THE RELATIONSHIPS OF MEDIA, TASK, SPATIAL PRESENCE, AND CRITICAL THINKING, IN AN ONLINE TUTORIAL DESIGNED TO TEACH ART CRITICISM

A Dissertation

by

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ABSTRACT

This experimental study analyzed the relationships between media type, task type, the learners' experience of spatial presence in media and learning outcomes. Spatial presence is believed to represent the users' focus of attention on and involvement with a media presentation. Some researchers believe that manipulating factors that increase spatial presence will increase learning and performance. Increased interest in media learning presentations raises questions about what types of media can best support learning, and whether design recommendations can be generalized across domains.

Undergraduate and graduate college students were assigned to four experimental treatments to test the hypothesis that spatial presence mediates the effects of task type and media type on a learning task that requires critical thinking: writing an art critique. Media types were static and interactive/immersive; task types were guided and unguided. The Witmer and Singer Presence Questionnaire and the Holistic Critical Thinking Scoring Rubric were used to measure spatial presence and critical thinking, respectively.

Results showed that Task type and Media type did not significantly influence Spatial Presence or Critical Thinking. Scores on Spatial Presence were significantly related to the Critical Thinking scores. The guided task immersive media treatment group had fewer high scores on Critical Thinking which suggests that the task structure and/or media type may have distracted from the main learning task. The results support contemporary theories of spatial presence as a phenomenon of mental processing that monitors intention and goal completion but is not dependent on specific media

characteristics. The results also suggest congruence between contemporary ideas about spatial presence and the cognitive load theory of learning.

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CHAPTER I

INTRODUCTION

When individuals are immersed in media, they are "…notably engaged and absorbed in the content made available to them through either linear presentations or through interactive media" (Association for Educational Communication and Technology-Multimedia Production Division [AECT-MPD], 2013). If the media is particularly engaging part or all of the user's attention may be focused on content presented by the technology and away from objects, events and people in the real world (International Society for Presence Research [ISPR], 2000). This intense psychological state of immersion and involvement with media is called *presence* (Lessiter, Freeman, Keogh, & Davidoff, 2001, Lombard & Ditton, 1997; Witmer & Singer, 1998). The user who is experiencing presence in media will deliberately disregard distracting elements in the real environment to stay focused on the media presentation (ISPR, 2000; Lessiter, et al., 2001; Waterworth & Waterworth, 2001).

The presence experience can have several dimensions. The most distinctive dimensions are s*patial presence,* which occurs when the user's conscious focus of attention is on a mediated environment and *social presence*, feeling present with other persons or with intelligent artificial entities (ISPR, 2000). Lombard and Ditton (1997) suggested that presence is best measured through self-reports. A number of subjective self-report questionnaires have been developed to measure the sense of presence (ISPR, 2005.

Spatial presence is considered to be a psychological state of immersion and involvement that occurs when a user is focused on a media presentation (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998). Computer games and virtual reality simulations that feature high fidelity graphics and interactive elements are believed to stimulate high degrees of spatial presence (Lessiter et al., 2001; Witmer & Singer, 1998; Sadowski & Stanney, 2002). But the involvement which participants experience in immersive environments does not always translate to an effective condition for learning (Moos & Marroquin, 2010; Rieber & Noah, 2008). Some research studies support the assumption that presence is important to accomplish learning goals in educational media (Limniou, Roberts, & Papadopoulos, 2008; Kontogeorgiou, Bellou, & Mikropoulos, 2008; McClean, Saini-Eidukat, Schwert, Slator, & White, 2001). But other studies have found that users of less immersive technologies out-perform the high immersion media users (Mania & Chalmers, 2001; Rieber & Noah, 2008; Schrader & Bastiaens, 2012).

The issue is complicated by the many possible design characteristics and the wide range of educational uses of media (Moos & Marroquin, 2010). It seems that the educational content, type of media presentation and specific learning task all interact to affect the learners' experience of spatial presence and subsequent task performance (Mania & Chalmers, 2001; Youngblut & Huie, 2003). Different types of learning tasks require different types of thinking (Jonassen & Reeves, 1996; Norman, 1983). Simple memory tasks, navigation problems or mechanical skills may be aided by rich graphics and interactive environments but more complex tasks involving concept formation and

problem solving may need less distracting media characteristics (Norman, 1983). User interaction can be a distraction in tasks that require deep thinking and reflection (Norman, 1983). Sweller's cognitive load theory (1994) may explain why some immersive and interactive media fail to show successful learning outcomes.

How can media characteristics be used most effectively to engage and involve students, and enhance learning outcomes? A better understanding of the relationships of learners' experience of spatial presence in the context of specific media and tasks may help put these questions into focus and facilitate design of effective learning presentations.

Background to the Study

The concept of presence has been discussed in peer-reviewed journal articles and edited book chapters from the fields of education, psychology, communication and human-computer interaction sciences for more than 25 years (Jacobson, 2001; Lombard & Ditton, 1997; Winn, 1993). Presence can occur in almost any media experience (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001). During the 20th century presence was discussed in the context of TV and film (Winn, 1993). With the development of personal computers the concept of presence began to be researched in the context of the computer interfaces and simulated realities (Lessiter et al., 2001; Sadowski & Stanney, 2002; Schubert, Friedmann, & Regenbrecht, 2001).

Presence has become an increasingly integral component of electronic game and virtual reality simulations research and is sometimes measured and used to improve

design even when learning outcomes are not measured (Mikropoulos, Chalkidis, Katsikis, & Kossivaki, 1997; Tichon, 2007). Some advertising researchers have discovered that spatial presence can mediate product knowledge and opinions (Li, Daugherty, & Biocca, 2002; Nicovich, 2010). While there have been many studies that measure the effects of different media characteristics on users' sense of spatial presence, there are few empirical studies that measure both spatial presence and learning outcomes.

Problem Statement

Constructivist theories of learning presume that deep learning is achieved through active student involvement in the learning process (Mayer, 2003). This includes paying attention to relevant information, organizing it into cohesive structures and connecting it to existing knowledge (Mayer, 2003). Media with immersive characteristics such as interactive games and virtual reality presentations are often assumed to be more engaging to learners and therefore effective learning tools. But research studies show mixed results (Moos & Marroquin, 2010).

The latent variable spatial presence is indicated by measures of the participants' subjective self-reports of their focus of attention on the media presentation (Lessiter, Freeman, Keogh, & Davidoff, 2001; Lombard & Ditton, 1997; Witmer & Singer, 1998). If paying attention to a learning presentation results in better learning outcomes, then measures of spatial presence should be related to learning outcomes. The research described in this paper explored the possibility that spatial presence mediates learning outcomes in a task that requires critical thinking. An understanding of the relationships

between spatial presence and the media characteristics in the context of specific learning tasks can inform design of instructional media.

Purpose and Significance of the Study

The goal of this research was to analyze the relationships between media type, task structure, the learner's experience of spatial presence in media, and learning outcomes in the context of a learning task that required critical thinking: critiquing a work of art. Spatial presence was examined as a measure of the participants' engagement with the media and as a possible mediator of the effects of the media type and task structure on their scores on a measure of critical thinking.

Technological advances have resulted in questions about which types of media can support learning and whether design recommendations can be generalized across various domains (Land & Hannafin, 2000). Richey and Klein (2007) recommend testing affordances of media in context to measure causal inferences. Results from my study will be of interest to instructional designers and faculty who design and use media for instruction.

Overview of Methodology

Research Design

Four simulation conditions were created in an online research tutorial. The four conditions comprised two levels of two factors: Media and Task. The two Media were Static, represented by a linked jpeg image of the artwork; and Dynamic Manipulation represented by an interactive Adobe Flash version with three dimensional imagery added. Task types were a Guided Task which has support in the form of several specific

question prompts, and an Unguided Task with only one general question prompt.

Participants were randomly assigned to one of the four versions of the online research tutorial. Outcome data collected participants' responses to a Likert questionnaire designed to measure their sense of spatial presence while using the media, and the art critique essays they wrote while visiting the tutorial. The data was analyzed using analysis of covariance (ANCOVA) to determine if spatial presence met the criteria as a mediator variable as described by Preacher and Hayes (2004).

Subjects

Eighty college students enrolled in undergraduate education or art classes or graduate education classes participated in the study. All participants were volunteers and they remained anonymous throughout the study. Most participants received a $5 Starbuck's gift certificate; some received extra credit points from their classroom instructor.

Methods of Assessment

Participants viewed a presentation on the fundamentals of visual design and image analysis and viewed one of two presentation types of a novel work of art. They answered questions about the artwork and then wrote a *formal* critique of the artwork they were viewing. A formal art critique is one which describes, analyzes and evaluates the relationships of the forms that comprise the work of art. The critiques were scored by two independent subject matter experts using the Holistic Critical Thinking Scoring Rubric (HCTSR) (Facione & Facione, 1994) shown in Appendix A.

The Spatial Presence Likert questionnaire included item stems from the Witmer

and Singer 1998 Presence Questionnaire (PQ) modified to fit the research treatments. The original Witmer and Singer 1998 Presence Questionnaire can be seen in Appendix B. Participants completed the Spatial Presence questionnaire after writing the art critique essay and before exiting the tutorial. Each participant's answers to the questionnaire were averaged for their Spatial Presence score.

Research Questions

1. What are the relationships between Task Type, Media Type, Spatial Presence and Critical Thinking?

Presence research indicates that spatial presence is influenced by characteristics of media and characteristics of the user. While spatial presence is believed to represent the users' focus of attention on the media presentation, most educational research that compares media has not measured spatial presence. In addition, structure of the task is seldom considered as a variable. In the hypothesized model, Task and Media have direct effects on Spatial Presence and Critical Thinking, and indirect effects on Critical Thinking mediated by Spatial Presence, as shown in Figure 1.

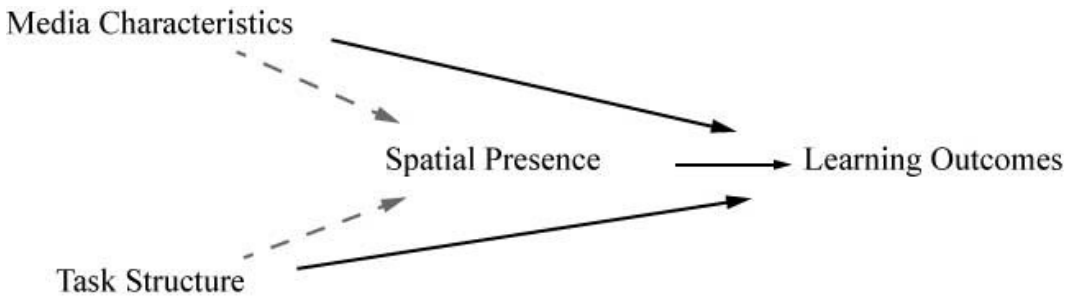

Figure 1. Spatial Presence Mediates the Effects of Task and Media on Learning.

2. What are the relationships of Task, and Media to learners' scores on Spatial Presence?

It was predicted that certain combinations of Task and Media would result in higher or lower scores on Spatial Presence. Presence research indicates that spatial presence is influenced by characteristics of media and characteristics of the user. While user interaction is considered to be a factor affecting spatial presence, the task structure is rarely considered.

Research Hypothesis

In a media learning presentation designed to teach art criticism the learner's experience of spatial presence is expected to mediate the effects of task type and media type on learning outcomes. In studies of 3D advertisements Li, Daugherty, and Biocca

(2002) found significant correlations between participants' reports of spatial presence and their subsequent scores on tests of product knowledge, supporting the view of spatial presence as a mediator variable.

Objectives and Outcomes

The specific objective of this dissertation is to study the relationships of media, task, the interaction of task and media, and learner engagement (measured as spatial presence) to learning outcomes in a task that requires critical thinking. The outcome of the research will be a clearer understanding of the relationships of the variables which will add to the body of knowledge of effective design of media learning environments.

Limitations

The users' ability to accurately report their memories of an internal experience using subjective self-reports can be disputed (Dror & Harnad, 2008). By placing the learning task in the media presentation and having participants complete the spatial presence questionnaire immediately after writing the critique, this research hoped to minimize memory inaccuracies.

Slater (2002) questioned the validity of self-report questionnaires to measure presence due to the subjectivity with which respondents may interpret each question. I revised the wording of each questionnaire item response option to specifically address the query. For example, question 15 asks "How distracting were the control mechanisms of your computer ?" The responses range from "Not distracting" to "Very distracting."

Slater (2002) recommends using objective measures such as monitoring eye movements or mouse clicks in addition to a questionnaire. Because the learning task for

this research involved deep thinking rather than observable actions, such objective measures may be less useful.

Delimitations

The study used volunteers who may not be representative of the overall population of interest. Students who chose to volunteer for the research study may have had specific motivations or characteristics which inspired their interest in the project.

An interactive Adobe Flash media piece with pan, tilt, and zoom capabilities was developed to represent the Dynamic Manipulation version of the artwork. Because the Flash plug-in is already installed on most personal computers participants did not need to install additional plug-ins to complete the research. The Adobe Flash presentation is less immersive than a fully three dimensional virtual environment, but it does fit the definition of immersive media as media which contains rich graphics and interactive elements (Lessiter, Freeman, Keogh, & Davidoff, 2001, Lombard & Ditton, 1997; Witmer & Singer, 1998). It also maintains the character of the original artwork as a two dimensional image.

Assumptions

The research makes the assumption that participants' subjective self-reports of their involvement with the media, measured by the research Spatial Presence questionnaire, are valid measures of the participants' engagement with the media presentation. Measuring a learners' sense of presence as well as learning outcomes can provide substantive information regarding the relationships of the media and task to the learning outcomes.

Definitions of Key Terms

Spatial Presence

For this research study spatial presence was defined as the users' subjective self-reports of their focus of attention on the media presentation (ISPR, 2000; Slater, 2002; Waterworth & Waterworth, 2001) measured by their responses to the research Spatial Presence questionnaire.

Critical Thinking

Critical thinking is defined as "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, or contextual considerations upon which that judgment is based" (Facione, 1990, p. 3). In the context of an art critique it refers to accurate descriptions, thoughtful and fair-minded analysis and evaluation and a value judgment based on features described and analyzed.

Immersion and Immersive Media

In the late twentieth century *immersive media* referred to virtual reality presentations which required head-mounted displays and data gloves as input devices (Chittaro & Ranon, 2007). Developments in late twentieth century technology allowed all types of complex renderings to be experienced on ordinary computer screens with no special input device (Chittaro & Ranon, 2007). At the same time, presence research revealed that the user's experience of *immersion* is a psychological response and is not media dependent (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998).

When individuals are immersed in media, they are "…notably engaged and absorbed in the content made available to them through either linear presentations or through interactive media" (AECT-MPD, 2013). Immersion is a continuous variable, it occurs in degrees from low to high (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Slater, 2002, 2004; Slater & Garau, 2007; Waterworth & Waterworth, 2001; Witmer & Singer, 1998).

In scholarly literature the term immersive refers to the characteristics of the media that are believed to stimulate an immersion response in the user (Lessiter, Freeman, Keogh, & Davidoff, 2001; Mania & Chalmers, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998; Youngblut & Huie, 2003). Media research has revealed that these characteristics are rich, naturalistic, graphical and user interactive (IJsselsteijn, de Ridder, Freeman, & Avons, 2000; Lessiter et al., 2001; Witmer & Singer, 1998). Immersive media includes "multimedia presentations, games, pervasive games, simulations, computer/web based applications and mobile applications" (AECT-MPD, 2013).

When used to describe media characteristics, "immersive" is a relative term. Media presentations may be described as fully immersive (Limniou, Roberts, & Papadopoulos, 2008), highly immersive, immersive, or low immersion, depending on characteristics of the media being used (IJsselsteijn, de Ridder, Freeman, & Avons, 2000; Lessiter, Freeman, Keogh, & Davidoff, 2001; Mania & Chalmers, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Waterworth & Waterworth, 2001; Witmer & Singer, 1998). A 3D virtual reality presentation viewed on a personal computer might be

considered “highly immersive” when compared to a printed image (Antonietti & Cantoia, 2000), a web search (McClean, Saini-Eidukat, Schwert, Slator, & White, 2001) or a 2D media presentation viewed on a computer screen (Schrader & Bastiaens, 2012). However, a 3D virtual reality presentation viewed on a computer screen is considered “low immersion” when compared to a head mounted display system, (Mania & Chalmers, 2001; Youngblut & Huie, 2003) or to an enclosed projection area (Limniou, Roberts, & Papadopoulos, 2008).

This paper will refer to the low immersion media treatment used in this study as “Static” (S). The moderate immersion media treatment which includes enhanced graphics, animation and interactive characteristics will be called “Dynamic Manipulative” (DM).

Task

For this research study task refers to the structure of the practice portion of the research tutorial. In a larger sense, task refers to the structure of the learning activities and methods used to direct learners towards achieving the learning goal.

Organization of the Dissertation

This dissertation uses a standard five chapter format recommended by Calabrese (2006). The first chapter explains the research objectives and rationale. Chapter 2 reviews literature that fits the research theoretical perspectives. Chapter 3 explains the research design, hypothesis, instruments and data collection procedures. Data analysis and results are discussed in Chapter 4. Chapter 5 discusses interpretation and implications of the data in relationship to the research hypothesis. It provides further insights into

limitations, strengths and weaknesses of the design and how they may have influenced outcomes. And it offers justification for the significance of the research project and its contributions to knowledge and practice.

CHAPTER II

LITERATURE REVIEW

Introduction

Literature selected for this review includes scholarly research that uses quantitative methods to analyze the relationships of the variables of interest: media type, task type, spatial presence and learning outcomes. The initial review in 2009 and a second search in June 2013 used the *critical analysis* method as described by Calabrese (2006, p.32) to select literature. The content of 142 articles was examined for depth, methodology, results and conclusions relevant to this author's research question. Then each article was categorized according to the article type: educational research, review, design research, presence research, presence theory, or instrument development.

Phase two of the critical analysis literature review (Calabrese, 2006, p.33) was conducted in July 2013. The quantitative educational research studies were examined and sorted into categories based on measures used and types of learning outcomes. Seven educational research studies were selected for analysis and then summarized according to variables that matched the study described in this paper.

In September 2013 a retrospective quasi-systematic review was conducted to provide specific detail about criteria used for inclusion and exclusion. The research question used for the systematic review was "to review published literature that reports the relationships of task, media, and learner engagement with media and learning

outcomes in quantitative educational research". The result is a literature review that "employs some systematic techniques" as described by Bearman et al. (2012, p. 262).

Criteria for Selection

Initially, 127 references were found during 2009 by searching the following databases: Psych Info, Web of Science, Science Direct, Academic Search Complete (Ebsco), OmniFile FT Mega (Wilson) and ERIC, using key words "virtual worlds" or "virtual reality" and "spatial presence" or "presence" jointly, and "virtual worlds" or "virtual reality" and "learning" or "education" jointly. The searches uncovered peer reviewed articles from scholarly journals in the fields of education, psychology and human-computer interaction and publications devoted exclusively to the study of presence, such as *Presence: Teleoperators and Virtual Environments* (published by MIT press journals) and the International Society of Presence Research (ISPR, 2007) website. Additional resources came from peer reviewed publications of organizations dedicated to educational technology and research: Association of Educational Communication and Technology (AECT), Association for Computing Machinery (ACM), and IEEE Computing Society. Results were imported into an Endnote library and duplicates were discarded. Pdf files were obtained from the Texas A & M University library system, and downloaded to the protocol director's personal computer. The pdf files were then linked to the Endnote references and reviewed individually while highlighting pertinent details and noting them in Endnote.

A second search of major databases was conducted in June 2013 to acquire recent research. Key words "media presence" or "spatial presence" and "learning" were

searched jointly. This search added 15 files.

Criteria for inclusion in the detailed educational research section of the literature review were the following: quantitative educational research that tested media and measured specific learning outcomes using adults or young people over the age of 13. Preference was given to research studies published during the last ten years and research that included measures of spatial presence or measured learning outcomes that required critical thinking. The rapid development and proliferation of media during the last decade has resulted in media presentations that are easier to design and use and learners who are more experienced in the use of media. Older research studies may be less relevant due to changes in media and user characteristics.

The review revealed a total of 17 educational research articles. Five of the studies measured the participants' experience of presence as well as specific learning outcomes (Kontogeorgiou, Bellou, & Mikropoulos, 2008; Limniou, Roberts, Papadopoulos, 2008; Mania & Chalmers, 2001; Schrader & Bastiaens, 2012; Youngblut & Huie, 2003). The remaining 12 educational research studies measured learning outcomes but did not measure spatial presence (Antonietti & Cantoia, 2000; Crosier, Cobb, & Wilson, 2000; McClean, Saini-Eidukat, Schwert, Slator, & White, 2001; Moreno & Mayer, 2005; Bridge, Appleyard, Ward, Philips, & Beavis, 2007; Levinson, Weaver, Garside, McGinn, & Norman, 2007; Zacharia, 2007; Dong et al., 2008; Rieber & Noah, 2008; Lin & Dwyer, 2009; Chen, Siau, & Nah, 2012). Seven articles were selected for detailed review: the five studies that measured spatial presence as well as learning outcomes (Kontogeorgiou et al., 2008; Limniou et al., 2008; Mania & Chalmers, 2001; Schrader &

Bastiaens, 2012; Youngblut & Huie, 2003), and two studies that included learning tasks that required critical thinking (Antonietti & Cantoia, 2000; McClean, Saini-Eidukat, Schwert, Slator, & White, 2001).

Antonietti and Cantoia's study (2000) is included because the critical thinking learning task is very similar to the research task described in this report; McClean, Saini-Eidukat, Schwert, Slator, and White's study of college students learning biology and geology (2001) measured a problem-solving task that required critical thinking. The nine rejected studies did not include measures of spatial presence, and their measured learning outcomes were multiple choice questions or short answers that did not require critical thinking (Crosier, Cobb, & Wilson, 2000; Moreno & Mayer, 2005; Bridge, Appleyard, Ward, Philips, & Beavis, 2007; Levinson, Weaver, Garside, McGinn, & Norman, 2007; Zacharia, 2007; Dong et al., 2008; Rieber & Noah, 2008; Lin & Dwyer, 2009; Chen, Siau, & Nah, 2012).

The selection process is diagrammed in the systematic review style of Yeager and Menachemi (2011) and shown in Figure 2. A table which summarizes the key points of the seven selected educational research studies can be seen in Appendix C.

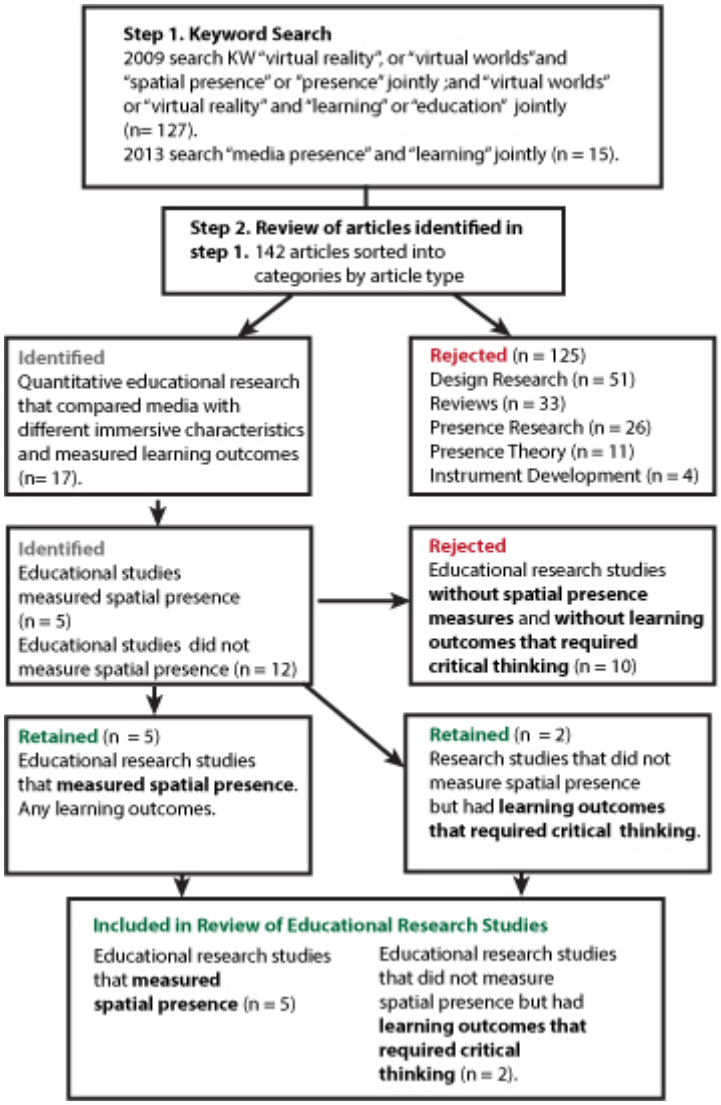

Figure 2. Selection Process Diagramed in the Systematic Style. A systematic analysis was conducted retrospectively in September 2013 to explain the original July 2013 critical analysis selection process.

Organization of the Literature

The first section of this review contains literature that is essential to any discussion of spatial presence: explorations of the factors that define and create spatial

presence and the development of instruments to measure spatial presence. Most of this defining research was conducted around the end of the twentieth century. The second section contains summaries of research studies that used quantitative measures to analyze the effects of media on learning in formal education or training settings. Educational research studies that measure the effects of spatial presence on learning are scarce, so this section includes two studies that used immersive media such as three dimensional visualizations and interactive computer games.

Competing Perspectives

Presence has been studied for its applications to entertainment, product knowledge and brand attitude, persuasion, memory and psychological conditioning, as well as education (Hew & Cheung, 2010; Li, Daugherty, Biocca, 2002; Moos & Marroquin, 2010). Spatial presence is considered to be a subjective state of a media user's focus of attention on the mediated presentation (Lessiter, Freeman, Keogh, & Davidoff, 2001; Lombard & Ditton, 1997; Witmer & Singer, 1998). Increased concentration and focus of attention on a learning presentation are usually considered to enhance learning and performance so many researchers assume that there is a positive relationship between presence and learning (Jacobson, 2001; Murray, Fox, & Pettifer, 2004; Waterworth & Waterworth, 2001; Winn, 1993; Witmer & Singer, 1998).

Spatial presence may "… connect learners' imagination and internal mental models with an external guided stimulus…" (Thomas & Brown, 2007, p.150). This connection may facilitate understanding of concepts. Romano and Brna (2001) emphasize the importance of the immersive characteristics such as multiple and

interactive viewpoints and the ability to see the results of different actions.

An alternative view is put forth by Clark (1983). He contends that differences in learning with different types of media are caused by differences in instructional method and the effect of using a novel type of presentation. Sweller's cognitive load theory (Sweller, 1994, 2010) and Mayer's multimedia learning theories (2001) stress that media compositions can add cognitive load that can interfere with learning. Moshell and Hughes (2002) surveyed the use of six different media learning presentations designed for a range of learning outcomes and found that none of the projects had produced significant, measurable learning results. System complexity and novelty had consumed most of the students' and experimenters' time.

Some educators believe that technology rich learning presentations are needed to motivate and engage contemporary students (Windham, 2005). However, empirical studies that examined the effects of various types of media on motivation and learning showed mixed results (Moos & Marroquin, 2010).

Conceptual Framework

The Evolution of the Concept of Spatial Presence

The concept of presence has been discussed in peer-reviewed journal articles and edited book chapters from the fields of education, psychology, communication and human-computer interaction sciences for more than 25 years (Lombard & Jones, 2007). With the development of immersive virtual reality programs that could simulate three dimensional realities researchers began exploring the likelihood of using presence as a measure of user engagement with the new technologies (Winn, 1993; Winn, Hoffman, &

Osberg, 1999).

Lombard and Ditton attempted to describe the components of the presence experience in their 1997 review of literature on technologies that provide natural and immediate user experiences similar to experiences in the real world. They analyzed research into video phones, arcade games, computer simulators and IMAX to define five components of presence: social richness, realism, transportation, immersion or involvement and social actor. These components influence the two main dimensions of presence in media: *spatial presence,* which occurs when the user's conscious focus of attention is on a mediated environment, and *social presence*, feeling present with other persons or with intelligent artificial entities. They advanced the theory that presence is a psychological state which can occur with any media. Lombard and Ditton (1997) believed that because presence is a subjective state, it is quantifiable only by the person experiencing it and is best measured through subjective self-reports.

The Development of Instruments to Measure Spatial Presence

The Witmer and Singer Presence Questionnaire. In 1998 Witmer and Singer conducted a factor analysis to identify the factors that make up a user's sense of spatial presence in single user media environments. They developed the 28 item Presence Questionnaire (PQ), a subjective self-report questionnaire that uses a seven point semantic differential scale to measure the factors in an individual's experience of spatial presence (Appendix B). Confirmatory factor analysis revealed that the presence construct was influenced by three subscales: *User control* or *involvement* includes perceived control and responsiveness of the environment and the immersive feeling of being

enveloped by the media; *naturalism*, means that the graphics and movement are consistent with reality and seem natural; and *interface quality*, the technical quality of images and interactivity. High quality images and smooth interactions will allow the user to concentrate on the presentation. A low resolution pixilated image or slow jerky interactivity might distract the user and lower the sense of spatial presence. Witmer and Singer (1998) also attempted to identify individual predilection towards immersion in media by developing an Immersive Tendencies Questionnaire (ITQ) seen in Appendix E, and used the correlation of the two questionnaires to test reliability of the PQ.

The final Witmer and Singer PQ (1998) contained nineteen items including eleven items to measure user involvement and sense of control over the environment. Greater involvement with the media environment results in a greater experience of immersion and spatial presence. Witmer and Singer define the involvement component of spatial presence as a "psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events" (1998, p.227). They point out that many people experience high levels of involvement with media such as movies, books and games.

The immersion component of spatial presence is the "… psychological state characterized by the perception of being in and interacting with an artificial, or simulated, environment" (Witmer & Singer, 1998, p.227). It creates a direct, first person feeling of interacting directly with a mediated environment enhanced by user control. Immersive media characteristic include rich three dimensional graphics and interactivity.

Witmer and Singer (1998) found a correlation between spatial presence and task

completion although the task was simple navigation. They speculated that spatial presence is an act of selective attention and that factors believed to increase immersion may also enhance learning. If that is the case, then measures of presence might be used instead of performance measures to evaluate the potential of media learning environments and to determine which types of media would benefit specific learners (p. 239).

Other presence questionnaires. Similar factor analyses of presence were conducted by Lessiter, Freeman, Keogh, and Davidoff (2001) and by Schubert, Friedmann, and Regenbrecht (2001). Both these studies revealed similar structures. Lessiter et al.'s 2001 analysis identified the factors "sense of physical space", "engagement", "ecological validity" and negative effects" (p.292). Schubert et al. (2001) called the factors "physical space", "engagement", and "naturalism" and did not include a fourth factor for negative effects (p.278). From Witmer & Singer's 28 item Presence Questionnaire (1998) Lessiter et al. (2001) developed the ITC Sense of Presence Inventory (SOPI), a 63 item self-report questionnaire using a five point scale. Schubert et al. (2001) developed a 75 item questionnaire that combined questions from Witmer and Singer's 1998 PQ and Lessiter et al.'s 2001 SOPI and added a few new questions. They described presence as an internally constructed mental model of possible actions within the virtual space. It includes the user's conscious suppression of conflicting stimuli to concentrate on the virtual stimuli.

A number of other researchers developed their own measures of presence and expanded the concept to include more dimensions (ISPR, 2005). Slater (2004) believes

that psychophysiological measures such as heart rate, skin measures or ocular measures should be used in conjunction with subjective questionnaires.

The Role of Immersion and Involvement in Spatial Presence

In the above studies, the most significant factor of spatial presence was user involvement or immersion: the user's focus on the media presentation. Murray, Fox, & Pettifer (2004) found significant correlations between presence and locus of control but not between presence and immersive characteristics of media. This finding supports observations that presence can occur in varying degrees of immersion and is not media dependent (Lessiter, Freeman, Keogh, & Davidoff, 2001; Chertoff, Schatz, McDaniel, & Bowers, 2008; Zahorik & Jennison, 1998; Jacobson, 2001).

Presence has been researched in three dimensional virtual reality simulations in which the participant is in a room and the virtual environment is displayed on the walls around them, and in high immersion head-mounted display systems (Limniou, Roberts, & Papadopoulos, 2008). But total media immersion is not necessary for the user to experience spatial presence (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Waterworth & Waterworth, 2001). User interactivity is considered to be more important than graphic quality in stimulating a sense of presence. Interaction with low fidelity displays can sometimes create a stronger sense of spatial presence than high fidelity displays. For example, a user playing *PONG, (*a simple two dimensional arcade game) on a low resolution desktop might be more immersed in the media than a user sitting passively in an IMAX theater presentation (Lessiter, et al., 2001).

Some authors emphasize the role of emotions in the experience of presence (Limniou, Roberts, & Papadopoulos, 2008). Nicovich (2010) found that spatial presence mediated game users' emotional responses to advertisements. The motivation to learn is also believed to be influenced by emotions (Chittaro & Ranon, 2007). The drama and increased concentration required by some immersive learning environments is believed to have positive effects on students' emotions and subjective perceptions (Takatalo, Nyman, & Laaksonen, 2008; Schrader & Bastiaens, 2012). Video computer games are considered to be very immersive due to their interactive capabilities and sense of drama (Tamborini, Bowman, Eden, Grizzard, & Organ, 2010; Cuenca López & Martín Cáceres, 2010; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012).

Various Theories about Spatial Presence

The definitions of presence as a theoretical construct have continually evolved over the past twenty-five years. The classical view of spatial presence which was developed around the millennium is that it includes an attentive side and a spatial cognitive side (Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998). In other words, spatial presence consists of a sense of an environment and the attention focused on the environment (Slater, 2002). Slater described deep presence as a successful gestalt of media which allows the user to experience the presentation holistically (2002). Waterworth and Waterworth (2001), Thomas and Brown (2007), and Murray, Fox, and Pettifer (2007) emphasized the psychological factors of the user's focus of attention to include excitement or interest. Still others found an emotional element (Schrader & Bastiaens, 2012; Schubert, Friedmann, & Regenbrecht, 2001).

A more recent approach proposes a broader definition of presence as related to a core neuropsychological phenomenon whose goal is to produce a sense of agency and control (Riva, Waterworth, Waterworth, & Mantovani, 2011). Maximum presence is experienced when the media supports the intentions of the user with no additional conscious effort of access to information (p.29). A higher level of presence is reported when the user is able to successfully complete their desired activity. This approach fits well with Sweller's cognitive load theory (1994, 2010).

Theoretical Framework

Sweller's 1994 cognitive load theory may explain why immersive environments can sometimes stimulate spatial presence but depress learning. *Cognitive load* refers to the amount of information one is trying to process in working memory. *Intrinsic* cognitive load is the difficulty inherent in the topic; it cannot be altered by instructional design. When cognitive load is effective for learning it is referred to as *germane* cognitive load (Sweller, 1994, 2010). During germane cognitive load, the learner gains understanding of new knowledge and creates more complex *schemas;* "A schema is a cognitive construct that organizes the elements of information according to the manner with which they will be dealt" (Sweller, 1994, p.296).

If the amount of information and interactions that must be processed simultaneously is too high it can overload the learners' working memory resulting in *extraneous* cognitive load. That is, cognitive load that is not related to learning but must be attended to. In a multimedia learning presentation this might include detailed graphics, interactivity from mouse clicks needed to navigate or even drama created by

characters and scenes. Mayer (2001) used the term *seductive details* to refer to superfluous media elements that increase cognitive load and distract from learning. Extraneous cognitive load from an immersive interactive environment can reduce instructional effectiveness of subject matter that occurs with high intrinsic cognitive load (Sweller, 2010). But as Schrader and Bastiaens point out, cognitive load theory does not explain the influence of emotions on learner attention as presence theory does (2012).

A learners' experience of spatial presence is believed to be moderated by both media characteristics and user characteristics (Murray, Fox, & Pettifer, 2004; Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998). User characteristics can include innate tendencies towards experiencing presence, interest in the subject matter or previous domain knowledge (Witmer & Singer, 1998). Cognitive load is also influenced by learner characteristics and media characteristics as well as the structure of the learning task (Sweller, 1994). A novice learner will experience high intrinsic cognitive load when learning new material (Sweller, 2004).

My review of the literature found research that showed improved learning outcomes through use of immersive media. But many of these studies used different types of task structure and/or additional guidance in the experimental conditions. Task guidance can improve learning by reducing extraneous cognitive load (Sweller, 2010; Clark, Kirschner, & Sweller, 2012, Spring).

Synthesis of the Research

The development of computer generated three dimensional environments enabled simulations that could facilitate psychological processes very similar to those that

operate when people interact with real objects and events (Winn, 1993). In those immersive learning environments spatial presence is believed to stimulate a first person experience that enables transfer of learning to the real world (Jacobson, 2001; Winn, 1993). Research supports the assumption that increasing the learners' sense of presence enhances the effectiveness of the training for skill acquisition in simulated learning environments such as airplane simulations, virtual car cockpits and truck driving simulators (Hofmann & Bubb, 2003; Romano & Byrna, 2001; Tichon, 2007).

The increased focus of attention that characterizes spatial presence is often the result of media environments that can be manipulated to provide multiple points of view (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998). Multiple views enable observation of processes or phenomena that would be difficult or impossible to observe in the real world (Chittaro & Ranon, 2007). This is believed to be valuable in the sciences where visualizations of subject matter are a key part of the learning process (Cai, Lu, Zheng, & Li, 2006; Limniou, Roberts, & Papadopoulos, 2008). Interactive visual displays of scientific events or phenomenon can enhance learning and aid in development of conceptual knowledge (Kontogeorgiou, Bellou, & Mikropoulos, 2008; Limniou et al., 2008; McClean, Saini-Eidukat, Schwert, Slator, & White, 2001). By changing size and position of simulations geology students are able to view the activity in volcanoes from directly overhead or inside, biology students can go inside molecules and atoms and astronomy students can study whole galaxies on one screen.

Proponents of these immersive media learning presentations often credit to them

increased interest and engagement experienced by learners (Kontogeorgiou, Bellou, & Mikropoulos, 2008; Limniou, Roberts, & Papadopoulos, 2008). But a close analysis of research studies reviewed here reveals that there were often differences in instructional methods used with the different types of media. Some researchers included additional task guidance in the immersive version that is not used in the control or non- immersive version (Antoinetti & Cantoia, 2000; Kontogeorgiou et al., 2008; Limniou et al., 2008). Others tested media as an additional enrichment for regular class instruction (McClean, Saini-Eidukat, Schwert, Slator, & White, 2001; Youngblut & Hiue, 2003). This supports Clark's assertion that it is the instructional method, not media type that is the real source of differences in learning outcomes (1983).

Studies that maintained consistent support for the different media treatments being compared found that lower immersive media users scored higher on learning than users of high immersion media (Mania & Chalmers, 2001; Schrader & Bastiaens, 2012) or that similar results could be obtained with lower immersion media (Youngblut & Huie, 2003). Detailed synopses of these studies can be found in Appendix E.

Critical Analysis of the Literature by Variable

Spatial Presence

Studies that used a formal measure of spatial presence found a correlation between the learners' sense of presence and their scores on learning outcomes (Kontogeorgiou, Bellou, & Mikropoulos, 2008; Mania & Chalmers, 2001; Schrader & Bastiaens, 2012; Youngblut & Huie, 2003), but the spatial presence scores did not always align with the more immersive media. In the study by Mania and Chalmers

(2001) participants who used the audio-only condition reported a higher sense of spatial presence than the desktop or head mounted display users. In that study learning scores were similar for real world and desktop display conditions, but lower for the more immersive head mounted display group. Schrader and Bastiaens (2012) found a significant correlation between learning outcomes and spatial presence scores, but the lower immersion media users scored higher on learning.

Sweller explained that for any type of learning the number of elements that must be attended to simultaneously is critical (1994). Interactivity and media richness may create extraneous cognitive load if they are not explicitly required to demonstrate concepts. In some types of learning presentations low immersion media users may experience as equivocal a sense of spatial presence as high immersion users simply because they are able to concentrate better on the topic.

Media Type

Rich, interactive visualizations that allow for multiple viewpoints are believed to be effective to help form mental images for understanding scientific phenomenon (Kontogeorgiou, Bellou, & Mikropoulos, 2008; Limniou, Roberts, & Papadopoulos, 2008; McClean, Saini-Eidukat, Schwert, Slator, & White, 2001). The Kontogeorgiou et al. (2008) and McClean et al. (2001) studies supported that view. Schrader and Bastiaens (2012) found better learning outcomes from less immersive media. The Limnou et al. (2008) study participants used both types of media consecutively.

In studies of other types of subject matter, lower immersion media resulted in higher learning outcomes (Mania & Chalmers, 2001; Youngblut & Huie, 2003). The

exception was the Antoinetti and Cantoia study (2000) which showed more critical thinking outcomes from the more immersive media.

Task Type

Task guidance is an important variable for learning. Clark, Kirschner, and Sweller (2012, Spring) report that novices usually perform better on learning tasks when the instruction includes specific guidance. Unguided tasks are more effective with learners who have sufficient prior subject knowledge so that they can create their own guidance (Clark, Kirschner, & Sweller, 2012, Spring; Kirschner, Sweller, & Clark, 2006).

Research studies that included additional guidance for learning tasks or that used the experimental treatments as enrichment to regular classroom instruction showed positive results from the more immersive environments (Antoinetti & Cantoia, 2000; Kontogeorgiou, Bellou, & Mikropoulos, 2008; Limniou, Roberts, & Papadopoulos, 2008; McClean, Saini-Eidukat, Schwert, Slator, & White, 2001; Youngblut & Hiue, 2003). In these studies task guidance from regular classroom activities may have reduced extraneous cognitive load from the media by directing learners to focus on relevant parts of the presentation. The reduction in cognitive load may have been sufficient to result in better learning outcomes.

The Schrader and Bastiaens (2012) study did not add extra guidance for either high or the low immersion conditions and participants who used the lower immersion media scored higher on learning outcomes. Without specific guidance the cognitive load of deciding which aspects of the high immersion game presentation were important may have resulted in extraneous cognitive load and distracted learners' attention from the

learning elements of the presentation.

Conclusion

The literature review indicates that spatial presence is related to learning outcomes. However, it may be more closely related to learners' ability to focus successfully on the required task than to specific media characteristics. Slater's 2004 suggestion that spatial presence questionnaires are actually measuring the respondent's sense of accomplishment might warrant further consideration.

The extensive variety of types of media presentations and learning outcomes makes it clear that one cannot make general recommendations about how best to use media in learning presentations. The subject matter, learner characteristic and type of learning must be considered. Task structure appears to influence outcomes in most types of learning.

In terms of cognitive load, the number of elements the learner must attend to is important in designing the instruction. Extraneous cognitive load from media elements is a problem if the intrinsic cognitive load is high for the learner. A less immersive environment may be more effective if the learner is a novice or if the task requires reflection and decision-making (Clark, Kirschner, & Sweller, 2012, Spring; Sweller, 2010). Support materials can be linked to an immersive presentation but the method of presentation might increase cognitive load and reduce spatial presence if the learner has to exit the main presentation to access the support material (Schrader & Bastiaens, 2008).

The Antoinetti and Cantoia (2000) research project was the only research study

found during this review that measured critical thinking without parallel class activities. It did not measure the participants' sense of spatial presence. The research project that is described in the next chapters analyzes the relationships of task type, media type, and users' experience of spatial presence in a task that requires critical thinking through writing an art critique. The goal of this research is to use the measure of spatial presence to help clarify the relationships of media, task, and learning outcomes.

CHAPTER III

METHODS

Introduction and Research Perspective

The goal of this research was to use measures of spatial presence to help clarify the relationships of media, task and learning outcomes in a task that requires critical thinking: writing an art critique. This chapter describes the research methodology, participants and materials used for the study.

The research study report is guided by a post-positivist critical realist approach. It acknowledges that all empirical observation is imperfect and that all theory is subject to revision (Trochim, 2006). The latent variable spatial presence can never really be measured with certainty and its very definition is continually debated (ISPR, 2007). However, attempts to observe and measure it objectively may facilitate the emergence of some facts that can help guide further studies. These observations can be triangulated with results from similar research to increase understanding of how learning happens.

Research Design

This research used a 2 x 2 factorial experimental design. Two fixed factors, Media type and Task type, each had two levels resulting in four conditions. The participants' scores on their final art critique essays were measured as the endogenous dependent variable. The third variable Spatial Presence was included as a mediator of Task and Media for learning outcomes. Data for Spatial Presence was participants' responses to the research Spatial Presence questionnaire, a modified version of the

Witmer and Singer 1998 Presence Questionnaire (PQ) provided in Appendix B.

Research Hypothesis

The *a priori* research hypothesis that spatial presence mediates the effects of task and media on learning outcomes was derived from a review of scholarly literature on presence theory and research studies that compared learning outcomes from different types of media. Because the structure of the learning task is also an important component in any learning presentation this study added learning task structure as a second predictor variable.

Research hypothesis: In a media learning presentation designed to teach art criticism the learner's experience of spatial presence mediates the effects of task type and media type on learning outcomes. H_{a_1}: $a_1b = 0$; H_{a2}: $a_2b = 0$, shown in Figure 3.

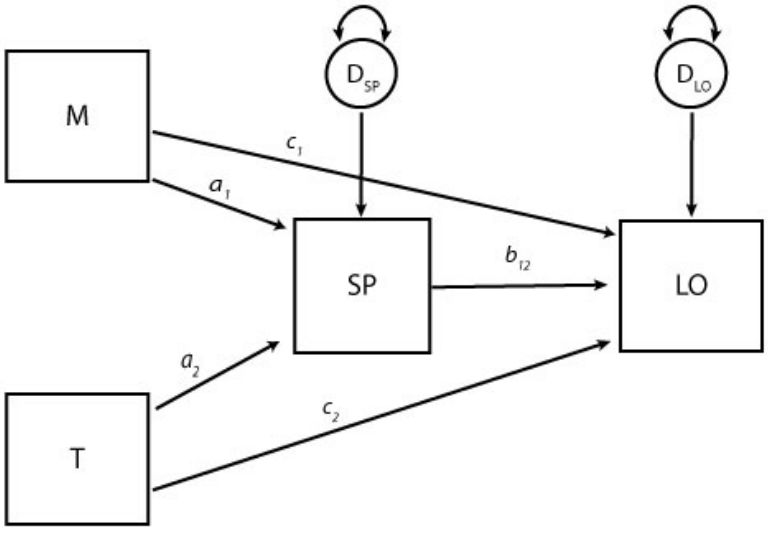

Figure 3. Hypothesis Path Model. In the proposed model Task type (T) and Media type (M) have direct effects on Spatial Presence (SP) and Learning Outcomes (LO), and indirect effects on Learning Outcomes (LO), mediated by Spatial Presence (SP).

Population, Sample and Participants

The study began in April of 2012 with student volunteers from the Interdisciplinary Teaching and Learning department in the College of Education at the University of Texas, San Antonio (UTSA). Additional participants were recruited from several other colleges and universities including Texas A & M University at College Station (TAMU); Texas A & M University at Corpus Christi (TAMUCC); and the Art Institute of Pittsburgh, Online Division (AIPOD). There were a few responses from students of members of professional organizations, Association for Educational Communications and Technology (AECT), and International Visual Literacy Association (IVLA).

Of the ninety-two participants who agreed to the online consent form, three did not respond to any of the survey questions beyond the consent form. Because participation was voluntary and anonymous the three participants who chose to drop out of the study did not communicate their reasons and no attempts were made to contact them to ask for their reasons. A total of eighty-nine responses from anonymous volunteers were collected. After duplicates (n = 5) and incomplete responses (n = 4) were removed eighty responses were used for the analysis.

Unit of Analysis

The unit of analysis is the individual learner. The participants were recruited from different universities and different classes and represent a diverse group of undergraduate and graduate learners.

Research Variables

Spatial Presence

The latent variable measured in this research is called Spatial Presence (ISPR, 2007) to differentiate it from social presence, the experience of interaction with real or artificial beings in a virtual environment. A latent variable is an unobservable construct that is measured by statistically related observed variables (Borsboom, Mellenbergh, & van Heerden, 2003). Spatial Presence was evinced by measures of the participants' subjective self-reports of their focus of attention on the media presentation. Its indicators included responses that suggested involvement and immersion in the media presentation. The research Spatial Presence questionnaire included item stems from the 1998 Witmer and Singer Presence Questionnaire (PQ), with wording of some questions modified to fit the conditions. The correlations of the item stems with all questions was $0.037 < r_{it} > 0.707$, reliability was reported as 0.84 (Cronbach's alpha). Five of the twenty questions did not significantly correlate with the overall scores.

Critical Thinking

The dependent variable Critical Thinking is the participants' scores on a formal art critique essay which they were instructed to write while they viewed the presented artwork. Critical thinking means "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, or contextual considerations upon which that judgment is based" (Facione, 1990, p.3). In the context of an art critique it refers to accurate descriptions, thoughtful and fair-minded analysis and evaluation based on

features described.

Works of art are open to multiple interpretations and types of analysis. Analyzing a work of art requires critical and complex modes of thought such as noticing subtle relationships, conceiving imaginative and abstract ideas, and interpreting metaphorical meanings (Eisner, 2004, p.85). It involves thought processes that can accept ambiguity and attempt to form connections between divergent interactive concepts (Arnheim, 1969, p.266). Barrett describes art criticism as "organized perception" (1999, p. 25).

A formal art critique is one that describes, analyzes and evaluates the relationships of the forms that comprise the work of art (Anderson, 1993; Feldman, 1992; Rose, 2007). It is used extensively in undergraduate art studio and art appreciation classes as a method of teaching students to observe and analyze basic elements of visual design. Because the participants in this study were novices and not required to research the presented artwork, contextual or historical analysis of the artwork was not relevant to this research. The essays were scored on demonstration of careful observation and analysis rather than mastery of specific art terms and concepts.

Media

The online tutorial used for this research is a single user asynchronous, presentation. The two media types were Static, a linked jpeg image of the digitally originated artwork *Hummingbird Sanctuary,* by Nan Pendarvis (2009), shown in Figure 4 and Dynamic Manipulation, an interactive Adobe Flash .swf version of the same artwork, shown in Figure 5.

Figure 4. Static Media Image. *Hummingbird Sanctuary (2009),* by Nan Pendarvis. Digitally-originated image. Used with permission.

Figure 5. Dynamic Manipulation Media Image. The interactive Adobe Flash version of the artwork placed the image in a larger 3D environment with an animation of a slowly moving sky as a background. It had pan, tilt and zoom capabilities that allowed the user to view the image from a many different points of view.

Three dimensional models of flowers and hummingbirds were purchased from the *Songbird Remix Hummingbirds of the Americas Collection* (Gilliland, 2011a; Gilliland, 2011b) and added to the Dynamic Manipulation version to enhance the sense

of a three dimensional space. The panning sky and lower background were created by the research protocol director using Bryce 3D Pro 7.0 (DAZ 3D, 2011) and Adobe Flash Professional CS5. The original artwork by Pendarvis was cropped and placed on a 3D box using Bryce 3D Pro 7.0 (DAZ 3D) then rotated and placed in the scene. All elements were edited using Adobe Photoshop CS5, then assembled in Aleo Flash Pan Zoom Viewer (Aleo Software, 2013) and finally output as an Adobe Flash player 9.0 .swf file and placed online. The finished Dynamic Manipulation media version can be viewed at http://pixelpaint.com/pilottest3/flash3.html

The Adobe Flash media type was chosen for the Dynamic Manipulation version because the Flash player plug-in is already installed on most personal computers making it easy to access and use without any specialized computer knowledge or equipment. The Dynamic Manipulation media presentation used in the research fits the definition of immersive media as described by Lessiter, Freeman, Keogh, and Davidoff (2001), Lombard and Ditton (1997), Waterworth and Waterworth (2001), and Witmer and Singer (1998) because it includes rich three dimensional imagery, animation and interactive elements which allow the user to control the view. The interactive presentation also maintained the character of the original artwork as a two dimensional image so that each group critiqued an equivalent image.

Task

The assigned task was to critique a work of art, a task that requires observation, analysis and a creative yet relevant evaluation and interpretation of the artwork. The Guided Task contained support in the form of several specific question prompts; the

Unguided Task had only one general question prompt.

The questions used in the Guided Task directed students to report specific aspects of the artwork that would be important in an analysis of the image. For example, "Describe the type of shapes or lines that create the forms" and "What shapes or forms are repeated or are similar; what shapes or forms contrast with each other?" These questions fit Moreno and Mayer's description of the *elaborative interrogation* method. Elaborative interrogation is believed to increase *generative* cognitive processing, the mental effort required to acquire knowledge, by facilitating the organization and assimilation of instructional materials with existing knowledge. This results in germane cognitive load and deeper learning (2010).

The Unguided Task consisted of just one open ended question: "Describe your reaction to the painting, what you see in the painting, the shapes, forms, and images and their relationships to one another". Both conditions used the same final critique question prompt. The complete list of questions can be seen in Appendix F.

Research Instruments

Spatial Presence was measured by responses to a modified version of the Witmer and Singer (1998) Presence Questionnaire (PQ) placed at the end of the online presentation. The Witmer and Singer PQ, provided in Appendix B, is generally accepted by the research community as an instrument that can measure the latent variable of presence through users' subjective self- reports (Insko, 2003; ISPR, 2005). It is a Likert questionnaire which uses a seven point semantic scale with opposing descriptors at either end. Likert scales are technically ordinal scales but in practice they can usually be treated

as continuous variables with relatively little detriment to the results (Newsom, 2013). Five or more categories are recommended for analyzing a Likert scale as a continuous measure and a seven point scale reaches the upper limits of the scale's reliability (Allen & Seaman, 2007).

A few items were modified to be relevant to all conditions. The practice of modifying the PQ is encouraged by the authors and several different versions have been developed by researchers in various fields (ISPR, 2005). The resulting Spatial Presence questionnaire used in this research consisted of twenty items: fifteen items measured the positive effects of spatial presence and five items measured negative effects of spatial presence. Thirteen of the questions deal with having a feeling of control over the media interactions. The other seven questions address the subjective feeling of being focused on the media presentation to the extent that the user is able to ignore external distractions. During data analysis scores on the negative questions were inverted and responses to all twenty items were averaged for each participant's Spatial Presence score.

The art critique essays were scored by two subject matter experts using The Holistic Critical Thinking Scoring Rubric (HCTSR) (Facione & Facione, 1994) seen in Appendix A. This rubric was selected after reviewing several rubrics used by college and high school art instructors to score art critiques. The key assessments of an art critique are description, analysis and evaluation of the presented artwork. These strategies are measured in the HCTSR.

The HCTSR rubric is a four level forced choice scale. Half point scoring is not

possible. Scores of 3 and 4 represent demonstration of critical thinking and scores of 1 or 2 represent hasty, inaccurate or biased thinking. Critical thinking is evidenced by thorough and accurate descriptions, thoughtful and fair-minded analysis and relevant, warranted value judgments based on observations. Lack of critical thinking is evidenced by irrelevant, unwarranted or fallacious conclusions.

Ordinal scales with only three or four categories represent a gray area in statistical analysis. They are often classified as discrete and analyzed using the binomial class of statistical tests (Newsom, 2013). A decision was made to treat the Critical Thinking scores as continuous for the initial analysis.

Pilot Study

A pilot study was conducted with two adult volunteers; the design of the online presentation was revised based on their input.

Data Collection Procedures

All data was collected through an online survey that was developed in Qualtrics Research Suite (Qualtrics Research Inc., 2013). It can be seen at the following URL

https://tamucehd.qualtrics.com//SE/?SID=SV_0kVCBViUuvzV1g8

a copy of the presentation can be downloaded from this URL

http://www.pixelpaint.com/pilottest3/definitions3.pdf

The online research site randomly assigned each participant to one of four conditions. All participants viewed a presentation on the Feldman (1992) method of formal image analysis seen in Appendix G. The presentation included a link to a video example of an art critique and a glossary of basic art terminology that participants could

download to their computers. The video example of an art critique can be viewed at the following URL:

http://www.screencast.com/users/NancyJWood/folders/hidden/media/4bc9209e-47ce-490b-aa15-9edde8236562

After the presentation participants viewed one of two versions of the digital artwork shown in Figures 4 and Figure 5. They were asked to respond to questions, about the artwork. Participants who had been randomly assigned to the Guided Task version received several specific question prompts to support reflective thinking. Participants who were randomly assigned to the Unguided Task received only one question prompt. Following the questions section participants were directed to continue to examine the artwork as they wrote their final short essay critiques. They entered their responses into text boxes on the survey interface shown in Appendix H.

After completing the essay portion of the research participants were presented with the twenty question Spatial Presence questionnaire. Examples of the item stems can be seen in Appendix I. The last page of the survey presented a link to a pdf version of their responses that they could download to their computers and a link to a separate website where they could receive a $5 Starbucks coupon.

Statistical Analysis

Data collected included essay responses to short answer questions, the art critique essays and participants' responses to the Spatial Presence questionnaire. Data was collected in Qualtrics Research Suite online (Qualtrics Research Inc., 2013) and later analyzed using IBM SPSS 21.0.

Each participant's scores on the twenty items of the research Spatial Presence questionnaire were averaged. The art critique essays were scored by two subject matter experts using the HCTSR (Facione & Facione, 1994). The research protocol director is also a SME; discrepancies of more than one level were reviewed by the raters and the protocol director together and the protocol director cast the final vote for the average score. Responses to the short answer questions were not evaluated.

Descriptive statistics were computed for each combination of the factors. An ANCOVA (analysis of covariance) was used to determine if spatial presence meets the criteria for a mediator variable as described by Preacher and Hayes (2004). Scores on the Spatial Presence questionnaire were analyzed for correlations with scores on Critical Thinking using Pearson's correlation.

Setting and Environment

The majority of the participants were given a link to the online research tutorial by their classroom instructor. A few participants found the link on a website for the professional group AECT. All participants could complete the tutorial at their convenience on their choice of computers.

Some classroom instructors allowed time during the class period for students to complete the research. Others referred the students to the research link via email or by posting it on a class site. At the request of one UTSA instructor, the research protocol director visited classes to introduce the research in person. The classroom presentation followed the script of the online presentation which was projected simultaneously on a screen at the front of the classroom.

Most participants spent less than one hour in the research tutorial. All who participated after June 4, 2013, were offered a $5 Starbucks gift certificate as an incentive for completing the research. Participants from AIPOD, a private college, were not offered the incentive as it would have violated school's policies on incentives to students. Eleven students from UTSA had participated before the incentive was approved by the IRB. Attempts were made to contact them to offer them the incentive too.

Some classroom instructors offered extra credit points to students who completed the research study. The online survey included a link that allowed participants to download their responses as a pdf file so they could turn them in to their classroom instructor and still remain anonymous in the study data. Faculty who offered extra credit to their students for completing the research were encouraged to offer alternative extra credit options.

Bias and Error

Independent raters were used to control for bias in the scoring of the art critiques. The subject matter expert raters attended a one hour phone conference training session with the research protocol director to discuss the Holistic Critical Thinking Scoring Rubric in terms of art critiques. The SME's agreed to confer with each other and with the protocol director if there was a difference of opinion on some scores. The protocol director who is also an SME reviewed the scores for relevancy. The SME's scores were similar for most of the essays. One SME tended to grade harder than the other assigning a rating of 3 on responses that the other would rate as 4. This was within expectations. Out of the 80 essays only two were found to have conflicting scores of more than one

level. In those cases the protocol director cast a third score to achieve the final rating.

Validity

The research Spatial Presence questionnaire is adapted from the Witmer and Singer 1998 Presence Questionnaire (PQ), which was based on literature reviews of the presence construct. The PQ measures three main factors of media that are considered to be the spatial dimension of media presence: user involvement and control (immersion), interface quality and naturalism (ISPR, 2005). Social presence and personal presence are not measured (Witmer & Singer, 1998).

The Holistic Critical Thinking Scoring Rubric was developed using findings from *The Complete American Philosophical Association Delphi Research Report* (Facione, 1990). The Delphi report included a consensus of opinions from 46 academics on the skills and sub-skills that represent critical thinking (Facione, 1990).

Reliability

Developed in 1998, the Witmer and Singer Presence Questionnaire has an internal consistency measure of reliability of .88 (Cronbach's *N* 5 152). The sensitivity of the PQ to distinguish multiple levels of spatial presence was tested by Nuñez and Blake in 2003. In comparisons between text based and graphics based environments the PQ was found to be able to distinguish between high and low reports of spatial presence.

The measure of reliability for my research Spatial Presence questionnaire is reported as .84 (Cronbach's alpha). The correlations of the item stems with all questions was $.037 < r_{it} > .707$. Five of the twenty questions did not significantly correlate with the overall scores. Removing these five questions would raise the reliability to .89.

However, omitting these questions from the ANCOVA analysis would not have changed the significance of the variables.

Data is not available on reliability of the Holistic Critical Thinking Scoring Rubric.

Summary

This chapter has described the research variables, instruments and methods used to gather and analyze the data. Throughout the process efforts were made to maintain consistency and objectivity. In order to minimize researcher bias, participants remained anonymous and independent raters scored the Critical Thinking essays. The conditions were designed to be alike except for the variables of interest. The next chapters will discuss results of the statistical analysis of the data.

CHAPTER IV

RESULTS

Tests of the Research Hypothesis

An analysis of covariance was used to test whether Spatial Presence mediates the effects of Task and Media on Critical Thinking. The following assumptions were checked: (a) independence of observations (b) normal distribution of the dependent variable (c) homogeneity of variances using Levene's test and (d) homogeneity of regression slopes. All assumptions were met.

Research Question One

What are the relationships between Task, Media, Spatial Presence and Critical Thinking? Spatial Presence was predicted to would mediate the effects of Task, and Media on Critical Thinking. In the hypothesis model Task and Media have direct effects on Spatial Presence and Critical Thinking and indirect effects on Critical Thinking mediated by Spatial Presence.

Two ANCOVA models were tested to determine if the covariance variable Spatial Presence mediates the effects of the two fixed independent variables Media and Task on the dependent variable Critical Thinking. The first model included IV's, the IV interaction term and the DV Critical Thinking, shown in Table 1.

Table 1 *Tests of Between-Subjects Effects for Task, Media and Task * Media, on Critical Thinking*

Dependent Variable: Critical Thinking

Source	Type I Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	5.431[a]	4	1.358	2.232	.074	.109	8.928	.627
Intercept	626.167	1	626.167	1029.444	.000	.934	1029.444	1.000
Media	1.648	1	1.648	2.709	.104	.036	2.709	.369
Task	1.102	1	1.102	1.811	.183	.024	1.811	.264
Media * Task	.002	1	.002	.003	.957	.000	.003	.050
Presence	2.679	1	2.679	4.405	.039	.057	4.405	.544
Error	44.403	73	.608					
Total	676.000	78						
Corrected Total	49.833	77						

a. R Squared = .109 (Adjusted R Squared = .060)

b. Computed using alpha = .05

The model indicated no significant effect from Media, Task or the Media * Task interaction on Critical Thinking scores at the .05 level. The Baron and Kenny (1986) and Preacher and Hayes (2004) approaches to establishing mediation require a significant relationship of the independent variables to the dependent variable. Spatial Presence cannot be a mediator variable for Task and Media because Task, and Media are not significantly associated with the dependent variable.

The second model shown in Table 2 included both IV's and the DV without the interaction term.

Table 2 *Tests of Between-Subjects Effects for Task and Media on Critical Thinking*

Dependent Variable: Critical Thinking

Source	Type I Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	5.430[a]	3	1.810	3.017	.035	.109	9.050	.688
Intercept	626.167	1	626.167	1043.542	.000	.934	1043.542	1.000
Media	1.648	1	1.648	2.746	.102	.036	2.746	.373
Task	1.102	1	1.102	1.836	.180	.024	1.836	.267
Presence	2.681	1	2.681	4.468	.038	.057	4.468	.550
Error	44.403	74	.600					
Total	676.000	78						
Corrected Total	49.833	77						

a. R Squared = .109 (Adjusted R Squared = .073)

b. Computed using alpha = .05

The second model also indicated no significant effect of Media or Task on Critical Thinking scores at the .05 level. Spatial Presence does not meet the criteria as a mediator variable because it does not play a role in governing the relationships between Task, Media and Critical Thinking. The research hypothesis that SP mediates the effects of T and M is not supported, because Task and Media do not significantly affect Critical Thinking.

In both models Spatial Presence had a significant effect on Critical Thinking scores: *p* .038 and p .039 respectively. The effect size is moderate, ≈ .27 partial correlation with moderate power of .55 in the model without the interaction term and .54 in the model with the interaction term. According to Cohen (1988) this is a medium

effect size. An effect size of .80 would be desirable to avoid a Type 2 error. The 95% confidence intervals for the difference between the means for the two models are [0.013, 0.508] and [0 .015, 0.507] respectively. See Appendix J for parameter estimates and marginal means for these two models.

Research Question Two

What are the relationships of Task and Media to learners' scores on Spatial Presence? I had predicted that certain combinations of Task and Media would result in higher or lower scores on Spatial Presence. Tests of between subjects effects using the Spatial Presence score as the dependent variable indicated that there were no significant differences between the effects of Media, Task nor an interaction of Media and Task on participants' subjective self-reports of their experience of Spatial Presence. Partial eta-squared for Media, Task and Media*Task on Spatial Presence was .01, .04, and .01 respectively. Table 3 presents the tests of between- subjects effects for the two fixed variables on Spatial Presence.

Table 3 *Tests of Between-Subjects Effects for Task, Media and Task * Media on Spatial Presence*

Dependent Variable: Spatial Presence

Source	Type I Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	.236[a]	3	.079	.148	.931	.006	.444	.076
Intercept	1960.514	1	1960.514	3683.241	.000	.980	3683.241	1.000
Media	.042	1	.042	.078	.780	.001	.078	.059
Task	.148	1	.148	.278	.599	.004	.278	.082
Media * Task	.046	1	.046	.087	.769	.001	.087	.060
Error	39.389	74	.532					
Total	2000.139	78						
Corrected Total	39.625	77						

a. R Squared = .006 (Adjusted R Squared = -.034)

b. Computed using alpha = .05

Confidence intervals for the effects of Task and Media on Spatial Presence ranged from -0.61 to 0.33 and from -0.57 to 0.76 respectively. These potential differences appear to be too small to influence the Spatial Presence mean scores. See Appendix K for parameter estimates and marginal means for the effects of Task, Media and Task * Media on Spatial Presence.

Additional Analyses

I analyzed the interactions of Task and Spatial Presence on Critical Thinking, and of Media and Spatial Presence on Critical Thinking. Neither interaction generated a significant effect. Using Pearson's correlation, scores on the Spatial Presence questionnaire correlate significantly with scores on Critical Thinking r (78) = .44.

Seventy percent of the responses that achieved an average score of 4.0/4.0 on CT scored above 5.5/7.0 on SP. Eighty percent of responses that received an average score of 1.5/4.0 on CT scored below 5.0/7.0 on SP. See Appendix L for details.

The Unguided Task Static condition was the only group with a mean average above 3.0 (M = 3.13) 95% CI [2.737, 3.515] on the Critical Thinking score. The Dynamic Manipulation Guided Task group had the lowest mean (M = 2.56). The confidence interval of 2.216 and 2.912, shown in Table 4, indicates that on the high end the scores on the Dynamic Manipulation Guided Task condition remain below 3.0.

Table 4 *Comparison of Means of Media* Task Interaction on CT*

Dependent Variable: Critical Thinking

Media	Task	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Static	Unguided	3.125[a]	.195	2.737	3.514
	Guided	2.865[a]	.159	2.548	3.182
Dynamic	Unguided	2.831[a]	.184	2.464	3.198
	Guided	2.564[a]	.174	2.216	2.912

a. Covariates appearing in the model are evaluated at the following values: Spatial Presence = 5.0135.

The dependent variable Critical Thinking is a measure of critical thinking in relation to the assigned task. The Facione and Facione (1994) Holistic Critical Thinking Rubric was used to score the essays is a four level ordered scale. A score of 3 or 4

indicates demonstration of critical thinking. Scores of 1 or 2 indicate little or no evidence of critical thinking. The difference between a score of 2 and 3 may be greater than the difference between scores of 1 and 2, or 3 and 4. Stem and Leaf plots (Appendix M) were examined for the number of scores 3 or higher on CT for each of the fixed variables.

As shown in Figure 6, of the 34 participants assigned to the Static groups, 27 had scores of 3 or higher on Critical Thinking. Of the 44 participants assigned to the Dynamic Manipulation groups, only 18 had scores of 3 or higher on Critical Thinking.

Using Treatment as the independent variable, Static Unguided had the highest percentage of scores above 3 for Critical Thinking. Seventy-five percent of Static condition participants scored 3 or 4 on Critical Thinking compared with 63 % for Static Guided, 56% for Dynamic Unguided and 40% for Dynamic Guided. Means of CT scores by condition are shown in Figure 7.

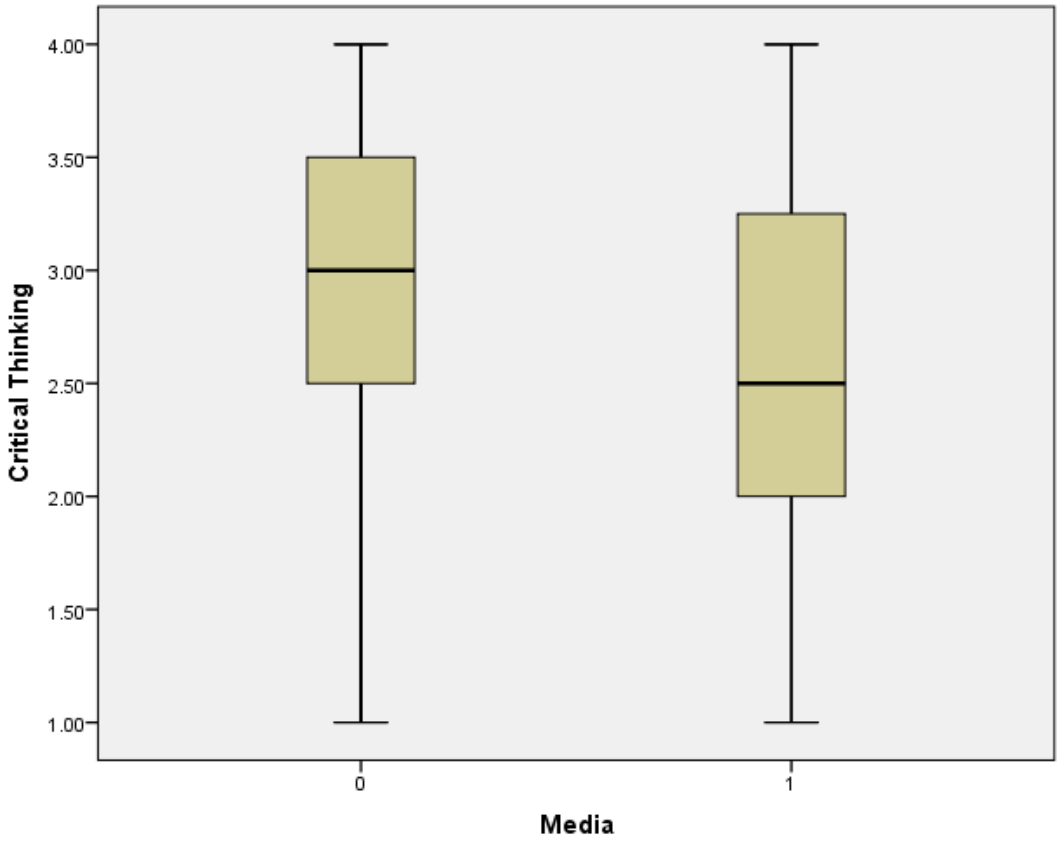

Figure 6. **Plot Showing Critical Thinking Scores for Media.** Seventy-nine percent of Static (0) participants scored 3 or 4 on Critical Thinking compared with 44% of Dynamic Manipulation (1) participants who scored 3 or 4 on Critical Thinking.

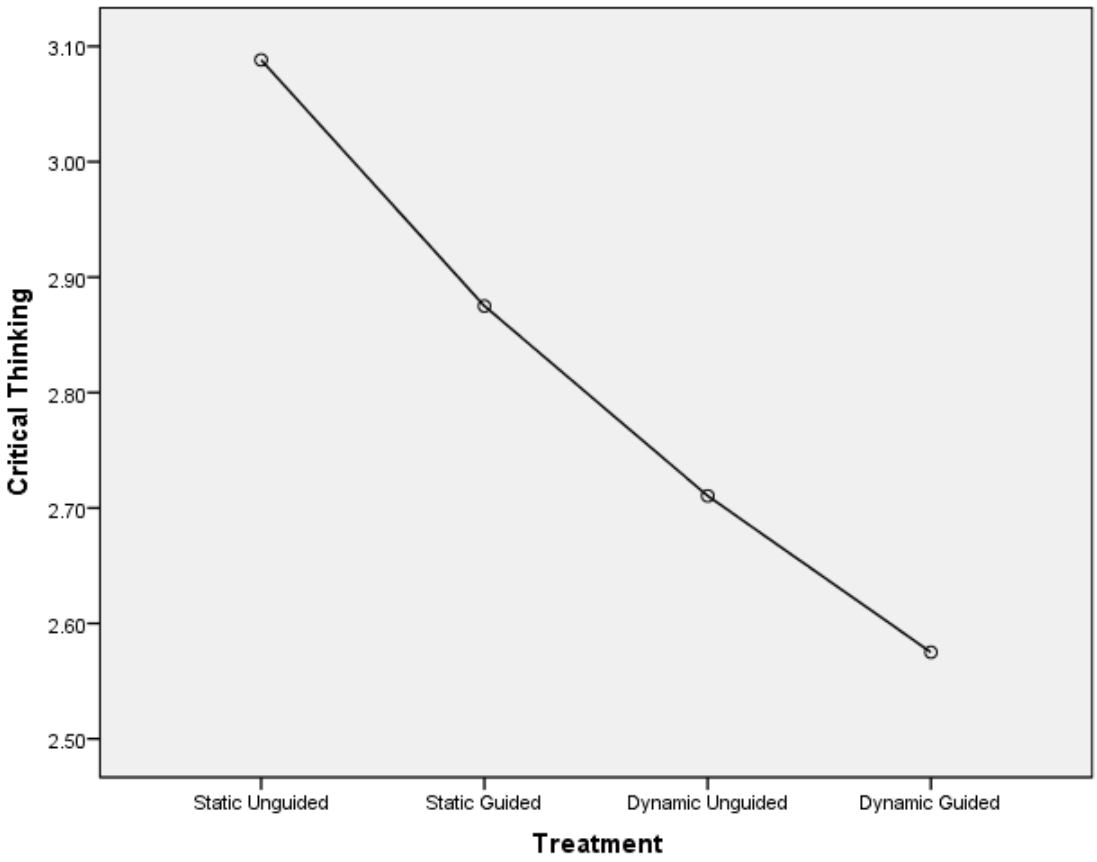

Figure 7. Estimated Marginal Means of Critical Thinking by Treatment. The CT Means for the treatment groups shows lower scores for the Dynamic Manipulation groups.

Pearson correlations showed Treatment was significantly correlated with Critical Thinking, r (80) = 0.46, but Treatment was not correlated with Spatial Presence. Eighty-nine percent of the total Spatial Presence scores were 4, 5 or 6 on the seven point scale, indicating that all participants experienced a similar sense of spatial presence.

I examined the possibility that differences in the populations might account for the different scores on Critical Thinking. Four different populations completed the tutorial: undergraduate education students at UTSA, undergraduate art students at AIPOD, undergraduate and graduate education students at TAMU and graduate students at other institutions. The AIPOD students scored highest as might be expected since they had some experience writing art critiques. There were no significant differences found between the other populations.

Results from this study show that SP does not mediate the effects of M and T on CT. But media characteristics may add to Task. Based on these results I am revising my path diagram, shown in Figure 8.

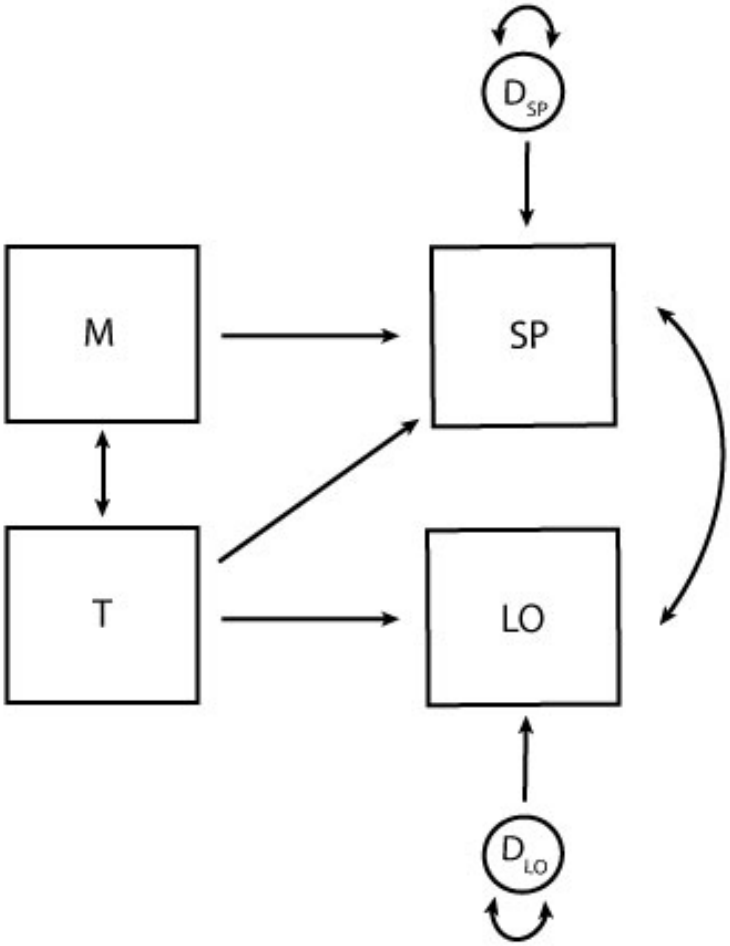

Figure 8. Revised Path Diagram Based on Results from Data Analysis. An unanalyzed relationship exists between Task (T) and Media (M). The relationships of Task (T) to Spatial Presence (SP) and Learning Outcomes (LO) are causal. The relationship of Media (M) to Spatial Presence (SP) is causal. Spatial Presence (SP) is correlated with Learning Outcomes (LO).

Posterior hypothesis: H_1: $r_{splo} = p_{lot} + p_{spt} + p_{spm.}$ Task is causal to SP because SP is the learner's self-monitoring of their intent and success in achieving task goals. Media is causal to SP, because the participant reacts to the characteristics of media by forming goals and intentions that correlate with learning outcomes. Media could be expanded to mean "presentation format", and could include any type of learning presentation, from classroom lecture to immersive virtual environments and even nuances of individual instructors. Additional conclusions about the relationships of Media, Task, and Spatial Presence to Critical Thinking will be discussed in Chapter 5.

CHAPTER V

SUMMARY AND CONCLUSIONS

Introduction

The proliferation of media during the last decade has resulted in an increased interest in media learning environments. Results from research that studies the effects of media on learning, however, are mixed (Moos & Marroquin, 2010). Spatial presence is a theoretical construct that represents a media user's focus of attention on the media presentation. Spatial presence encompasses factors such as intentional disregard of distractions, increased participation and perceived control of the assigned activity. These factors can also enhance learning and performance.

It has been suggested that increasing a learner's experience of spatial presence can increase learning (Witmer & Singer, 1998). An understanding of the relationships between spatial presence and learning in the context of specific task structure and media type may inform design of instructional media. The research project described in this paper analyzed the relationships of static and dynamic manipulative media, and guided and unguided task structure on the participants' sense of spatial presence and on scores of a learning task that required critical thinking.

Summary of Results

The research began with a hypothesis that spatial presence mediates the effects of task type and media type on learning outcomes on a task that requires critical thinking. Neither of the two independent exogenous variables Task nor Media was significantly

related to scores on Spatial Presence or Critical Thinking. The null hypothesis that Spatial Presence does not mediate the effects of Media or Task on Critical Thinking is supported. The overall SP average score was 5.0 on the seven point Likert scale and 89% of the SP scores were 4, 5, or 6, indicating that most participants were experiencing a similar sense of spatial presence.

Spatial Presence scores correlated significantly with scores on Critical Thinking $r(78) = 0.44$. Seventy-nine percent of the Static group scored 3 or 4 on Critical Thinking compared with just 44% of the Dynamic Manipulation participants who scored 3 or 4 on CT. At the treatment level 75% of the CT scores for the Static Unguided Task group were above 3, only 40% of the Dynamic Manipulation Guided Task group scored above 3 on CT.

The populations who completed the research included undergraduate and graduate students at different institutions. Five of the six undergraduate art students who completed the research received scores of 3 or 4 on Critical Thinking. There were no significant differences found in the CT mean scores between other three populations who participated in the research.

Discussion of Results

This study acknowledges that the findings are not definitive due to the subjective nature of the variables and measures. Both instruments are ordinal and the critical thinking measure has only four levels. A larger number of participants was needed for more conclusive statistical effects. The results of the research will be examined for similarities to other research studies of educational media and with regard for learning

theories that are typically associated with media.

Spatial Presence

Like many of the research studies that were reviewed this study found that Spatial Presence scores were related to learning outcomes but did not always align with the more immersive media. There were no significant effects from Task or Media on Spatial Presence. According to classical presence theory (Lessiter, Freeman, Keogh, & Davidoff, 2001; Schubert, Friedmann, & Regenbrecht, 2001; Witmer & Singer, 1998) the interactive Dynamic Manipulation version should have received higher scores on Spatial Presence than the Static media version.

The lack of significant differences on SP scores could be due to the similarity of the conditions. All four conditions included the same online tutorial presentation. Participants may have been thinking of the tutorial presentation as well as the media type when they responded to the Spatial Presence questionnaire. The differences in media types were moderate. The Dynamic Manipulation condition allowed zooming, panning, and tilt but it was essentially a 2D image rendered on the X and Y axes, without illusions of rotation or movement on orthogonal axes.

Other educational research studies that compared users' reports of spatial presence using media with varying levels of immersive characteristics also found little difference in the spatial presence measures when participants in each condition were performing the same task (Mania & Chalmers, 2001; Schrader & Bastiaens, 2012; Youngblut & Huie, 2003). Mania and Chalmers (2001) found the real- world classroom condition group was the only group to report a significantly higher sense of SP when

compared to three different media conditions.

Critical Thinking

There was also no significant effect from Task or Media on Critical Thinking. Static had the highest percentage of scores above 3 on Critical Thinking. The HCTSR is a four point scale and while it is comparable to classroom scoring rubrics it may not be sensitive enough for experimental research (P. A. Facione, personal communication, July 1, 2013).

Twenty-seven of the averaged CT scores were not whole numbers. The HCTSR scale is ordinal and its authors caution against using half numbers as scores (Facione & Facione, 1994). An informal reconsideration of the scores by the research protocol director showed that if each score was converted into a whole number the relationships of the variables would be unchanged. Spatial Presence would continue to be significantly related to Critical Thinking; and Task and Media would have no significant effect on Spatial Presence or Critical Thinking.

Task

Differences in Task did not significantly affect the participants' reports of spatial presence. Participants may have been describing their reactions to the tutorial presentation in their responses to the Spatial Presence questionnaire. Both tasks asked participants to answer questions about the artwork and type their answers in the online text fields. Tasks that involved diverse activities with the media may have resulted in more significant differences on spatial presence between the groups.

The scores on Critical Thinking may be indicative of the effects of Task. While

not statistically significant, in both media conditions the mean scores for the Guided Task conditions were lower than scores for the Unguided Task. More variation in the Task portion of the treatment might have resulted in statistical significance.

Participants from one university program (n=37) visited an art museum as part of their classroom activities before completing the research. The other university students (n=32) did not. There were no significant differences between those groups in mean scores on Critical Thinking.

The Guided Task questions fit Moreno and Mayer's description of the elaborative interrogation method designed to increase generative cognitive processing (2010). The Critical Thinking score means (seen in Figure 6, chapter 4) suggest that the reflection questions in the Guided Task did not positively influence scores on learning outcomes and may even have depressed critical thinking.

It is possible that after reviewing the tutorial participants were primed for learning and did not need the extra reflection questions in the Guided Task. Guidance that is not needed by the learner can increase cognitive load and be detrimental to learning (Sweller, 2010). The Unguided Task fits Sweller's description of flexible goal- free learning (2004, p.26) which may have been a better task structure for the art critique essay task.

The final art critique task required description, analysis, and evaluation of the presented artwork. The Guided Task condition consisted of six questions that asked participants to describe or list components of the artwork, and two questions that asked for an analysis of elements they observed. The Unguided Task was one analysis question.

The task in the Guided condition may have created a perspective instantiation of learning task type that did not align with the type of thinking required for the final essay task. The difference in task type of the Guided condition may have added to cognitive load when the participants completed the final critique essay.

Media

There was no statistically significant relationship of Media with Spatial Presence or with Critical Thinking. A close examination of the scores suggests that the Dynamic Manipulation presentation may have depressed scores on CT. I am hypothesizing that the interactive mechanisms of the Dynamic Manipulation condition added extra tasks which distracted from the learning task.

The interactive zooming and panning capabilities of the Dynamic Manipulation version gave the participants choices about which views to use. These choices and the interaction itself are all elements of the design that can add extraneous cognitive load and make it more difficult for learners to focus on a learning task that requires deep thinking (Sweller, 2010).

The lower scores on critical thinking for the DM version support Moreno and Mayer's findings that for reflection to be effective learners must reflect on correct models (2010). A formal art critique requires a holistic assessment of the image to judge how the various forms work together to create a unified whole. Given multiple choices of how to view the image, the novice participants may have had difficulty assessing the relationships of the forms.

The Relationship of Spatial Presence to Learning Outcomes

Spatial Presence was significantly related to measures of Critical Thinking in all statistical analyses. The correlation of Spatial Presence scores with Critical Thinking was positive indicating that a higher sense of presence accompanied better thinking. Seven of the ten participants who received scores of 4/4 on CT scored above 5.5/7.0 on SP.

Considering that research studies have found presence scores related to several different types of learning, Slater's (2004) suggestion that presence is the user's feeling of accomplishment at completing tasks becomes more tenable. Spatial presence has been found to be related to several different types of learning. Witmer and Singer's research (1998) reported a small but strong correlation between PQ scores and task completion, although the assigned task was simple navigation and did not require deep thinking. In several of the studies described in the literature review, spatial presence scores were related to learning task scores (Mania & Chalmers, 2001; Schrader & Bastiaens, 2012; Youngblut & Huie, 2003). Presence may be a sense of successfully supported action in a mediated environment (Zahoric & Jenison, 1998).

Riva (2009) suggests that presence is not dependent on media but is instead a type of mental processing: an unconscious, automatic monitoring of action and experience that provides feedback about the status of the intended activity and the means by which it can be successfully performed. When the learner's intentions and actions result in successful performance the learner feels a higher level of presence (Riva, 2009; Riva, Waterworth, Waterworth, & Mantovani, 2011). Students who are experiencing spatial presence may actually be participating in the media experience on a deeper level

and deliberately disregarding distractions in order to focus on the presentation. Individual characteristics of the learner such as domain knowledge and interest in the subject will influence the quality of their intentions and goals. Of course, the individual characteristics of the learner, such as domain knowledge and interest in the subject, will influence the quality of their intentions and goals.

Instead of thinking of spatial presence as a users' experience of a mediated environment perhaps we should be thinking of it as a type of deep thought process during which the user intentionally stays focused on the task at hand and disregards distractions. The simpler the task the more likely it is that the user can experience maximal presence by attending to immersive media (Riva, Waterworth, Waterworth, & Mantovani, 2011). In studies of immersive learning environments where the participants' task is simply to explore the environment, the rich media would easily facilitate spatial presence and successful completion of exploration tasks. When immersive media is used for more difficult learning tasks, inessential imagery and interaction can add superfluous cognitive load because all of the presentation elements must be considered simultaneously by the learner (Sweller, 2010). Detailed imagery gives the learner more visual information to absorb and interactivity adds manipulative tasks. Drama and competitiveness can also create extraneous cognitive load (Rieber & Noah, 2008; Schrader & Bastiaens, 2012).

This would explain why learners in the Dynamic Manipulation condition had fewer high scores on Critical Thinking. The interactive media version included an additional task and goal: the task of exploring and choosing from different views. The

positive Spatial Presence scores may have represented the participants' feelings of success at achieving goals that included using the media interface. The addition of the interactive interface goal may have depressed the primary learning goal of writing the critique.

Summary Statement

From this research study three ideas have emerged.

1. Spatial Presence does not mediate the effects of task and media on learning.
2. Spatial Presence has been found to be related to learning outcomes, in a variety of situations and types of learning.
3. Spatial Presence is not directly a product of characteristics of media. But rather, it is a product of mental processes attempting to resolve a task(s) or problem(s) using mediated tools.

Additional Considerations

Results from this study also suggest that media characteristics may impose peripheral tasks on the learner. These may be tasks that are necessary to view the presentation, such as input device manipulations. Or they may be subliminal tasks: for example extraneous graphic elements that attract the learner's attention. In either case the media element causes the learner to form a goal and intent to complete that task. The effects of the tasks embedded within the media may interact with learning tasks to enhance or detract from the immersive effects of the media. This would explain why in learning presentations SP is not consistently related to high immersion media.

Implications for Further Research

Witmer and Singer (1998) proposed that measures of spatial presence might be used to gauge the potential effectiveness of a media learning presentation. This research studied a learning task which required critical thinking. Other studies might measure spatial presence in relation to comprehension or memory.

Educational research studies that compare very different conditions generally provide more useful insights. A comparison of two very different learning conditions with learners of equivalent prior knowledge could reveal more clearly how the different presentation styles influence learning, especially if spatial presence is measured. Mania and Chalmers (2001) found equivalent learning outcomes in a classroom setting and a desktop display and higher spatial presence scores in the real classroom condition. Bulger, Mayer, Almeroth, and Sheridan (2008) found greater learner engagement in an interactive media assignment compared to a classroom lecture. Greater differences in style of presentation may yield more pertinent information.

Conversely, research that holds the media characteristics constant could enable comparisons of the effectiveness of different task structures. Measures of SP might help explain the effects of different task structures on learning if the media was held constant.

Our study suggests that a sense of presence is related to critical thinking. Riva (2009) suggests that presence may be a type of self- regulation. An exploration of the relationships of learners' experience of spatial presence to other successful habits of mind, such as metacognition and critical thinking, could clarify the type of mental processing that spatial presence promotes.

Implications and Recommendations for Practice

Media characteristics are important insofar as they enable effortless processing of information and actions towards accomplishing goals. But media characteristics may impose additional tasks on the learner and create extraneous cognitive load.

Participants in the Dynamic Manipulation group had to open the media in a separate window and explore different views to determine which view(s) would provide information relevant to their critique. They typed their critiques into text boxes in the original tutorial window. Reducing some of the manipulative tasks of opening windows and moving around in the image, or placing the image in the tutorial text box window might have reduced cognitive load and improved learning outcomes.

More complex tasks involve more intentional levels (in the learner) that need to be supported by the media presentation (Riva, Waterworth, Waterworth, & Mantovani, 2011). This support includes allowing times for reflection as well as active exploration. Interactivity might be useful for simple tasks like accessing information; multiple views and detailed images can be used when they are essential to learning.

Instructional design should study the type of thinking that is required for the learning task, and consider the cognitive load imposed by media elements. Sweller explains that for high intrinsic load tasks extraneous media components can be detrimental to learning (2010). For simpler tasks the media can have more elements that add cognitive load without overloading the user. An effective learning presentation will decompose the activity of the user into its different components and identify each type of task that the user performs. A systematic task analysis in the manner of Dick, Carey, and

Carey (2005) which counts the features of the media as tasks could be used to optimize design of effective media learning environments.

Qualitative methods of determining the learners' engagement with the media appear to emphasize emotional responses from the learners (Kontogeorgiou, Bellou, & Mikropoulos, 2008; Limniou, Roberts, & Papadopoulos, 2008; Rieber & Noah, 2008). The emotional aspect of spatial presence has not been shown to be strong enough to influence successful learning outcomes (Moos & Marroquin, 2010; Schrader & Bastiaens, 2012; Rieber & Noah, 2008). This is especially true of educational games that include drama and a competitive element. (Gee, 2003; Rieber & Noah, 2008). Measures of spatial presence that use Likert scales or physiological measures may be preferable over interviews and think aloud methods.

Relationships of Results to Theory

This study suggests a need to move away from the classical description of spatial presence as an effect of specific types of media to a broader view of presence as a phenomenon of an individual's internal focus and monitoring of intentions (Riva, Waterworth, Waterworth, & Mantovani, 2011). The experience of spatial presence in a mediated presentation arises from a "... combination of form and content, able to support the intentions of the user" (Riva et al., 2011, p.24). Views of Schubert, Friedmann, and Regenbrecht (2001) that presence involves the construction of a spatial-functional mental model from interaction with media (p.266) are not supported.

The array of scores on Critical Thinking, although not statistically significant, supports Sweller's cognitive load theory (1994, 2004, 2010) and suggests that the

Guided Task condition added cognitive load which lowered critical thinking. Moreno and Mayer's theory of using elaborative interrogation (2010, p.266) to encourage reflection and reduce cognitive load is not supported because the Unguided Task asked only one question and resulted in a higher percentage of scores above 3 on Critical Thinking. The Unguided Task exemplifies Sweller's concept of goal-free problems (2004, p.26) because it is less structured and allows for more flexible responses. Clark's assertion (1983) that it is the instructional method not the media type that influences differences in learning outcomes appears to be supported.

Summary and Conclusions

This research study was an attempt to add to the body of knowledge about the relationships of media, task and learner sense of spatial presence in media in the context of a learning task that requires critical thinking. Like other studies that measured spatial presence and learning outcomes it that found spatial presence was positively associated to learning outcomes but not to media type or task type.

This study also noted parallels between contemporary ideas about spatial presence (Riva, Waterworth, Waterworth, & Mantovani, 2011) and cognitive load theory (Sweller, 1994, 2004, 2010). Both spatial presence and cognitive load are influenced by learner responses to task requirements. The media type and task type can add extraneous cognitive load. Using these theories as guides instructional designers and faculty can optimize design of media learning presentations. Presence questionnaires appear to measure habits of mind that are related to successful learning. Additional consideration could be given to identifying and strengthening these successful habits of mind.

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APPENDIX A

RUBRIC USED TO SCORE CRITIQUES

The Holistic Critical Thinking Scoring Rubric - HCTSR

A Tool for Developing and Evaluating Critical Thinking

Peter A. & Noreen C. Facione

Strong 4 -- Consistently does all or almost all of the following:

Accurately interprets evidence, statements, graphics, questions, etc.
Identifies the most important arguments (reasons and claims) pro and con.
Thoughtfully analyzes and evaluates major alternative points of view.
Draws warranted, judicious, non-fallacious conclusions.
Justifies key results and procedures, explains assumptions and reasons.
Fair-mindedly follows where evidence and reasons lead.

Acceptable 3 -- Does most or many of the following:

Accurately interprets evidence, statements, graphics, questions, etc.
Identifies relevant arguments (reasons and claims) pro and con.
Offers analyses and evaluations of obvious alternative points of view.
Draws warranted, non-fallacious conclusions.
Justifies some results or procedures, explains reasons.
Fair-mindedly follows where evidence and reasons lead.

Unacceptable 2 -- Does most or many of the following:

Misinterprets evidence, statements, graphics, questions, etc.
Fails to identify strong, relevant counter-arguments.
Ignores or superficially evaluates obvious alternative points of view.
Draws unwarranted or fallacious conclusions.
Justifies few results or procedures, seldom explains reasons.
Regardless of the evidence or reasons, maintains or defends views
based on self-interest or preconceptions.

Weak 1-- Consistently does all or almost all of the following:

Offers biased interpretations of evidence, statements, graphics, questions,
information or the points of view of others.
Fails to identify or hastily dismisses strong, relevant counter-arguments.
Ignores or superficially evaluates obvious alternative points of view.
Argues using fallacious or irrelevant reasons, and unwarranted claims.
Does not justify results or procedures, nor explain reasons.
Regardless of the evidence or reasons, maintains or defends views
based on self-interest or preconceptions.
Exhibits close-mindedness or hostility to reason.

APPENDIX B

WITMER AND SINGER PRESENCE QUESTIONNAIRE

ITEM STEMS (VERSION 2.0)

Item Stems	Factors	Subscale	*ITCorr*
1. How much were you able to control events?	CF	INV/C	0.43*
2. How responsive was the environment to actions that you initiated (or performed)?	CF	INV/C	0.56*
3. How natural did your interactions with the environment seem?	CF	NATRL	0.61*
4. How completely were *all* of your senses engaged?	SF		0.39*
5. How much did the visual aspects of the environment involve you?	SF	INV/C	0.48*
6. How much did the auditory aspects of the environment involve you?	SF	AUD[a]	0.32*
7. How natural was the mechanism which controlled movement through the environment?	CF	NATRL	0.62*
8. How aware were you of events occurring in the real world around you?	DF		0.03
9. How aware were you of your display and control devices?	DF		−0.14
10. How compelling was your sense of objects moving through space?	SF	INV/C	0.51*
11. How inconsistent or disconnected was the information coming from your various senses?	RF		0.33*
12. How much did your experiences in the virtual environment seem consistent with your real-world experiences?	RF, CF	NATRL	0.62*
13. Were you able to anticipate what would happen next in response to the actions that you performed?	CF	INV/C	0.43*
14. How completely were you able to actively survey or search the environment using vision?	RF, CF, SF	INV/C	0.59*
15. How well could you identify sounds?	RF, SF	AUD[a]	0.34*
16. How well could you localize sounds?	RF, SF	AUD[a]	0.30*
17. How well could you actively survey or search the virtual environment using touch?	RF, SF	HAPTC[b]	0.15
18. How compelling was your sense of moving around inside the virtual environment?	SF	INV/C	0.62*
19. How closely were you able to examine objects?	SF	RESOL	0.55*
20. How well could you examine objects from multiple viewpoints?	SF	RESOL	0.49*
21. How well could you move or manipulate objects in the virtual environment?	CF	HAPTC[b]	0.11
22. To what degree did you feel confused or disoriented at the beginning of breaks or at the end of the experimental session?	RF		−0.06
23. How involved were you in the virtual environment experience?		INV/C	0.52*
24. How distracting was the control mechanism?	DF		0.37*
25. How much delay did you experience between your actions and expected outcomes?	CF	INV/C	0.41*
26. How quickly did you adjust to the virtual environment experience?	CF	INV/C	0.42*
27. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?	CF	INV/C	0.45*
28. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?	DF	IFQUAL	0.44*

Item Stems	Factors	Subscale	*ITCorr*
29. How much did the control devices interfere with the performance of assigned tasks or with other activities?	DF, CF	IFQUAL	0.44*
30. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?	DF	IFQUAL	0.51*
31. Did you learn new techniques that enabled you to improve your performance?	CF		0.33*
32. Were you involved in the experimental task to the extent that you lost track of time?		INV/C	0.41*

Table C1

Researchers	Date	Population Studied (*n*)	Subject Matter and Learning Goals	Presentation Media and Treatments/Conditions	Task Description	Task Guidance	Presence Measures	Learning Measures	Other Measures	Analysis Method	Learning Measures Results	Presence Measures Results	Other Outcomes or Results
McClean, Saini-Eidukat, Schwert, Slator, & White	2001.	North Dakota State University students (*334, 338*), volunteers in experimental groups, randomly assigned. Non-volunteers in Control groups.	***Cell Biology, Geology*** Comprehension and problem-solving.	***Cell Biology*** 1)*Virtual Cell* VLE immersive + classroom; 2)WWW + classroom; 3)Control group-Classroom only. ***Geology*** 1)*Geology Explorer* VLE immersive + classroom; 2)WWW + classroom; 3) Control group-Classroom only.	*Pre-treatment*: scenario based exercise, *Treatment:* Identification activities	Classroom lectures	NA	*Pre-treatment:* Scenario based exercise, problem –based questions specific to disciplines. *Post treatment:* ***Cell Biology*** One problem-solving scenario completed one month after experimental activity, assessed by 3 student graders. ***Geology*** Fourteen problem-solving scenarios completed one month after experimental activity, assessed by 3 student graders	ANOVA of class sections.	***Cell Biology*** ANOVA Treatment population sizes: Control=145; WWW=94; and VLE=93. ***Geology*** ANCOVA Treatment population sizes: Control=195; WWW= 95; and VLE=78	***Cell Biology*** Post-intervention mean score of the VLE group was significantly higher than the corresponding score for the WWW and Control groups at P=0.05 using LSD mean separation test. WWW group mean scores were significantly higher than those of the control group. ***Geology*** Post-intervention mean scores of VLE group significantly higher than the alternative and control groups at P=0.05 using LSD mean separation test. No difference between WWW and classroom groups.	NA	ANOVA of class sections showed no significant difference from different teachers.
Limniou, Roberts, & Papadopoulos	2008.	Eccles College,UK students, convenience sample (*15*).	***Chemistry*** Comprehension of Chemistry concepts.	Animation in two levels of immersion: 1) Projected desktop 2) Immersive CAVE™ with students wearing 3D glasses	Students watched animations of chemical reactions while participating in teacher led discussions of the key concepts.	*Pre-treatment:* Powerpoint lecture of subject matter. *Treatment:* Same students participated in both conditions. Teacher led both presentations.	Self-reports of feelings of immersion.	The same four multiple choice questions on comprehension were given after each presentation.	NA	ANOVA	p = 0.05. Q1. Desktop (M% = 35.71, SD% = 49.72) – CAVE (M% = 85.71, SD% = 36.31). Q2. Desktop (M% = 42.86, SD% = 51.36) – CAVE (M% = 92.86, SD% = 26.73). Q3. Desktop (M% = 28.57, SD% = 46.88) – CAVE (M% = 92.86, SD% = 26.73). Q4. Desktop (M% = 14.29, SD% = 36.31) – CAVE (M% = 57.14, SD% = 51.36)	Students described feelings of immersion in, and enthusiasm for CAVE™ presentation.	Students were more active in discussion during the CAVE™ presentation. Students stated they understood the concepts better after the CAVE™

Table C1 Continued

Researchers	Date	Population Studied (*n*)	Subject Matter and Learning Goals	Presentation Media and Treatments/Conditions	Task Description	Task Guidance	Presence Measures	Learning Measures	Other Measures	Analysis Method	Learning Measures Results	Presence Measures Results	Other Outcomes or Results
Kontogeorgiou, Bellou & Mikropoulos	2008	First year university students at Department of Primary Education, University of Ioannina, Greece. (*38*)	***Quantum Mechanics*** comprehension.	3D interactive visualization viewed by all participants both with and without stereoscopic glasses.	*Treatment*: Explored 3D visualization three times without 3D stereoscopic glasses and three times with 3D glasses, while answering semi- structured interview questions from researchers.	Semi- structured interview questions from researchers.	*Slater-Usoh-Steed Presence Questionnaire SUS.*	*Pre-treatment:* Answered questionnaire about quantum mechanics of hydrogen atom. *Post -treatment:* Answered subject questionnaires and sketched the hydrogen atom in different energy states. *Two months after treatment:* Answered another subject questionnaire and sketched the hydrogen atom in different energy states again.	NA	Scores on questionnaires and sketches were evaluated for correctness.	*Post-treatment:* 84% of participants demonstrated comprehension of subject and correct mental image based on responses to questionnaire and sketches. *Two months after treatment:* 78% demonstrated comprehension of subject and correct mental image based on responses to questionnaire and sketches.	*Post-treatment:* *32* expressed experiencing a stronger sense of presence with stereoscopic glasses, *5* expressed same sense of presence with or without stereoscopic glasses, *1* expressed limited sense of presence with or without glasses. *Two months after treatment:* *31* remembered the VLE as a place they had visited, *29* felt the stereoscopic glasses had created a stronger sense of presence.	NA
Antonietti & Cantoia	2000	Volunteers, students in Pedagogy and Psychology at Catholic University of Sacred Heart, Milano, Italy. (*40*), randomly assigned.	***Visual Art*** critique and analysis.	High quality 2D reproduction on paper. Interactive 3D simulation of the painting on a computer screen, allowed changing point of view on orthogonal axes.	Answer four questions about the painting while viewing the artwork.	3D group was given virtual tour of the painting.	NA	Four Questions: Q1) Give the painting a title. Q2) Interpret the painting's meaning. Q3) What questions do you have about the painting? Q4) What comments do you have about the painting?	Inter-judge correlations	Two independent judges classified responses according to multiple criteria. Responses cross-tabulated. Percentage distribution of responses compared according to experimental condition.	Q1.Types of titles by treatment: *X2 (3, N = 40) = 8.00, p < 0.05.* Q2.Meaning of painting by treatment: (2, N = 40) = 10.52, p < 0:01]. Q3. Questions about painting by treatment: No significant differences t_{38} = - *0.99.* Q4. Comments about the painting by treatment: No significant differences *[X2 (2, N = 40) = 0.75, n.s.],*	NA	Inter-judge correlations *(0.78 to 0.93.* Q1. 2D titles focused on character; 3D titles focused on spatial or abstract concepts. Q2. 2D group more cultural meanings. 3D group more explanatory meanings. Q3.2D group more cultural questions, 3D group more meta-questions. Q4. More abstract concepts and free associations in 3D group.

Table C1 Continued

Researchers	Date	Population Studied (*n*)	Subject Matter and Learning Goals	Presentation Media	Task Description	Task Guidance	Presence Measures	Learning Measures	Other Measures	Analysis Method	Learning Measures Results	Presence Measures Results	Other Outcomes or Results
Mania & Chalmers	2001	Volunteers from University of Bristol and Hewlett Packard Laboratories in Bristol, UK.. (*72*), randomly assigned, 18 to each group.	***Non-science topic*** unfamiliar to participants. Memory, recall.	15 minute seminar presented in four different levels of immersion: 1)Real world face to face lecture. 2)3D computer model of seminar viewed on desktop. 3)3D model of seminar viewed using head mounted display (HMD). 4) Audio-only Recording.	Listen and watch a 15 minute seminar presentation on an unfamiliar subject.	None	*Slater-Usoh-Steed Presence Questionnaire (SUS)*	Seminar info memory recall test, 16 questions.	5-point Likert scale test for confidence of memory questions. 6 spatial memory questions embedded in memory questionnaire. *Simulator Sickness Questionnaire (SSQ)* for HMD group.	*SUS*: ANOVA with post-hoc Scheffe. *Memory recall and confidence questionnaires:* ANOVA with post-hoc Scheffe.	*Memory recall:* $F(3,71)5$ 6.590, p , 0.05, Significantly higher for condition 1 compared with 3 and 4. No significant difference between 1 and 2. Significantly higher for 2 compared to 3. *Memory recall and confidence:* Higher rate of correct "guess" responses for condition 3 compared with 1 (p , 0.05) 2 (p , 0.05).	Presence significantly higher (p , 0.05) condition 1compared with 2.3, and 4. No significant differences between condition 2, 3, or 4. Mean scores for condition 4 slightly higher than mean scores for condition 2. Negative correlation between SSQ score and presence score *-0.4*	*Confidence of memory tests:* Significant main effect of condition upon the "remember," $F(3,71)5$ 4.059, p , 0.05, and "guess," $F(3.71)5$ 4.587, p , 0.01. Higher scores for "remember" for condition1 compared with 3 and 4. No significance in spatial memory scores due to low number of questions.
Youngblut & Huie	2003	Intern employees (*35)*, randomly assigned.	Basic mission procedures for weapons of mass destruction civil support teams.	*VERTS* prototype training program available as rear projection screen or desktop interface. Printed training manual. *Immersive condition: VERTS* projected in room-like environment with rear projection screen *Desktop condition: VERTS* viewed on a desktop computer. *Control group:* Printed manual only.	Two training scenarios, search a designated area to locate, identify, properly handle and report dangerous materials.	*All groups:* Printed training manual. *Experimental groups:* Coaching during first scenario. After action review following 2nd scenario.	*Witmer-Singer Presence Questionnaire (PQ)* and the *Slater-Usoh-Steed Presence Questionnaire (SUS).*	Performance scores on knowledge of mission procedures, including number, completeness, and correctness of activities, tested using a real-world "transfer" test in a suite of rooms.	Performance scores: ANOVA and Tukey-Kramer HSD. Presence scores, *PQ* and *SUS*: Pearson product-moment correlations with performance scores.	Significant difference from training effect, *F(2,35) = 7.56 (p < 0.002).* Differences between Control group and Experimental groups, higher scores for experimental groups. No differences between Immersive and Desktop conditions.	*SUS* scores correlated with task performance, *r = 0.42, p < 0.04,* No significant correlation between *PQ* and performance scores, *r = 0.39, p < 0.059.*	NA

Table C1 Continued

Researchers	Date	Population Studied (*n*)	Subject Matter and Learning Goals	Presentation Media	Task Description	Task Guidance	Presence Measures	Learning Measures	Other Measures	Analysis Method	Learning Measures Results	Presence Measures Results	Other Outcomes or Results
Schrader & Bastiaens	2012	Students from two different classes of eight graders of the same higher track secondary high school ‘‘Albrecht-Dürer Gymnasium’’ in Hagen, Germany (*84*) (40 boys and 44 girls). Randomly assigned. Mean age was 13.4 years (SD = .56).	***Physics*** Light refraction, magnetism and air resistance.	*High-immersive:* 3D educational computer game with audio, characters, and storyline. n=*42*. *20* male, *22* female. *Low-immersive:* Desktop hypertext-environment with static pictures and actively controllable animated simulations application with written and spoken instructions and explanations. *n=42*. *20* male, *22* female.	Perform three virtual physics experiments.	Spoken and written text explanations in both conditions.	5 point Likert questionnaire based on Witmer and Singers’ *Presence Questionnaire (PQ),* Reliability= *.81 (Cronbach’s alpha).*	Pre and posttests of physics knowledge. *Pre-test*: Four questions about physics concepts presented in tutorials *(Cronbach’s a = .73).* *Post –test:* Retention: five multiple choice-Questions, reliability *.65 (Cronbach’s alpha).* Comprehension: Four open-ended questions, reliability *(Cronbach’s a = .63).* Transfer: Three near transfer tasks using objects analogous to ones used in practice conditions *(Cronbach’s a = .62).* Three far transfer tasks required knowledge to be applied to unknown and more complex situations *(Cronbach’s a = .70).*	5 point Likert cognitive load questionnaire, *(Cronbach’s a = .76).* *High-immersive group:* Games knowledge test, 12 items on game storyline and knowledge about how to control the game system *(Cronbach’s a = .62).*	ANOVA and ANCOVA tests of mean levels of virtual presence, cognitive load as well as in the sum of the learning outcomes. Correlation analyses for relationship between virtual presence, cognitive load, and learning outcomes. Virtual presence was tested for mediator effects on learning outcomes. Separate linear regression analyses for mediator cognitive load as mediator on each learning outcome (retention, comprehension, transfer).	*Pre-test*: No significant difference of prior knowledge concerning the learning content (F(1,82) = 2.08, p = .07). *Post-tests:* Significant effects between conditions. Higher scores for Low-immersive condition. Retention (F(1,82) = 25.52, p < .05, n2 = .23). Comprehension (F(1,82) = 23.97, p < .05, n2 = .22). Transfer , near transfer: F(1,82) = 20.91, p < .05, n2 = .20; far transfer: F(1,82) = 16.17, p < .05, n2 = .16). Comprehension was partly mediated by cognitive load, but not by presence.	Presence correlated positively with Comprehension *r = .29***. Retention, *r = .39***. and Cognitive load *r =.23* **p <.05, two-tailed, ** p < .01,two-tailed..* High Immersive slightly higher for presence *M 3.65 (.87)* Low Immersive *M 3.24 (.66*) Cognitive Load, High Immersive *M 2.66 (.54)* Low Immersive *M 2.55 (.82)* Presence significant, positive relationship to cognitive load *r = .23.* Presence has no significant effect on near and far transfer.	Negative correlation between cognitive load and learning. Retention *r = -.10* Comprehension *r = -.29* Near Transfer *r = -.35* Far Transfer *r = -.15.* Marginally significant differences between both groups for cognitive load *(F(1,82) = 3.53, p < .06, n2 = .14).* High Immersive Cognitive load *M =2.66 (.54)* Low Immersive Cognitive load *2.55 (.82).* Cognitive load has no significant effect on retention and game knowledge

APPENDIX D

SYNOPSES OF ARTICLES

Research Studies that Found Positive Effects from Highly Immersive Media

McClean, Saini-Eidukat, Schwert, Slator, and White (2001) developed a three dimensional virtual learning environment (VLE) for teaching geology and cell biology. They compared groups of college students who used the VLE to others who performed a web based activity or only attended classes. Both experimental groups' activities were supplemental to the regular classroom instruction. Post treatment tests indicated that the VLE group out-performed the other groups in their abilities to solve authentic problems in the manner of professionals in those fields. There was little difference in performance between the web based group and the classroom- only group. The description of the VLE suggests that it was carefully structured to present learning content in a logical progression. There was no explanation of the type of activities done by the web group.

Limniou, Roberts, and Papadopoulos (2008) compared use of two-dimensional (2D) chemical animations designed for computer desktops with three-dimensional (3D) chemical animations displayed on screens in a fully immersive CAVE™, a room like enclosure where the environment was projected on the walls around the participants and viewed using 3D glasses. The researchers noted increased enthusiasm and participation by students in the 3D version and concluded that the virtual reality environments increased the students' motivation for learning as well as their comprehension of chemical reactions and molecular structure. However, the same students used both

versions of the learning presentation and in both treatments the teacher guided the students through the task of exploring key concepts shown in the animations. The researchers did not use a quantitative measure of the learners' experience of spatial presence, but the students' retrospective post-treatment descriptions of the experience could be considered the informal interview method of measuring spatial presence, as was used by Murray, Arnold, and Thornton (2000).

Kontogeorgiou, Bellou, and Mikropoulos (2008) developed a VLE to teach the principles of quantum mechanics and found that 84% of the students tested retained vivid and accurate memories of the experience two months later. To measure the participants' sense of presence the researchers asked participants two questions from the Slater-Usoh-Steed Sense of Presence Questionnaire (SUS) (Slater, Usoh, & Steed, 1994). The percentage of students who drew correct sketches of the quantum atom corresponded with the number of students who reported a high sense of spatial presence in their responses to the presence questionnaire. Kontogeorgiou et al. (2008) believed that the learners' experience of presence played an important role in the learning outcomes. However, participants performed the tasks while being interviewed by one of the researchers and the questions posed to each learner depended on answers to previous questions. This could be considered a type of task support. Also, there was no control group. Participants were asked to sketch a model of the quantum atom immediately after treatment; that activity could have had an effect on their successful retention of the image two months later.

Antonietti and Cantoia (2000) created a desktop 3D virtual simulation of a

figurative Renaissance painting. The simulation was developed in a 3D program which rendered the elaborate architectural setting on three axes, adding interactive volume and depth. This created the illusion of a space which viewers could enter and view from different positions within the virtual scene. In other words, the participants could virtually "walk" around in the room to examine the details, instead of just seeing the frontal perspective view presented in the original painting.

The researchers compared the student questions and comments from the 3D users with those of students who viewed a printed 2D reproduction of the same painting. The students who explored the virtual painting assumed a meta-perspective asking more "why" and "how" questions. They discussed the painting in abstract terms and expressed innovative elaborations. Antonietti and Cantoia's (2000) study suggests that the immersive 3D version stimulated abstract thinking and imagination, characteristics necessary for application of abstract concepts to specific problems. However there were differences in the learning tasks. The 3D virtual reality users received guidance in the form of a structured tour of the space and the symbolic objects it contained.

The involvement that participants experience in immersive environments does not always translate to an effective condition for learning (Moos & Marroquin, 2010; Moshell & Hughes, 2002; Rieber & Noah, 2008).

Research Studies that Found Positive Effects from Less Immersive Media

Mania and Chalmers (2001) measured learner sense of spatial presence using the Slater-Usoh-Steed Presence Questionnaire (SUS) (Slater, Usoh, & Steed, 1994) for four levels of treatment: a live classroom presentation, a desktop virtual simulation of the

seminar, a head mounted display of the virtual seminar and an audio- only version. Participants listened to a fifteen minute seminar presentation on an unfamiliar subject with information presented on slides. A posttest of recall of facts revealed similar high memory scores for the real and the desk top conditions. The level of reported presence was positively associated with accurate memory recall in the real condition but not in the other conditions. The Spatial Presence mean values for the audio- only condition were slightly higher than scores for the desktop condition.

Youngblut and Huie (2003) investigated the relationships between spatial presence and task performance in two versions of a training exercise used for Nuclear, Biological and Chemical (NBC) emergency response teams. The task was to explore an unfamiliar environment, locate and identify any dangerous materials and deal with them properly. The immersive 3D version used a rear projection screen, while the desktop version was low immersion. After viewing the presentations participants were tested in a real world setting to assess their transfer of skills and knowledge. The researchers found no difference in performance between the high immersion and low immersion groups. Both media groups out- performed the control group which had only studied the procedures manual. It was pointed out that the media groups had opportunity for practice and coaching that the control group did not receive. All three groups had studied the procedures manual.

The researchers used two measure of spatial presence: the Witmer and Singer 1998 Presence Questionnaire (PQ) and the Slater-Usoh-Steed Presence Questionnaire (SUS) (Slater, Usoh, & Steed, 1994). The PQ questionnaire scores did not correlate with

task performance but the SUS measures did. The researchers attributed this to the fact that the Witmer and Singer PQ included more questions about interface quality. The task of surveying the media environment for hazardous materials could have influenced participants' responses. The Witmer and Singer PQ (1998) measures the media users' attentiveness or lack of attentiveness to time and to their real world environment. A conscientious trainee might have hesitated to report being so immersed in the task that they failed to notice events in the real world around them.

The researchers concluded that spatial presence is related to task performance when transferred to a real world situation and that low immersion media may be as effective for training as a high immersion virtual environment. The researchers also believed that similar results could be obtained from the control group if they had spent more time studying the procedures manual.

Schrader and Bastiaens (2012) found that users of a low immersion media presentation outperformed users of a high immersion game on tests of comprehension and transfer of physics principles. The researchers had adapted a commercial game to use for the immersive version. It featured three dimensional images of a virtual world and a game storyline. Figures in their report showed detailed graphic imagery not related to the learning task. Participants assumed the identity of one of the game characters and made decisions about how to complete certain tasks. The low immersion presentation was a multimedia desktop presentation. It featured text explanations; static image illustrations and animations with play and pause controls. There was no story line or characters in the low immersion version. In both versions participants studied properties

of light and selected the correct procedures to perform a scientific experiment. Both versions featured support in the form of written text that introduced, explained and defined concepts and included links to presentations on other relevant topics.

Spatial presence was tested using a Likert questionnaire based on Witmer and Singer's 1998 Presence Questionnaire (PQ). Cognitive load was tested using another Likert questionnaire. Tests of physics knowledge consisted of questions of comprehension and questions that required transfer of knowledge to a similar but different situation.

The PQ scores showed a significant positive relationship between virtual presence, retention and comprehension but the low immersion learners scored higher overall. The researchers disregarded the correlation of spatial presence to learning because the low immersion users scored higher on tests of learning. They concluded that the higher sense of spatial presence that participants had experienced in the game version had caused extraneous cognitive load and depressed learning. The difference in measures of cognitive load were only "marginally" significant $p = <0.06$ while the correlations of spatial presence to both retention and comprehension were statistically significant $p =<0.01$ (p.653). The spatial presence scores for the high immersion game users were only slightly higher than scores for the low immersion users.

APPENDIX E

WITMER AND SINGER IMMERSIVE TENDENCY QUESTIONNAIRE ITEM STEMS (VERSION 2.0)

Item Stems	Subscale	*ITCorr*
1. Do you ever get extremely involved in projects that are assigned to you by your boss or your instructor, to the exclusion of other tasks?		0.26*
2. How easily can you switch your attention from the task in which you are currently involved to a new task?		0.26*
3. How frequently do you get emotionally involved (angry, sad, or happy) in the news stories that you read or hear?		0.27*
4. How well do you feel today?		0.20
5. Do you easily become deeply involved in movies or TV dramas?	FOCUS	0.49**
6. Do you ever become so involved in a television program or book that people have problems getting your attention?	INVOL	0.47**
7. How mentally alert do you feel at the present time?	FOCUS	0.40**
8. Do you ever become so involved in a movie that you are not aware of things happening around you?	INVOL	0.56**
9. How frequently do you find yourself closely identifying with the characters in a story line?	INVOL	0.53**
10. Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?	GAMES	0.55**
11. On average, how many books do you read for enjoyment in a month?		0.16
12. What kind of books do you read most frequently? (CIRCLE ONE ITEM ONLY!) Spy novels Fantasies Science fiction Adventure Romance novels Historical novels Westerns Mysteries Other fiction Biographies Autobiographies Other non-fiction		—
13. How physically fit do you feel today?	FOCUS	0.30**
14. How good are you at blocking out external distractions when you are involved in something?	FOCUS	0.46**
15. When watching sports, do you ever become so involved in the game that you react as if you were one of the players?		0.43**
16. Do you ever become so involved in a daydream that you are not aware of things happening around you?	INVOL	0.56**
17. Do you ever have dreams that are so real that you feel disoriented when you awake?	INVOL	0.50**
18. When playing sports, do you become so involved in the game that you lose track of time?	FOCUS	0.46**
19. Are you easily disturbed when working on a task?		−0.03
20. How well do you concentrate on enjoyable activities?		0.49**
21. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)	GAMES	0.35**

Item Stems	Subscale	*ITCorr*
22. How well do you concentrate on disagreeable tasks?		0.29**
23. Have you ever gotten excited during a chase or fight scene on TV or in the movies?	FOCUS	0.51**
24. To what extent have you dwelled on personal problems in the last 48 hours?		−0.10
25. Have you ever gotten scared by something happening on a TV show or in a movie?	INVOL	0.42**
26. Have you ever remained apprehensive or fearful long after watching a scary movie?	INVOL	0.31**
27. Do you ever avoid carnival or fairground rides because they are too scary?		−0.05
28. How frequently do you watch TV soap operas or docu-dramas?		0.28**
29. Do you ever become so involved in doing something that you lose all track of time?	FOCUS	0.49**

Note. Subscales: INVOL = Tendency to become involved in activities, FOCUS = Tendency to maintain focus on current activities, GAMES = Tendency to play video games

Note. ITCorr = Pearson correlation coefficients between ITQ item scores and the ITQ Total Score.

* $p < 0.01$

**$p < 0.001$

APPENDIX F

TUTORIAL MODULE QUESTIONS

Guided Task

Describe the forms or shapes you see in the painting.

What forms or shapes are repeated? List three shapes that are repeated.

Describe contrasts you see. These can be contrasts of size, shape, color, position, style, texture or concept. List three forms or shapes that are contrasted

Which part of the artwork stands out the most or is emphasized?

Why does it stand out? How is it emphasized?

Unguided Task

Describe your reaction to the painting, what you see in the painting, the shapes, forms, and images and their relationships to one another.

Final Critique Question: Both Short and Guided Task

Using your observations from above as notes, write a two to three paragraph formal critique of the artwork you analyzed. Describe what you find original or compelling about the work. Explain how the work comes together as a successful whole, or how it could be improved. What is your interpretation of the work?

APPENDIX G

ART CRITIQUE PRESENTATION

Art Critiques

Art criticism is a process of learning to look at and talk about art. The Feldman method (1992) of formal art criticism is widely used by educators to help learners develop an awareness of the formal elements of art, and how artists use these elements to create an effective composition. The method has four stages: description, analysis, interpretation, and judgment.

Description and analysis

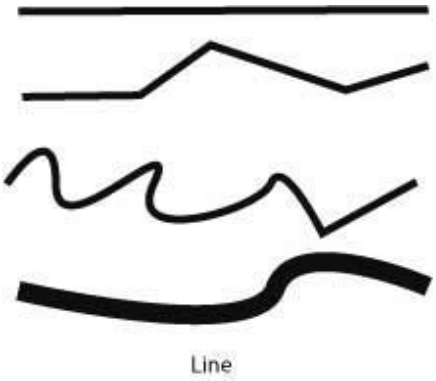
The first two stages, description and analysis, are an objective description of the visual design elements used, and their relationships to one another. An initial reaction to the work may be included (Anderson, 1993), but interpretation of the work's "meaning", and evaluation of the merits of the work, should be delayed until after the description and analysis, have been completed. Gillian Rose calls this approach "the good eye" (2007, p.25). Through careful observation and description of the elements that comprise the work of art, you will notice relationships that may hold the key to your interpretation and evaluation of the work.

Let's take a look at some of the elements of art that can be described and analyzed for these first two stages of your formal critique.

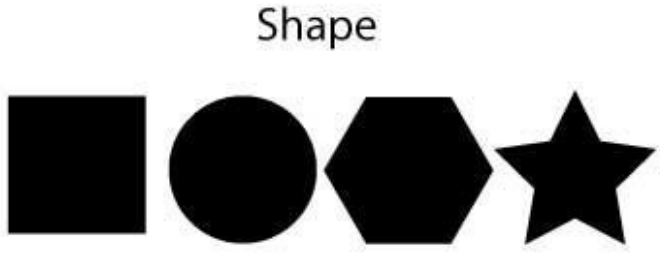
Elements of Art

The elements of art include **shape, line, value, texture, color, space**

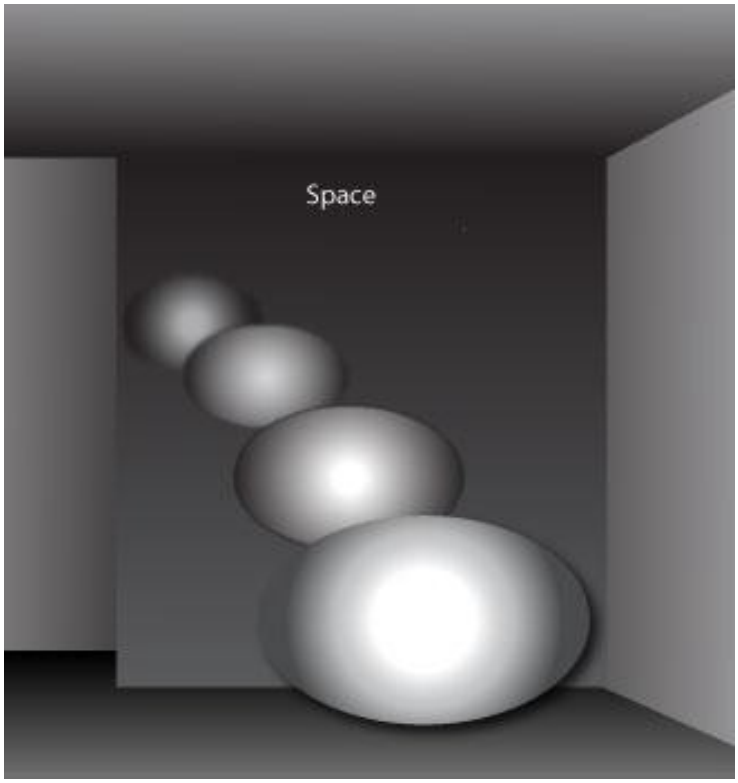
Line. A line is a simple form that is relatively narrow in width and prominent in length (Davis, 2011).



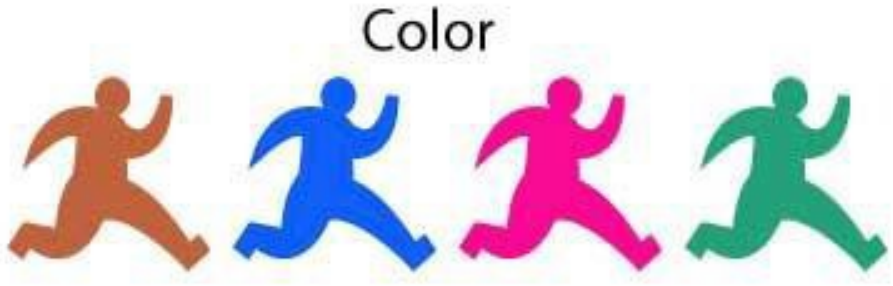
Shape/Form. A shape is a closed two-dimensional figure with a discrete length and width. Also known as *form* (Davis, 2011).



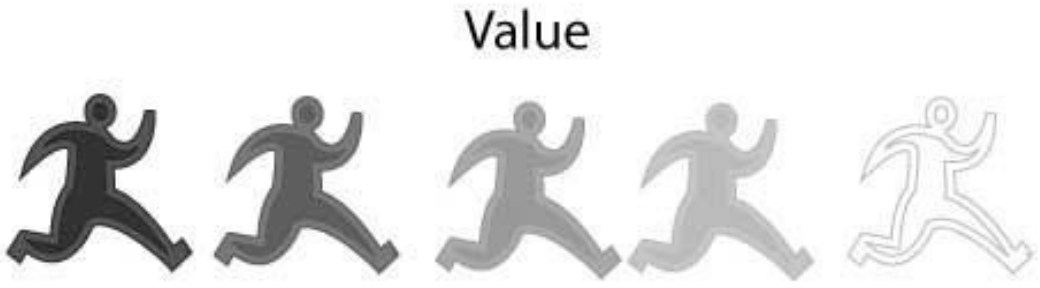
Space. In two-dimensional design, an illusion of space occurs when the composition suggests the existence of a third dimension behind the picture plane. Also known as *depth* (Davis, 2011).



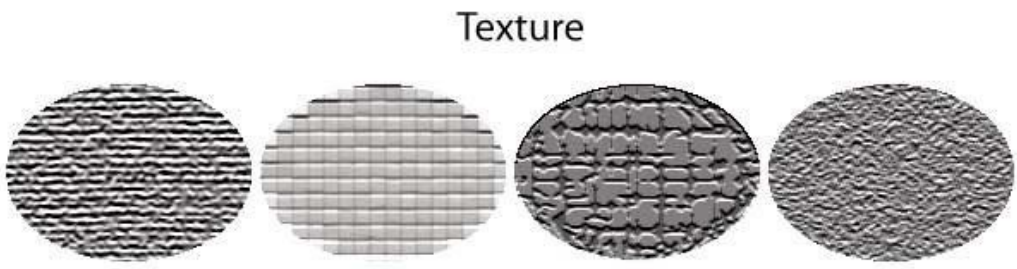
Color. A color is defined by a unique combination of hue, value, and saturation (Davis, 2011).



Value. Value is the relative lightness or darkness of a color (Davis, 2011).



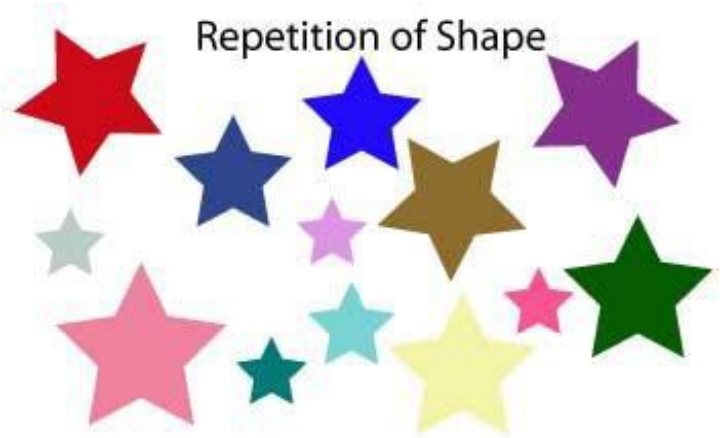
Texture. Texture is defined as the physical surface quality of an object (Davis, 2011).

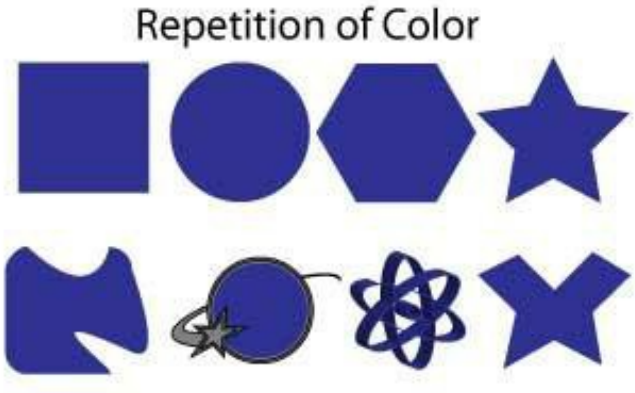


Artists create relationships between these formal elements of art by either repeating or contrasting them. A good design will balance the contrasting elements of art (things that are different) with the elements that are repeated, to create an image that is visually interesting, without being “busy”, and that is unified, without being boring.

Repetition

Artists can repeat color, value, texture, line quality, shape, size, and so on. Forms that share a similar characteristic, like shape, color, size, texture, etc., will seem connected. Repetition of one or more elements of art throughout the composition will connect things and unify the artwork.



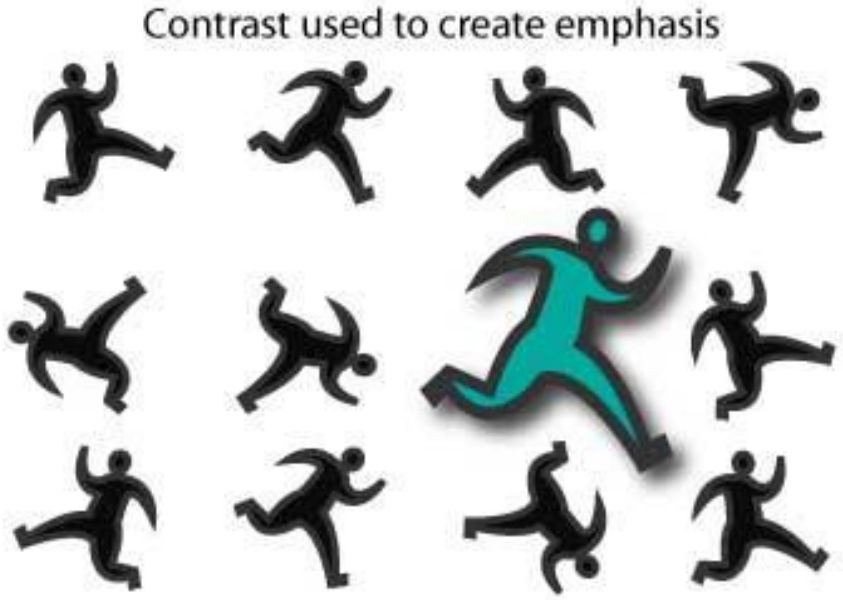


Contrast

Artists can contrast color, value, texture, line quality, shape, and size, and so on to create variety, visual interest and emphasis. The elements with the greatest amount of contrast with other elements in the work will usually grab your attention first. An example might be a group of shapes of similar size, with one much larger shape. The larger shape will stand out.

Emphasis

The artist uses contrast of size, shape, position, color, or texture to emphasize important areas of the painting. Areas with the greatest contrast will stand out the most. Usually the artist applies the greatest amount of contrast to what she wants the viewer to see and think about. We call this the focal point of the artwork.



Contrast and repetition used together

When an artwork has too much similarity of forms, we may find it dull and uninteresting to look at. When an artwork has too much variety of form, we say the work is busy or cluttered or chaotic. A successful work of art balance repetition and contrast to create a unified composition that has visual interest for the viewer. Repeating a form with some

characteristics that are similar, and other characteristics that are different, will create visual interest in a work of art, while retaining a sense of unity.

Unity

When a composition exists as a complete and coherent whole, and becomes greater than the sum of its parts, it is in unity.

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APPENDIX H

TEXT BOXES IN SURVEY

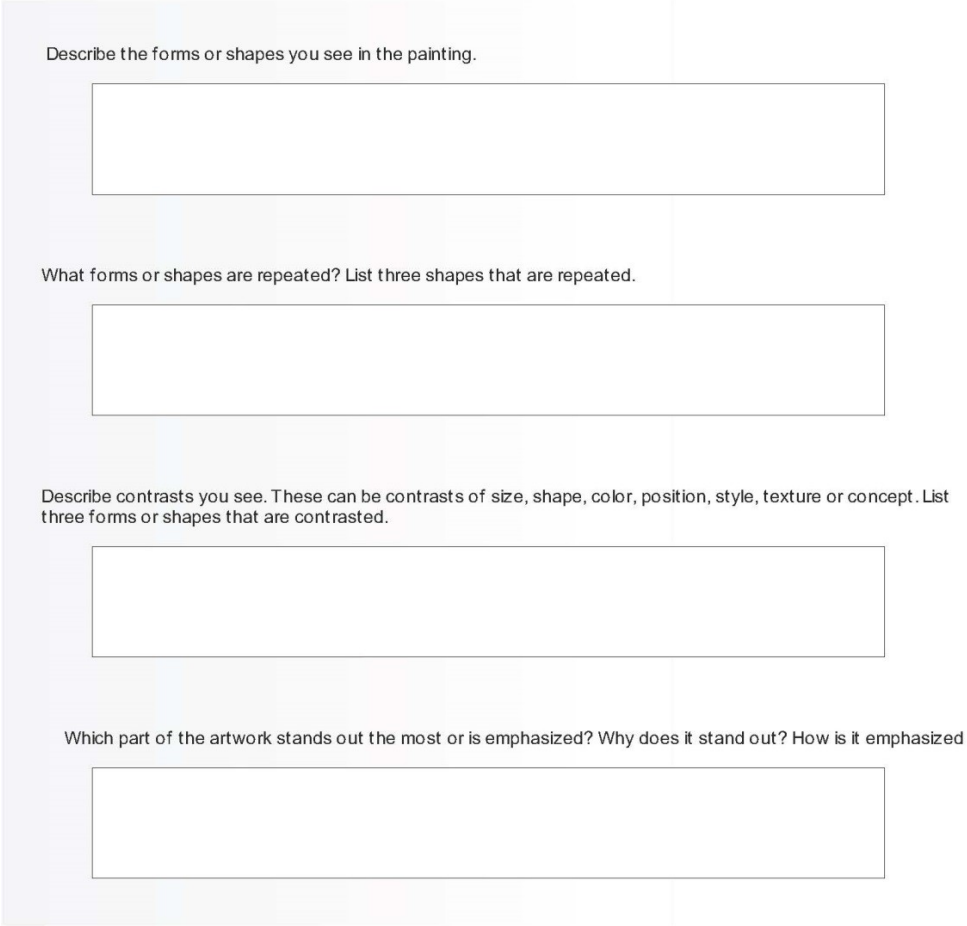
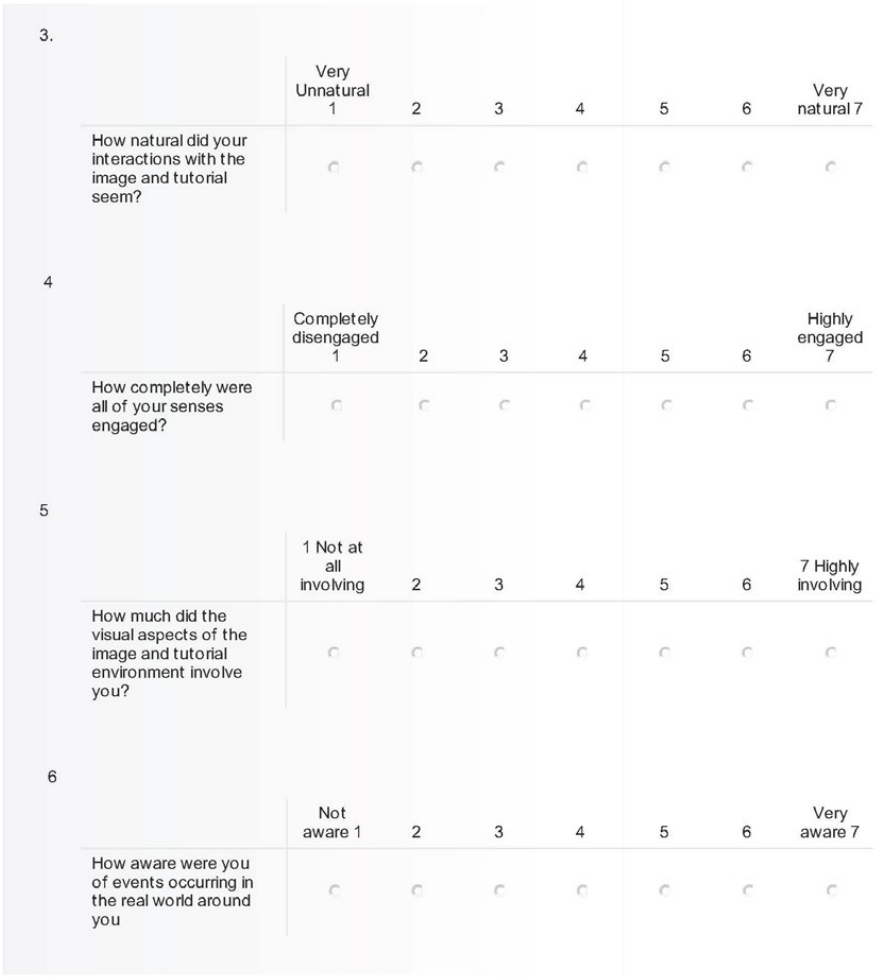


Figure H1. Examples of Text Boxes in Survey.

APPENDIX I

LIKERT QUESTIONNAIRE ITEMS



3.	Very Unnatural 1	2	3	4	5	6	Very natural 7
How natural did your interactions with the image and tutorial seem?	○	○	○	○	○	○	○

4	Completely disengaged 1	2	3	4	5	6	Highly engaged 7
How completely were all of your senses engaged?	○	○	○	○	○	○	○

5	1 Not at all involving	2	3	4	5	6	7 Highly involving
How much did the visual aspects of the image and tutorial environment involve you?	○	○	○	○	○	○	○

6	Not aware 1	2	3	4	5	6	Very aware 7
How aware were you of events occurring in the real world around you	○	○	○	○	○	○	○

Figure I1.Examples of Likert Questionnaire Item Stems

APPENDIX J

PARAMETER ESTIMATES AND MARGINAL MEANS FOR CRITICAL THINKING

Table J1 *Parameter Estimates for Media, Task, Media * Task, and Presence on Critical Thinking*

Dependent Variable: Critical Thinking

Parameter	B	Std. Error		Sig.	95% Confidence Interval		Partial Eta	Noncent. Parameter	Observed Power[b]
					Bound	Bound			
Intercept	1.257	.652	1.928	.058	-.043	2.556	.048	1.928	.477
[Media=0]	.301	.236	1.274	.207	-.170	.771	.022	1.274	.242
[Media=1]	0[a]	.	.	.	.	.	.	.	.
[Task=0]	.266	.254	1.049	.297	-.240	.773	.015	1.049	.179
[Task=1]	0[a]	.	.	.	.	.	.	.	.
[Media=0] * [Task=0]	-.006	.357	-.018	.986	-.719	.706	.000	.018	.050
[Media=0] * [Task=1]	0[a]	.	.	.	.	.	.	.	.
[Media=1] * [Task=0]	0[a]	.	.	.	.	.	.	.	.
[Media=1] * [Task=1]	0[a]	.	.	.	.	.	.	.	.
Presence	.261	.124	2.099	.039	.013	.508	.057	2.099	.544

a. This parameter is set to zero because it is redundant.

b. Computed using alpha = .05

Table J2 *Means and CI for Media on CT*

Dependent Variable: Critical Thinking

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
2.995[a]	.126	2.744	3.246
2.697[a]	.127	2.445	2.950

a. Covariates appearing in the model are evaluated at the following values: Spatial Presence = 5.0135.

Table J3 *Means and CI for Task on CT*

Dependent Variable: Critical Thinking

Task	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Unguided	2.978[a]	.134	2.711	3.245
Guided	2.715[a]	.118	2.479	2.950

a. Covariates appearing in the model are evaluated at the following values: Spatial Presence = 5.0135.

Table J4 *Means and CI for Media * Task on CT*

Dependent Variable: Critical Thinking

Media	Task	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Static	Short	3.125[a]	.195	2.737	3.514
	Long	2.865[a]	.159	2.548	3.182
Dynamic	Short	2.831[a]	.184	2.464	3.198
	Long	2.564[a]	.174	2.216	2.912

a. Covariates appearing in the model are evaluated at the following values: Spatial Presence = 5.0135.

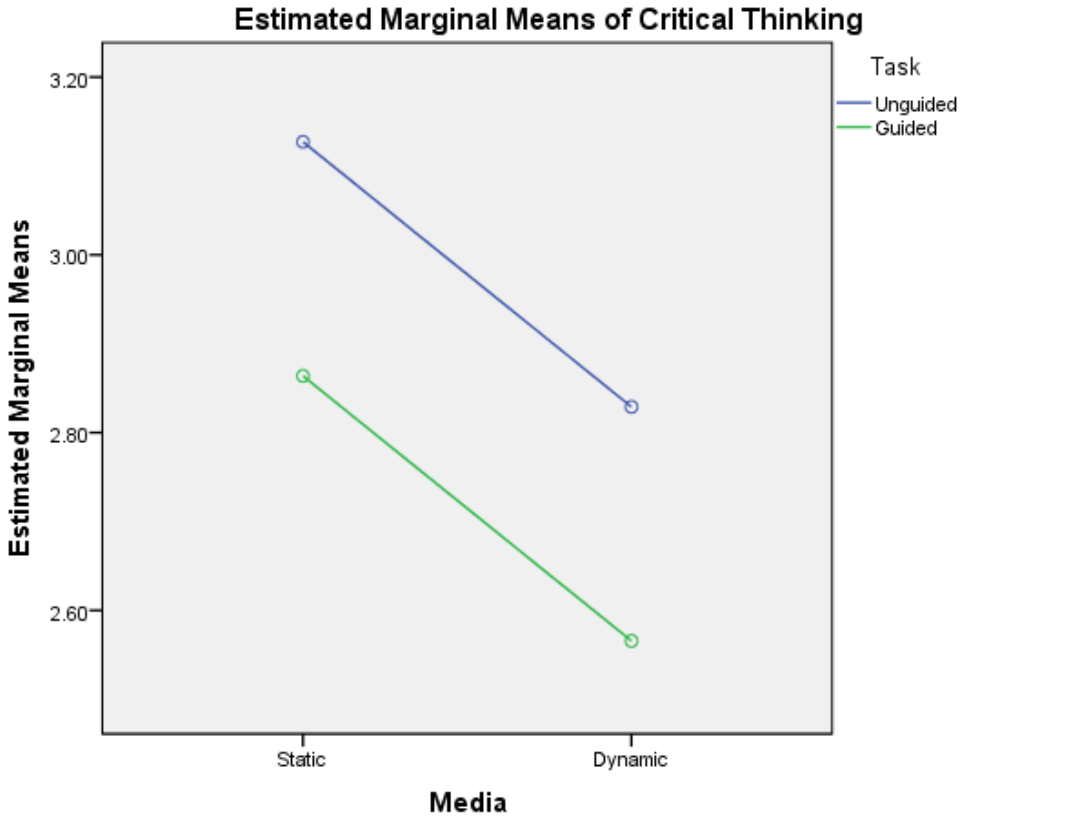


Figure J1. Profile Plots of Critical Thinking Means.

Table J5 *Parameter Estimates of Media, Task, and Presence on Critical Thinking*

Dependent Variable: Critical Thinking

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
					Lower Bound	Upper Bound			
Intercept	1.259	.639	1.970	.053	-.014	2.531	.050	1.970	.494
[Media=0]	.298	.176	1.694	.095	-.053	.649	.037	1.694	.387
[Media=1]	0[a]	.	.	.	.	.	.	.	.
[Task=0]	.263	.178	1.482	.143	-.091	.617	.029	1.482	.310
[Task=1]	0[a]	.	.	.	.	.	.	.	.
Presence	.261	.123	2.114	.038	.015	.507	.057	2.114	.550

a. This parameter is set to zero because it is redundant.

b. Computed using alpha = .05

Table J6 *Estimated Marginal Means for Media on CT*

Dependent Variable: Critical Thinking

Media	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Static	2.995[a]	.124	2.749	3.242
Dynamic	2.697[a]	.126	2.447	2.948

a. Covariates appearing in the model are evaluated at the following values:

Spatial Presence = 5.0135.

Table J7 *Estimated Marginal Means for Task on CT*

Dependent Variable: Critical Thinking

Task	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Unguided	2.978	.133	2.713	3.243
Guided	2.715	.117	2.481	2.948

a. Covariates appearing in the model are evaluated at the following values: Spatial Presence = 5.0135.

APPENDIX K

PARAMETER ESTIMATES FOR MEDIA, TASK, AND TASK * MEDIA ON SPATIAL PRESENCE

Table K1 *Parameter Estimates for Media, Task, and Task * Media on Spatial Presence*

Dependent Variable: Spatial Presence

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared	Noncent. Parameter	Observed Power[b]
					Lower Bound	Upper Bound			
Intercept	5.055	.163	30.98	.000	4.730	5.380	.928	30.986	1.000
[Media=0]	-.003	.221	-.015	.988	-.443	.437	.000	.015	.050
[Media=1]	0[a]	.	.	.	.	.	.	.	.
[Task=0]	-.138	.237	-.581	.563	-.610	.335	.005	.581	.088
[Task=1]	0[a]	.	.	.	.	.	.	.	.
[Media=0] * [Task=0]	.099	.334	.295	.769	-.567	.764	.001	.295	.060
[Media=0] * [Task=1]	0[a]	.	.	.	.	.	.	.	.
[Media=1] * [Task=0]	0[a]	.	.	.	.	.	.	.	.
[Media=1] * [Task=1]	0[a]	.	.	.	.	.	.	.	.

a. This parameter is set to zero because it is redundant.

b. Computed using alpha = .05

Table K2 *Estimated Marginal Means for Media on SP*

Dependent Variable: Spatial Presence

Media	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Static	5.032	.118	4.797	5.267
Dynamic	4.986	.119	4.750	5.222

Table K3 *Estimated Marginal Means for Task on SP*

Dependent Variable: Spatial Presence

Task	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Unguided	4.965	.125	4.715	5.215
Guided	5.053	.110	4.833	5.273

Table K4 *Estimated Marginal Means for Media * Task on SP*

Dependent Variable: Spatial Presence

Media	Task	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Static	Short	5.013	.182	4.649	5.376
	Long	5.052	.149	4.755	5.348
Dynamic	Short	4.917	.172	4.575	5.260
	Long	5.055	.163	4.730	5.380

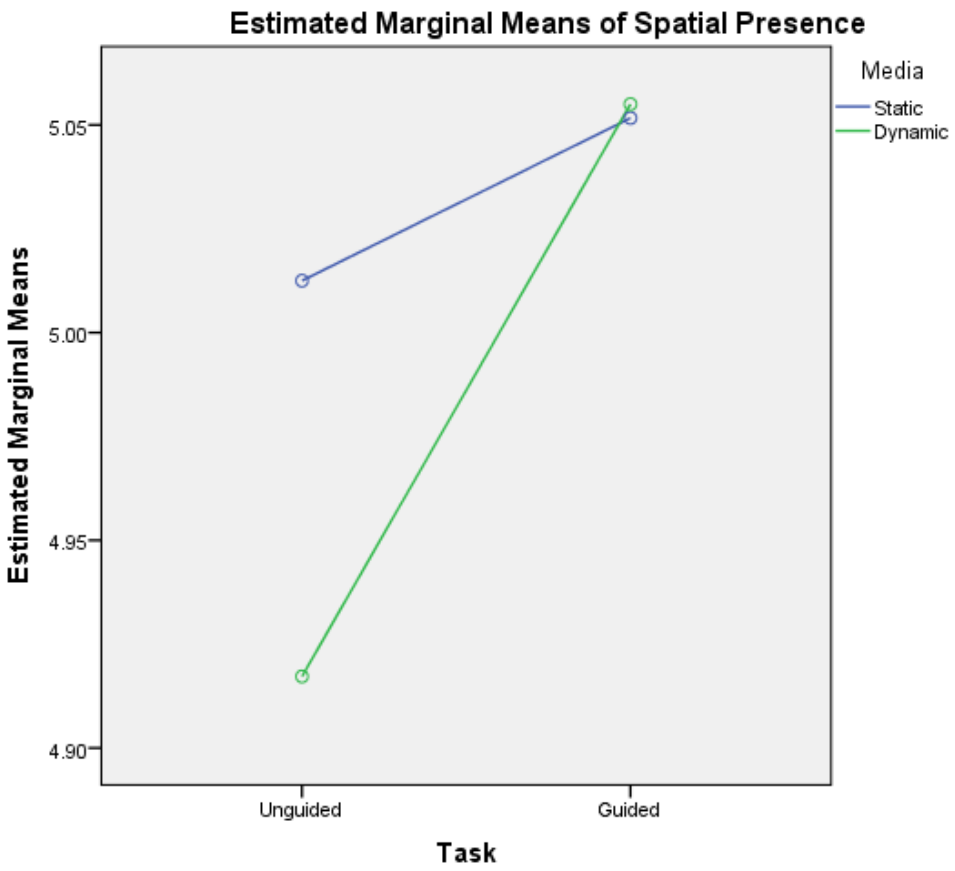


Figure K1. Profile Plots for Spatial Presence Means.

APPENDIX L

RELATIONSHIP OF SPATIAL PRESENCE TO CRITICAL THINKING

Table L1 *Descriptive Statistics*

	Mean	Std. Deviation	N
Spatial Presence	5.0135	.71736	78
Critical Thinking	2.8063	.82098	80

Table L2 *Correlations of Spatial Presence to Critical Thinking*

		Spatial Presence	Critical Thinking
Spatial Presence	Pearson Correlation	1	.228*
	Sig. (2-tailed)		.044
	Sum of Squares and Cross-products	39.625	10.140
	Covariance	.515	.132
	N	78	78
Critical Thinking	Pearson Correlation	.228*	1
	Sig. (2-tailed)	.044	
	Sum of Squares and Cross-products	10.140	53.247
	Covariance	.132	.674
	N	78	80

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

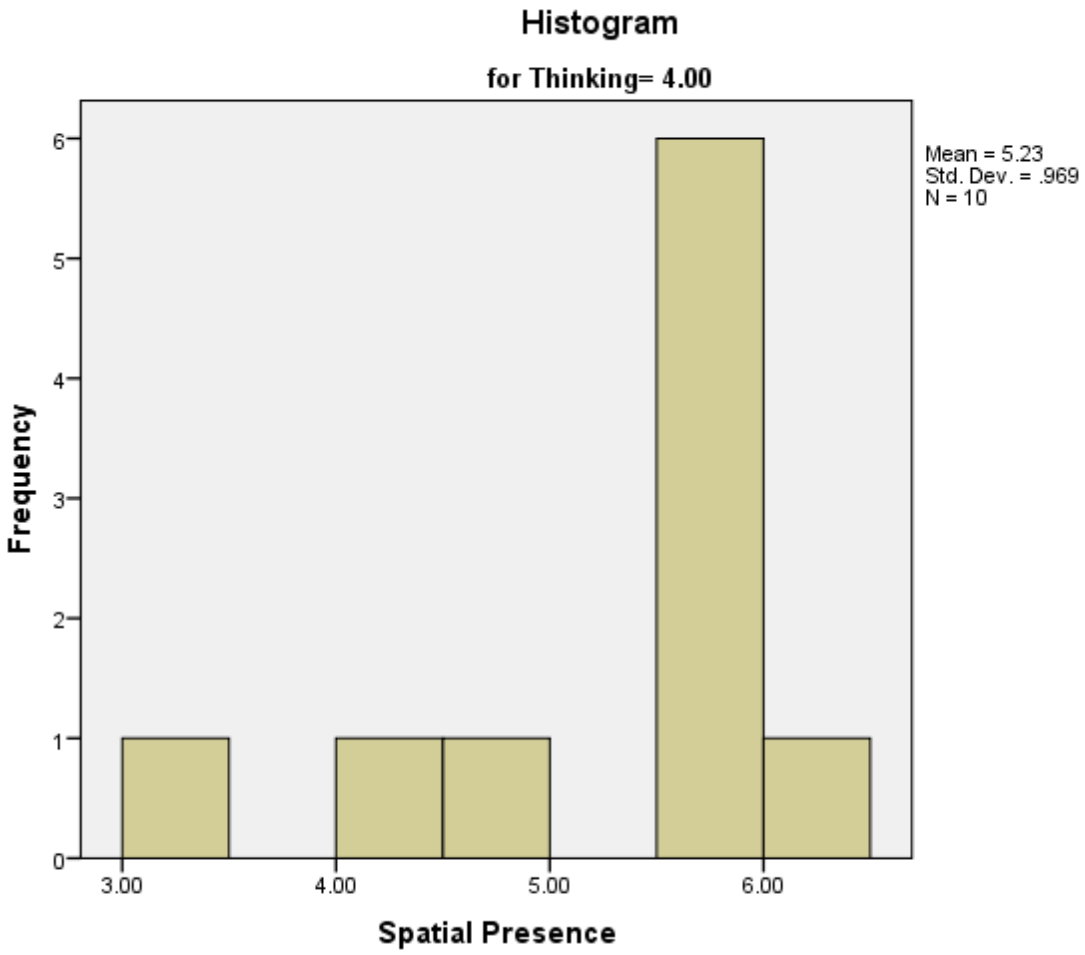


Figure L1.Histogram for Spatial Presence with CT = 4.00. Seven of the 10 participants who received scores of 4.00 on CT scored above 5.5 on SP.

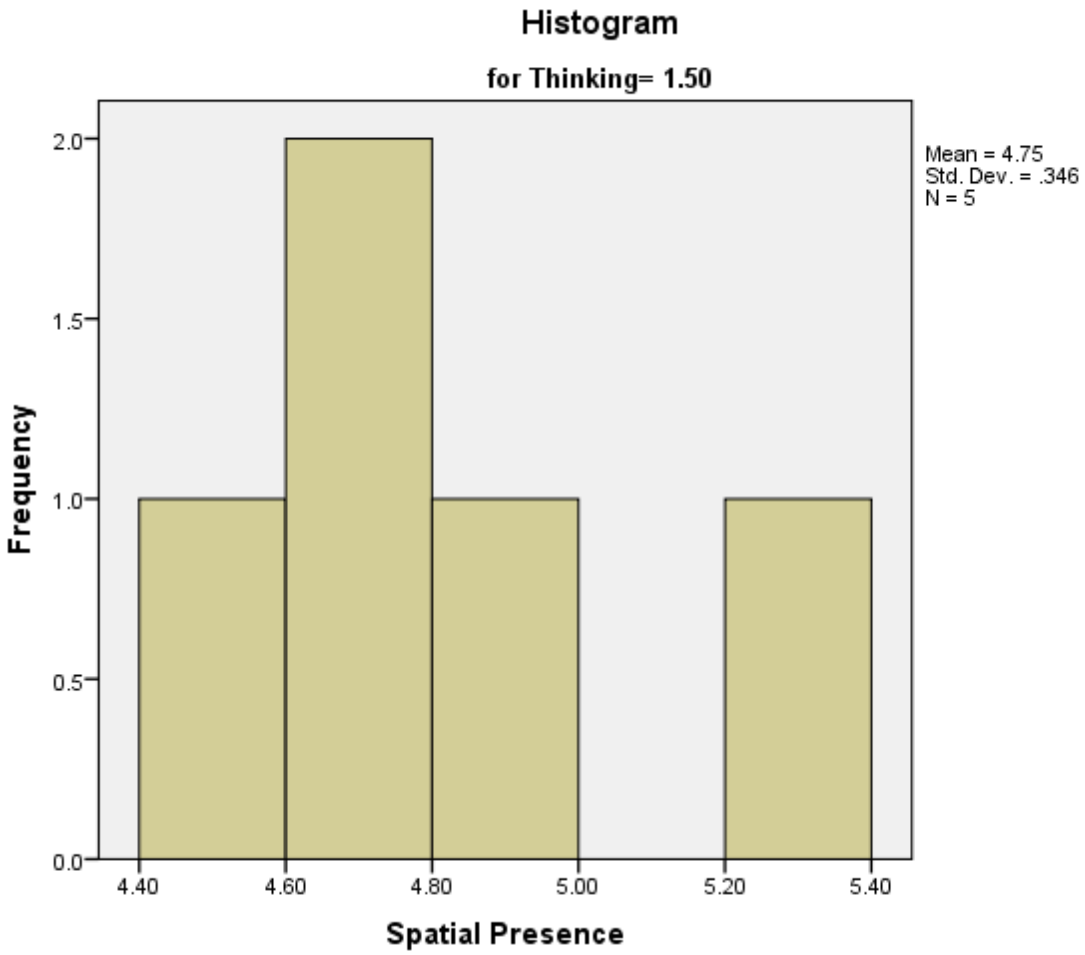


Figure L2.Histogram for Spatial Presence with CT = 1.50. Four of the five participants who received scores of 1.50 on CT scored below 5.00 on SP.

APPENDIX M

CRITICAL THINKING SCORES BY MEDIA TYPE

Table M1 *Critical Thinking Scores for Media 0 (Static) and Media 1 (Dynamic).*

AVG Stem-and-Leaf Plot for
Media= 0

Frequency	Stem & Leaf
1.00	1 . 0
3.00	1 . 555
4.00	2 . 0000
5.00	2 . 55555
10.00	3 . 0000000000
10.00	3 . 5555555555
7.00	4 . 0000000

Stem width: 1.00
Each leaf: 1 case(s)

AVG Stem-and-Leaf Plot for
Media= 1

Frequency	Stem & Leaf
2.00	1 . 00
2.00	1 . 55
7.00	2 . 0000000
9.00	2 . 555555555
8.00	3 . 00000000
7.00	3 . 5555555
3.00	4 . 000

Stem width: 1.00
Each leaf: 1 case(s)