation and those who do not. Surry (1997) specifically related innovation

adoption theory to the range of adoption of instructional technologies in education,

claiming that "Some instructional technologists blame teachers and an intrinsic resistance

to change as the primary causes of instructional technology's diffusion problem"

(Diffusion theory and instructional technology section, ¶ 3).

According to Rogers' theory, the majority of innovation adopters (68%) reside

within the early majority and late majority region of the innovation diffusion curve.

Adoption by this segment could be seen to have a relationship with the observed

experiences from the innovators and early adopters. Gustafson and Surry (1994) claimed

that "The perceived attributes of an innovation can be important considerations for those

attempting to facilitate the adoption and diffusion of instructional innovations" (p. 23).

Rogers further proposed that while laggards undoubtedly affect the holistic adoption

curve, it is the critical mass that determines the effectiveness of adoption. Thus

significant attention is paid to individuals residing in this group by educational

technologist who seek to promote adoption of new instructional methods.

Prime Theory and Supraliminal Bipolar Primes

As a concept, priming has been studied and practically implemented since the

1970s. According to DeCoster and Claypool (2004), "Researchers investigating the effect

of primes on impression formation have demonstrated that mentioning traits in one

context can reliably change the way that people think about a social target in an entirely

different context, often without the awareness of the perceiver" (p. 2). Conceptually this

effect is often seen in common activities used as a social ice breaker. For example, asking

an individual to stand before a group and say silk, silk, silk, silk, silk three times and then

immediately asking the individual "What do cows drink?". Almost invariably the individual will respond with the answer "milk" (R. Roberts, personal communication, August 16, 2006). It is common knowledge to the group as well as the individual that cows drink water, not milk. However, through the process of repeating the word "silk" several times, the individual was primed for the "milk" response. In essence, future behavior was affected for a fixed duration following the prime treatment. Bargh, Chen, and Burrows (1996) summarized the priming concept: "Priming refers to the incidental activation of knowledge structures, such as trait concepts and stereotypes, by the current situational context" (p. 230). Thus, according to priming theory, the affects of administered treatments remain for durational periods, thereby affecting future behavior. Bargh, Chen, and Burrows (1996) asserted that "Many studies have shown that the recent use of a trait construct or stereotype, even in an earlier or unrelated situation, carries over for a time to exert an unintended, passive influence on the interpretation of behavior" (p. 230).

Several types of priming exist and have been researched or implemented within their respective constructs. *Supraliminal* and *subliminal* are the descriptors associated with the priming technique, the former being implemented for the present study. DeCoster and Claypool (2004) provided an explanation of the supraliminal priming technique and distinguished it from subliminal priming:

> Used originally by Higgins et al. (1977), research participants are exposed to trait primes in an initial task. Then, in an ostensibly unrelated part of the experiment, the participants are asked to provide their impression of a person or behavior. This method is known as 'supraliminal priming' because participants are made consciously aware of the primes, although not of the link between the primed construct and the object of impression. The dissociation of the primes and the target relies on the fact that participants believe that the priming and impression tasks are unrelated. (p. 4)

DeCoster and Claypool (2004) also distinguished between two other comparative priming treatments: *unipolar* and *bipolar*. *Unipolar* refers to studies where primes are related to a single trait, one primed group and a control group for example. *Bipolar*, the treatment type used in this study, "are typically related to two descriptively similar but evaluatively opposite traits" (DeCoster & Claypool, 2004, p.5). This is usually implemented with one positive prime and one negative prime. The analysis therefore would determine the differences between groups primed in these opposite directions.

Bandura's Theory of Self-Efficacy

As a line of inquiry, conceptual forms of self-efficacy have been prevalent since the mid to late 1960s. Albert Bandura laid the foundation for such work with his 1969 book *Principles of Behavior Modification*. He continued to inquire along these same lines with "Self-efficacy: Toward a Unifying Theory of Behavioral Change" which appeared in a 1977 volume of the *Psychological Review*. The theory base has been continually expanding and includes a 1997 book by Bandura titled *Self-Efficacy: The Exercise of Control*. Self-efficacy has thus been a primary focus for Bandura over several years. The theory has been studied by many scholars and applied across numerous research areas (Bandura, Delia, Taylor, & Brouillard, 1988; Bandura & Locke, 2003; Dawes, Horan, & Hackett, 1997; Hipp, 1996; Luzzo, 1994; Peterson & Arnn, 2005; Ritter, Boone, & Rubba, 2001; Thiessen, 1995; Williams, 1998; Wise, 2007;). However, it is Bandura and his original social cognitive theory that is generally recognized as the foundational knowledge base from which further adaptations have derived. According to Cervone and Scott (1995), "Perceived self-efficacy must be understood as part of a much broader theoretical perspective, namely, Banudra's social cognitive theory" (p. 356).

At its core, self-efficacy basically "refers to perceptions of capabilities for performance within a given situation, activity, or domain" (Cervone & Scott, 1995, p. 360). The theory is broad enough to be applied to multiple diverse areas. Many situations, socially driven or otherwise, that involve self-perception of an individual in association with a given outcome can be studied using Bandura's theory of self-efficacy (Cervone & Scott, 1995).

Several factors, both internal and external, are proposed to affect self-efficacy. These include experience, social modeling, social persuasion, and physical and emotional states. These factors are also identified by various scholars as enactive experience, vicarious experience, verbal persuasion, and affective and psychological states (Cervone & Scott, 1995). While concept descriptors vary, the theoretical construct remains, thereby providing a sustainable foundational meaning.

Bandura's theory of self-efficacy has been directly applied to technology and its use or adoption (Brown, 1996; Dusick, 1998; Lumpe & Chambers, 2001; Tam, 1996; Wang, Ertmer, & Newby 2004; Webster & Hackley 1997). The principal components of the theory and its various constructs are directly applicable to individual attempted use, and adoption of, new technology. The self-efficacy concept can be further applied toward gaining an understanding of why an individual technology is or is not adopted for instructional use. According to Wang et al. (2004), "There is substantial evidence to suggest that Teachers' beliefs in their capacity to work effectively with technology – that is, their *self-efficacy* for technology integration – may be a significant factor in determining patterns of classroom computer use" (p. 231).

The theoretical framework for this study is shown in Figure 2 as a conjunction of innovation diffusion, priming, and self-efficacy theories. The framework conceptualizes virtual reality (VR) as an innovation and combines innovation diffusion theory, priming theory, and self-efficacy theory to form the researcher's substantive theory or working hypothesis that priming may be able to influence users' dispositions toward VR. Figure 2 shows that priming can act as either a negative influence or positive influence on an individual's perception of VR prior to being introduced to the technology innovation. According to this framework, following the primed introduction to the VR innovation, perceptions are formed which lead to an effect on an individual's technology self-efficacy. From the individuals' various levels of technology self-efficacy emerge either reluctance or willingness to accept the technology innovation. This could be observable through elective viewing time of a VR presentation and self-reported confidence in the

Figure 2. Theoretical and Conceptual Framework for the Study
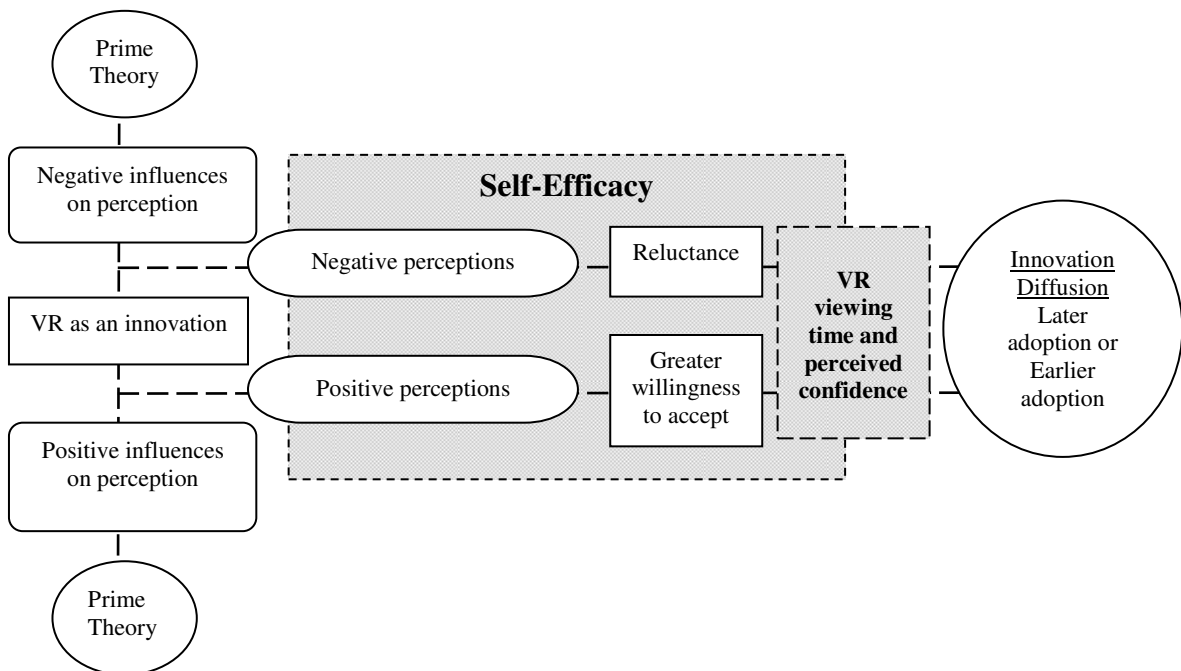
medium. Ultimately the effects of perceptions of VR on technology self-efficacy would represent themselves in either later adoption or earlier adoption of the technology innovation. In essence, Figure 2 proposes that if an individual can be primed for a positive disposition toward a technology innovation (e.g. VR) which affects their technology self-efficacy, then they might possibly adopt the innovation earlier than would have transpired without the priming treatment. The positive impact of positive priming would initially be manifested in increased VR viewing time and higher levels of self-reported confidence in VR.

Many variables are present when a technology adoption decision is made on either the individual or organizational level. Rogers' diffusion of innovation theory and Bandura's self-efficacy theory illustrate the complexity underlining such variables and how they relate to individual adoption outcomes. Conservatism should therefore be maintained in gross applicability of the model shown in Figure 2 when interconnecting various theory bases to form a theoretical framework for a specific technology study.

This study was conceptualized as an experiment in influencing technology self-efficacy through the use of a specific strategy in the form of supraliminal bi-polar priming. It was theorized for the present study that by combining the theories discussed here, the likelihood of positively affecting the personal perception of VR and ultimately the adoption of this new innovation is high. To examine this substantive theory operationally, priming technique was used as a tool to affect an individual's disposition which, in turn, could impact self-efficacy, thereby affecting Rogers' identified individual threshold for innovation. Thus, the theory presented a possibility of turning a potential technology laggard into a late majority adopter or a late majority adopter into an early

majority adopter. Holistically, this could skew the technology adoption curve, essentially expediting the adoption process. It should be noted that testing actual changes in VR adoption as an outcome of priming was beyond the scope of this study. Thus the far right circle of the framework diagram (Figure 2) must remain for further research. The present study was confined to examining the effects of priming on the *intermediate* outcomes of VR viewing time and confidence as represented as the penultimate block in the conceptual diagram. These were viewed as prerequisite to, and explanatory of, any resultant changes in VR adoption patterns that might eventually occur.

Statement of the Problem

While research has shown virtual reality (VR) to be an effective medium for technical instruction, many individuals among CTE educators may be resistant or reluctant to adopt this innovation. Participation in numerous educational reform movements and pressures for continual integration of emerging instructional technologies may have contributed to developing in some CTE educators a disposition toward falling into the late majority or laggard sectors of the technology adoption curve. This would be problematic in light of the documented high levels of success and potential of VR in technical training. The problem for this study is that it is currently not known what techniques can overcome resistance to VR adoption and thus facilitate its use in appropriate technical training applications. The study was conceived to open this line of inquiry.

Purpose of the Study

The study is based on the premise that reluctance or willingness to adopt an innovation may ultimately be influenced by the creation of a negative or positive

disposition thereby affecting self-efficacy, and that disposition and self-efficacy could be influenced by priming techniques. Therefore, the purpose of the study was to compare measures of disposition and self-efficacy toward a desktop VR presentation of CTE educators who receive no primes, negative primes, and positive primes. In the context of this study, "disposition" was defined operationally as voluntary viewing time of a VR presentation and self-reported confidence level in ability to describe to others the scene presented in the VR presentation. Self-efficacy was defined operationally as self-reported confidence in being able to effectively use desktop VR and manipulate it in ways that permit the obtainment of the intended outcome.

Research Hypotheses

The study used experimental methodology to test the following null hypotheses:

1. There is no difference in the voluntary VR viewing time of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation.

2. There is no difference in the perceived confidence levels (ability to describe scene) of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation.

3. There is no difference in the perceived self-efficacy level (ability to operate the technology) of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation.

4. There is no relationship between VR viewing time and reported VR confidence level of CTE educators.

5. There is no relationship between VR viewing time and reported self-efficacy level of CTE educators.

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6. There is no relationship between reported VR confidence level and reported self-efficacy level of CTE educators.

Definition of Key Terms

<u>Conceptual Definitions</u>

Virtual reality: "VR can range from simple environments presented on a desktop computer to fully immersive multi-sensory environments experienced through complex headgear and bodysuits. In all its manifestations, VR is basically a way of simulating or replicating an environment and giving the user a sense of 'being there', taking control, and personally interacting with that environment with his/her own body" (Ausburn & Ausburn, 2004, p. 34.).

Innovation diffusion: "Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system…a kind of social change, defined as the process by which alteration occurs in the structure and function of a social system" (Rogers, 2003, p. 5).

Priming: Priming refers to the incidental activation of knowledge structures, such as trait concepts and stereotypes, by the current situational context (Bargh, Chen, and Burrows, 1996, p. 230).

Supraliminal priming: This type of priming makes participants consciously aware of the primes, although not of the link between the primed construct and the object of impression (DeCoster & Claypool, 2004).

Bipolar primes: Typically related to two descriptively similar but evaluatively opposite traits (DeCoster & Claypool, 2004).

Self-efficacy: "Refers to perceptions of capabilities for performance within a given situation, activity, or domain" (Cervone & Scott, 1995, p. 360).

Operational Definitions

Viewing time: The total time (in seconds) a subject spends without prompting viewing the VR presentation.

Perceived confidence level: A subject's self-reported level of confidence on a 5-point Likert-like scale that he/she is capable of effectively describing the scene shown in the VR presentation to another person.

Disposition: Time spent voluntarily exploring a VR presentation and the subsequent self-reported level of confidence in the ability to effectively describe the scene presented in the VR to another person.

Virtual Reality (VR): A 3-D environment presented on a desktop or laptop computer and controlled by the user through a keyboard and/or mouse.

Virtual Reality (VR) presentation: Interior of a house showing several interconnected rooms and numerous pieces of furniture and décor.

Self-Efficacy: A subject's self-reported level of confidence on a 5-point Likert-like scale that he/she can interact with the technology and receive the expected outcome in the VR presentation.

Limitations and Assumptions of the Study

Several limitations were identified for this study:

1. Limitations of the posttest-only control group research design: Because the study used a true experimental design, issues of internal validity were not as severe as those inherent in a pre-experimental or quasi-experimental design. However, because the

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study used a posttest-only design, some issues with regard to internal validity were present. They were brought about by concerns of equivalence among groups. Because of the lack of information prior to the posttest, questions arise regarding the equivalence of the experimental and control groups. However, the true randomization of the study allowed this limitation concerning internal validity to be addressed. According to Campbell and Stanley (1966), "The most adequate all-purpose assurance of lack of initial biases between groups is randomization. Within the limits of confidence stated by the tests of significance, randomization can suffice without the pretest" (p. 25). Thus, the potential limitation on internal validity introduced by the study's post-test only design was reasonably controlled by the use of random selection and treatment assignment of subjects.

2. Limitation of external validity due to the population from which the sample was extracted: The study focused on career and technical education. While its random sampling was ideal, the study cannot be generalized to the broader population of occupational educators. Certain defining attributes of the CTE population sampled such as geographical location and organizational properties hinder the study's broad genberalizability. However, as previously discussed, to effectively analyze a study's main effects, laboratory-like environments are highly desirable. Thus, a trade off of generalizability for increased internal validity was consciously made and accepted.

3. Assumption of increased technology confidence ultimately resulting in increased adoption: While it is admitted by the researcher and prevalent in literature that several factors are involved in the decision to adopt or not to adopt any given innovation,

it was also assumed that given the holistic nature of the adoption process, confidence in a given innovation is likely to be positively related to future adoption.

4. Assumption associated with the priming exercise in the instrumentation: Supraliminal bipolar priming was the experimental treatment used in this study. It was assumed that the subjects, when given the instrument illustrating a scrambled sentence test with the associated primes, completed the test in its entirety as they were instructed. If this did not occur, proper implementation of the priming effect could be diminished.

5. Confidence and self-efficacy based on self-assessment on a single statement: The levels of confidence and self-efficacy were self-reported by the subjects during the study. It was therefore assumed that each subject was honest in their reporting and that inference could occur from a single statement.

6. Limitation of the virtual reality treatment instrumentation: Despite the VR instrument's ease of use, subjects with very limited knowledge of such software could have found the process prohibitive therefore resulting in unusual barriers to natural exploration.

7. Assumptions of ANOVA: Given that the primary statistical method used in the study was the fixed effects analysis of variance, the underlying assumptions of ANOVA needed to be identified and addressed. These are the assumption of independence, the assumption of normality, and the assumption of homogeneity of variances. Each assumption was addressed in this study. The assumption of independence was fulfilled in that the score for any particular subject was independent of the scores for all other subjects. The assumption of normality was addressed in that the scores in the group were assumed to be sampled from a population of scores that is normal in distribution.

Additionally, the ANOVA was robust to violations of the assumption of normality because the independent variable had a fixed number of levels. The assumption of homogeneity of variances was met in that the cell sizes were equal, and the ANOVA is also robust to violations of the assumption of homogeneity of variances.

8. Researcher was employed within the district where the sample population was selected: The principal investigator for the study was employed in an administrative position within the technology center district where the sample population was selected. This could have affected the perception of the subject's voluntary participation despite such occurrence being specifically stated within the notification letter and consent document.

Significance of the Study

This study conceptualized the use of desktop VR technology as an innovation. It was designed to test the researcher's substantive theory – based in priming theory and research – that the presentation of positive and negative primes to CTE educators prior to presenting them with a VR presentation of a complex scene could affect their disposition and in turn self-efficacy toward the innovative technology. It was the intent of the researcher to make inquiry into the possibility that the relationship between VR viewing time and confidence level may be causal, and that increased viewing time may be an outcome of the priming technique.

Establishment of priming as a successful technique for favorably disposing occupational educators toward desktop VR could have important implications for CTE. VR technology has a record in the research literature of success as both an instructional medium in technical education and as an effective workplace tool in a variety of

industries. For both these reasons, VR should be considered an important technology for CTE and adult occupational education. Ausburn and Ausburn (2006) also pointed to VR's efficacy at presenting the type of three-dimensional, complex scenic environment that is frequently required in CTE and occupational education. They claimed that this is a class of learning environments that is very important in CTE and that VR is an excellent vehicle for teaching mastery of such environments. These appear to be sound reasons for CTE to take a leadership role in the adoption of desktop VR technology, that is, to assume innovator, early adopter, and early majority roles in terms of Rogers' innovation diffusion curve, rather than settling at the late majority and laggard end of the curve.

It may be possible to advance the adoption rate of VR as an instructional tool among occupational educators. This study was a first step in the examination of priming techniques as agents for promoting more positive dispositions toward, and confidence in, desktop VR technology within CTE. VR may be an important tool for CTE and adult occupational programs, and research into possibilities for expediting its adoption could be a productive line of inquiry for the field. These possibilities appeared to the researcher to merit investigation.

CHAPTER II

REVIEW OF LITERATURE

Virtual Reality

Virtual reality has been an active topic of discussion, research, and innovation since its early conception. The term *virtual reality* has permeated today's culture to the extent that any technology innovation attempting to increase the realism of an experience is associated with the term. Some video games are said to be virtual worlds. The realism is such that a legislative debate has arisen regarding whether to tax or not to tax the virtual money that is exchanged within these environments. However, the establishment of virtual reality (VR) has been a long process, and there is still no single product, level of realism, or general perspective that defines this technology.

Early forms of virtual reality, like the Link Trainer that was described in chapter one, were not quite successful at establishing themselves as a valuable training solution or viable alternative to physical reality. Figure 3 shows the Link Trainer. The limited success of the Link could be in part due to the technological capabilities that were available at the time of introduction as well as overall functionality. With limited technology, the early models left much to be desired in terms of virtual reality. However, the evolution of pilots flying by instrument, in part due to weather constraints, enabled the Link trainer to make advancements in terms of contextualization which proved

beneficial during World War II "when over 10,000 'blue box' trainers were used to improve safety and shorten training time for 500,000 pilots. The trainers were used as a step preceding actual flight training" (Roberson Museum and Science Center, 2000, p. 3).
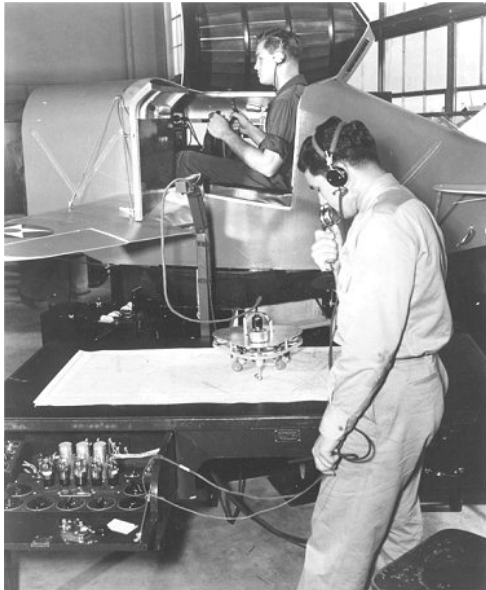
Figure 3. USAAC Cadet training in a Link Trainer
Source: http://www.oldbeacon.com

The lack of early commercial success for such a product did not inhibit progress in the conceptual development of VR. The Link Trainer was a valid attempt at increasing the "realness" of flight training. However, approximately 20 years later a cinematographer named Morton Heilig advanced the idea of virtual reality to conceptually resemble more closely what is seen today. He invented the Sensorama, shown in Figure 4. The Sensorama had the capabilities to display stereoscopic three dimensional images through a wide angle viewing screen, tilt the body of the individual participant, supply stereo sound, and even had wind as well as aroma stimuli. Today such immersive VR, while much more advanced, conceptually is very similar to what Heilig thought possible. His 1955 paper *Cinema of the Future*, perhaps considered farfetched

then, introduced the public to the idea of multisensory experiences that could have played

a role in the development of the concept known today as virtual reality.

Figure 4. Sensorama apparatus
Source: http://www.humanproductivitylab.com

Also known as artificial reality, synthetic reality, augmented reality, or

cyberspace, virtual reality is commonly experienced through a computer-based

multimedia environment that enables the participant to become an active learner within

an essentially, or virtually, real world. Virtual reality can therefore be seen as a computer

generated sensory learning environment that allows learners to participate in a responsive

way so that they will become engaged in full body-brain kinesthetic learning (Kuo &

Levis, 2002). It basically allows for the learning experience to become more

contextualized in ways that might not otherwise be fully obtainable due to a number of

given constraints. The learning experience virtual reality provides varies with differences

within its common operational components. The five common operational components

present in virtual reality include: involvement, immersion, learner control, presence, and

active interaction (Kim & Song, 1997).

The operational components of VR can be experienced at various levels. At high levels, the highly immersive forms of VR can require numerous devices and/or software applications. Fully immersive virtual reality often consists of a visual rendering device, orientation tracking mechanism, an input device, sound, and sometimes sensory feedback (Van Dam, Forsberg, Laidlaw, LaViola, & Simpson, 2000).

First developed by Ivan Sutherland in 1968 at Harvard University, head mounted displays, or HMD's, have become common within fully immersive VR. Today the devices are available in monoscopic and stereoscopic formats. The main difference lies in the number of screens used for imagery. Monoscopic devices are generally less expensive and supply a single screen. This provides an effect similar to sitting close to a television. Stereoscopic devices provide a screen for each eye. This allows the software to send different images to each eye, which is required to obtain a three dimensional view (Lim, Indhumathi, & Cai, 2006).

Magnetic, mechanical, and ultrasonic are the three most commonly used tracking mechanisms in fully immersive VR. Magnetic arrangements use transmitters that emit magnetic fields which can then be used to measure movement from within the virtual environment. Mechanical systems generally use structures attached to the individual with systematically placed sensors for recording of movement. Differing in method but accomplishing the same task, ultrasonic setups use high frequency sound produced by several emitters that sequentially send out pulses in order to obtain a measurement of orientation. More recent VR technologies have enabled inertial systems which use miniature gyroscopes to measure pitch, roll, and yaw; optical systems, using the tracking

of LEDs or other identifiable points; and image extraction systems, which use the identification of imagery via a camera and computer, as an exciting alternative to the above listed orientation tracking mechanisms.

Input devices within fully immersive VR consist of more than the traditional mouse and keyboard provided at the desktop. Wired gloves, isometric devices, and floating mice are among the technologically advanced options available for immersive VR applications. Additional assistance in departing from the normal experience include three dimensional sound and sensory feedback occurring in forms like vibrations, air, audible effects, and even resistance of force (Van Dam et al., 2000).

A major user and developer of highly immersive VR is the United States military and its contracted vendors. The adoption of VR now extends beyond flight simulators for training of pilots. The military has also used virtual reality to assist with training personnel in such skill areas as welding (VRSim Inc., 2007).

Welding is one technical discipline that has been shown to benefit a great deal from incorporating a VR trainer. The consumable cost of raw materials required to develop critical welding skills is greatly reduced when using such technological innovations:

> There are many benefits to the SimWelder, but I think the main one is the cost-avoidance to the institutions of not having to purchase steel, wire for the wire feeds and the different types of welding rods" said Art Hernandez, Vice Principal, Vocations, Office of Correctional Education, CDCR. "There's also savings in electricity. Instead of the high electrical demands needed for regular welding machines, the SimWelder simply needs a 110-volt outlet. That's a huge cost savings that's exponential because we're running 20 units, at 20 different institutions. (VR Sim Inc., 2008, ¶2).

An increase in performance review and assessment possibilities also exist by using the VR device. VRSim Inc. (2005) pointed out that a student can review the entire welding

task from the computer and see where his arc was too close or too far and where he moved too fast as well as the overall relative positioning. Figure 5 shows a side-by-side screen shot of a student and the student's relative view when performing a simple welding task on a piece of virtual angle iron.

Figure 5. VR Welder
Source: http://www.simwelder.com

The military use of virtual reality is not limited to functions related to technical skill. It can also be used when developing tactical skills as well. Oxley (2008) described devices like the virtual sphere as a good example of what is possible with today's technology. With this technology, the participant is basically immersed within a metal sphere set atop several wheels connected to a stable platform. This allows the training participant to move freely and even run without requiring a large amount of physical space to do so. As the trainee runs, the sphere turns and rotates. Inside the sphere the training participant is supported by a great deal of VR equipment consisting of a visual rendering device, orientation tracking mechanism, an input device, sound, and sensory feedback. From the participant's perspective, he/she is moving freely within a completely

autonomous three dimensional virtual world. This arrangement allows for a plethora of training scenarios to be implemented. Figure 6 shows a training participant within the virtual sphere.

Figure 6. Virtual Sphere
Source: http://www.virtusphere.com

Whether it is fully immersive virtual reality or desktop VR as described in chapter one, a viable format exists for training that could prove beneficial in ways currently unimagined. This researcher concluded from reviewing the literature that the possible adoption of a technology that has the probability of major gains in terms of educational value, be it from a state funded public institution, the United States Military, or a private organization, becomes an issue of considerable value. Thus an examination into possible ways to expedite such an innovation was viewed as beneficial.

Innovation Diffusion

<u>Background and Development</u>

The development of an innovation and how or if it is adopted has been an area of great research interest for a considerable time. Numerous variables can affect the success or failure of any given innovation. The concept of why or how an innovation is adopted has therefore been a point of emphasis for many researchers. According to Rogers (2003), the basic question or line of inquiry in innovation diffusion theory stretches back to a time when other perspectives were in their respective infancies: "The roots of diffusion theory trace to Europe about a century ago, when sociology and anthropology were emerging as new social sciences" (p. 40).

These fundamental influences could have affected the approach diffusion research took during the developmental stages of establishing a line of inquiry. The theory itself was included within the broad spectrum of many disciplines. This might have led to a disjointed collection of theoretical derivatives stemming from the same basic conceptual question supporting the theory of innovation diffusion. However, the literature indicates that the various research-driven initiatives culminated in the development of very similar findings, thereby allowing strong theoretical concepts to be included and supported within the theory base. Rogers (2003) noted:

> Research on the diffusion of innovations started in a series of independent intellectual enclaves during the 1940s and 1950s...Despite the distinctive nature of these approaches to diffusion research, each invisible college uncovered remarkably similar findings (for example, that the diffusion of an innovation followed an S-shaped curve over time and that innovators had higher socioeconomic status then did later adopters). (p. 39)

Therefore, on some levels a general regard for innovation diffusion and its varied components became accepted and extended across many disciplines. In other words, an

innovation diffusion study in education, while topically different, would somewhat resemble in terms of conceptual components a study conducted in communication or social psychology.

A sense of uniformity or consistency in the theory base developed, allowing for validity and reliability levels to be more objectively analyzed across disciplines. According to Rogers, this fostered holistically the pursuit of very good research in innovation diffusion. Rogers (2003) asserted that "The contributions of diffusion research today are impressive. For recent decades the results of diffusion research have been incorporated into basic textbooks in social psychology, communication, public relations, advertising, marketing, consumer behavior, public health, rural sociology, and other fields" (p. 103).

Current Theory

The cross-disciplinary convergence of innovation diffusion theory does not mean, however, that differing theories or derivatives thereof do not exist. In fact, besides Rogers' diffusion of innovations theory, there are two other theoretical perspectives that have received considerable attention from both the academic world and the private sector. They are each outlined in their own respective books, Moore's *Crossing the Chasm* and Atkisson's *Believing Cassandra*. However, to fully understand the extension or derivation of these theories, a firm understanding of the basic framework of Roger's theory is needed.

The concept of innovation is broad in its definition. An innovation can be many things. It is not limited to a concrete product or technological advance; it can be an abstract idea as well. Rogers (2003) defined an innovation as "an idea, practice, or object

that is perceived as new by an individual or other unit of adoption" (p. 12). One should

note the careful combination of terms in this definition – most notably, "perceived as

new" and "individual or other unit of adoption". This is critical in understanding the

concept of innovation diffusion. The innovation doesn't have to be new, it just has to be

perceived as new by the individual or other unit of adoption. Thus, an innovation can be

adopted in a much broader sense by an organization.

In terms of classifying adopter categories, the basic five types outlined by Rogers

as innovators, early adopters, early majority, late majority, and laggards are consistently

used throughout most of the current research literature. Rogers (2003) claimed that "The

method of adopter categorization just describe is the most widely used in diffusion

research today (p. 282). As shown in Figure 1, these categories are usually illustrated in a

bell curve where the percentage of adopters, as determined by rate of adoption of a given

innovation, is innovators 2.5%, early adopters 13.5%, early majority 34%, late majority

34%, and laggards 16%. The same relative proportions exist in Moore's theory of

innovation diffusion chasms described below.

Noted technology consultant Geoffery A. Moore, authored *Inside the Tornado,*

The Gorilla Game, Living on the Fault Line, as well as *Crossing the Chasm*, in which he

discussed technology innovation diffusion. The technology industry is known for

continuous advancements in product and process. It is routine to see a technological

innovation travel through its product life cycle without much ado. The VCR is one

example of a technology that, while very desired and useful in its day, has become

obsolete. Thus, this particular industry can be seen as somewhat of an innovation

diffusion hot bed. The manipulation of the innovation and adoption process can lead to a

significant difference in profitability for a product, division, and company as a whole. Given the stakeholders involved and corresponding economic factors associated with a company's success or failure, it is not surprising that the literature shows that many private consultants focus on innovation diffusion theory.

In essence, this same reasoning is the fundamental driver behind Moore's theory of *innovation diffusion chasms*. His framework is clearly a derivative of Rogers' overarching innovation diffusion theory. However, Moore posits a different perspective relating to the success or failure of consumer behavior in adopting an innovation, or specifically in buying a product or opting to use a new process or protocol. According to Moore (2006) "The basic flaw in the [Rogers] model… is that it implies a smooth and continuous progression across segments over the life of a product, whereas experience teaches just the opposite" (p. 56).

It is Moore's contention that while the same five adopter categories identified by Rogers exist in business product/process adoption, the transition from one adopter category to the next does not happen smoothly as proposed by Rogers. He argues that each group is different and thus has a unique experience with the innovation itself. Given Moore's background, his proposal has identifiable parallels with the business world. From a marketing perspective, this would resemble demographic variation in values and as is the practice of the private sector, adjustments would be made in presenting the same product to different groups. Therefore, while Moore retains the overall theory of Rogers, he does present a different point in terms of its fluid progression:

> The components of the life cycle are unchanged, but between any two psychographic groups has been introduced a gap. This symbolizes the dissociation between the two groups – that is, the difficulty any group will have in accepting a

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new product if it is presented in the same way as it was to the group to its immediate left. (Moore, 2006, p. 16)

Moore's chasm theory was dramatically disputed by Rogers. That is not to say specific results he achieved through research were contested by Rogers, but rather the validity was called into question with regard to the chasms between adopter groups. Rogers noted that in Moore's work, "Pronounced breaks in the innovativeness continuum do not occur between each of the five categories, although some scholars claimed that a discontinuity exists between the innovators and early adopters versus the early majority, late majority, and laggards (Moore, 1991)" (Rogers, 2003, p. 282). However, Rogers did not accept the Moore's proposed changes to his theory. He noted that there were differences between the categories but asserted that innovativeness was continuous:

> Past research shows no support for this claim of a "chasm" between certain adopter categories. On the contrary, innovativeness, if measured properly, is a continuous variable and there are no sharp breaks or discontinuities between adjacent adopter categories (although there are important differences between them). (Rogers, 2003, p. 282)

While Moore's theory retained the common adopter classification with a relatively minor deviation to Rogers's theory, Atkisson's Amoeba of Culture theory proposes a pronounced conceptual change in the way innovation diffusion is examined. With regard to the concept of time as it relates to innovation diffusion, Atkisson and Rogers appear to agree. However, their adopter classifications do not coincide. Thus a dramatic variation exists between Rogers' graphical illustration of the adopter classification bell curve and Atkisson's Amoeba of culture. Figure 7 shows the features of Atkisson's amoeba of culture and how each interact in striving towards innovation diffusion. It is indeed an organism as seen by the adaptability of each internal part in

relation to the whole. The theory moves further in that direction with its analogy of the

amoeba being attracted to a new idea like a piece of food. Atkisson (1999) noted:

> Cultures are like amoebas: Change starts out at the edge of the pseudopod, on the "cultural membrane," where a new idea has attracted the "amoeba of culture" like a piece of food. Then, if the idea is compelling enough, the entire amoeba follows the pseudopod in that direction. The "nucleus", which symbolizes the power center of the culture, is actually very late to arrive on the scene (and often slows the process down, which can sometimes be good) (Atkisson, 1999, pp. 180-181).

Atkisson's proposed adopter classification system is not only unique in it

graphical illustration and how each interact in the diffusion of innovation, it also presents

different elements to the theory itself, for example the spiritual recluses and

curnmudgeons categories. These specific adopters or in this case, non-adopters, are

The Anatomy of Cultural Change

RENUNCIATE CURMUDGEON

SPIRITUAL RECLUSE

ICONOCLAST

INNOVATOR

REACTIONARY

CHANGE AGENT

UNWILLING LAGGARD

TRANSFORMER

MAINSTREAMERS ("NOISY MAJORITY")

Figure 7. Atkisson's Anatomy of Cultural Change
Source: Atkisson, A. (1999). *Believing Cassandra: An optimist looks at a pessimist's world.* Vermont: Chelsea Green Publishing Company.

represented outside the amoeba and can be seen as detractors to those adopters within the amoeba. This is in stark contrast to Rogers' theory in which diffusion did not occur until all categories of a specified system had adopted the innovation. Atkisson's theory allows for diffusion to occur without every adopter category having accepted the innovation. Table 1 further defines the respective adopter categories identified in Atkisson's innovation diffusion theory.

Despite the complex process presented within Atkisson's amoeba of culture theory, he actually proposed a simple explanation as to how an innovation is adopted. According to Atkisson (1999), "For an innovation to be adopted and change to occur, the

Table 1: *Atkisson's Amoeba of Culture Adopter Category Definitions*

Innovator	A person or group who invents, discovers, or otherwise initiates a new idea
Change Agent	People who actively and effectively promote new ideas
Transformers	Early adopters
Late adopters or Laggards	Satisfied with the status quo and not likely to change until they really don't have a choice
Reactionaries	People who actively resist innovations, and who have a vested interest in maintaining the status quo
Iconoclasts	The gadflies, the protestors, the angry critics of the status quo
Spiritual Recluses	Contemplatives who withdraw (actually or metaphorically) from the culture to seek, and preach, the eternal truths
Curmudgeons	Those who have given up on the culture, they see change efforts as useless, and they project a nihilistic sense of disappointment and disillusionment

difference in perceived value between the old and the new way of doing things has to seem greater than the perceived costs of the switch" (p.192). Moore's chasm theory is a Rogers derivative in much the same way, the main difference being how an innovation is

adopted. This is in essence, a tribute to Rogers' early work toward developing his unified

general theory of innovation diffusion.

<u>Critical Elements of Rogers' Theory</u>

Rogers' innovation diffusion theory is very complex when examined from a

micro perspective and then viewed holistically. His theory breaks the innovation

diffusion process into five mutually exclusive steps as they relate to time. Rogers (2003)

proposed that "The innovation-decision process involves time in the sense that the five

steps usually occur in a time-ordered sequence of (1) knowledge, (2) persuasion, (3)

decision, (4) implementation, and (5) confirmation" (p. 21). He posited that these

conceptual steps are present with each individual adopter category. Therefore, individual

innovators will encounter their own knowledge, persuasion, decision, implementation,

and confirmation steps. The early majority will also encounter the same steps in the

process, however they will occur for that category at a different time in the innovation

diffusion. Rogers (2003) noted this occurrence:

> The time element of the diffusion process allows us to classify adopter categories
> and to draw diffusion curves. The adoption of an innovation usually follows a
> normal, bell shaped curve when plotted over time on a frequency basis. If the
> cumulative number of adopters is plotted, the result is an S-shaped curve. (p. 272)

Figure 8 illustrates Rogers' S-shaped curve. It should be noted that this graphic is from

Atkisson's book on his amoeba of culture. This was intentionally done to show the

significant parallel between the two theories. When viewing the S-shaped adopter curve,

it is important to note two things.

First, the S-shaped curve directly corresponds to Rogers' bell curve illustrating

adopter classification as shown in chapter one. When the two are simultaneously

examined, it is clear that the specific adopter categories will appear within certain points
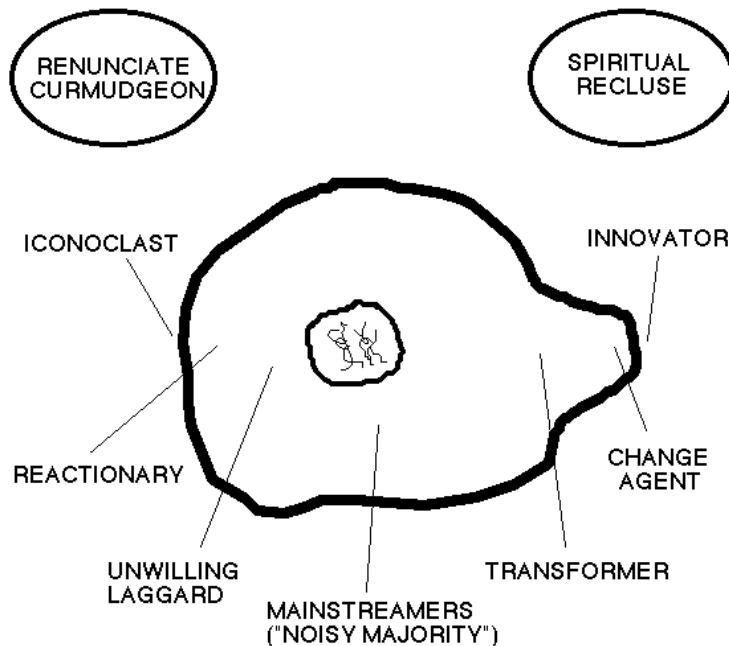
The Innovation Adoption Curve
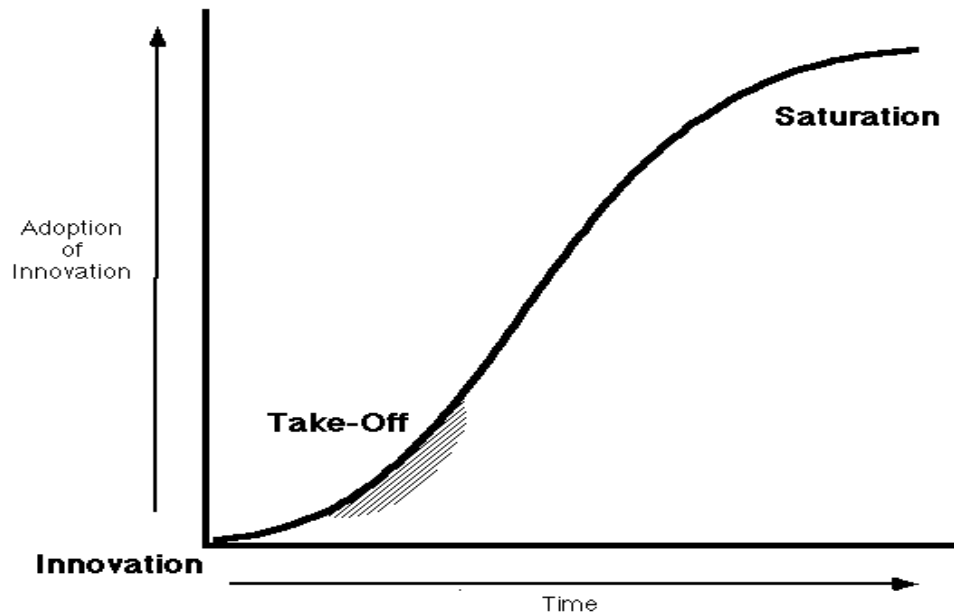
Figure 8. Atkisson's Anatomy of Cultural Change
Source: Atkisson, A. (1999). *Believing Cassandra: An optimist looks at a pessimist's world*. Vermont: Chelsea Green Publishing Company.

of the S-shaped curve. Innovators, for example, would be close to the bottom of the S-shaped curve, while laggards would be at the top near the saturation area. Thus each illustration is representative of the same occurrence within the innovation diffusion process where the S-shaped curve is a cumulative perspective and the bell curve is non-cumulative. Figure 9 is an adaptation of a graph shown in Rogers' book *Diffusion of Innovations* depicting the number of new adopters each year of hybrid seed corn in two Iowa communities. It further illustrates how the S-shaped curve corresponds to the bell curve in regards to the relationship time has within the theory of innovation diffusion. However, the comparison should not lead to the assumption that the S-shaped curve is not normal in nature due to its visual representation. Rogers (2003) addressed this:

> This S-shaped curve is normal…Many human traits are normally distributed, whether the trait is a physical characteristic, such as weight or height, or a

behavioral trait, such as intelligence or the learning of new information. Hence, a variable such as the degree of innovativeness is also expected to be normally distributed. (p.272)
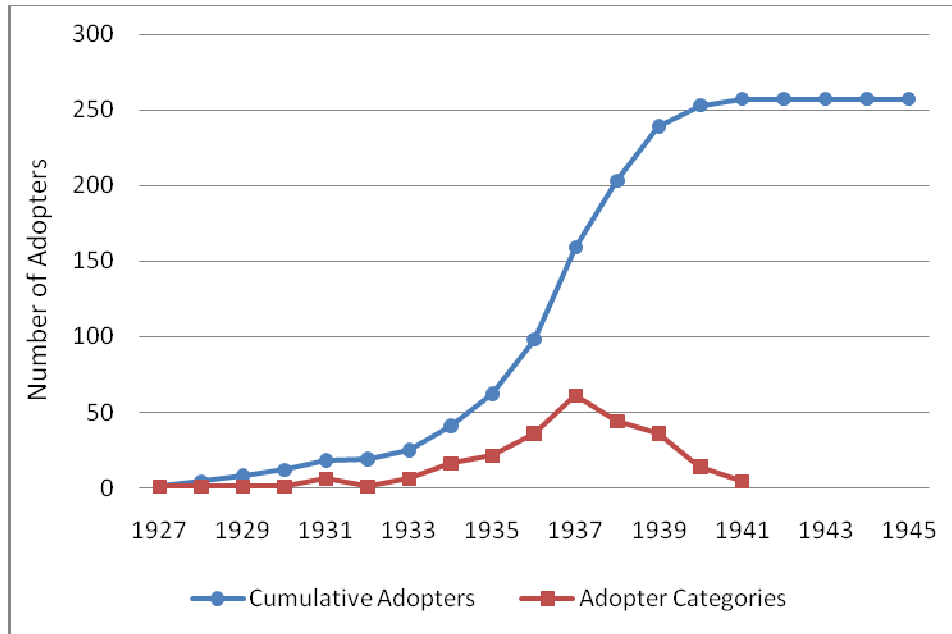
Figure 9. S-shaped curve and the bell curve
Source: Adapted From Rogers, E.M. (2003). *Diffusion of innovations*. New York: The Free Press.

However, this is not to say that all innovation diffusion curves, either S-shaped or bell, will be normal. As noted within Rogers' innovation diffusion theory, many characteristics of such a process can be related to the type of innovation being adopted or the system adopting it. Therefore certain contingencies should be placed on gross application of specific curves across all innovations and systems. Rogers (2003) noted:

> The S-curve, it must be remembered, is innovation-specific and system-specific, describing the diffusion of a particular new idea among the member units of a specific system...The main point here is not to assume that an S-shaped rate of adoption is an inevitability. Rather, the shape of the adopter distribution for a particular innovation ought to be regarded as an open question, to be determined empirically. (pp. 275-277)

Second, the area shaded and listed as "take-off" on the S-shaped curve is an important point of reference for innovation diffusion. Rogers (2003) called this area of the S-shaped curve the critical mass and stated that "The critical mass occurs at the point at which enough individuals in a system have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining" (p. 343). To marketing diffusion scholars this term is known as "take off" or "time to take off". The occurrence as such has become a point of interest for obvious reason. If a particular innovation becomes self-sustaining in the diffusion process, then considerably positive affects to product or firm profitability can been achieved. As Rogers (2003) explained:

> When a critical number of individuals have adopted an interactive innovation, a further rate of diffusion becomes self-sustaining as reciprocal interdependence increases the relative advantage of the interactive innovation for both past and future adopters. The critical mass is thus a kind of "tipping point" (Gladwell, 2000) or social threshold in the diffusion process. (p. 352)

However, as stated in Rogers' theory, the threshold is an individual component while the critical mass becomes more of a systemic perspective of many individuals. Therefore the threshold is more of a social feature of the process rather than an experiential component. Thus, what one individual observes within his or her social system may have a larger influence on his/her adoption decision than the same observation from a different individual. In other words the threshold varies from person to person and from adopter category to adopter category. According to Rogers (2003):

> A threshold is the number of other individuals who must be engaged in an activity before a given individual will join that activity (Granovetter, 1978; Markus, 1987). In the case of diffusion of an innovation, a threshold is reached when an individual is convinced to adopt as the result of knowing that some minimum number of other individuals in the individual's personal communication network have adopted and are satisfied with the innovation. (p. 355)

The threshold concept is also affected by what step the individual happens to be in during the innovation diffusion. If an individual is in the knowledge step, for example, then he or she may be less likely to experience an individual threshold leading to adoption without first progressing through the other five steps of the process. However, if the same individual is in the persuasion step, then he or she may be ripe for reaching an individual threshold. Thus the five steps of the innovation decision process and its specific elements are a critical part of the theory (Rogers, 2003).

The Innovation Decision Process

Rogers outlined the innovation decision process to include five steps or stages that an individual, organization, or adopting unit will encounter. He stated that "The thinking of John Dewey and George Herbert Mead had a direct bearing on the rural sociologist who first posited the idea of stages in the innovation-decision process (Beal, Rogers, and Bohlen, 1957)" (Rogers, 2003, p. 196). These stages include knowledge, persuasion, decision, implementation, and confirmation. Adopting units may experience the stages at different intervals and with varied experiences. This is the case on both an individual and organizational level. "One of the most distinctive problems in the diffusion of innovations is that participants are usually quite heterophilous" (Rogers, 2003, p. 19). Therefore, conceptualizing the intricacies of each stage is critical in order to further understand the theory.

Rogers (2003) claimed that several preceding conditions exist leading to the beginning of the innovation diffusion process. These conditions vary between individuals or adopting units and to a certain extent are somewhat related to their adopter category and where they will most likely fall on the S-shaped curve. These prior conditions

include previous practice, felt needs and problems, innovativeness, and norms of the social system. While these conditions are present and observable prior to entering into the knowledge stage, a set of different characteristics come into play when the individual or adopting unit enters into the knowledge stage. "The innovation-decision process begins with the knowledge stage, which commences when an individual (or other decision-making unit) is exposed to an innovation's existence and gains an understanding of how it functions" (Rogers, 2003, p. 171). These characteristics of the decision-making unit include socioeconomic characteristics, personality variables, and communication behavior. Each plays an important role with regard to how a decision-making unit progresses to stage two, the persuasion stage.

The persuasion stage has its own set of characteristics as identified by Rogers (2003). These are perceived characteristics of the innovation and include relative advantage, compatibility, complexity, trialability, and observability. The key point with the characteristics relating to the persuasion stage is that they are all *perceived* characteristics. This is a critical element in the theory base considering that this is the specific stage in the decision-making process where this study attempts to position itself. If the persuasion stage is where disposition and attitude with regard to the innovation are formed, then the implementation of prime theory is an attempt to alter the perception that the decision-making unit it forming. "At the persuasion stage in the innovation-decision process, the individual forms a favorable or unfavorable attitude toward the innovation. Attitude is a relatively enduring organization of an individual's beliefs about an object that predisposes his or her actions" (Rogers, 2003, p. 175). Thus, an attitude or a change thereof can have an effect on an innovation being viewed favorably or unfavorably.

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When an innovation is observed on those terms, it then becomes possible for a given view to develop into a general perception. The persuasion stage is therefore where any attempts to skew the adoption curve need to be focused, or as Rogers stated "It is at the persuasion stage that a general perception of the innovation is developed" (Rogers, 2003, p. 175). However, in terms of innovation diffusion, perception is just one component required to skew the adoption curve. If behavioral change does not stem from the attitudinal and perceptual conditions, then observable and measurable changes may be an unlikely occurrence. Thus, it is therefore assumed that from such conditions there generally occurs a corresponding change in behavior. In other words, as attitude and perception change, in general so does behavior:

> The main outcome of the persuasion stage in the innovation-decision process is a favorable or unfavorable attitude toward the innovation. It is assumed that such persuasion will lead to a subsequent change in overt behavior (that is, adoption or rejection) consistent with the individual's attitude. (Rogers, 2003, p. 176)

The culmination of acquiring the requisite knowledge and being persuaded towards a specific stance with regard to the innovation leads to the decision stage. The decision stage "takes place when an individual (or other decision-making unit) engages in activities that lead to a choice to adopt or reject an innovation" (Rogers, 2003, p. 177). However, that is not to say that making a decision always follows the same path of reasoning and action. In all actuality the decision to adopt a given innovation can sometimes incur significant barriers. This is especially true within an educational system. Rogers (2003) addressed adoption within a system and detailed decision types by categorizing them in three groups. First, *optional innovation decisions* "are choices to adopt or reject an innovation that are made by an individual independent of the decisions of other members of the system" (Rogers, 2003, p.28). This decision type is sometimes

seen within educational cultures that provide significant levels of autonomy concerning

individual decision making. Second, *collective innovation decisions* "are choices to adopt

or reject an innovation that are made by consensus among the members of a system"

(Rogers, 2003, p.28). This type of innovation adoption decision is often seen in

organizations that use committees to guide incremental processes. Third, *authority*

innovation decisions "are choices to adopt or reject an innovation that are made by a

relatively few individuals in a system who possess power, status, or technical expertise"

(Rogers, 2003, p.28). Organizations using a centralized approach to management might

tend to make this type of innovation adoption decision. On a practical level, the types of

innovation adoption decisions made by a given organization are not categorical and

should be viewed as a continuum. Educators could be susceptible to any of Rogers' three

decision types with specific circumstantial contingency. Other factors including social

system constraints and financial caveats also play a role in an innovation decision. Thus,

the innovation-decision process can be systemic on many levels (Rogers, 2003).

Implementation is the fourth stage in the decision-making process and is unique in

that it can differ uniformly from the decision stage with regard to the active participants

driving it. "Implementation occurs when an individual (or other decision-making unit)

puts an innovation to use" (Rogers, 2003, p. 179). From an organizational perspective the

decision maker may not always be the same individual who implements the innovation.

Thus, a considerable amount of uncertainty could arise between the various ranks of

disconnectedness. Those who implement may not have the same vision for the innovation

in terms of use, capability, and applicability as the decision-making unit. This occurrence

could affect the resulting action of the confirmation stage.

The confirmation stage is the fifth and last stage in the innovation decision-making process. It can occur directly after or an extended time after the implementation stage. "At the confirmation stage the individual (or other decision-making unit) seeks reinforcement for the innovation-decision already made, and may reverse this decision if exposed to conflicting messages about the innovation" (Rogers, 2003, p. 189). This occurrence could easily arise on the organizational level if, as previously discussed, the implementers differ from the decision makers. If the decision makers are not receiving the feedback they anticipated or observing the results they desire, then they could attempt to reduce the level of dissonance they are encountering or pursue a discontinuance strategy.

<div align="center">**Prime Theory and Its Background**</div>

<u>An Introduction to Priming</u>

Prime theory on the cognitive level has been prevalent in research since the 1960s. It is predominantly seen in research in the psychology and social psychology disciplines. However, applied prime theory can be found in research across numerous other disciplines. It is even seen in the business world on an international scale.

Yale professor Ian Ayres (2007) referenced the practice of priming in his book *Super Crunchers*. According to Ayers, the South African firm Credit Indemnity is a very large micro lender that specializes in pay day loans. The company conducted a randomized experiment with their pay day loans ranging from 3.25% to 11.75% and found that demand was higher for lower rate loans. The interesting part of the experiment came when Credit Indemnity found that simply adding a picture of a smiling woman in

the upper right hand corner raised demand by as much as lowering the interest rate by 4.5 percentage points.

An even larger effect was observed when Credit Indemnity hired a market research firm to call potential clients about a week prior to receiving the solicitation and simply asking them questions about their anticipation in making a large purchase. The researchers asked about things like home repairs, school fees, appliances, ceremonies, weddings, and even paying off other debt. Ayers (2007) stated,"Talk about your power of suggestion. Priming people with a pleasant picture or bringing to mind the possible need for a loan in a non-marketing context dramatically increased their likelihood of responding to the solicitation" (disc 2, track 4).

Recently the concept of priming was more widely reviewed in a science channel television program titled *Fool Proof Equations for a Perfect Life* in which the host mathematician Garth Sundem examined the human ability to make decisions versus a mathematical approach. In this program, Yale psychology professor John Bargh was interviewed regarding his extensive research with priming. An actual research project was presented that involved the effect warm or cold temperatures may have on initial evaluations.

In this priming experiment, as in most priming studies, the subjects are exposed to the stimuli through a process that appears to them to be completely unrelated to the research project. In this particular case, hidden cameras recorded the elevator trip to the research lab. While in the elevator, the researcher asked each subject to hold his drink while he writes something on his clipboard. Unbeknownst to the subject, the beverage was either warm or cold. The subject was then led to the research lab and introduced to

the so-called principal investigator (PI). The PI explained to the subject how to complete the research questionnaire and then left the room. After the subject completed the questionnaire, the individual who escorted him to the lab and who also introduced the priming stimuli returned. He asked the subject to evaluate the principal investigator in terms of hiring him for a leadership position like a project manager. The results showed that those subjects who were primed by holding the warm beverage evaluated the PI much more favorably than those who were primed by holding the cold beverage (The Science Channel, 2008).

While frequently presented in academic literature and in varied forms throughout the private sector, priming is itself part of a much broader movement of inquiry. It has derived from behaviorism's debate of free will as it relates to conscious and non-conscious behavior as well as the concept of automaticity. The majority of such inquiry and its corresponding development of extending theory, while applied in various disciplines, have developed from the psychological ranks of academia. Bargh (2002) discussed the origins of priming research and cited several key studies:

> The original priming studies from the 1960s and 1970s were not laboratory studies but were carried out in the field. These concerned the impact of the presence of aggressive cues such as weapons on subsequent aggressive behavior (Turner, Layton, and Simons, 1975), the impact of exposure to television violence on aggressiveness in children (Belson, 1978), and the impact of witnessing helpful acts on subsequent liklihood to help a person in need, such as a stranded motorist (Bryan and Test, 1967). Those studies showed consistently strong influences of contextual primes on behavior in real world settings; indeed, the model of aggressive cues developed in the laboratory holds even more strongly when it is tested in the field (Bushman and Anderson, 1998). (pp. 281-282)

The various aspects of priming presented in the literature review can be seen to have somewhat interdependent relationships. Behaviorism, for example, is clearly aligned with a particular view with regard to psychological free will. Correspondingly, the

concept of automaticity also clearly extends from a specific stance on free will. Both particular concepts fall under the behaviorism umbrella. Thus, it would be very difficult to examine prime theory without first acknowledging the contributing elements of the theory base.

Behaviorism and Free Will

As a philosophy, Behaviorism was led by early scientists and researchers Ivan Pavlov, Edward Thorndike, James Watson, and B.F. Skinner. While each is renowned and known for their scientific accomplishments, their respective theoretical paradigms can be said to align with a behavioristic stance. The main overarching principle that can be extracted from behaviorism as it relates to prime theory as presented in the research literature is that an individual's behavior is conditioned through external forces. In other words people are a product of their environment. Therefore, whether an analysis is being made of Pavlov and Watson's classical conditioning, Thorndike's S-R theory, or Skinner's operant conditioning, the environment is still given precedence over psychological free will.

To be clear however, a distinction needs to be made with regard to the type of free will that is referred to within psychological research. Bargh (2007) asserted that "Free will as a psychological concept concerns the individual, and actions that are under the individual's power to perform" (p. 4). Bargh further claimed that this is commonly confused with the more common non-academic definition of free will: "Free will or freedom as a political or societal-level concept (which is often confused with the psychological sense of the notion), concerns plurality, and actions that depend on or are restricted by the consent or cooperation of others" (Bargh, 2007, p. 4). Thus, the

psychological definition of free will does not appear to address the outward actions one may view in the sense of having freedom or the right to choose. Rather, it deals with the internal factors and whether those factors are influenced or determined. Bargh (2007) posed the critical question: "In the psychological domain: are behaviors and judgments and other higher mental processes the product of free conscious choices, as *influenced* by internal psychological states (motives, preferences, etc.), or are those higher mental processes *determined* by those states?" (p. 5). Bargh's question fundamentally breaks down the philosophical perspective that behaviorism posits with regard to prime theory. It is the behaviorist stance that higher mental processes are determined by internal psychological states thus allowing the environment to influence the state thereby in turn affecting the mental process. The same premise is held by psychological researchers studying the concept of automaticity. Bargh (2007) provided an analogy explaining the stance:

> The phenomenological feeling of free will is very real, just as real for those scientists who argue against its actual existence as for everyone else, but this strong feeling is an illusion, just as much as we experience the sun moving through the sky, when in fact it is we who are doing the moving. Each of us lives in a difficult to predict present and near future, which includes our own behavior in it, and which therefore makes our behavior feel spontaneous and undetermined – but what we don't experience, yet which are just as real, are the multitude of unconscious influences and determinants of what we think, act, and feel. (p. 31)

This line of inquiry has been a dominating force in psychological research. It is an elemental factor in major debates such as the frequently-referenced nature versus nurture debate. Analysis has examined several facets of the conscious and unconscious mind with regard to potential influences and their effect on behavior. While Behaviorism prefers to examine the observable outward actions of an individual, there are those researchers who focus on the innate internal processes that precede such action as well. Thus the inquiry,

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while ongoing and a current issue of interest for many, has proponents on both sides of the line in the research literature. The significant debate can be summarized as follows:

> The major historical perspectives of the 20th-centry psychology can be distinguished from one another based on this question: Do people consciously and actively choose and control (by acts of will) these various experiences and behaviors, or are those experiences and behaviors instead determined directly by other factors, such as external stimuli or internal, unconscious forces? (Bargh & Chartrand, 1999, p. 462)

Automaticity

Behaviorism and its stance concerning psychological free will directly enable the concept of *automaticity* to be held with high regard in terms of a bona fide theory base. Automaticity can be seen as a capstone term and many different methodological approaches can be pursued in order to enact its practice. In other words, automaticity can be viewed as the overarching theory that encompasses practices like priming, either through subliminal or supraliminal means. Bargh and Williams (2006) defined the term clearly: "Automaticity refers to control of one's internal psychological processes by external stimuli and events in one's immediate environment, often without knowledge or awareness of such control" (p. 1). Thus, priming is the procedure and automaticity is its corresponding effect on behavior. Therefore, automaticity can occur through processes different from those commonly associated with the priming method used in this study. The literature shows that research in determining the effectiveness of such practices has been conducted for many years in both the academic and private sectors. According to Bargh's (1989) summary, "The notion of automatic cognitive processing has a tradition as old as the field of psychology itself" (p. 3).

A lengthy research history indicates that this concept is widely accepted and in some circles revered. Many discussions have been presented with regard to the effects

media, video games, and even music have on individual as well as collective behavior (Baranowski, Buday, Thompson, & Baranowski, 2008; Dixon, Trigg, & Griffiths, 2007; Persky & Blascovich, 2008; Polman, De Castro, & Van Aken, 2008). It was Bargh's conclusion that, "The idea that social perception is a largely automated psychological phenomenon is now widely accepted. Many years of research have demonstrated the variety of ways in which behaviors are encoded spontaneously and without intention in terms of relevant trait concepts" (Bargh & Chartrand, 1999, p. 465).

Figure 10 is a graphical representation of how automaticity can occur either through an intentional or unintentional route, as explained by Bargh and Chartrand (1999). Differences occurring at the beginning of the process are critical. The individual

(a) *Conscious, Intentional Mediation of Goal Pursuit Within a Situation and* (b) *Automatic Activation and Operation of Goals by Situational Features Following Repeated Choice of the Same Goal*
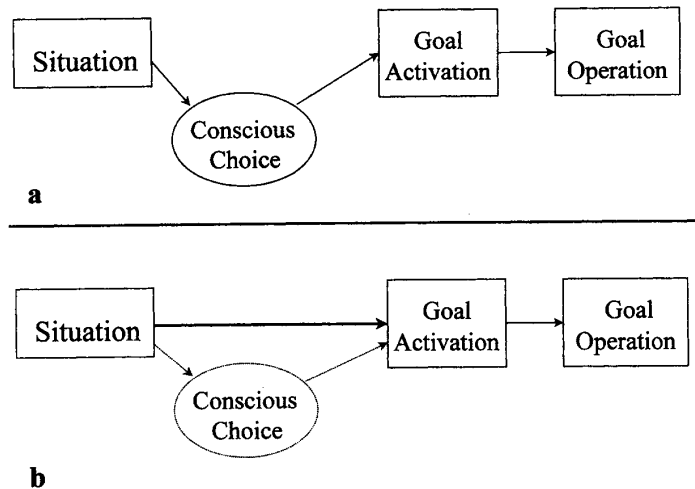
Figure 10. Unintentional Acquisition of Automaticity
Source: Bargh, J., and Chartrand, T. (1999). The unbearable automaticity of being. *American Psychologist,* 54 (7), 462-479 The American Psychological Association

either has an existing goal or is conditioned from having repeatedly made the same choice for a given situation. This is of particular importance in the process of priming and automatization simply because previous studies have shown that priming without the

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subject having a specific goal ostensibly related to the activity is less effective. For example, you cannot make someone thirsty who has recently had something to drink, but you may be able to make someone thirsty who hasn't had something to drink recently but is unaware that they may indeed be thirsty (Bargh, 2002).

However, through automatization the goal can be activated where it seemingly did not exist previously. The process can transpire from a given situation due to such choices occurring with certain similarity. According to Bargh and Chartrand (1999), "This is how goals and motives can eventually become automatically activated by situations" (p. 469). They provided a fundamental example of this in a study where the subjects were primed for a goal of impression formation or not primed at all. After being primed the subjects then participated in an ostensibly unrelated study where they were exposed to a series of behaviors engaged in by a target person. "Those participants whose impression-formation goal had been nonconsciously activated were found to have formed an impression of the target during information acquisition, whereas control participants had not (Bargh & Chartrand, 1999, p. 470). The impression formation occurred outside the normal situation and as such can be seen to bypass the conscious choice portion of the automaticity process. In summary, "The goal, once activated, should operate to produce the same effects as if it had been consciously chosen" (Bargh & Chartrand, 1999, p. 469)

Types of Priming

There are basically two types of primes: subliminal primes and supraliminal primes. The major distinction between the two is that subliminal primes expose subjects to stimuli below their level of awareness while with supraliminal primes, subjects are aware of the stimuli but not of the intended influence. Bargh (2002) asserted that "Both

forms have been shown to be successful in influencing judgments, motivations, and behaviors in social cognition research" (p. 282).

Subliminal priming is a somewhat controversial topic that has been debated since its early conceptual introduction. The practice of this technique was really brought into the mainstream of research in the late 1950s with Vance Packard's book *The Hidden Persuaders*. Bargh claimed that "Indeed, one reason why consumer research seemed to shy away from the study of motivational influences over the past 40 years is the legacy of Vance Packard's 1957 book *The Hidden Persuaders"* (2002, p. 282). According to Bargh (2002), Packard's primary contention revolved around market researchers' proposed ability to affect an individual's unconscious motives through subliminal advertising. He referenced the movie theatre's attempt to increase the sale of concessions through subliminal advertising as the main example in support of his claim. "However, the early reports of subliminal ads in movie theatres turned out to be a hoax" (Bargh, 2002, p. 282). Despite the efforts of movie theatres, as well as other attempts at subliminal advertising, demonstrated lack of effectiveness, the very notion of such occurrences brought about controversy. Bargh concluded that "The book, published in an era of prisoner of war brain-washing attempts and cold war paranoia, was a sensation and gave the scientific study of consumer motivations an unsavory public image" (2002, p. 282).

However, in today's society there may be more concern for practices using subliminal priming. Research has progressed in the area of cognitive psychology, and it has been contended that "Today, most people remain concerned about the possibility of being influenced by subliminal messages (Wilson & Brekke, 1994), and perhaps now, finally, they should be. Contemporary researchers are consistently obtaining subliminal

effects on consumption and product evaluation" (Bargh, 2002, p. 282). This change in

results is not necessarily associated with a shift in the theory base, but rather a honing of

technique. While the theory of automaticity posits that a goal can be activated, the

process of goal activation with varied conditions can become cumbersome in terms of

measuring a main effect. This is particularly the case considering the varied stimuli that

can be encountered when one is conducting a field study. A successful example of this

was reported by Bargh:

> Levin's influential field theory (1951) held that one could not induce in people
> goals they do not already have themselves, but you could influence them by
> activating or manipulating the goals that they already possessed. The most recent
> work on subliminal influence exploits this principle by matching the subliminal
> stimulus with the subject's current goal or need state; it also makes use of known
> effective primes. Thus Berridge and Winkielman (forthcoming) subliminally
> presented subjects with a happy, a neutral, or an angry face. Those who had been
> shown the happy face subsequently evaluated a fruit flavored drink more
> favorably and also drank substantially more of it than did neutral-primed
> participants. Those who had been shown the angry face drank least of all. Most
> important, these effects held only for those participants who were thirsty (having
> been instructed not to drink anything for hours before the experiment); the
> evaluations and drinking behavior of non-thirsty participants were unaffected by
> the same subliminal primes. (Bargh, 2002, p. 283)

Differing significantly in context and application, supraliminal primes are another

way to attempt to influence behavior. Bargh (2002) supported supraliminal priming,

stating that, "Supraliminal influence attempts, including goal activation, can be as

effective - if not more effective - than subliminal priming" (p. 283). While supraliminal

primes occur at the level of consciousness, there remains a disassociation between the

priming stimuli and their intended associational target. Thus, awareness with regard to

the connections of a given treatment remains non-existent.

It might appear somewhat unlikely that exposure to an array of priming words

that are strongly associated to a given behavior could have any effect on or change in an

individual's behavior. However, the practice of supraliminal priming has been applied

across many diverse settings. Bargh provided an example:

> As an example, we routinely bemoan negative or "dirty" political campaign advertising and insist that such ads do not affect our own vote, yet the reason such ads do not go away, and even increase in frequency each election season, is that they are, in fact, quite effective. (Bargh, 2002, p. 283)

The effects of supraliminal priming are not restricted to negativity. Positive

priming can be found within many areas of consumerism. The preceding example of

Credit Indemnity's attempt to increase the sale of their loan products is evidence of such

practices. The process in itself is becoming more focused and successful in achieving a

significant result. "The main reason for recent success is that researchers are taking the

consumer's (experimental participant's) current goals and needs into account" (Bargh,

2002, pp. 282-283). Therefore, participation, either consciously or unconsciously could

become more prevalent across a broadened spectrum and further infuse the decision-

making process with varied automatic responses.

Theoretical Elements of Self-Efficacy

Albert Bandura's concept of self-efficacy is a well-established and foundationally

strong theory within the psychology discipline. It is a somewhat predictive theory in that

self-efficacy constructs are relational to outcome expectancies and control. The theory

can be applied on the individual, collective, and organizational levels. Self-efficacy

theory has for the most part focused on outcome. This often appears in studies that have

been conducted to examine self-efficacy in relation to performance. Manipulating the

individual, collective, or organizational level of self-efficacy has been seen to affect the

likely outcome of a given performance measure (Bandura, 1997). In essence, if the

individual, collective group, or organization *believes* their likelihood of success in

performing a certain task and achieving a certain outcome is high, then the likelihood of achieving said outcome is increased, thus influencing their performance level.

The cognitive progression of achieving such an outcome is debated in some circles. One perspective found in the literature is that from a perceived outcome an individual will make a judgment of his or her likely performance level. An alternative view is that the individual first judges his or her ability, then reasons to the likely outcome. Bandura (1997) provided an overview of the casual relationship of self-efficacy to performance and outcome:

> The outcomes people anticipate depend largely on their judgments of how well they will be able to perform in given situations. To claim as some writers have (Eastman & Marzillier, 1984), that people visualize outcomes and then infer their own capabilities from the imagined outcomes is to invoke a peculiar system of backward causation in which the outcomes that flow from actions are made to precede the actions. People do not judge that they will drown if they jump in deep water and then infer that they must be poor swimmers. Rather, people who judge themselves to be poor swimmers will visualize themselves drowning if they jump in deep water. (p. 21)

Performance and outcome, associated as operational variables, have therefore been seen to have relational qualities within the supporting literature of self-efficacy theory. Clarification of terms is thus necessary in order to properly segment the post-cognitive events as either/or. According to Bandura (1997), "As conventionally defined, a *performance* is an accomplishment; an outcome is something that follows from it. In short, an *outcome* is the consequence of a performance, not the performance itself" (p. 22). When examining specific post-cognitive events, it is therefore necessary to determine if the related occurrence is the performance or the outcome.

According to Bandura (1997), the performance/outcome difference is of critical relevance when conducting research based on precepts provided through self-efficacy

theory. He asserted that it must be determined through proper methodology if the specific

measure being examined within the study is either a performance measure or an outcome

measure. This determination is essential and to misjudge the supporting methodological

foundation would result in misguided conclusions: "Those who misconstrue a

performance marker as the outcome of itself launch themselves on an endless

performance regress" (Bandura, 1997, p. 23). Figure 11 illustrates the multifaceted

associations exhibited through the various connected elements within the theory of self-

efficacy. It clearly shows the causal relationships and corresponding components

Person ⟶ Behavior ⟶ Outcome

Efficacy Beliefs **Level** **Strength** **Generality**	Outcome Expectancies **Physical** **Social** **Self-evaluative**
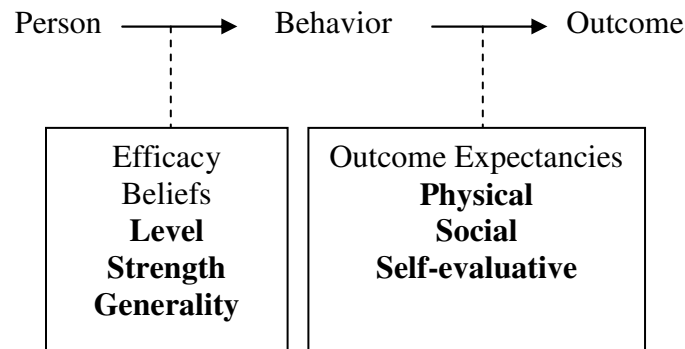
Figure 11: The causal relationship between beliefs of personal efficacy and outcome
expectations
Source: Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H.
Freeman.

throughout the theory's progression. Thus, misinterpretation of a measure appearing

within a study using self-efficacy as a cornerstone element of its analysis could easily

occur. Clarification of where in the process the data collection occurs becomes an

important issue in addressing validity within certain methodologies. Bandura (1997)

warned that "Some writers have misconstrued beliefs of personal efficacy as judgments

of motor acts in a 'behavioral repertoire' or as a decontextualized quality of perceived

ability" (p. 37).

A considerable portion of the reported research within self-efficacy theory is based on varying performance or outcome measures due to different levels of self-efficacy prior to the occurrence of a given event. Knowledge of the relationships among variable associations is therefore essential in interpreting the results of an event in reference to the level of self-efficacy. In other words, as Bandura pointed out, self-efficacy is not always a preceding predictor of a given aspect during an event. This is especially true when the aspect of controllability comes into play: "Controllability affects the extent to which efficacy beliefs shape outcome expectancies and how much outcome expectancies add incrementally to prediction of performance" (Bandura, 1997, p. 23). Thus, as the level of controllability varies, the interplay of self-efficacy, outcome expectancies, and prediction of performance is affected: "Where performance determines outcome, efficacy beliefs account for most of the variance in expected outcomes. When differences in efficacy beliefs are controlled, the outcomes expected for given performances make little or no independent contribution to prediction of behavior" (Bandura, 1997, p. 24).

That is not to say, of course, that self-efficacy in and of itself can be held as a panacea for outcome or performance predictions. Many variables have been demonstrated to come into play when an attempt is made at identifying a causal relationship. Self-efficacy could account for a small part, or even no part of any given outcome or performance. Further, Bandura pointed out that when self-efficacy theory is addressed on the individual level, identifying a clear and concise co-linearity of factors can sometimes become convoluted:

> Efficacy beliefs operate as a key factor in a generative system of human competence. Hence, different people with similar skills, or the same person under

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different circumstances, may perform poorly, adequately, or extraordinary, depending on fluctuations in their beliefs of personal efficacy. (Bandura, 1997, p. 37)

This appears to recognize that while self-efficacy is an important part of performance and outcome, it is not the sole associated variable. Circumstance, individual ability, variance in cognition, and many other issues come into play when examining self-efficacy theory. Delineating performance from outcome in connection with the numerous aspects previously described can become challenging to even an experienced researcher, as Bandura (1997) illustrated in his explanation of *driving efficacy*:

> In measuring people's beliefs in their driving efficacy, they are not asked to judge whether they can turn the ignition key, shift the automatic transmission, turn a steering wheel, accelerate and stop an automobile, blow the horn, interpret road signs, and change traffic lanes. Rather, they judge the strength of their perceived efficacy that they can navigate an automobile adequately under traffic conditions that present different levels of challenge. The subskills of driving are trivial, but the generative capability of maneuvering an automobile under very narrow margins of error through congested city traffic, around vehicles on crowded expressways propelled by drivers differing in proficiency, and on narrow twisting mountain roads is not. (pp. 37-38)

This is one reason why many different self-efficacies exist. It is essentially dually definitive. Each individual has his or her specific self-efficacy. However, one's technology self-efficacy may be in stark contrast to one's athletic self-efficacy. Thus multiple levels of the self-efficacy theory can co-exist while simultaneously having affect on outcome and performance (Bandura, 1997).

Developing Self-Efficacy

Bandura (2000) claimed that *experience* is the most effective way to build self-efficacy. That is, the more individuals perform a certain task and receive a specified outcome, the more they believe in their capability to replicate the task. Levels of difficulty are an important aspect of experience. According to Bandura (2000),

"Successes build a belief in one's self efficacy. Failures undermine it. If people have only easy success, then they are easily discouraged by failure. Development of a resilient sense of efficacy requires experience in overcoming obstacles through perseverant effort" (p. 212). Familiarization with various levels of rigor allows the individual to more accurately assess situational circumstances and in some cases potential barriers that may inhibit the obtainment of a specified outcome. Thus, the increased difficulty is somewhat expected and allows the individual to persevere (Bandura, 2000).

Social modeling is the second way an individual can strengthen self-efficacy, according to Bandura. Much of what is learned is accomplished through observation. "If people see others like themselves succeed by sustained effort, then they come to believe that they, too, have the capacity to do so" (Bandura, 2000, p. 212). The individual observes the actions and derived outcomes of others and makes cognitive judgments in the likelihood of replicating such actions and receiving similar outcomes. The same could be said for observed failures. If an individual observes a failure and has little belief in his or her ability to adapt to such an environment and in turn changes action from what was observed, then the individual will have lower self-efficacy. "Observing the failures of others instills doubts about one's own ability to master similar activities. Competent models also build efficacy by conveying knowledge and skills for managing environmental demands" (Bandura, 2000, p. 212).

Social persuasion is the third method identified by Bandura of building self-efficacy. This can be seen in many different situations. It appears in classroom instruction, athletic coaching, and the business environment. People can be persuaded to believe in their ability through the social reinforcement of others. This can come in the

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form of verbal affirmations as well as such things as management practices. Bandura

(2000) asserted that:

> If people are persuaded that they have what it takes to succeed, they then exert more effort than if they harbor self-doubts and dwell on personal deficiencies when problems arise. But effective social persuaders do more than convey faith in people's capabilities. They arrange things for others in ways that bring success and avoid placing them prematurely in situations where they are likely to fail. (p. 212)

Bandura claimed that physical and emotional states can also play a role in the

development of self-efficacy. These states can vary among individual circumstance and

change over time. In some cases one can act as a preceptor to the other. Thus, as

individuals physically weaken during the course of completing a specified task, there is a

possibility that they will also become emotionally weak as well. As Bandura explained,

"They read their tension, anxiety, and depression as signs of personal deficiency. In

activities that require strength and stamina, they interpret fatigue and pain as indicators of

low physical efficacy" (2000, p. 212).

Teacher Self-Efficacy and Technology

As an overarching theory, self-efficacy can be examined within many diverse

environments. For example, an individual's self-efficacy in public speaking may have

little to do with his or her self-efficacy in writing. It is therefore very important to

establish a specific context in which self-efficacy is to be studied. Woolfolk and Davis

(2006) used this context argument to discuss teacher self-efficacy stating that "Like all

self-efficacy judgments, teacher self-efficacy is context-specific. Teachers can be

expected to feel more or less efficacious under different circumstances" (p. 118). This

context argument suggests that connecting the self-efficacy context to a specific measure

can be very important to the internal validity of a study. If the study does not measure what it intended to measure, then the results become questionable upon close scrutiny.

The act of teaching and the use of technology are themselves open to context analysis when trying to measure individual self-efficacy. Teaching and technology could actually be mutually exclusive topics. By applying Woolfolk and Davis' (2006) context argument, an individual with a high level of self-efficacy in teaching could be very comfortable with instruction through non-technology instructional strategies. That, however, would not shed any light on their self-efficacy towards technology as they may not use technology in the classroom. The opposite could be said as well. A teacher with a high level of self-efficacy for using technology may have very low levels of self-efficacy in teaching. The literature clearly indicates that the development of self-efficacy scales or taking a general measure of self-efficacy should be done with consideration to the variables existing *within the context* in which the study is positioned. "Therefore, in making an efficacy judgment, it is necessary to assess one's strengths and weaknesses *in relation to* the context and requirements of the task at hand" (Woolfolk & Davis, 2006, p. 119).

The specific context of using technology within instruction is an area that has become more prevalent. Advances in technology as well as the lowering of costs could have played a role in the integration of instruction and technology. More schools are now able to invest in alternative forms of content delivery. According to Woolfolk and Davis (2006), this brings about a whole new environment for the student as well as the teacher:

> Today, teachers are expected to prepare their students for the demands of living in this Information Age. With increasing pressure to train and support new and practicing teachers in technology integration, researchers have begun to examine the role of teachers' sense of efficacy for using technology. (pp. 121-122)

<u>Self-efficacy as a Means for Change</u>

A large amount of research positioned within the theory of self-efficacy has in some way revolved around the concept of change. That could mean a change in behavior, a change in performance, or a change in outcome. This distinction is not excluded from the education discipline. As an environment, education has many diverse variables that can be affective in nature. Bandura (1995) recognized that, "Teachers' beliefs in their personal efficacy affect their general orientation toward the educational process as well as their specific instructional activities" (p. 20).

What affects teachers can then affect their classroom, their students, the administration, and many other stakeholders. "Teachers operate collectively within an interactive social system, rather than as isolates" (Bandura, 1995, p. 20). This interconnectedness brings about the complexities of change in and of itself. More specifically, it brings about the concept of change as a component of self-efficacy and the idea of self-efficacy leading to change on both the individual and collective levels. Bandura supported this view in stating that, "Group achievements and social change are rooted in self-efficacy" (1995, p. 34).

Thus, changes in individual self-efficacy could perpetuate change on a much broader level. An increase in technology self-efficacy among teachers could lead to increases in technology use or adoption on an organizational level. Bandura supported this possibility himself and cited other researchers with similar views:

> Early adopters of beneficial technologies not only increase their productivity but can gain influence in ways that change the structural patterns of organizations. Burkhardt and Brass (1990) report a longitudinal study showing that efficacy beliefs promote adoption of new technologies, which, in turn, alter the organizational structure. (1997, p, 459)

These claims relate self-efficacy theory to innovation diffusion theory, bridging the principles advocated by Bandura and Rogers, and building a bridge of logic between technology self-efficacy and adoption of technology innovations such as the virtual reality that was the focus of this study.

CHAPTER III

METHODOLOGY

Research Design

This study used a posttest-only control group design, identified by Campbell and Stanley (1966) as a true experimental design. In this design, the dependent variable is measured for each subject only after the treatment has been administered. Traditionally, experimental designs have fewer issues with internal validity than non-experimental alternatives. However, when using the post-test only design, some concern arises with regard to equivalence among groups. The problem is that despite the design's use of a control group, there is no pre-measure to determine the identified level of each group with regard to certain variables of interest. Although there are research designs and methods that adequately address such concerns, Campbell and Stanley (1966) asserted that "The most adequate all-purpose assurance of lack of initial biases between groups is randomization. Within the limits of confidence stated by the tests of significance, randomization can suffice without the pretest" (p. 25). Because both random selection of subjects and random assignment to treatments was used in this study, the post-test only design was considered adequate and initial between-group bias was believed to be adequately controlled as a potential danger to internal validity.

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Given the narrowed scope of experimental post-test only designs, some

researchers find difficulty in assessing its external validity and substantiating an adequate

level of generalizability (Campbell & Stanley, 1966). However, in some instances

initiating a pre-test could alter the outcome or performance of subjects on the dependent

variable. This is particularly true when dealing with perceptual issues and elements of

evaluation. A subject's prior knowledge of certain aspects of interest can thus limit the

effect of treatments (DeCoster & Claypool, 2004). Because the subjects' perception and

evaluation of virtual reality were critical in this study, the post-test only design was

believed to support its validity by avoiding pre-testing bias. The post-test only design was

appropriate because a pre-test would have served as a prime.

Population and Sample

According to Gravetter and Wallnau (2007), "A population is the set of all

individuals of interest in a particular study" (p. 5). The population for this study consisted

of the full-time faculty teaching career and technical programs employed at Indian

Capital Technology Center geographically located in the state of Oklahoma (N=65). The

technology center district has campuses located in the towns of Muskogee, Sallisaw,

Stilwell, and Tahlequah. It was selected for the study because of its relative mixture of

large metropolitan and small rural campuses.

"A sample is a set of individuals selected from a population, usually intended to

represent the population in a research study" (Gravetter & Wallnau, 2007, p. 5). The

sample for this study (n=45) was drawn at random from the full-time faculty of Indian

Capital. So that each faculty member would have equal probability of participating in the

study, participants were randomly selected using a random number generator to assign

identification codes. The codes were then numerically sorted so that the first 45 faculty members were selected to participate in the study. The faculty assigned to rural campuses were adequately represented within the sample, thus there was no need for a stratified sample. Further, The 45 subjects in the sample were randomly assigned in equal numbers ($n = 15$ in each group) to three non-repetitive, mutually exclusive treatment groups: (a) negative prime/experimental group 1, (b) neutral prime/control group, and (c) positive prime/experimental group 2. Therefore, as required by experimental designs, true randomization was maintained on both the selection and assignment of subjects (Campbell & Stanley, 1966).

Description of Sample

A frequency distribution was developed to establish a descriptive profile of the sample. The demographic breakdown is illustrated in Table 2 showing the gender, ethnicity, campus location, age group, and years of experience for the subjects selected in the sample. The majority of the sample (60%) was female, and the great majority (89%) were either Caucasian (51.1%) or Native American (37.8%). African Americans were not strongly represented within the sample (11.1%), but upon further examination it was determined that this particular demographic was similarly represented within the faculty population. The Muskogee campus, the largest campus in the district, accounted for just over half of the sample. This is congruent with the total number of faculty dispersed across the four campuses. The Muskogee campus is the only campus from which African American subjects were selected. This was not problematic because the Muskogee campus is the only campus with African American faculty. Geographical proximity and ethnicity concentrations within communities surrounding the various campuses

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correspond well to the ethnic distribution in the sample (U.S. Census Bureau, 2006). The

seemingly substantial percentage of Native Americans appearing within the sample,

approximately 38%, can be compared with the large number of Native American people

Table 2
Demographic Variable Frequencies (n=45)

Variable	Frequency	Percent	Min	Max	Mean	Std. Dev.
Gender			-	-	-	-
Male	18	40.0				
Female	27	60.0				
Ethnicity			-	-	-	-
Caucasian	23	51.1				
African American	5	11.1				
Native American	17	37.8				
Campus			-	-	-	-
Muskogee	23	51.1				
Sallisaw	9	20.0				
Stilwell	5	11.1				
Tahlequah	8	17.8				
Age groups (years)			29	62	44.36	8.186
26-30	3	6.7				
31-35	4	8.9				
36-40	9	20.0				
41-45	9	20.0				
46-50	9	20.0				
51-55	8	17.8				
56-60	2	4.4				
61-65	1	2.2				
Experience (years)			1	35	10.76	9.190
1-5	17	37.8				
6-10	12	26.7				
11-15	2	4.4				
16-20	6	13.3				
21-25	4	8.9				
26-30	3	6.7				
31-35	1	2.2				

living in the state of Oklahoma (U.S. Census Bureau, 2006). This becomes more particularly appropriate in this study's sample considering that Tahlequah, Oklahoma is the capital of the Cherokee Nation, the seven-county service area of the selected technology center surrounds that area, it has a campus located in Tahlequah itself, and the name of the district is Indian Capital Technology Center.

The percentage of those sampled from their respective campuses was representative of the size each exhibits within its full-time faculty ranks for the total district. Essentially, the Muskogee campus is approximately the size of the other three campuses combined. Thus Muskogee's (51.1%) percentage of the sample compared to the other three campuses' - Sallisaw (20.0%), Tahlequah (17.8%), Stilwell (11.1%) - total percentage of 48.9% is congruent with the campus percentages appearing in the total population.

The age groups of those appearing in the sample appear to be relatively evenly dispersed. However, there does appear to be some skewness with regard to the years of experience the faculty reported. Approximately 64.5% of the faculty appearing in the sample had 10 or fewer years of experience.

Figure 12 is a histogram illustrating the dispersion of the age groups. The curve shown as an overlay gives reference to a curve that is normal in shape and form in relation to the observed data collected from the sample. The age groups appearing within the study were derived by simply grouping the subjects into categories no more than 5 years apart. The segmentation produced a total of 8 groups with the youngest being 29 years of age, the oldest 62 years of age, the average being 44 years of age, and the

median falling within group 4. This resulted in a distribution that appeared to resemble the population.

Figure 12
Age group histogram
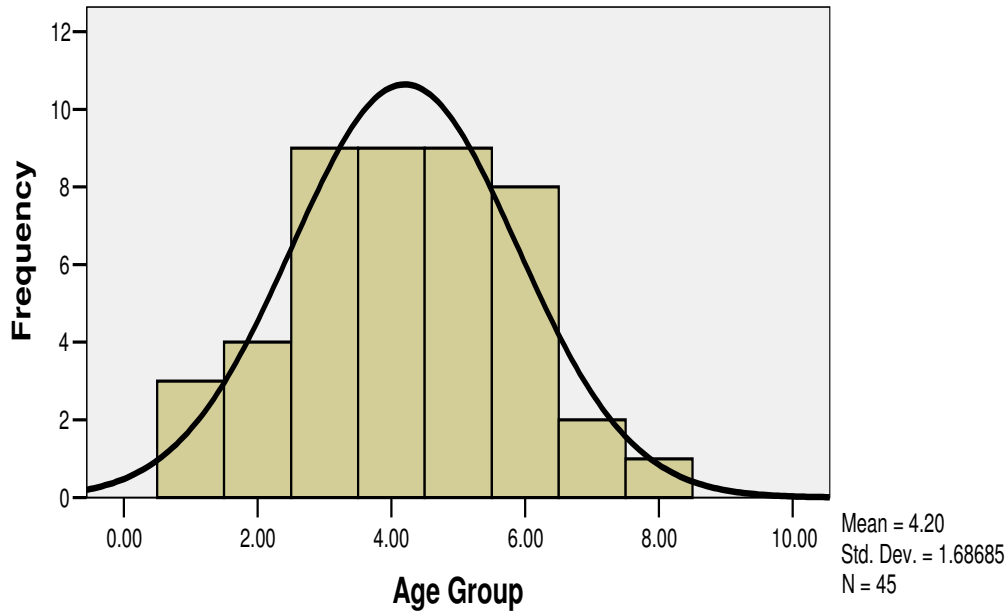
Pre-measures of VR familiarity and technology literacy were recorded by the subjects prior to being exposed to their respective priming treatment. Table 3 and Table 4 illustrate the frequency distribution of these variables in the overall sample. The majority of the sample (71%) was either familiar or not very familiar with desktop virtual reality. This indicated that the majority of the sample has either heard of or seen demonstrated desktop VR prior to participating in the study, but were not well acquainted with it. The strong majority of the sample (77.8%) perceived themselves to be relatively technologically literate at the time of the study.

Table 3
Desktop VR Familiarity Frequency Distribution

		Frequency	Percent
Valid	Not at all	8	17.8
	Not very	17	37.8
	Familiar	15	33.3
	Moderately Familiar	4	8.9
	Very Familiar	1	2.2
	Total	45	100.0

Table 4
Technology Literacy Frequency Distribution

		Frequency	Percent
Valid	Very Low	0	0.0
	Moderately low	7	15.6
	Average	22	48.9
	Moderately high	13	28.9
	Very high	3	6.7
	Total	45	100.0

Instrumentation

The study used three instruments in collecting data to answer the five research hypotheses. These included the questionnaire, the experimental scrambled sentence tests, and the VR presentation. They were administered in the same sequence listed above. The three instruments were piloted by Williams (in press) in a previous study scheduled to appear in the Journal of Industrial Teacher Education titled *Pilot study of the effects of supraliminal bipolar primes on occupational educators' viewing time and perceived confidence with desktop virtual reality*. The priming instruments derived from a previous priming study by Bargh, Chen, and Burrows (1996) titled *Automaticity of social behavior: Direct effects of trait construct and stereotype activation on action* as well as a

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chapter within The Handbook of Research Methods in Social and Personality Psychology edited by Reis & Judd (2000) written by Bargh and Chartrand (2000) titled *The mind in the middle: A practical guide to priming and automaticity research.*

<u>The Questionnaire</u>

Although the study's design was post-test only, a questionnaire was developed to collect certain demographic data prior to the administration of the experimental treatment scrambled sentence tests and the VR presentation. The questionnaire consisted of two parts. Part one of the questionnaire collected information in two segments. Segment one consisted of six questions requesting demographic data, and segment two had two questions relating to the subjects' familiarity with desktop virtual reality and their technology literacy. More specifically, segment one requested the subjects' gender, ethnicity, year of birth, campus location, the number of years taught in career and technical education, and the professional discipline taught. Question one in segment two asked the subjects to select the statement that best described their familiarity with desktop virtual reality. Their options included the following:

- Not at all familiar: I have never seen or heard of the technology

- Not very familiar: I have heard of the technology but have never seen it demonstrated

- Familiar: I am aware of the technology and have seen it demonstrated but have never used it in the classroom

- Moderately familiar: I have used desktop virtual reality in my instruction methods at least once

- Very familiar: I routinely use desktop virtual reality in my instruction methods.

Question two in segment two asked the subjects what they considered their technology literacy to be. The subjects could select from five options: Very high, Moderately high, Average, Moderately low, and Very low.

Part two of the questionnaire was administered after the subjects had completed part one, finished the scrambled sentence test, and explored the desktop VR presentation. It consisted of two questions. The first question asked the subjects what level of confidence they had in being able to describe the room they had just viewed in desktop virtual reality to another individual in detail. The subjects had five options:

- Very low confidence level

- Low confidence level

- Moderate confidence level

- High confidence level

- Very high confidence level.

Question two on part two of the questionnaire asked the subjects what level of confidence they had in being able to interact with the virtual reality technology and successfully perform the available functions such as zoom in to view a specific object, rotate to determine room layout, and look up and down. The subjects had five available options:

- Very low confidence level

- Low confidence level

- Moderate confidence level

- High confidence level

- Very high confidence level.

The scales used in part two of the questionnaire were identical to those used by Ausburn and Ausburn (2006) and Ausburn et al. (2006) in previous studies of desktop VR using the house scene presentation.

<u>The Scrambled Sentence Tests</u>

Prior to viewing the VR presentation, each subject group received their respective primer in the common form of a scrambled sentence test. The priming treatment and procedures were taken from a priming study of social behavior by Baugh, Chen, and Burrows (1996). The priming stimuli appeared in a scrambled sentence test. Each experimental test was 20 sentences in length. The subjects were required to reorganize the words appearing in the scrambled sentences so that they were grammatically correct and made sense. Within each sentence test, a primer stimulus was included. Prime Experimental Group 1 received a negative prime, Prime Experimental Group 2 received a positive prime, and the Control Group received neutral priming.

Every third sentence in both experimentally primed groups consisted of a neutral prime which Baugh, Chen, and Burrows (1996) defined as not having any strong stereotypical values associated with it. This was done to maintain a level of neutrality, because, as described by DeCoster and Claypool (2004), "The dissociation of the primes and the target relies on the fact that participants believe that the priming and impression tasks are unrelated" (p. 4). The positive priming sentences included the following words as stimuli: respect, considerate, appreciate, discretely, courteous, polite, cautiously, patiently, yield, graciously, honor, sensitively, behaved, cordially. The negative priming sentences included the following stimuli among its scrambled words: bother, disturb, intrude, infringe, interrupt, bold, obnoxious, bluntly, rude, aggravating, aggressively,

impolitely, annoyingly, and brazen. The neutral primes appearing in both priming

treatments and the control included the words exercising, successfully, normally,

prepares, occasionally, and send. Table 5 shows examples of the scrambled sentence tests

the subject viewed and rearranged to make sense. For identification purposes the primes

are italicized in the table, but in the actual instruments there were no identifications of the

priming stimuli. Thus, to the subject the stimuli were just unmarked words appearing

within the scrambled sentences.

Table 5
Examples of the Scrambled Sentence Test Items

Positive Primes	them was *respect* give always from are here *considerate* people can the show *appreciate* they
Negative Primes	they her *bother* see usually should now *intrude* purposely we *infringe* sometimes get rights upon
Neutral Primes	good your *exercising* improves health occurs *normally* this with us *occasionally* up and stop look

The Desktop VR Presentation

The VR presentation used in this study was previously developed for a recent

study of the effects of desktop VR compared to still imagery on learner performance and

confidence in mastery of a scenic environment (Ausburn & Ausburn, 2006; Ausburn, et

al., 2006). It was used in the present study with permission of the principal investigators

of the original study. The VR presentation consisted of interconnected rooms in a house

that contained a complex array of visual details, cues, and interrelationships. The scenic

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environment allowed for exploratory autonomy by the subjects and gave each participant an equal starting point, as no subject had previously seen the location or its content and details. Ausburn and Ausburn (2006) pointed out that the house scene was also appropriate for a generic test of desktop VR in a CTE environment because it represented an entire class of learning tasks frequently found in technical training, i.e. mastery of the orientation and details in a complex environment such as laboratories, shops, equipment interiors, on-site locations, etc.

The VR presentation was made via computer as a Quicktime 360-degree panorama VR movie under learner control. Each learner used the computer's mouse to move at will around the scene and a zoom feature to examine various details within the house rooms. The technology was easily used to look up and down as well as turn left or right, thereby simulating an exploration of the environment.

Procedures

The procedures for this study were piloted in a small-scale study (Williams, 2007; in press) and found to work satisfactorily. The general procedural functions used were derived from a previous priming study by Bargh, Chen, and Burrows (1996) and a chapter by Bargh and Chartrand (2000) published in *The Handbook of Research Methods in Social and Personality Psychology*.

Each potential subject was given a letter outlining the study, its administrative approval, and the likelihood of their selection for participation. The faculty population (*N*=65) was then entered into an Excel spreadsheet alphabetically by campus. The Excel software generated a random number for each subject in the population via its random number generator. Once each subject was assigned a number by the random number

generator, they were then all numerically rank ordered from the smallest assigned number to the largest assigned number. The first 45 subjects appearing in the rank ordered list were then designated as the sample for the study and were contacted to schedule an individual appointment to administer the respective instruments. If a particular subject declined or was unable to participate in the study, he or she was replaced with the next subject appearing in the rank ordered list. After an appointment with each subject was scheduled, all subjects were assigned another random number by the Excel software program's random number generator. The sample of 45 subjects was then numerically rank ordered from the smallest assigned number to the largest assigned number. The first 15 subjects were thus randomly assigned to receive the positive prime treatment, the second 15 subjects the negative prime treatment, and the third 15 subjects the control group neutral prime treatment.

When an individual data collection appointment began, the subject was given part one of the questionnaire. Attached to the front of part one of the questionnaire was the consent document approved by Oklahoma State University's Institutional Review Board. The subject was instructed to review the consent document and upon their agreement to participate in the study to tear it away from part one of the questionnaire. Once the subject demonstrated consent by removing the consent document from part one of the questionnaire, he or she was directed to read the instructions located at the top of part one of the questionnaire. The subject was then instructed to proceed by answering the questions provided in segment one, demographic information, and segment two, technology, of part one of the questionnaire.

Following completion of part one of the questionnaire, the subject turned the page to view the scrambled sentence test. Each experimental group received their respective primer via the appropriate scrambled sentence test, either positive or negative, while the control group received a small neutral treatment. After reading the instructions located at the top of the page and reviewing the provided example, the subject began the assigned scrambled sentence test. After reviewing a scrambled sentence, the subject would attempt to write a functional sentence next to the scrambled sentence in the space provided. This process continued until the entire scrambled sentence test was completed.

Once each subject completed the appropriate scrambled sentence test, he or she was given an opportunity to explore the desktop VR presentation on a laptop computer provided by the researcher. Because of its ease of use, minimal explanation was given with regard to the VR technology. A very brief demonstration was provided in order to show the subject how to pan left, right, up, and down as well as zoom in and out in virtual space. Subjects were instructed to explore the VR presentation until they felt comfortable with the interior layout of the house and its relative positioning of the rooms and their contents. While the VR exploration was in progress, a continuous timer was maintained on a stopwatch in order to determine each subject's voluntary exploration time with the VR medium. The stopwatch was not concealed, but to eliminate any stress the consciousness of time might cause, the timing was not called to the subjects' attention.

When the subjects acknowledged their exploratory acceptance regarding the VR presentation, part two of the questionnaire was then administered. Using the 5-point Likert-like scale outlined above, the subjects were then asked "What level of confidence do you have in being able to describe the room you just viewed in desktop virtual reality

to another individual in detail". Following completion of question one on part two of the questionnaire, using the same 5-point Likert-like scale the subjects were then asked "What level of confidence do you have in being able to interact with the virtual reality technology and successfully perform the available functions such as zoom in to view a specific object, rotate to determine room layout, and look up and down". Following the completion of question two on part two of the questionnaire, the subjects were then thanked by the principal investigator and informed that the scheduled session was complete. Thus the full session for each subject constituted completion of part one of the questionnaire, the respective priming activity as determined by randomly assigned group, the exploration of the VR presentation, and part two of the questionnaire.

Data Analysis

Data collected from the 45 faculty members within the Indian Capital Technology Center district were analyzed in this study. The quantitative data collected through the questionnaire and a timed experimental treatment were coded, prepared, and analyzed using the SPSS software package. More specifically, frequency distributions, descriptive statistics, cross tabulations, Analysis of Variance (ANOVA), Tukey's Honestly Significant Difference, and Pearson's r correlation were used to address the five hypotheses of this study.

The randomly selected sample of 45 subjects were randomly assigned to three mutually exclusive groups receiving either a positive prime, negative prime, or neutral (control) prime as shown in Table 6. The dependent variables analyzed in the study were (a) time spent voluntarily viewing the VR presentation after the priming treatment, (b) perceived level of confidence in the VR presentation, and (c) perceived self-efficacy level

Table 6

Schematic Diagram and Sample Sub-Groups

N = 65	Random Group Assignment		
Dependent Variables: VR Exploration Time Reported Self-confidence Reported Self-efficacy	Positive Prime	Negative Prime	Neutral (control) Prime
Sample	n = 15	n = 15	n = 15

of the VR presentation. Viewing time was defined operationally as the total time (in seconds) the subject spent, without prompting, viewing the VR presentation. Perceived confidence level was defined operationally as the subjects' self-reported level of confidence on a 5-point Likert-like scale that they could effectively describe the scene shown in the VR presentation to another person. Perceived self-efficacy level was defined operationally as self-reported confidence in ability to effectively use and manipulate the desktop VR to obtain the intended outcome, measured on a 5-point Likert-like scale.

Data Analyzed to Address Each Research Question

The first research question for this study, i.e. *there is no difference in the voluntary VR viewing time of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation*, was addressed by measuring the time each subject spent voluntarily viewing the desktop VR movie. These data were coded and entered into the SPSS software program and descriptive statistics, cross tabulation, and analysis of variance (ANOVA) were used to determine if there was a statistically significant difference among the treatment groups.

The second research question for this study, i.e. *there is no difference in the perceived confidence levels of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation*, was addressed by recording the self-reported scores the subjects submitted in answering the question "What level of confidence do you have in being able to describe the room you just viewed in desktop virtual reality to another individual in detail". These data were entered in the SPSS software program and descriptive statistics, cross tabulation, and analysis of variance (ANOVA) were used to determine if there was a statistically significant difference among the treatment groups.

The third research question for this study, i.e. *there is no difference in the perceived self-efficacy level of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation*, was addressed by recording the self-reported scores the subjects submitted in answering the question "What level of confidence do you have in being able to interact with the virtual reality technology and successfully perform the available functions such as zoom in to view a specific object, rotate to determine room layout, and look up and down". These data were entered in the SPSS software program and descriptive statistics, cross tabulation, and analysis of variance (ANOVA) were used to determine if there was a statistically significant difference among the treatment groups.

The fourth research question for this study, i.e. *there is no relationship between VR viewing time and reported VR confidence level of CTE educators*, was addressed by recording the time each subject spent voluntarily viewing the desktop VR movie and the self-reported scores the subjects submitted in answering the question "What level of confidence do you have in being able to describe the room you just viewed in desktop virtual reality to another individual in detail". These data were entered in the SPSS

software program and a Pearson's r correlation was used to determine if there was a statistically significant relationship.

The fifth research question for this study, i.e. *there is no relationship between VR viewing time and reported self-efficacy level of CTE educators*, was addressed by recording the time each subject spent voluntarily viewing the desktop VR movie and the self-reported scores the subjects submitted in answering the question "What level of confidence do you have in being able to interact with the virtual reality technology and successfully perform the available functions such as zoom in to view a specific object, rotate to determine room layout, and look up and down". These data were entered in the SPSS software program and a Pearson's r correlation was used to determine if there was a statistically significant relationship.

The sixth research question for this study, i.e. *there is no relationship between reported confidence level and reported self-efficacy level of CTE educators*, was addressed by recording the self-reported scores the subjects submitted in answering the question "What level of confidence do you have in being able to describe the room you just viewed in desktop virtual reality to another individual in detail" and the self-reported scores the subjects submitted in answering the question "What level of confidence do you have in being able to interact with the virtual reality technology and successfully perform the available functions such as zoom in to view a specific object, rotate to determine room layout, and look up and down". These data were entered in the SPSS software program and a Pearson's r correlation was used to determine if there was a statistically significant relationship.

CHAPTER IV

FINDINGS

To address the five research questions that guided this study, several statistical analyses were conducted for the three dependent measures. Descriptive statistics, cross tabulations, one-way analysis of variance (ANOVA), Tukey's Honestly Significant Difference, and Pearson's r correlation were used to address the research questions. Separate ANOVAs were conducted for each of the dependent measures: VR viewing/exploration time, perceived confidence level, and perceived self-efficacy level. Eta-squared (η^2) was also calculated to determine effect size. A Tukey Honestly Significant Difference (HSD) test was conducted to locate any significant pair-wise differences for statistically significant ANOVA results. A Pearson r correlation was calculated as a direct measure of the strength of association between the dependent variables of VR exploration time, the subsequently reported confidence levels, and the reported self-efficacy levels.

Research Question 1: There is no difference in the voluntary VR viewing time of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation

Means were initially calculated for the dependent variables of VR exploration time (in seconds), VR confidence, and VR Self-efficacy as shown in Table 7 so that overall averages could be obtained for the sample data.

Table 7
Descriptive Statistics for Dependent Variables

Variables	N	Min	Max	Mean	Median	Std. Dev.
VR Exp Time (Seconds)	45	17	555	177.24	135	132.201
VR Confidence	45	1	5	3.38	3	.747
VR Self-efficacy	45	2	5	3.87	4	.815

As shown in Table 8, a cross tabulation of means was prepared for the subjects in the control and experimental groups for the dependent variable of VR viewing or exploration time. An observable difference appeared between the three mutually exclusive groups. This difference was tested for statistical significance with Analysis of Variance.

Table 8
Experimental/Control Group Cross-tabulation
of Means for VR Viewing Time

Treatment		VR Exp Time (S)
Positive prime	Mean	276.27
	N	15
	Std. Dev.	148.468
Negative prime	Mean	101.93
	N	15
	Std. Dev.	79.227
Control group	Mean	153.53
	N	15
	Std. Dev.	97.074
Total	Mean	177.24
	N	45
	Std. Dev.	132.201

A one-way ANOVA was computed for VR viewing time. The statistical results are shown in Table 9. The difference between groups was statistically significant at the .05 alpha level (F=9.562; df=2,42; p=.000; η^2=.313). According to Green and Salkind (2005) "η^2 of .01, .06, and .14 are, by convention, interpreted as small, medium, and large effect sizes, respectively" (p. 178). Therefore the ANOVA for VR viewing time had a

large effect size. To locate which treatment groups the significant difference occurred

between, a Tukey Honestly Significant Difference (*HSD*) test was conducted. As shown

in Table 10, the test revealed that the significant difference occurred between the positive

prime group and the negative prime group (*HSD*=174.33, *p*=.000) as well as between the

positive prime group and the control group (*HSD*=122.73, *p*=.012). However, the

difference between the negative prime group and the control group was not significant.

The post-hoc result, R-squared, and large eta-squared value for the ANOVA indicated

that a considerable amount of the variance between groups on their reported VR

exploration time could be related to the priming treatments conducted prior to

introduction of the desktop VR presentation medium. Given that the observed *F* value

exceeded the critical *F* value at the .05 alpha level, the null hypothesis for research

question one was rejected, or H1: μ_i-μ_g≠0.

Table 9
ANOVA for VR Viewing Time (in seconds)

Source	Type III Sum of Squares	df	Mean Square	F	p	η^2
Treatment	240590.711	2	120295.356	9.562	.000	.313
Error	528401.600	42	12580.990			
Total	2182694.000	45				

Computed using alpha=.05   R Squared = .313 (adjusted R Squared=.280)

Table 10
Dependent Variable: VR Exp Time (S)
Tukey HSD (*) P≤.05

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	p
Positive prime	Negative prime	174.33(*)	40.957	.000
	Control group	122.73(*)	40.957	.012
Negative prime	Positive prime	-174.33(*)	40.957	.000
	Control group	-51.60	40.957	.425
Control group	Positive prime	-122.73(*)	40.957	.012
	Negative prime	51.60	40.957	.425

Research Question 2: There is no difference in the perceived confidence levels of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation

As shown in Table 11, a cross tabulation of means was prepared for the subjects in the control and experimental groups for the dependent variable of VR confidence. An observable difference appeared between the three mutually exclusive groups. This difference was tested for statistical significance with Analysis of Variance.

A one-way ANOVA for perceived confidence level in being able to accurately describe the house scene after viewing the VR presentation showed that there was a difference between treatment groups on this dependent variable. Table 12 shows the statistical results for the data collected in addressing research question two, (F=1.247; df=2,42; p=.298; η^2=.056). While there was a greater difference between groups than within groups, the observed F did not exceed the critical F at the .05 alpha level; the obtained p-value of .298 was not statistically significant. Thus, for research question two, the null hypothesis was retained, or H0: μ_i-μ_g=0.

Table 11
Experimental/Control Group Cross-tabulation of Means for VR Confidence

Treatment		VR Confidence
Positive prime	Mean	3.53
	N	15
	Std. Dev.	.640
Negative prime	Mean	3.13
	N	15
	Std. Dev.	.834
Control group	Mean	3.47
	N	15
	Std. Dev.	.743
Total	Mean	3.38
	N	45
	Std. Dev.	.747

Table 12
ANOVA for VR Confidence

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*p*	η^2
Treatment	1.378	2	.689	1.247	.298	.056
Error	23.200	42	.552			
Total	538.000	45				

Computed using alpha=.05   R Squared = .056 (adjusted R Squared=.011)

Research Question 3: There is no difference in the perceived self-efficacy level of CTE educators who receive neutral, positive, and negative primes prior to a VR presentation

As shown in Table 13, a cross tabulation of means was prepared for the subjects in the control and experimental groups for the dependent variable of VR self-efficacy. An observable difference appeared between the three mutually exclusive groups. This difference was tested for statistical significance with Analysis of Variance.

Table 14 presents the one-way ANOVA for self-efficacy as it relates to the desktop VR software used to explore the virtual environment. The ANOVA yielded no significant difference between groups (F=1.325; df=2,42; p=.277; η^2=.059). A small comparative distinction existed when examining the data derived from the variation between groups and within groups. However, the difference in the respective mean squares was small. Additionally, the eta-squared value was also small, further emphasizing the small variation in data recorded between groups and its corresponding minimal effect size. The observed F score did not exceed the critical F score and the ANOVA produced a p-value of .277. A .05 alpha level was used to address research question three of the study and therefore the null hypothesis was retained, or H0: μ_i-μ_g=0.

Table 13
Experimental/Control Group Cross-tabulation
of Means for VR Self-Efficacy

Treatment		VR Self-Efficacy
Positive prime	Mean	4.13
	N	15
	Std. Dev.	.834
Negative prime	Mean	3.80
	N	15
	Std. Dev.	.775
Control group	Mean	3.67
	N	15
	Std. Dev.	.816
Total	Mean	3.87
	N	45
	Std. Dev.	.815

Table 14
ANOVA for Self-efficacy

Source	Type III Sum of Squares	df	Mean Square	F	p	η^2
Treatment	1.733	2	.867	1.325	.277	.059
Error	27.467	42	.654			
Total	702.000	45				

Computed using alpha=.05   R Squared = .059 (adjusted R Squared=.015)

Research Question 4: There is no relationship between VR viewing time and reported VR confidence level of CTE educators

Analysis addressing research question four was conducted by incorporating a two-tailed Pearson's r correlation for the dependent variables of VR exploration time and VR confidence level. As shown in Table 15, the correlation values for the dependent variables in research question four were not statistically significant at the .05 alpha level. Thus, for research question four, the null hypothesis was retained, or H0: μ_i-μ_g=0.

Table 15
*Correlation for VR Viewing/Exploration Time
and Confidence Level (df=43)*

		VR Exp Time (S)	VR Confidence
VR Exp Time (S)	Pearson Correlation	1	-.065
	Sig. (2-tailed)		.670
	N	45	45
VR Confidence	Pearson Correlation	-.065	1
	Sig. (2-tailed)	.670	
	N	45	45

Computed using alpha=.05

Research Question 5: There is no relationship between VR viewing time and reported self-efficacy level of CTE educators

Analysis addressing research question five was conducted by incorporating a two-tailed Pearson's r correlation for the dependent variables of VR exploration time and VR Self-efficacy level. As shown in Table 16, the correlation values for the dependent variables in research question five were not statistically significant. Thus, for research question five, the null hypothesis was retained, or H0: $\mu_i-\mu_g=0$.

Table 16
*Correlation for VR Viewing/Exploration Time
and VR Self-efficacy Level (df=43)*

		VR Exp Time (S)	VR SelfEfficacy
VR Exp Time (S)	Pearson Correlation	1	.067
	Sig. (2-tailed)		.663
	N	45	45
VR Self-efficacy	Pearson Correlation	.067	1
	Sig. (2-tailed)	.663	
	N	45	45

Research Question 6: There is no relationship between reported VR confidence level and reported self-efficacy level of CTE educators

Analysis addressing research question six was conducted by incorporating a two-tailed Pearson's r correlation for the dependent variables of VR confidence level and VR Self-efficacy level. As shown in Table 17, a significant relationship was observed between VR confidence and VR self-efficacy ($r=.458$; $df=43$; $p=.002$). The analysis indicated that approximately one-fifth of the variance in these variables was related to common variance ($r^2=.21$). This relationship supported the general conceptual framework of variable relationships for the study. Thus, for research question six, the null hypothesis was rejected, or H1: $\mu_i - \mu_g \neq 0$.

Table 17
*Correlation for VR confidence level
and VR Self-efficacy Level (df=43)*

		VR Confidence	VR Self-Efficacy
VR Confidence	Pearson Correlation	1	.458
	Sig. (2-tailed)		.002
	N	45	45
VR Self-efficacy	Pearson Correlation	.458	1
	Sig. (2-tailed)	.002	
	N	45	45

CHAPTER V

CONCLUSIONS

Summary of the Study

Problem and Conceptualization

Desktop VR has been shown to be an instructional tool capable of enriching the instructional process within many technical skill areas (Abhishek, Hai-Jun, & Vance, 2005; Aoki, Oman, Buckland, & Natapoff, 2008; Gaoliang, & Wenjian, 2008; Rodriguez, 2001; Wang, & Li, 2004). However some faculty members among career and technical educators may be uncertain or even reluctant to adopt such an innovation. There are numerous possible causes to which this reluctance might be attributed, ranging from individual issues such as low levels of technology literacy to broader problems such as lack of organizational resources. For whatever reasons, there may exist in some CTE educators a negative disposition towards VR technology. This could prove detrimental to the field of CTE considering the documented success and potential of desktop VR in technical fields. The problem for this study was that it is not currently known what techniques might help overcome resistance to VR adoption and thus facilitate its use in appropriate technical training applications.

The study conceptualized desktop VR as an innovation, and was based on the premise that reluctance or willingness to adopt an innovation may ultimately be influenced by the creation of a negative or positive disposition thereby affecting self-efficacy, and that disposition and self-efficacy could be influenced by priming techniques. Therefore, the purpose of the study was to compare performance on measures of disposition and self-efficacy toward a desktop VR presentation of CTE educators who receive no primes, negative primes, and positive primes. In the context of this study, "disposition" was defined operationally as voluntary viewing time of a VR presentation and self-reported confidence level in ability to describe to others the scene presented in the VR presentation. Self-efficacy was defined operationally as self-reported confidence in being able to effectively use desktop VR and manipulate it in ways that permit the obtainment of the intended outcome. This study was designed to test the researcher's substantive theory – based in priming, innovation diffusion, and self-efficacy theories – that the presentation of positive and negative primes to career and technical educators prior to presenting them with a desktop VR presentation of a complex scene could affect their disposition toward this innovative technology.

Research Design and Data Analysis

This study used a post-test only true experimental design incorporating random sampling and random assignment. The dependent variables analyzed in the study were VR viewing time, VR confidence level, and VR self-efficacy level. Data analysis was quantitative, using descriptive statistics, cross tabulations, one-way analysis of variance (ANOVA), Tukey's Honestly Significant Difference, and Pearson's r correlation to address the research questions.

The major findings of the study for the five research questions were (a) significant differences between the positively primed group, the negatively primed group, and the control group on the dependent variable of VR exploration time, (b) directional trend toward differences in VR confidence level between the positively and negatively primed groups, (c) directional trend toward differences in VR self-efficacy level between the positively and negatively primed groups, and (d) no correlation between VR viewing time and reported confidence level or VR viewing time and reported self-efficacy level, and (e) significant correlation between VR confidence and self-efficacy.

Priming and VR viewing time. As predicted by the study's theoretical/conceptual framework, it appears there could be a causal relationship between supraliminal priming and the amount of time career and technical educators spend viewing VR presentations. The study's true experimental design strengthened a conclusion of a causal link from positive priming and negative priming to increased or decreased VR viewing/exploration time. Analysis of variance and post-hoc test showed that the positively primed group viewed the VR significantly longer than either the negatively primed or neutrally primed control group, and that the negatively primed group performed similarly to the control group. Thus, positive priming appears to result in longer VR viewing time. This relationship was reasonably substantial based on eta-squared and R^2 values for the ANOVA.

Priming and VR confidence levels. ANOVA determined that the between group variance, while exceeding the within group variance, was not substantial enough to be statistically significant. This was also reflected in small eta-squared and R^2 values. This

does not support the theoretical/conceptual framework for the study. However, the descriptive statistics suggested that, as predicted by the study's theoretical/conceptual framework, a trend may exist between priming and VR confidence, with positive priming associated with higher confidence levels.

Priming and VR self-efficacy. Descriptive analysis of the mean scores showed that the positive primed group exceeded both the negative prime group and the control group. ANOVA determined that differences between priming groups on the self-efficacy variable did not attain statistical significance. This was also reflected in small eta-squared and R^2 values. This does not support the theoretical/conceptual framework for the study. However, the descriptive statistics suggested that, as predicted by the study's theoretical/conceptual framework, a trend may exist between priming and VR self-efficacy with positive priming associated with higher self-efficacy levels.

VR viewing time and VR confidence level. Pearson correlation showed that a significant correlation did not exist between these two variables. This was contrary to the prediction of the study's theoretical/conceptual framework.

VR viewing time and VR self-efficacy level. Pearson correlation showed that a significant correlation did not exist between these two variables. This was contrary to the prediction of the study's theoretical/conceptual framework.

VR confidence level and VR self-efficacy level. Pearson correlation identified a moderate and statistically significant correlation between these variables. This indicated a possible relationship between VR confidence level and VR self-efficacy level that is supported by the research literature. Additionally, the occurrence of such a possibility is supportive of the overall theoretical/conceptual framework for the study.

Discussion

Prior to conducting this study, a pilot study was performed (Williams, 2007; in press) that tested the theoretical/conceptual framework, predicted outcomes, and methodology that were applied in the present study. Conducting the pilot was undoubtedly beneficial in designing and refining the larger, more controlled study. The pilot study is discussed here because in addition to providing theoretical and methodological guidance for the present study, its findings are also relevant to the conclusions that can be drawn from the outcomes of this larger study.

In both theory and methodology, the pilot was nearly identical to this expanded study and provided a model for its development and implementation. However, there were several noteworthy differences, essentially as limitations to the pilot. At the theoretical level, the VR self-efficacy variable was not included in the pilot. It was added to the larger study because further research revealed an appropriate connection between the self-efficacy concept and technology innovation adoption that enriched and expanded the theoretical/conceptual framework for this line of inquiry. In terms of research design and procedures, the pilot had limitations that were at least to some degree corrected in this larger study. One limitation in the pilot that was fully corrected in the present study was the experimental design. Whereas the pilot used a pre-experimental design due to lack of random selection of subjects, the present study's replication was strengthened by use of a true experimental design with random selection as well as random assignment of subjects to treatments. Another limitation of the pilot was its very small sample, which consisted of only 10 subjects in each of two experimental treatments plus 10 in the

control group, for a total sample size of 30. The sample was expanded in this larger study to 15 subjects in each treatment group, for a total sample size of 45.

Research procedures, instrumentation, and statistical analyses were very similar in the pilot and this expanded study. Noteworthy differences were that the pilot did not include demographic data or self-assessments of technology literacy and VR familiarity for the subjects and did not include a measure of VR self-efficacy.

Comparison of the findings of the pilot and the present larger study, plus the addition of sample demographics in the replication, provide some similarities, differences, and additions that have direct bearing on the conclusions drawn from this study. In the pilot, VR exploration time differences for the positive and negative priming treatment groups approached statistical significance, with the positively primed group voluntarily viewing the VR presentation for the longer time. There was also a significant difference in the VR confidence levels of the primed groups, with the positively-primed group reporting the higher confidence. The pilot study also found a significant positive correlation between VR exploration time and confidence level.

Based on these findings of the pilot, the present study produced some expected and some unexpected results. In the present study, the difference in VR exploration time for the positively-primed group and negatively-primed group reached statistical significance with a large effect size. Thus, the recommendation and prediction presented in the pilot that a larger sample size might result in attaining of statistical significance for this outcome was supported. In contrast, the significant difference in VR confidence levels for the priming groups that was observed in the pilot was apparent in this study as a trend, but failed to reach statistical significance despite the larger sample size.

Similarly, a correlation between VR exploration time and confidence level reached statistical significance in the pilot but was not observed in the present replication. Correlations analyzed in the present study only were between VR exploration time and VR self-efficacy, which was not observed; and between VR confidence level and VR self-efficacy, observed at significance level.

Comparison of these findings in the pilot and the present study, plus the addition of self-assessed information on the technology literacy and VR familiarity of the subjects, inform several overall conclusions.

Several Aspects of the Study's Proposed Theoretical/Conceptual Framework Were Supported

Findings from both the pilot and the present study were similar in that predicted outcomes regarding relationships of positive/negative priming with higher/lower VR exploration time and confidence levels were observed at either significance or trend levels. These results support the proposition that prime theory and priming techniques can influence an individual's disposition toward an innovation and thus may be ultimately able to influence behavior with regard to speed of adoption of the innovation. Also, the notion within the theoretical/conceptual framework that priming influences can be either negative or positive was supported in the two studies. This support is sufficient to warrant continued refinement of, and research with, the proposed framework in a line of inquiry.

There Were Some Disparities between the Outcomes of the Pilot and the Present Study That May be Related to Sample Size

Outcomes regarding predicted relationships between priming and VR exploration time, and between priming and VR confidence were similar in the two studies and in the directions predicted by the theoretical/conceptual framework. However, in some cases the relationships were at trend level in one study and at statistical significance level in the other study. Consistency of results was not achieved despite increasing the sample size slightly in the present study. Thus, future studies may benefit from a larger sample size. The larger sample would allow for extreme outlier scores in any group to have less influence, thereby allowing for more statistically reliable results as predicted by the proposed theoretical/conceptual model. The problem may be sample size rather than inaccuracies in the model.

Priming May Be Able to Directly Affect VR Viewing Time, VR Confidence, and VR Self-Efficacy

These direct influences are proposed in the study's theoretical/conceptual model and were supported to some extent by the results of both the pilot and the present study. This support derives from the findings of the predicted positive and negative relationships, at least at trend levels. However, inconsistencies in the attainment of these relationships at statistically significant levels, while perhaps artifacts of small sample sizes, could have another explanation, as discussed in the next conclusion.

Relationships among Priming, VR Viewing Time, Confidence, and Self-Efficacy May Be More Complex than Predicted in the Proposed Conceptual Framework

The study's research design and statistical analyses supposed a direct relationship between priming and the dependent variables. However, lack of consistency of statistical significance in the observed relationships, coupled with low effect sizes (eta-squares) and

R^2 values suggest that other variables besides priming may be involved in explaining differences in VR viewing/exploring time, confidence, and self-efficacy. Several technology-related factors may have contributed to the relationships, including past computer experiences, technology skill levels, and familiarity with VR. This proposition is supported by the fact that the sample in this study had a fairly narrow range on both technology literacy and familiarity with VR, and both were relatively high, with 77.8% perceiving themselves to be relatively technologically literate and 82.2% having at least some familiarity with VR. What may occur is that the relationship of priming to VR viewing time, confidence, and self-efficacy may be *indirect* rather than direct, filtered through individuals' previous experiences and skills with computers and technology and their prior exposure to VR as intervening variables. Research designs that use larger samples with more evenly and thoroughly dispersed levels on these variables and/or that build these variables into the study may help clarify these possibilities and lead to amendment and refinement of the conceptual model for this line of inquiry.

A Relationship between VR Confidence and Self-Efficacy May Exist and May Be Complex

If the relationship between VR viewing time and the confidence and self-efficacy variables is in fact indirect, then, the significant correlation between VR confidence and self-efficacy found in this study may also be indirect and complex. This relationship may be more related to previous technology and VR skill and experience than to VR viewing time. It is possible that the chain of relationships among the variables in this study's conceptual model is quite complex: the impact of priming on VR viewing time may be indirect, filtered through entry levels of technology confidence and self-efficacy, which

may *both* be related to previous experience. These possibilities should be examined to improve and refine the accuracy of the theoretical/conceptual model for this line of inquiry.

Implications of the Study

<u>General Implications</u>

The diffusion of innovations, whether on the individual or collective level, is complex in its orientation and makeup. Conceptually, the diffusion theory base can be applied across very diverse areas of discipline. Some of the first diffusion of innovation studies focused on farmers, while today a general literature search identifies studies spanning almost all disciplines. Numerous factors both internal and external can affect the rate of innovation adoption. They can range from the complexity of the product and its relative advantages to the organizational culture and available resources. While adoption is undoubtedly a complex behavior with several factors underlying a specific action, the disposition of the adopter at the *persuasion stage* of adoption remains a critical area of the process (Rogers, 2003).

An adopter's disposition towards a particular innovation is one common element that comes into play on both individual and organizational levels. Therefore, if a method is developed that can influence disposition, the possibility of skewing the innovation diffusion curve becomes more likely. Supraliminal priming is one such method that is high in potential. At its foundation, priming was demonstrated in this study to have a statistically significant effect on the desktop VR exploration time as well as possible trends regarding confidence and self-efficacy in the technology. Therefore, exposing adopters to a priming treatment during the persuasion stage of the innovation-decision

process may have a critical affect on adoption through the influence of their disposition, as described by Rogers (2003):

> The main outcome of the persuasion stage in the innovation-decision process is a favorable or unfavorable attitude toward the innovation. It is assumed that such persuasion will lead to a subsequent change in overt behavior (that is, adoption or rejection) consistent with the individuals attitude. (p. 176)

Implications for Career and Technical Education

Establishment of priming as a successful technique for favorably disposing occupational educators toward desktop VR could have important implications for CTE and occupational education. VR technology has a record in the research literature of success as both an instructional medium in technical education and as an effective workplace tool in a variety of industries (Ahlberg, et al. 2007; Dickey, 2005; Ganai et al., 2005; McClusky, et al. 2004; Neel, 2006; Park et al., 2006; Revenaugh, 2006; Seymour, et al. 2002; Shim, et al., 2003; Smedley & Higgins, 2005; Tiala, 2007; Vogel et al., 2004). For both these reasons, VR should be considered an important technology for CTE and adult occupational education.

Ausburn and Ausburn (2006) also pointed to VR's efficacy at presenting the type of three-dimensional, complex scenic environment that is frequently required in CTE and occupational education. They claimed that this is a class of learning environments that is very important in CTE and that VR is an excellent vehicle for teaching mastery of that class of environments. These appear to be sound reasons for CTE and occupational education to take a leadership role in the adoption of desktop VR technology; that is, to assume innovator and early adopter roles in terms of Rogers' innovation diffusion curve, rather than settling at the late adopter/laggard end of the curve.

The conceptual implementation also extends beyond desktop VR. Innovation diffusion and priming are broad enough to encompass many other innovations. Thus, the applicability of such a method, once perfected, could play an important role in the process that is undertaken when introducing or exposing CTE educators to any innovation. All technical program areas are subject to rapid change and will witness advancements in their field that can place instructors in the situation of decision makers with regards to adopting or not adopting an innovation. Therefore, they will experience the persuasion stage of the innovation-decision process and will likely have a predisposition to the innovation. Thus, priming as a method to affect the individual disposition could prove beneficial in the adoption process of other innovations.

This could theoretically work in both directions considering the nature of the priming techniques. A change in disposition could be positive or negative. Therefore, if an instance should arise that called for a uniquely negative disposition to be developed in regard to a given innovation or process, then the possibility of using negative priming could be explored. However, positive priming has the most potential for functional implementation. In the future CTE will have many opportunities to transform its delivery methods through new and emerging innovations. The successful adoption on the individual level of such innovations will be critical for diffusion to occur.

The Private Sector

The private sector is undoubtedly a major stakeholder in any method that is developed with the intent to skew the innovation diffusion curve. Supraliminal priming is one such method that could become very attractive to companies interested in the adoption rate of a particular innovation. One of the leading authors in innovation

diffusion research, Geoffrey Moore, focuses solely on the private sector. Thus considerable interest in implementing such a method during the persuasion stage of the innovation-decision process could already exist.

This is particularly true considering the difficulties that are experienced when the adoption of such innovations require significant training in order to effectively benefit from its adoption. Companies spend vast amounts of resources, both financial and intellectual, to develop an effective marketing strategy that has essentially the same objective outcome as the overarching concept of this study: trying to positively affect the innovation diffusion curve. Therefore, if a method were developed that could aid in the process of affecting the individual dispositions of potential adopters, or in this case consumers, during the persuasion stage of the innovation-decision process, a considerable competitive advantage could be established.

Use of such methods is not restricted to technological innovations within the private sector. The fundamental basis of priming and innovation diffusion technique is the influence of individuals during the persuasion stage of the innovation-decision process. Thus many innovations could benefit from such practices. The presentation of a new process for example, could use a priming exercise prior to initial exposure to potential adopters to increase positive disposition. This could occur from an internal company approach geared specifically towards creating a catalyst or change agent within its respective culture. Much like entering a room with delightful music can change an individual's attitude, priming could possibly lower the common barriers of resistance that occasionally appear when an individual encounters a change of some sort.

<u>The Education System</u>

Teachers and administrators could also benefit from the use of priming within the educational setting. Much like the private sector, schools have their own cultures. Within this culture exists certain groups that coincide with the adopter groups identified by Rogers (2003). That is not to say that a laggard will always be a laggard with regards to every innovation he or she encounters. However, it does provide identified organizational groupings that allow for a varied approach to be pursued when attempting to diffuse a given innovation. Thus, a school system could use priming techniques in much the same way that a private company could. Key to this claim is the broad nature of the framework for priming and innovation diffusion theories. Almost anything new or perceived as new can be conceptualized as an innovation. Since innovation diffusion is related to individual adoption rates, both theories can be implemented and applied contextually.

Therefore, considerable flexibility is available in the conceptual framework allowing for further adaptation within an educational setting. Additional priming techniques, different implementation mechanisms, and innovation diffusion strategies could all be implemented while remaining congruent with the foundational framework of this study. This would allow for the theory base to become applicable and relevant within the strategic operations of an educational system.

<div align="center">

Recommendations

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<u>Refinement of Theoretical/Conceptual Framework, Sampling, and Methodology</u>

The conceptual framework for this study is a unique linking of several theory bases. Rooted in innovation diffusion theory, priming theory, and self-efficacy theory, this study was a first step in further defining their interrelationships. While the pilot

research for this study showed priming to affect the exploration time and confidence in regards to desktop VR (Williams, 2007; in press), it also showed exploration time and confidence level to be correlated. This study did not perfectly replicate those findings. While the priming treatment had an effect on desktop VR viewing/exploration time in this study, the differences in means for VR confidence level was not statistically significant even though it did trend as predicted by the conceptual framework. Further, the correlation between exploration time and confidence level was not statistically significant as anticipated. Given the similarities each study had with regards to methodology, the observed discrepancies in these findings could have resulted due to the small sample size. Therefore, it is recommended that additional research be conducted with a larger sample size and with a similar experimental design.

Alternatively, the relationships among the variables in the conceptual framework could be more complex than currently presented and could be impacted by their variables such as individual background and experiences. It is therefore recommended that further research be conducted to explore these possibilities and expand or refine the theoretical/conceptual framework for further application.

While experimental designs are more time intensive and expensive to conduct, some studies require such methods in order to objectively measure the variables of interest. This particular study is a good example of such a scenario. However, given the sample size of 15 subjects that was used within each priming group, it is recommended that when further research is conducted along the same premise, a larger sample of at least 30 subjects per group be used. This will allow for high or low scores on relevant measures to have less effect on central tendency measures and the corresponding

ANOVA. While a possible trend was identified with regard to the effects of priming on the confidence ratings of desktop VR, the result was not statistically significant. Pilot research (Williams, 2007; in press) conducted with the same theoretical/conceptual framework and methodology found the comparison to be statistically significant despite having an even smaller sample size. Thus, a large sample would provide a research environment to more definitively assess this important relationship. To examine the possibilities arising from this study's conclusions of complex relationships among priming, VR viewing time, VR confidence, VR self-efficacy, previous technology and VR skills and experience, it is further recommended that technology confidence, self-efficacy, skills, and experience be built into future studies as intervening variables and directly included in statistical analysis.

An additional finding that merits further research is the relationship between desktop VR confidence level and self-efficacy level. While this study revealed a significant correlation between these variables of modest size, it is unclear what caused such a correlation and how it might be added to the proposed conceptual framework. One methodological issue that needs to be addressed is how to measure these variables. While this study used a general measure of self-efficacy for its data collection instrument, other self-efficacy measurement instruments have used scales that provide for large variation between ratings. This study used a basic Likert-like scale with 5 rating possibilities while other researchers have used scales with up to 100 rating possibilities. Therefore, it is recommended that further research be conducted towards developing a comprehensive self-efficacy measurement instrument that can be validated and implemented to achieve a comprehensive desktop VR self-efficacy rating.

<u>Addition of Qualitative Data</u>

Qualitative research in the form of a mixed methods design is also recommended. Personal interviews conducted with the participating subjects offer the possibility to yield valuable data about numerous aspects of the study and its design. The practice of collecting qualitative data could allow analysis of very short and very long VR observational times to be more fully understood. For example, it would be very valuable to know whether subjects were exploring VR for such a long time because they were engrossed in the technology, were finding it difficult to navigate, or were simply trying to memorize the depicted scenic layout and its content because they thought they were going to be tested.

A mixed methods approach could also provide further insight into the priming instrument. A subject's level of superficiality regarding stimuli and corresponding intent is very important when using supraliminal priming methods in research. Thus it would be very valuable to know if a particular subject identified the link between the priming stimuli and its associated task. This would allow for more accurate analysis of the observed effect of priming on the dependent variables.

Additionally, a mixed methods approach would prove very beneficial in the further development of instruments designed to measure the self-efficacy and confidence levels of desktop VR. While general measures were used in this study, more detailed expansive instruments are needed for further research. Once validated, these instruments could facilitate further investigation into the relationship between confidence level and self-efficacy.

<u>Applied Applicability</u>

Emerging technologies can sometimes be cost prohibitive. High costs can occur in financial purchases of hardware or software as well as required labor hours of installation, customization, training, and development. Common objections of this type can arise when considering the types of change a new technological integration could bring about. This is further exacerbated by individuals who view technology within the classroom or laboratory to be an alternative and not a necessary instructional method. Therefore, it is recommended that further applied research based on financial feasibility, instructional effectiveness, and the return on investment gained from such adoption be conducted in order to determine if an innovation is capable of producing defensible net gains.

<u>Further Research</u>

Additional research needs to be pursued in regards to whether a change in disposition toward desktop VR actually leads to changes in the adoption intention and/or actual adoption speed. Holistically, the theoretical/conceptual framework for this study progresses to the outcome of affecting the innovation diffusion curve through impacting disposition. If changes in the disposition toward desktop VR during the persuasion stage of the innovation-decision process does not actually affect the adoption rate, then the theoretical/conceptual framework will need to be reconsidered before any type of theory validation can occur. This may entail conducting research with different methods for achieving such an outcome. While priming is one proposed method, there may be others that could prove beneficial.

A second area that is recommended for further research is whether priming can be influential in the disposition and subsequent adoption speed of other innovations besides virtual reality.

Conclusion

This study was a first step in the examination of priming techniques as an agent for increasing positive dispositions toward and confidence in desktop VR technology in CTE and occupational education. If continued research can further establish this connection, it may be possible to advance the adoption rate of this particular innovation within the CTE ranks. This proposition should be a major focus for further research. Additional research focused on practical applications and derived instructional advantages as demonstrated in its effects on learning are also vital to further support sustained adoption. Areas of instruction that consume considerable amounts of scare resources or require access to difficult locations may benefit from the development of such initiatives in desktop VR. Research into exploring the adoption of other innovations using a similar priming technique is also important. Further research into the effectiveness such techniques have in other innovative areas, their adoption, and different priming techniques that could affect the innovation-decision process could prove beneficial to many other disciplines studying innovation diffusion theory.

These possibilities appear to this researcher to merit further investigation. Cost-effective and instructionally beneficial desktop VR may be an important tool for CTE and adult occupational programs as well as other potential areas of implementation. Further research into speeding its adoption may be a productive line of inquiry for the field.

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APPENDICES

Oklahoma State University Institutional Review Board

Date: Monday, March 03, 2008

IRB Application No   ED0830

Proposal Title: The Effects of Supraliminal Bipolar Primes on Career and Technical Educators' Viewing Time, Perceived Confidence, and Technology Self-Efficacy of Desktop Virtual Reality

Reviewed and   Expedited
Processed as:

Status Recommended by Reviewer(s): Approved   Protocol Expires: 3/2/2009

Principal
Investigator(s):
Michael Scott Williams   Lynna Ausburn
P.O. Box 1266   257 Willard
Warner, OK 74469   Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 4 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approva stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

Scott Williams
Business and Entrepreneurial Services
Indian Capital Technology Center
2403 North 41st Street East
Muskogee, OK 74403
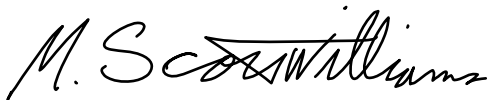

All Faculty
Indian Capital Technology Center

Potential participant,

I am a current employee of Indian Capital Technology Center within the Business and Industry Services Division and am conducting a research study as part of the requirements for obtaining a Ph.D. in Occupational Studies from Oklahoma State University. The primary purpose of the research is to collect information about how individuals may be influenced in reference to their disposition of desktop virtual reality.

This research has been approved by the district superintendent, Tom Stiles. However it is voluntary. If you are randomly chosen to participate you therefore have the option to decline. If participating you will be asked to complete a questionnaire, complete a brief activity, review a virtual reality treatment via a laptop computer, and then complete another questionnaire. You will be contacted to schedule a specific date and time for completing the above referenced components of the study. In total it will take approximately 45 minutes to 1 hour.

All information collected will be anonymous and confidential. Thus any answer given or data recorded cannot be associated with a specific individual. If you have any questions of concerns please don't hesitate in contacting me. I can be reached by phone at (918) 682-1965 or by email at scottw@ictctech.com.

Sincerely,

M. Scott Williams

M. Scott Williams
Business and Entrepreneurial Services
Indian Capital Technology Center

Participant Consent Document

This research project is being conducted by Scott Williams, a Ph.D. candidate at Oklahoma State University, to study desktop virtual reality and its introduction into Career and Technical Education programs.

The purpose of the research is to collect information how CTE educators may be encouraged to adopt desktop virtual reality (VR) technology.

Your participation in this research is voluntary. There are no special incentives for participation, no negative consequences for declining participation, and you are free to decline participation for any reason without explanation. There are no known risks in participating in the research beyond those encountered in daily life.

 If you agree to participate, you agree to the following conditions regarding your voluntary participation in this research:

- Your participation will involve completing a questionnaire requesting specific demographic and technology background information, taking a scrambled sentence test, reviewing a desktop virtual reality presentation of the interior of a house, and completing another short questionnaire regarding the VR technology.
- Your participation will take approximately 45 minutes to 1 hour.
- Information you provide will be anonymous and treated with complete confidentiality, your name will not be recorded on any of the research documents.
- Information you provide will be secured at all times by the principal investigator
- The data yielded from this research will be used solely for research.
- Any data from this research used in preparation and publication of professional literature and reports will be anonymous and reported only in aggregate and/or in codes, specific reference to your personal identity will not be made at any time.
- All research questionnaires will be kept under locked security by the principal investigator for up to two years for analysis and preparation of professional literature. After two years all questionnaires will be shredded. The only documentation that will be retained after 2 years will be the coded and anonymous SPSS data file. This may be retained by the Principal Investigator for reference and further research.

If you have questions or concerns you may contact the principal investigator, Scott Williams, by phone at (918) 682-1965 or by email at scottw@ictctech.com or his academic advisor at OSU, Dr. Lynna Ausburn at 405-744-8233 or lynna.ausburn@okstate.edu.

If you have questions about the research and your rights as a research volunteer you may contact Dr. Sue C. Jacobs, IRB chair, 219 Cordell North, Stillwater, OK 74078, (405) 744-1676 or irb@okstate.edu.

To give your consent to participate in this research and submit your data for inclusion in analysis and use in professional education literature, please remove this consent form and complete the participant information questionnaire.

For each question below please select the most appropriate answer provided and place a mark in the blank beside it. If you have any questions or concerns you may ask the researcher. After completing the questionnaire turn the page and continue to the next section.

****

DEMOGRAPHIC INFORMATION

****

Gender
___Male   ___Female

Ethnicity
___Caucasian   ___African American   ___Native American
       ___Latino
___Other – Please specify_____

What year were you born_____

Campus location
___Muskogee   ___Sallisaw   ___Stilwell   ___Tahlequah

How many years have you taught in Career and Technical Education _____

What professional discipline do you
teach_____

****

TECHNOLOGY

****

Please select which best describes your familiarity with desktop Virtual Reality

___Not at all familiar, I have never seen or heard of the technology
___Not very familiar, I have heard of the technology but have never seen it demonstrated
___Familiar, I am aware of the technology and have seen it demonstrated but have never used it in the classroom
___Moderately Familiar, I have used desktop virtual reality in my instruction methods at least once
___Very Familiar, I routinely use desktop virtual reality in my instruction methods

Would you consider your technology literacy to be:

___Very high ___Moderately high   ___Average   ___Moderately low   ___Very low

Instructions

From each set of words listed below, create a grammatical sentence in the space provided to the right. You have up to 30 minutes to complete the test. After completing the test return the form to the researcher so you can begin the next activity.

****

Example - flew eagle the plane around: The eagle flew around

****

1. them was respect give always: _____

2. from are here considerate people: _____

3. good your exercising improves health: _____

4. can the show appreciate they: _____

5. he observes discreetly people watches: _____

6. task successfully was completed that: _____

7. be will often courteous they: _____

8. polite the new instructor is: _____

9. occurs normally this with us: _____

10. should now withdraw cautiously we: _____

11. us patiently act be let: _____

12. practice well really you prepares: _____

13. must the driver yield quickly: _____

14. information be graciously should received: _____

15. occasionally up and stop look: _____

16. him will honor she always:_____

17. should now sensitively listen we: _____

18. they her send see usually : _____

19. they behave him often with: _____

20. us cordially sing play let: _____

Instructions

From each set of words listed below, create a grammatical sentence in the space provided to the right. You have up to 30 minutes to complete the test. After completing the test return the form to the researcher so you can begin the next activity.

****

Example - flew eagle the plane around: The eagle flew around

****

1. they her bother see usually: _____

2. facts can disturb be sometimes: _____

3. good your exercising improves health: _____

4. should now intrude purposely we: _____

5. infringe sometimes get rights upon: _____

6. task successfully was completed that:_____

7. be will often interrupt he:_____

8. statements bold common are they:_____

9. occurs normally this with us:_____

10. he obnoxious likes act to: _____

11. bluntly to rather speak also: _____

12. practice well really you prepares: _____

13. rude very behavior was it: _____

14. mannerisms aggravating his very were: _____

15. occasionally up and stop look: _____

16. behaves aggressively acts he: _____

17. they line in cut impolitely: _____

18. they her send see usually : _____

19. watches he annoyingly peoples: _____

20. is he brazen always so: _____

Instructions

From each set of words listed below, create a grammatical sentence in the space provided to the right. You have up to 30 minutes to complete the test. After completing the test return the form to the researcher so you can begin the next activity.

****

Example - flew eagle the plane around: The eagle flew around

****

1. good your exercising improves health: _____

2. task successfully was completed that:_____

3. occurs normally this with us:_____

4. practice well really you prepares: _____

5. occasionally up and stop look: _____

6. they her send see usually : _____

Using the scale provided below each question as a guide, please place a check mark by the answer that most agrees with your self-assessment. When you have answered both questions please return the form to the researcher. Thank you.

---

1. What level of confidence do you have in being able to describe the room you just viewed in desktop virtual reality to another individual in detail?

    ____1. Very Low confidence level

    ____2. Low confidence level

    ____3. Moderate confidence level

    ____4. High confidence level

    ____5. Very High confidence level

2. What level of confidence do you have in being able to interact with the virtual reality technology and successfully perform the available functions such as zoom in to view a specific object, rotate to determine room layout, and look up and down?

    ____1. Very Low confidence level

    ____2. Low confidence level

    ____3. Moderate confidence level

    ____4. High confidence level

    ____5. Very High confidence level

VITA

Michael Scott Williams

Candidate for the Degree of

Doctor of Philosophy

Dissertation: THE EFFECTS OF SUPRALIMINAL BIPOLAR PRIMES ON CAREER AND TECHNICAL EDUCATORS' VIEWING TIME, PERCEIVED CONFIDENCE, AND SELF EFFICACY OF DESKTOP VIRTUAL REALITY

Major Field: Education (Occupational Studies)

Biographical:

Personal Data: Born in Muskogee, Oklahoma, On March 22, 1979, the son of Mike Williams and Patsy Johnson, Married to Carol Williams with one daughter Makayla Williams

Education: Completed the requirements for the Doctor of Philosophy in Education (Occupational Studies) at Oklahoma State University, Stillwater, Oklahoma in December, 2008.

Completed the requirements for the Master of Business Administration in Business Administration at Northeastern State University, Muskogee, Oklahoma in May, 2003.

Completed the requirements for the Bachelor of Business Administration in Management at Northeastern State University, Tahlequah, Oklahoma in May, 2002.

Experience: Indian Capital Technology Center, 2005 – present
Connors State College, 2003 – 2005
Employment Resources Incorporated, 2003 – 2003
Walgreens, 2001 – 2002

Professional Memberships: Omicron Tau Theta, Association of Career and Technical Education, Oklahoma Association of Career and Technical Education, Customized Business and Industry Training Services

Name: Michael Scott Williams

Date of Degree: December, 2008

Institution: Oklahoma State University

Location: Stillwater, Oklahoma

Title of Study: THE EFFECTS OF SUPRALIMINAL BIPOLAR PRIMES ON CAREER AND TECHNICAL EDUCATORS' VIEWING TIME, PERCEIVED CONFIDENCE, AND SELF-EFFICACY OF DESKTOP VIRTUAL REALITY

Pages in Study: 127

Candidate for the Degree of Doctor of Philosophy

Major Field: Education – Occupational Studies

Scope and Method of Study:

Virtual reality (VR) has been demonstrated to offer learning benefits in many technical and occupational areas. This study used Rogers' innovation diffusion theory and stimulus priming theory to study the effects of supraliminal priming on viewing time, confidence, and VR self-efficacy of desktop VR in Career and Technical Education. The study was informed and refined by a pilot study and used experimental methodology to test the possibility of positively influencing the dispositions of occupational educators toward desktop VR through application of prime theory. Supraliminal bipolar primes in the form of scrambled sentences were used to test whether a positive disposition more conducive to future VR adoption could be created in a sample of 45 occupational educators prior to introduction of a desktop VR presentation, with "disposition" defined as voluntary VR viewing time, self-reported VR confidence, and self-reported VR self-efficacy on 5-point Likert-scales.

Findings and Conclusions:

The inquiry used descriptive statistics, analysis of variance, and correlation statistical analyses to produce results that were expected and unexpected given the indications of the pilot study. The conclusions resulting from this study are:

1. Several aspects of the study's proposed theoretical/conceptual framework were supported.
2. There were some disparities between the outcomes of the pilot and the present study that may be related to sample size.
3. Priming may be able to directly affect VR viewing time, VR confidence, and VR Self-efficacy.
4. Relationships among priming, VR viewing time, confidence, and self-efficacy may be more complex than predicted in the proposed conceptual framework.
5. A relationship between VR confidence and self-efficacy may exist and may be complex.

ADVISER'S APPROVAL: Dr. Lynna Ausburn