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The Viability of Virtual Worlds in Higher Education: Can Creativity Thrive Outside the Traditional Classroom Environment?

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ABSTRACT

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In spite of the growing popularity of virtual worlds for gaming, recreation, and education, few studies have explored the efficacy of 3D immersive virtual worlds in post-secondary instruction; even fewer discuss the ability of virtual worlds to help young adults develop creative thinking. This study investigated the effect of virtual world education on creative thought for university level students.

Over the course of two semesters, a total of 97 university students participated in this study. Forty-six of these participants (experimental group) spent time in a specially designed virtual world environment, the V.I.E.W., while 51 of the participants (control group) met exclusively in a real-world classroom. Creative thought was measured before and after the intervention with the Torrance Test of Creative Thinking Verbal Forms A and B. Although the experimental group's ending scores did not reach the level of the control group's scores, results showed overall statistically significant gains for the experimental group at $p = .033$. The experimental group also achieved greater gains in the subcategories of fluency and flexibility, with significance at $p = .036$ and $p = .043$, respectively. At the end of the course, independent raters measured the creativity expressed in student art critiques, using a scale developed for this study. No overall significant differences between groups were found in the art critiques, except in the category of spatial awareness, where the experimental group's scores were significantly higher than the control group's scores at $p = .039$. For both instruments, analysis of variance (ANOVA) was used to evaluate statistical data.

Results suggest that immersive worlds can be at least as well suited as traditional university classrooms for developing creative thought—particularly in the context of art education. Implications for researchers, students, educators, and administrators are discussed.

Keywords: virtual worlds in education, creativity, Torrance Test of Creative Thinking

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CHAPTER 1: INTRODUCTION

Creativity, traditionally acknowledged as the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints) (Sternberg & Lubert, 1999), is a key element in the overall development of the individual in society. Toynbee (1936-1954) emphasized the importance of creativity as "mankind's ultimate capital asset" (p. 4). In business, creativity is a highly sought-after quality in employees (Sternberg & Lubart, 1999). Mental health and emotional well-being have been linked to creativity (Runco, 2004). According to Amelang & Bartussek (1997), creativity is considered the second major area of human performance next to intelligence. Einstein believed that "imagination is more important than knowledge" (Burleson, 2005, p. 441). McCulloch-Lovell (2005) characterized creativity as a touchstone of American identity and recounts a heritage of creativity: "We trust in our creative powers. We define ourselves as explorers. We have built intercontinental railroads and ocean-linking canals, sent men to the moon and created the microchip" (p. 14).

In education various agencies such as the National Council on Educational Reform (Ogawa, Kuehn-Ebert, & DeVito, 1991) have highlighted the importance of encouraging creativity in the classroom. Smilan and Marzilli Miraglia (2009) pointed to the need for developing creativity in all students because "without creative thinkers, society and culture may suffer, leaving a dangerous gap . . . between those who lead and those who blindly follow the status quo" (p. 40).

Notwithstanding its profound impact and acknowledged importance, creativity has lost ground in the American educational arena. Kim (2011) analyzed nearly 300,000 Torrance Test of Creativity (TTCT) scores for children and adults, and found that creativity scores are falling,

especially from kindergarten through third grade. Kim evaluated the TTCT scores for kindergarten through third grade, fourth through sixth grade, seventh through eighth grade, high school students and adults from 1966 to 2008. Although subscales fluctuated from year to year, the overall trend was found to be a significant decrease in creativity scores during the last 20–40 years.

Europe has also recognized the pressing need for a greater focus on creativity in education, and declared the year 2009 as the European Year for Creativity (Cachia, Ferrari, Ala-Mutka, & Punie, 2010). Indeed, the manifesto of the European Commission (who sponsored a broad study of creativity of its member states) asserted, "The need for change and new initiative is urgent. Europe and its Member States must give full attention to creativity and innovation now in order to find a way out of the current stalemate" (2008, p. 13).

In light of the apparent benefits associated with creativity and the recognized need to refocus on creativity, a primary task of educators should be to cultivate creativity in their students. Csikszentmihályi (1996), who explored the lives of more than 90 of the world's most creative people such as author Madeline L'Engle and scientist Jonas Salk, concluded that, "If the next generation is to face the future with zest and self-confidence, we must educate them to be *original* (italics added) as well as competent" (p. 12).

Net Generation Students

Students of today are the next generation of whom Csikszentmihályi (1996) wrote; they have been named the "Net Generation." These students will be called upon to use creative thought in many aspects of their schooling and future careers. The National Science Foundation in 2005 sponsored a conference entitled, "Creativity Support Tools" that focused attention on the impact of online technologies on creativity. During this conference, Shneiderman, with

coauthors Fischer, Czerwinski, Myers, and Resnick (2006), delivered an address that discussed the significant impact of these creativity support tools on "global competitiveness, successful civic infrastructures, scientific leadership and educated citizenry" (p. 66).

Some of the creativity support tools associated with the "Net Generation" students are current Internet technologies. This generation, 80 million strong and the largest generation in America's history, consumes a wide range of technology (Junco & Mastrodicasa, 2009) and spends a significant amount of time each day using it. Rideout, Foehr, and Roberts (2010) conducted a national survey for the Kaiser Family Foundation from 2008–2009 of over 2,000 3rd- to 12th-grade students, ages 8–18. They found that this demographic devotes an average of 7 hours 38 minutes daily to technology and since these individuals multitask, that number increases to 10 hours and 45 minutes worth of media content within that timeframe (see Table 1). According to this study, the total number of hours spent on technology per day stayed relatively static from 1999 to 2004, but then rose significantly by 2009 from 6 hours and 21 minutes per day to 7 hours 38 minutes per day. It is evident in these statistics that the "Net Generation" has become increasingly engaged in current technologies. According to Hamlen (2009), this pattern of widespread, daily use of a variety of technologies presents a "growing gap" between how students are expected to learn in school and how they actually learn outside of school (p. 19).

Dede (2005) also found today's students to be highly engaged and expert in outside-of-school technologies. He discussed their technology patterns and characterized them as possessing unusual abilities in interfacing with technology. Dede described these students as having a neo-millennial learning style that includes the following characteristics and preferences: (a) fluent in multiple media, (b) preference for learning that is based on collectively seeking experiences rather that individually locating and absorbing information from a single best source,

Table 1

Media Use of Youth, Ages 8–18, in 1999, 2004, and 2009, Shown in Hours per Day

Media type	2009	2004	1999
V content	4:29	3:51	3:47
Music/audio	2:31	1:44	1:48
Computer	1:29	1:02	:27
Video games	1:13	:49	:26
Print	:38	:43	:43
Movies	:25	:25	:18
Total media exposure*	10:45	8:33	7:29
Multitasking proportion**	29%	26%	16%
Total media use***	7:38	6:21	6:19

Note. Data from *Generation M^2: Media in the Lives of 8- to 18-Year-Olds,* by V. J. Rideout, U. G. Foehr, and D. F. Roberts, 2010, Kaiser Family Foundation. The children surveyed were in grades 3–12, ages 8–18.
*Total media exposure is the sum of time spent with all media.
**Multitasking proportion is the amount of media time spent using more than one medium concurrently.
***Total media use refers to the actual number of hours spent daily on media taking multitasking into account.

(c) preference for active learning based on experience (real and simulated) that includes frequent opportunities for reflection, (d) preference for expression through non-linear, associational webs of representations rather than linear stories (e.g. authoring a simulation and a Web page rather than writing a paper), and (e) preference for co-design of learning experiences that are personalized to individual needs (p. 15.15).

Virtual World Technology

These Net Generation students use a variety of technologies including Twitter, Facebook, YouTube, and a multitude of video games and virtual world platforms like Second Life. According to KZERO (2011), a marketing analytics corporation, registered users of virtual worlds are approaching the two billion mark (see Table 2), with the 10- to 15-year-old age group accounting for around 787 million registered users. Virtual worlds appear to appeal to a large segment of the population. Educators can take advantage of interest in this medium to enhance creativity in their students. Shneiderman et al. (2006) stated, "the telescopes and microscopes of previous generations are giving way to advanced user interfaces on computer tools that enable exploratory search, visualization, collaboration, and composition" (p. 62).

Pense (2008) noted that "Millions of teenagers are already involved in virtual (world) games . . . and when they reach college age, they will expect to see this technology that has become familiar to them" (p. 177).

Virtual world technology has been described by Bell (2008) as "A synchronous, persistent network of people, represented as avatars, facilitated by networked computers" (p. 2). The virtual world platform provides students with learning strategies and affordances that are different than those experienced in the traditional classroom. Although virtual worlds have the ability to incorporate text-based materials for traditional lecture-based learning, they also provide

a navigable 3D environment for exploration. This learning environment hosts multiple sensory and terrain furnishings that offer realistic as well as imaginative situations difficult or impossible to replicate in the traditional classroom environment. Most virtual world environments also provide communication tools for social collaboration.

Shneiderman (2000) made some early predictions about student technology requirements that align with these virtual world capabilities and called for technologies that facilitate users' abilities to search and collect information from digital libraries, visualize data and processes, consult with peers and mentors, create new information through free associating, exploring, composing, reviewing and replaying; and disseminate results broadly and easily. Current virtual world technologies show potential in fulfilling these recommendations.

Potential of Virtual Worlds to Improve Creativity

Torrance identified three categories of thought that are widely accepted as important to creativity namely, originality, fluency, and flexibility. He defined originality as the statistical infrequency of ideas, fluency as the overall number of relevant ideas, and flexibility as the number of different ideas. His test, the Verbal Torrance Test of Creative Thinking, measures creative thought in these three categories.

Some of the capabilities of the virtual world may encourage creativity in terms of originality, fluency and flexibility. For example, students in the virtual world are able to choose from a large number of options in avatar customization, modes of communication types of movement, and ways to build various forms. This ability to rapidly create and iterate may facilitate fluency and originality. In addition, students exploring the virtual environment have the ability to circumnavigate objects in the world from any perspective. This capability may facilitate flexibility.

Study of Potential of Virtual Worlds to Improve Creativity

Since the use of virtual worlds for education is in its early stages, research studies regarding this venue are limited. Studies involving the intersection of virtual world education and creativity are rare. In order for educational institutions and educators to more effectively evaluate whether or not to use the virtual world environment for education, it is necessary to add to the literature on this topic. The topic of this study will be the potential of virtual worlds to improve creativity.

To accomplish this purpose, this research attempted to shed light upon the questions surrounding the effect of virtual world education on creative thought. By testing virtual world pedagogies, this study addressed two questions, (1) Using the TTCT Verbal (Scholastic Testing Service, 2007) as a metric, do students from virtual world classroom environments show more, less, or a similar amount of originality, fluency, and flexibility than students in comparable face-to-face classroom environments? and (2) How do students from face-to-face classrooms and virtual world classrooms compare in their representations of originality, fluency, flexibility, multiple perspectives and play in art critiques?

Educators like Pense (2007–2008) are anxious to explore the virtual world environment with their students: "It appears that 3D virtual worlds are poised to make a significant contribution to higher education . . . the potential applications offer many exciting possibilities. Developing effective pedagogies for teaching in virtual space may be the most serious challenge to face higher education in the coming decade (p. 177). It is hoped that this study will provide information to institutions and educators about this important topic.

CHAPTER 2: LITERATURE REVIEW

Literature on creativity is abundant. In contrast, academic studies investigating educational virtual worlds is less abundant, but increasing. Literature regarding the intersection of creativity and virtual world studies, however, is rare. Since research in this area is in its infancy, it is at this intersection that I centered my investigation.

In an effort to better effectuate this research, I conducted a thorough literature review by searching educational research databases such as ERIC, JSTOR, EBSCO, PsychINFO, Wiley Online, Google Scholar, and Questia. I read journals such as *Creativity Research Journal, Journal of Virtual World Research, Journal of Mental Imagery, Journal of Educational Research, Journal of Creative Behavior, Journal of Educational Technology Systems, International Journal of Instructional Technology and Distance Learning, Psychological Review, SAGE Journals, Journal of Educational Psychology, Educational Technology & Society, Art Education, and International Journal of Human-Computer Interaction.* I looked for information related to creativity and its key sub-constructs of originality, fluency, flexibility, play, and multiple perspectives. In addition, I searched for literature related to virtual world education.

In this review I will describe five topics appearing in the literature that are pertinent to the study. First, I will briefly touch on the definitions of creativity. Second, I will elaborate on a theoretical framework for understanding creativity, including the constructs of originality, fluency, flexibility, multiple perspectives, and play. Third, I will discuss bridges and barriers to fostering creativity in the classroom. Fourth, I will discuss the definition of virtual worlds, the differences between virtual education and virtual world education, and how the constructs of originality, fluency, flexibility, multiple perspectives and play might be enhanced in virtual

world education. Fifth, I will close with a report on what studies exist at the intersection of creativity and virtual world education and what future studies might be conducted to address this timely issue.

Creativity Defined

Creativity is a multi-faceted concept with a variety of definitions. This section will focus on the multiple definitions of creativity expressed in the literature as well as the definition selected for this study.

Description. "Creativity has been attributed variously to divine intervention, cognitive processes, the social environment, personality traits, and chance . . . It has been associated with genius, mental illness, humor and REM sleep" ("Creativity," *New World Encyclopedia*, 2006, p. 1). Csikszentmihályi (1996) used a variety of phrases to describe creativity: "unquenchable curiosity," "fierce determination," and "enjoying the process of creation for its own sake" (p. 158). Ruppert (2010) characterized creativity as "imagination instead of imitation," "developing new and useful perspectives to satisfy a need," or "applied imagination" (p. 2). Sternberg and Lubart (1999) defined creativity as, "the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)" (p. 3). Cachia et al. (2010) described creativity "as a product or process that shows a balance of originality and value. It implies the ability to make unforeseen connections and to generate new and appropriate ideas" (p. 17).

Cachia and colleagues' (2010) definition not only embodies Sternberg and Lubart's (1999) focus on product, but includes idea generation as well. It represents perhaps the most common perspectives of creativity in the literature—that of creativity being the domain of ideas that are novel and useful. Cachia et al.'s definition also aligns with this study in investigating

creativity in terms of originality, fluency, and flexibility of ideas. This study will focus on the novelty of ideas portion of the Cachia et al. (2010) definition.

Universal versus domain-specific. Part of defining this multifaceted concept of creativity includes identifying whether creativity is the province of experts (domain-specific creativity) or available to all (universal creativity). Proponents of the domain-specific creativity approach assert that a deep knowledge of the domain must be present to claim creativity. Gardner (1999), known for his work exploring multiple intelligences, adopted the élite definition of creativity and frames the creative individual as one who changes society by moving thinking forward in a particular domain.

Proponents of the universal creativity approach assert that all human beings possess the ability to be creative to a greater or lesser degree. Although no agreement has been reached in the field, Torrance (1979, 1993) wrote extensively on the importance of employing a universal rather than a domain-specific approach to creativity. Reflecting on his own definition of creativity, Torrance stated, "Such a definition places creativity in the realm of everyday living and does not reserve it for ethereal and rarely achieved heights of creation" (p. 233). Universal creativity is the theoretical basis for his nearly 60 years of research. For example, Torrance's (1979) book, *The Search for Satori and Creativity,* outlines ways to cultivate creativity at home, school and work. Torrance and other advocates of universal creativity offer the idea of a continuum of creativity that does not preclude creative efforts of domain-specific experts, but does preempt the idea of creativity being the "special province of special individuals at rare moments in time" (Ripple, 1989, p. 192).

Although arguments for both theories possess merit, the universal approach aligns more closely with educational systems that seek to provide fertile environments for creativity growth

in all students. According to Ripple (1989), the alternative position tends to undermine the confidence of those attempting creative behaviors. Ripple stated, "It is a mark of progress in social thinking, and is more in the human individual interest as well as the national interest, to develop creativity in all people as a precious national human resource (p. 200). Since this study seeks to provide information to educational systems regarding creativity in students, creativity will be viewed as a universal skill that can be developed in everyone.

Theoretical Framework of Creativity

To better understand the complex topic of creativity, it is important to examine it within a theoretical framework both as a whole as well as its constituent parts. In this study, the work of Torrance (1979) formed the theoretical foundation for understanding creativity.

Torrance (1974) described the motivation for creativity as a "natural human process of sensing incompleteness and disharmonies, and then engaging in activities, consciously or unconsciously, to resolve the tensions created by this incompleteness" (p. 8). Torrance (2000) assembled "a battery of tests that require the kinds of thinking analogous to the thinking involved in recognized creative achievements" (p. 5). According to Torrance, the three qualities of creativity, originality, fluency and flexibility, provide a theoretical framework for measuring individuals' creative thinking abilities. In the following review, these principles of creativity were investigated individually and as a whole.

Constructs of creativity. In the TTCT, Torrance specifically highlights the constructs of originality, fluency, and flexibility, but also includes "unusual perspectives" and "playing with ideas" as part of his metric (Millar, 2002, p. 31). This section will discuss originality, fluency, and flexibility, as well as the additional concepts of multiple perspectives and play as important constructs of creativity.

Originality. One of the individual characteristics of creativity is originality. "Originality is the most commonly acknowledged facet of creativity and is necessary (though not sufficient) for creativity" (Runco, 1993, p. 57). Originality, or uniqueness of thought, is a primary focus of many divergent thinking tests that seek to measure creativity. According to Runco (1999), "To the extent that tests of divergent thinking are reliable and valid, they can be taken as estimates of the potential for creative thought" (p. 577). Divergence has been described as the "distance between an idea and the initial stimulus or problem" (Runco, 1992, p. 234). Guilford (1968) described divergent thinking as "a matter of scanning one's stored information to find answers" (p. 105). It involves free association and variety of thought.

Originality is one possible outcome of divergent thinking. Guilford (1953) characterized originality as one of the primary cognitive traits related to creativity; he described originality as perceiving remote associations (divergent thinking), generating clever responses, or producing responses of low frequency in the population. Torrance defined originality as the number of statistically infrequent ideas produced by the participant (Kim, 2006). The Torrance Test of Creative Thinking is the most widely implemented and studied *divergent* thinking test, and it uses originality as one of its three measures in assessing creativity (Kim, 2006).

A number of studies have indicated pedagogical techniques that could improve the quality of originality. For example, Graham, Sawyers, and DeBord (1989) used the Multidimensional Stimulus Fluency Measure (MSFM) to assess the number of original ideas and the Adult Behavior Inventory to measure playfulness of ideas among a sample of 83 adult teachers who taught young children, and 46 university students enrolled in child development classes. Shown various scenarios, participants were asked to reply to 31 statements, evaluating themselves as to how they would respond to the situation from "very uncharacteristic" to "very

characteristic." A play disposition score was derived from this inventory. Although the MSFM scores were not significantly correlated with the playfulness score for the adult teachers, the scores for the student group were statistically significant. Students who scored high on originality also scored high on playfulness. According to these findings, the attitude of playfulness in the classroom could be important to eliciting original ideas.

Maltzman (1960) conducted a series of studies on what he termed, "the training of originality" (p. 229). The underlying assumption was that creativity could be learned according to the principles of operant conditioning and that reinforcement of uncommon responses would facilitate originality. Maltzman gave a control group an initial list of 25 words to which they replied with free associations, then a different final list of 25 words to which they replied with free associations. The control group was not given instructions or "training" (positive reinforcement for unique responses). The experimental group was presented the same treatment except that the first list was given five additional times, with instructions to give a unique response on each repetition. An additional experimental group was given the same treatment as the first experimental group except that they were told "good" after every approximately fifth uncommon response during training. Results showed that both training and instructions produced a significant increase in originality for the experimental groups.

The previous experiment was one in a series of experiments that Maltzman conducted. Maltzman, Simon, Raskin and Light (1960) examined at least two ideas: First, that operant conditioning can increase originality, and second, that the evocation of uncommon responses to a free association pretest prior to an unrelated, succeeding problem-solving task can increase originality on the succeeding task. As a result of a series of experiments testing these two ideas, Maltzman offered three recommendations: (1) The evocation and reinforcement of uncommon

responses increased the likelihood of additional uncommon responses; (2) It was as important to inhibit common responses as reinforce uncommon responses, and (3) A procedure involving repeated presentation of a list of stimulus words in a modified free association situation accompanied by instructions to give different responses to each stimulus produced conditions under which responses become more uncommon. These findings suggest that operant conditioning can have an impact on originality. The operant conditioning techniques—that is, positively reinforcing unique responses and the technique of stimulating free association ideas prior to a creative task—may improve originality when implemented in the classroom setting.

The foregoing studies have shown ways that originality might be encouraged. In summary, Graham et al. (1989) found that students who scored high on originality also scored high on playfulness. Maltzman (1960) found that using positive reinforcement of uncommon ideas increased originality. He also found that using the technique of repeating a free association list coupled with positive reinforcement had beneficial results in stimulating originality. Thus we see that playfulness, positive reinforcement, and creative techniques that precede the actual creative task can stimulate originality.

Fluency. Fluency has been described as the ability to produce a large quantity of ideas (Torrance, 1979). Studies reveal several important ideas surrounding the principle of fluency. Kurtzberg (2005) explored fluency in cognitively diverse teams. Three hundred fifty-seven participants in 119 teams of three people each from a business school negotiations course were tested. Each participant was designated by thinking style as an Adaptor or Innovator. Each team was assigned one of two sides of a simulated management-labor negotiation. An objective fluency measure was used to determine number of ideas generated. According to coders, heterogeneous teams (teams composed of a mix of participants of adaptive style cognition and

participants of innovative style cognition) produced significantly more ideas than the homogeneous teams (those teams that were all Adaptive or all Innovative cognitive styles). Since results showed that cognitively diverse teams outperformed homogeneous counterparts in fluency, perhaps instructors could evoke greater fluency of ideas by organizing their students into cognitively diverse groups. It is interesting to note that fluency in this experiment was highly correlated with flexibility and originality.

Heinzen (1989) hypothesized that moderate frustration, typically thought to undermine creativity, might have the opposite effect and enhance the production of ideas, or fluency. He studied 72 college students whose prospects for summer employment fell into three categories: (1) "No problem at all," (2) "Moderately challenging," (3) "Absolutely impossible." Each of these groups of students was tasked to generate as many ideas as possible on how to obtain summer employment. As hypothesized, Group 1 yielded the lowest mean for number of ideas, Group 2 produced the highest mean for fluency, and Group 3 generated a somewhat lower number of ideas than Group 2 but more than Group 1. The comparison between Group 1 and Group 2 was statistically significant, indicating an upward trend in fluency for Group 2, who experienced the moderate challenge. In generalizing these results, it might be possible that students would enjoy greater creativity as a result of moderate challenge included in their curriculum. Thus we see that fluency might be increased by organizing task groups into cognitively diverse teams and by introducing moderate challenge into the curriculum.

Flexibility. Flexibility has been described as the ability to move from one ideational category to the other. Flexibility may also be characterized as "as the number of categories or themes used when solving a problem" (Runco & Okuda, 1991, p. 436), or "the seeing of all the components in a problem, and not just fixating on one of the parts [making a person] much more

likely to produce a creative solution" (Runco, 1999, p. 731). The opposite is functional fixity, that is, depending upon initial, conventional, or stereotypical ideas as solutions to problems.

Runco and Okuda (1991) studied flexibility and hypothesized that there would be benefit from giving students explicit instructions designed to enhance ideational flexibility. Their experiment engaged 29 pre-college students in a creativity test adapted from Wallach and Kogan (1965). The most important outcome of the study was that flexibility scores were enhanced with explicit instructions. As a corollary, Runco and Okuda also found that explicit instructions encouraging originality improved originality scores, and explicit instructions encouraging fluency improved fluency scores. These results indicate that teachers who give specific instruction urging flexibility, fluency, or originality might trigger student creativity.

Studies by Vosburg (1998) examined flexibility in relationship to mood. She tested 68 university students by examining the quantity and quality of ideas generated in divergent thinking tasks by students with self-reported positive mood, negative mood, and alertness. Flexibility and fluency were found to be significantly correlated with a positive mood, whereas originality was not. The researcher hypothesized that each response might have needed to be given an independent and separate examination to derive a more accurate originality assessment. Overall, findings indicated that providing a positive atmosphere for learning might increase the qualities of flexibility and fluency in students.

From these studies we see that explicit instructions directed toward students urging them to use originality, fluency and flexibility in tasks can contribute to student flexibility of thought. In addition, providing a positive classroom atmosphere can increase flexibility and fluency in student creative thought.

Multiple perspectives. Traditionally, creative problem-solving methods have incorporated the practice of viewing a problem from different intellectual vantage points or perspectives (de Bono, 1992). It may also be appropriate to consider improving creative success by viewing things from different virtual physical vantage points or perspectives. In fact, viewing objects from different physical vantage points aligns with the TTCT task that requires individuals to engage in the exercise of seeing things from unusual physical perspectives. The TTCT uses this concept as one of its measureable components of creativity.

Salzman, Dede, and Loftin (1999) conducted research on virtual physical perspectives. The study included 48 high school students from an advanced physics class who were to learn complex concepts related to electric fields. Dede developed MaxwellWorld, a virtual environment that offered high-end virtual reality with advanced head-mounted displays, a 3Ball, and a Silicon Graphics Indy workstation. Students were expected to use this equipment in building electric fields.

In this study, Salzman and Dede tested the efficacy of three separate perspectives or frames of reference (FORs) found in virtual world experiences. These FORs are exocentric, egocentric, and bicentric and refer to exterior, interior, and alternating between exterior and interior, respectively. In this experiment, students were immersed alternately in all three of these virtual physical perspectives. Students investigated electric fields as an observer from the edge of the fields from the exocentric or exterior point of view. They explored the electric fields as though they were a test charge immersed within the fields, coming from the egocentric or interior point of view. Students alternated between these two FORs for successive learning activities and used the bicentric point of view. Students were to master abstract concepts related to electric

fields in this experiment. The researchers contended that each view gave different information to the learner.

In their study, Saltzman and Dede found that FORs do influence mastery of learning concepts. They also concluded that a combination of FORs has benefits for learning. This finding came as a result of giving students a mastery test that assessed student understanding of electric fields. Students were given manipulatives to demonstrate their knowledge and were also required to complete a paper and pencil test including sketches of conceptual questions. An ANOVA was applied to test scores and final data from these tests showed that the bicentric FORs facilitated learning beyond the other two FORs. A comparison showed that the bicentric group had better mastery scores than either the egocentric group or exocentric groups (F single-vs-bi $(1, 45) = 9.20$, $p = .004$). Thus, incorporating different FORs into visualization tools may help people work with and learn abstract and multidimensional information more effectively. Additionally, study outcomes are consistent with the notion that the egocentric FOR or perspective supports local information while the exocentric FOR highlights global information.

Rothenberg (1980) conducted four experiments with another type of perspective called the homospatial perspective. This perspective was tested for its potential to enhance creativity. He defined the homospatial perspective as visualizing two or more discrete entities inhabiting the same space, thereby leading to the expression of new identities. Four separate experiments were done, including samples of 43 writers, 46 writers, 43 artists, and 39 artists, respectively. The writers were randomly assigned to a control group and an experimental group. Rothenberg exposed writers to 10 different pairs of slide stimuli, with the control group viewing the slides one after the other, and the experimental group viewing the pairs of slides superimposed upon each other. The same random assignment and viewing protocol was followed for the artists,

although the artists in the control group viewed three single-image slides, and the artists in the experimental group viewed three slides superimposed upon each other. Findings revealed that participants who viewed the superimposed visual stimuli produced artistic creations that were rated significantly higher in creativity than participants who viewed the visual stimuli as separate slides. Using this type of unusual perspective may have implications for widening creative abilities for students.

Karlins, Schuerhoff, and Kaplan (1969) conducted a study that examined the effects of spatial abilities on creativity. Seventeen graduating architecture students from Princeton University were required to confer with their architecture professor at least three afternoons per week. Additionally, the bulk of each student's time was devoted to working on representing their architectural designs at their drafting desks. (Typically, architects must use a type of perspective or visualization that converts 2D objects into 3D representations.) Contact between professor and student was described as frequent and extensive. The two faculty members who spent the greatest amount of time with the fourth-year students served as raters of the students' work. Each faculty member had had at least two years of close contact with the students he was asked to evaluate. Raters were asked to rate student work on both a provided definition of creativity and on their own conception of the definition of creativity. The provided definition follows:

Rate the product of the man's work as to its creativity. Consider the implication of his work, its impact, the originality of the approaches used by the student, the comprehensiveness and novelty of the solutions, the degree to which his work has opened the way and stimulated other solutions and raised new, unforeseen problems. In short, evaluate the importance of his

work in terms of its breadth of applicability. Do not consider other aspects of his performance—only the creativity of his work. (p. 206)

Students took four tests during this experiment: the Wonderlic Personnel Test (a standard general intelligence test), the Remote Associates Test (RAT), the Surface Development Test (a spatial factor test), and the Cubes test (a measure of spatial skills). No correlation was found between intelligence and rated creativity. The RAT test was not correlated with structured or unstructured creativity ratings and the Surface Development Test results were inconsequential. However, the Cubes Test was found to be highly correlated with both structured and unstructured ratings of student creativity and student independent work. As a result, Karlins et al. (1969) claimed a link between spatial skills and rated creativity. The ability to observe or visualize objects from any vantage point and from unusual perspectives may increase spatial skills and thus, creativity.

Zovotka (1986) also discussed spatial skills that may contribute to student creativity. He noted the following four skills: (1) mentally seeing two-dimensional elements in a three-dimensional surrounding; (2) visualizing the three-dimensional environment from a two-dimensional drawing; (3) mentally rotating objects to another plane; and (4) visualizing objects in scale (p. 45). Additionally, McKim (1972) noted that perceiving height in plane, relative sizes of objects, and focus—qualities of atmospheric and linear perspective—are important spatial skills. These spatial skills might also influence creativity.

In summary, the foregoing studies indicated that, (1) Using the perspective technique of incorporating both the exocentric and egocentric point of view, or the bicentric FOR, can lead to better understanding of abstract concepts; (2) The technique of superimposing images upon each other, or homospatial perspective, can increase creativity; (3) A link exists between spatial skills

and rated creativity; (4) The spatial skills of visualizing 2D and 3D objects and visualizing various qualities of atmospheric and linear perspective may be important to consider when seeking to increase creativity.

Play. An important paradox found in creative individuals is their ability to solve problems by combining playfulness with a disciplined approach. These individuals have the ability to work very hard and persist in their efforts (usually at a level of determination rarely matched by others) yet address problems with a playful attitude. This facility allows them to engage with ideas using freedom and imagination (Csikszentmihályi, 1996 p. 4).

Research findings point to the importance of the relationship between play and creativity. Lieberman (1965) investigated the relationship between playfulness and divergent thinking, including originality, fluency and flexibility. Kindergarten students were given orally administered tests. Using a factor analysis, Lieberman found playfulness to be a singular behavior dimension that correlated significantly with the stated measures of creativity.

More creative children tend to spend more time in imaginative play (Dansky, 1980, Pepler & Ross, 1981). Amabile (1996) suggested that to reverse the behaviors of highly gifted and creative underachievers, educators should playfully engage them. Johnson (1976) observed that the direction of the effect is difficult to determine, as play may influence creative skill, or creative skill may in turn influence play, but asserted that, nonetheless, a strong connection exists between playing with ideas and producing original ones. Nickerson (2009) observed that "finding pleasure in playing with ideas" has been demonstrated in much of the thinking that scientists do and that in fact it was an act of intellectual playfulness (riding on a photon at the head of a beam of light) that eventuated in the Einstein's discovery of the Theory of Relativity (p. 329). We see then, that creative individuals often combine playfulness and discipline; that

playfulness in kindergarten students was strongly correlated with creativity; that more creative children spend more time in imaginative play; that highly gifted and creative underachievers can benefit from playful engagement; and that a strong connection exists between playing with ideas and producing original ones.

Connections among originality, fluency and flexibility. Important to the study of creativity are the ways in which the constructs of creativity work together. Torrance and Safter (1999) recognized a connection between originality and fluency and asserted that the person who produces a large quantity of ideas is more likely to produce an original idea due to the sheer numbers produced.

Snyder, Mitchell, Bossomaier, and Pallier (2004) recognized a connection between fluency and flexibility and developed a metric for scoring ideational fluency that included flexibility. Their study underscored the idea that fluency, or the number of ideas, might well take on added significance when combined with flexibility, or different categories of ideas, for overall creativity. With this in mind, Snyder et al. (2004) designed a metric, the "creativity quotient," to estimate potential for creative thought. They defined creativity as "the ability to link seemingly disparate ideas into a novel synthesis" (p. 2). Snyder et al. (2004) hypothesized that more creativity was involved in the suggestion of new categories by Participant A than the suggestion of additional uses within the same category by Participant B. The researchers of this study did not conduct any statistical analyses but merely examined their theoretical construct in a real-world setting and found that fluency, or the number of ideas, might well take on added significance when combined with flexibility, or different categories of ideas, for overall creativity.

Fleming and Weintraub (1962) found connections between originality, fluency and flexibility. In an effort to identify creativity in gifted children, these researchers studied 68 academically talented elementary school children by giving them a battery of verbal and nonverbal creativity tests. They discovered a moderate inverse relationship between verbal creativity scores and attitudinal rigidity scores, indicating that students who are less rigid tend to be more creative (verbal creativity score: $r = -.41$, significant at the .01 level). A related discovery revealed that the creativity subtests of originality, fluency, and flexibility correlated with each other in the same order of magnitude as the rigidity score did with the overall creativity score, indicating a similarity between the subtests (originality, fluency, and flexibility were significantly correlated with rigidity at $r = -.37, -.40,$ and $-.32$ respectively). This information might suggest that teachers should use appropriate methods to create a positive, relaxed atmosphere for student learning—thus perhaps diminishing rigidity—to increase creativity.

Shaw and DeMers (1986) found originality, flexibility, and fluency to have a connection to imagery in their study of 138 elementary students. Students from the experimental group numbered 54 and were participating in a program for academically gifted students. Students from the control group numbered 84 and came from four regular classrooms. According to Shaw and DeMers, since creative abilities have been shown to be more likely to exist above an IQ threshold of about 115, the researchers used students above that level for their study, and students from regular classrooms for the control group. Tests for IQ were obtained for each group.

Researchers investigated relationships between selected measures of visual imagery with originality, flexibility, and fluency. Using both verbal and figural tests, they tested 54 high IQ (

>115) fifth to sixth graders and 84 normal IQ children. Units of both of these tests correlated

with the following imagery tests: Vividness of Visual Imagery Questionnaire, Visual Memory

Test, and Test of Visual Imagery Control.

Findings indicated that the Just Suppose originality scores correlated with VVIQ and

TVIC very significantly in the high-IQ group (VVIQ = p <.0001 and TVIC = $p < .0002$) but non-

significantly with the comparison group. For flexibility scores, a similar pattern emerged. The

VVIQ correlated significantly with the flexibility scores of both the Just Suppose and the Circles

creativity tests (Just Suppose = $p < .049$ and Circles $p < .0001$), while no significant correlations

were found in the comparison group. Fluency scores differed somewhat. In the high-IQ group,

the VVIQ correlated significantly with the fluency portion of the Circles Test ($p < .0006$). A

significant correlation was discovered between the fluency score and the VMT in the comparison

group ($p < .005$); however, this was the only instance in which visual memory correlated with

one of the creativity variables. According to Shaw and DeMers, this finding suggests that

memory for images may be important to fluency for children in the comparison group but not for

children in the high-IQ group. Overall, creative thinking in terms of originality, fluency, and

flexibility were linked strongly or moderately strongly with imagery, and these links occurred

more often and more strongly with the high-IQ group than with the comparison group.

Hocevar (1979) also alluded to the interconnectedness of originality and fluency in a

study using Guilford's tests of divergent thinking. Hocevar asserted that fluency might be a

confounding factor in the measurement of originality since the characteristics appear to overlap

and there appears to be a lack of discriminant validity between them. This idea may lead to the

conclusion that creativity is a unitary function. However, though Hocevar stated that his findings

suggest a lack of statistical evidence of differentiation between originality and fluency, he

qualified his findings with the acknowledgement that the delineation of the three qualities is used in *most* theories of creativity. Hocevar cited Hammaker, Shafto, and Trabasso (1975) as using the distinction amongst all three categories in judgments of creativity. For these two reasons, Hocevar conceded that the distinction is a "worthwhile one" (p. 194). Runco and Albert (1985) noted, "Hocevar relied on one type of test method (verbal) and one scoring procedure and employed only non-gifted individuals as subjects" (p. 485). Thus, although a limited test gave some indication of an overlap between originality and fluency, it is still unclear as to the extent or existence of that overlap. Scholars believe that there could be a difference between these qualities, and various theories of creativity (Torrance, 2000) distinguish originality and fluency as separate categories.

The foregoing studies have shown the characteristics of creativity to be both complex and related. In summary, Fleming and Weintraub (1962) studied the complexity of creativity and discovered a mild inverse correlation between creativity and rigidity. Snyder et al. (2004) investigated how fluency and flexibility are related, and hypothesized that more creativity was involved in the suggestion of new categories than the suggestion of additional uses within the same category. Shaw and DeMers (1986) found a similar magnitude of correlation between creativity and visual imagery for all three categories of originality, fluency and flexibility. They found the link between creativity and imagery strongest with high-IQ children. Torrance and Safter (1999) and Hocevar (1979) all indicated that some overlap between originality and fluency may exist, but also affirmed the usefulness of examining the widely accepted categories of creativity, originality, fluency, and flexibility separately.

It has been useful to examine the interconnection between creativity's individual characteristics. This information might allow researchers to interpret data more accurately as

well as be sensitive to potential statistical confounds that may arise from category overlap. This information regarding creativity constructs might also help educators guide students toward creativity more effectively.

Bridges and Barriers to Creativity in the Classroom

After reviewing the separate and collective qualities of creativity and teachers reported creativity in the classroom through academic studies, we now turn our attention to examining how teachers have observed and encouraged these constructs anecdotally and qualitatively in the classroom.

In October 2009, the European Commission conducted a large, multi-site study of creativity analyzing 7,659 surveys from teachers originating from 32 countries (Cachia et al., 2010). Although no unanimous agreement emerged, the study did reveal some strong indications of conditions that seemed to foster or block creativity in school settings based on teacher observations.

According to teachers participating in this study, environments that built bridges to creativity valued (a) divergent, original thinking; (b) play, exploration, iteration, imagination and elaboration; (c) space and time to reflect, think, create; (d) experiential learning; (e) inquiry/problem based lessons; and (f) activities involving multiple perspectives/spatial awareness. The findings of Sternberg and Williams (1996) aligned with the European Commission results. They also added that fostering creativity in educational settings should include imagining other viewpoints. Hennessey and Amabile (1987) made observations that coincide with these teachers' observations regarding play and imagination and suggested opportunities for free play with various materials and engagement in fantasy as important in fostering creativity. Nickerson (2009) included offering "activities they have chosen for

themselves rather than activities that have been selected for them by others" (p. 416) as important to increasing student creativity.

According to teachers in the European Commission study, environments that posed barriers to creativity included (a) teacher- versus student-centered curriculum, (b) fact-based, over-loaded curricula, (c) overly disciplined approaches that discourage play and risk taking, (d) traditional assessment methods based on memorization, (e) emphasis on knowledge acquisition, and (f) rewards for conformity. McCoy and Evans (2002) stated that "a rigid environment in which conformity is apparent, that has boundaries not intended for change or manipulation, and that overtly exhibits restriction and rules would be inimical to creative behavior" (p. 411). Amabile (1989) observed that competition and restricted choices are creativity barriers for students; Amabile also found that environments valuing the status quo are in direct conflict with conditions that enhance creative behavior.

Virtual Worlds

One environment that may indicate a departure from the status quo is the virtual world platform. Various versions of virtual worlds have been part of the digital landscape since 1970. As the technology supporting virtual worlds has evolved, so has their definition.

Definition. Bartle (2003), who co-wrote the first text-based multiuser world in 1979, described this technology as a shared world or self-contained environment (p. 4). By the 1990s, virtual world developer Koster (n.d.) added the idea of persistence (that is, the world continues to exist even when the participant has exited it) to the initial definition. Castronova (2005), author of multiple articles and books on virtual worlds, offered another element, explaining that virtual worlds are "crafted places inside computers that are designed to accommodate large numbers of people" (p. 4). Bell (2008) added two final components by describing the users' digital

representation, an avatar, as a "graphical representation beyond a simple label" and included the importance of networked computers. Bell ultimately arrived at the following definition of a virtual world: "A synchronous, persistent network of people, represented as avatars, facilitated by networked computers" (p. 2).

Different forms of online education. In reviewing the literature, the term *virtual education* is often used loosely to refer to a variety of online educational approaches that use a broad spectrum of technologies. It is important to clarify the specific characteristics of both virtual education and *virtual world education*.

Virtual education. Although often used interchangeably in the literature with virtual world education, the term virtual education generally refers to education that uses various technologies to provide online learning opportunities for students. Other terms often applied to this approach to education are distance education, online education, and e-learning. There have been recent efforts to enliven and strengthen online education with more interactive technology including web cam technology. Students participating in some distance online education courses, however, are confronted with a preponderance of text and limited interaction with colleagues or professors. Muirhead (2004) described these instructional experiences that lack dynamic interactivity as "wooden and lifeless," leaving educators and their students disillusioned with the process (p. 4). It is possible that virtual world education could improve these less collaborative, text intensive courses.

Virtual world education. Bell (2008) offered some insights into this current immersive technology:

Virtual worlds offer an awareness of space, distance and co-existence of other participants found in real life spaces, giving a sense of environment. The concepts of "near" and

"far" are difficult to apply to something like *CNN.com*, but not *Second Life*. The greatest difference between these entities is that pages of a website, even when shared, do not constitute a navigable landscape, but rather a walled finite space. Virtual worlds however, regardless of scale, offer participants a sense of geography and terrain. (p. 3)

Courses taught in a virtual world provide at least four conditions that distinguish them from typical virtual education experiences. First, synchronous collaboration can occur with all classmates and teachers simultaneously, allowing for full class collaboration in a 3D environment as opposed to a 2D website. Second, a feeling of embodiment and psychological immersion or presence in specific spaces is experienced via a moving avatar representation. Third, the power to influence and interact with the environment, a navigable terrain with multiple sensory stimuli is offered, allowing for experiences not reproducible in the physical world classroom or typical virtual education experiences. Fourth, countless choices that allow for rapid iteration and nearly unlimited experimentation are available in the virtual world setting.

Synchronous collaboration. The synchronous collaboration previously noted as vitally important to student learning (Muirhead, 2004) is achieved in virtual world educational platforms in part by real time, 3D voice and text/chat capabilities. Virtual worlds have emerged as highly social platforms, and entities like Second Life have millions of active users. According to a 2011 report by KZERO, a virtual world marketing analytics firm, Second Life currently has 30 million registered users (see Figures 1 and 2). KZERO analytics research reveals that as of Quarter 4 of 2011, there are 1 billion, 772 million registered users of virtual worlds (see Table 2).

Kalyuga (2007) identified a key feature of complex interactive environments as their responsiveness and described multi-user virtual environments [virtual worlds] as, "rich, inquiry-based, collaborative interactive e-learning environments that involve feedback, manipulation,
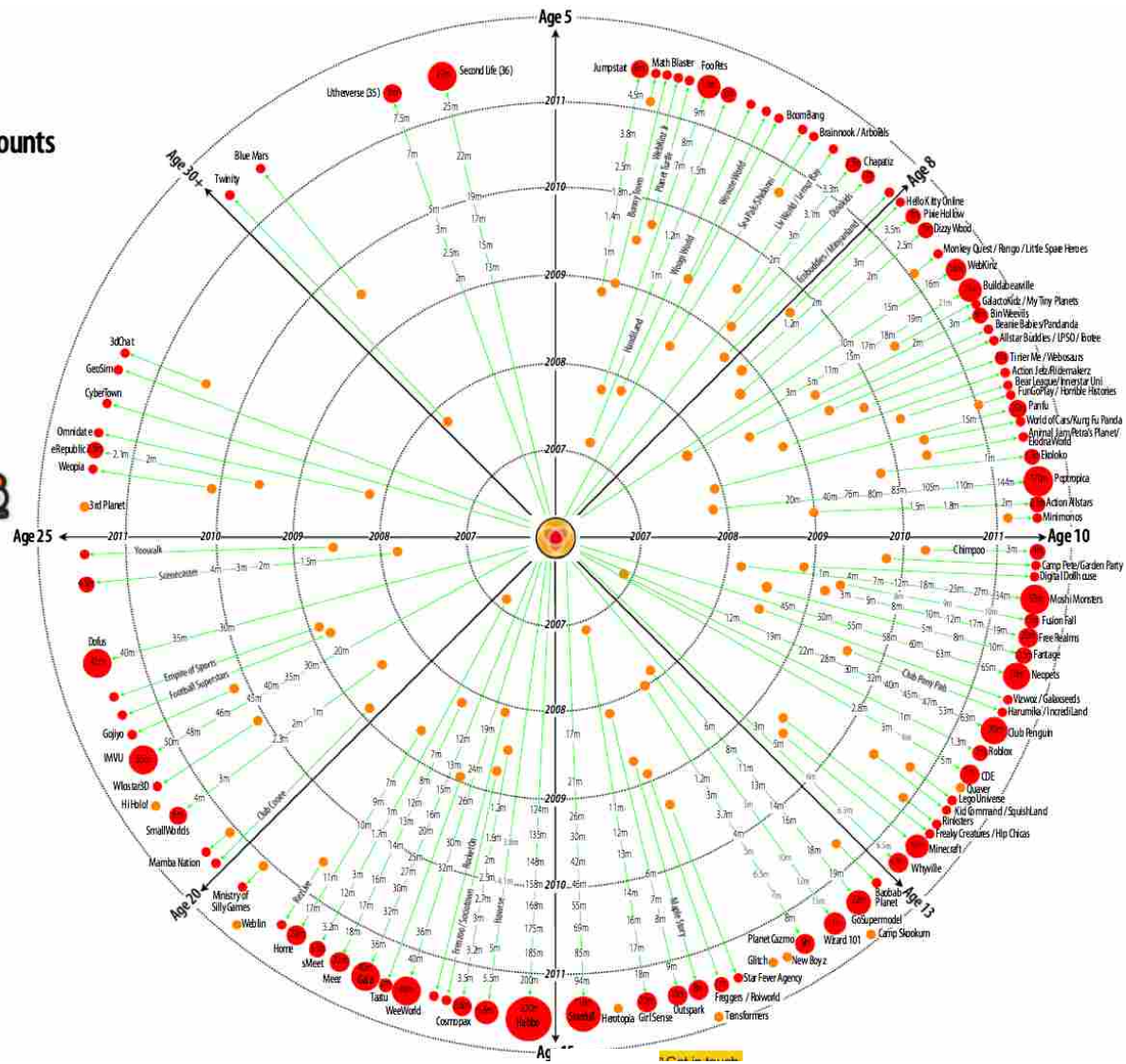
Figure 1. Virtual worlds by size, with date of inception and number and age of users. Reprinted from KZERO (2011).
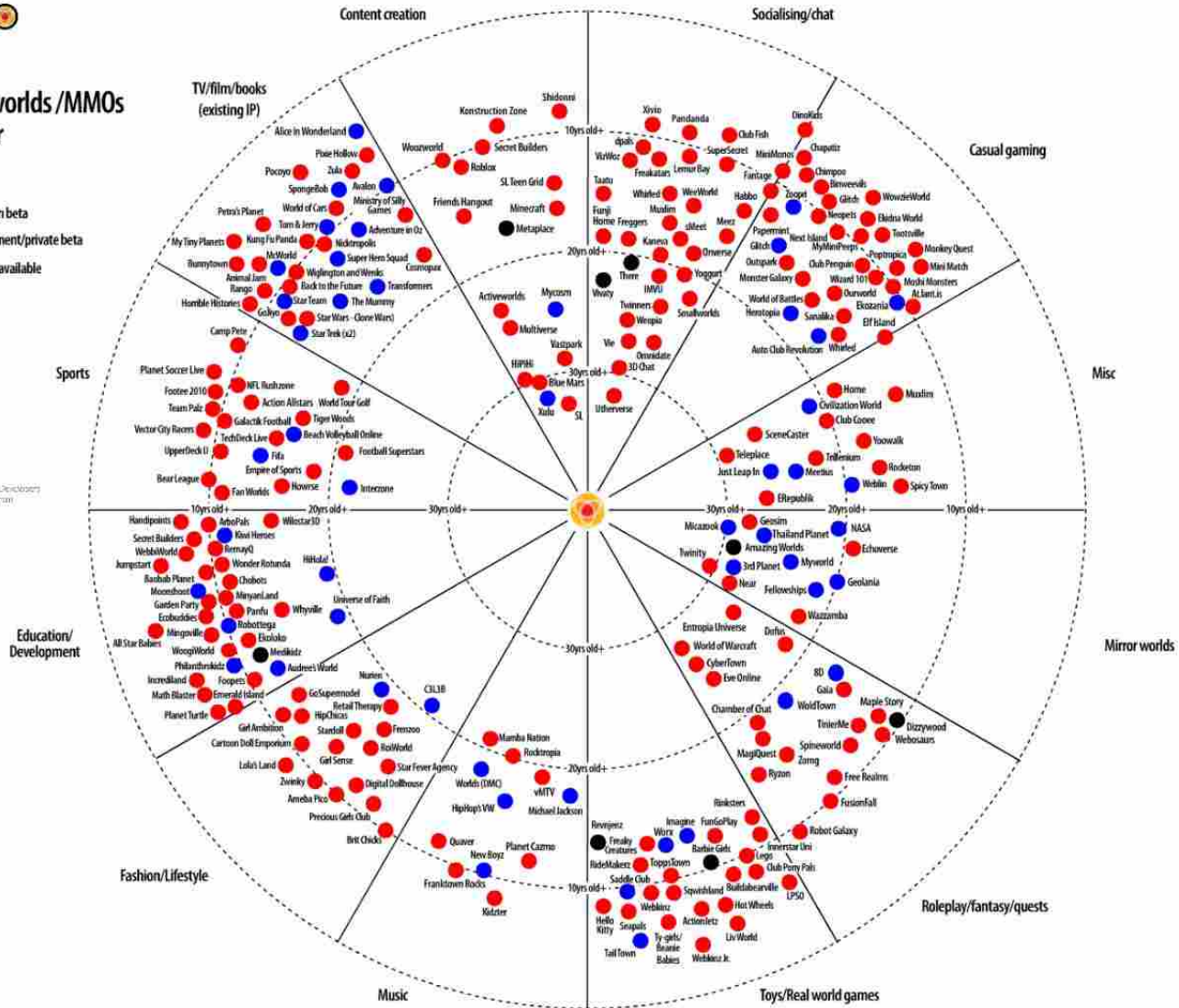
Figure 2. Virtual worlds by market sector, with availability status as of 2011 and age of users. Reprinted from KZERO (2011).

Table 2

Cumulative Registered Virtual World Accounts (in Millions) for 2009, 2010, and 2011, by Age of Users

Age range	2009				2010				2011			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5–10	77	114	152	179	190	211	219	235	232	270	296	340
10–15	246	334	367	392	413	444	468	511	601	652	694	787
15–25	73	99	117	193	237	273	228	299	313	385	456	596
25+	18	21	23	25	27	30	34	36	39	42	44	49
Total	414	568	659	789	867	958	1,009	1,081	1185	1,349	1490	1,772

Note. Adapted from KZERO (2011).

and communication levels of interactivity" (p. 393). Important for upper levels of communication interactivity and responsiveness, Kalyuga recommended that synchronous or asynchronous communication amongst learners and between learners and instructors be included. Both of these aspects of communication are found in most virtual world platforms.

Another part of the collaboration and sociality experienced by students participating in the virtual world platform derives from social co-presence and a sense of shared experience in a 3D environment. In a mixed methods study in the virtual world Second Life, Jarmon (2009) found that students repeatedly referenced the immediacy of the experience of embodied social connection as well as the tangible nature of the 3D experience as important to their learning. In Jarmon's (2009) study, as students navigated through the 3D environment and used 3D building tools to complete the assigned housing project with individuals across disciplines and across geographic boundaries, a sense of shared presence and shared experience emerged.

In sum, the virtual world platform facilitates students' ability to meet synchronously in a 3D environment and allows for full class collaboration. Real-time, 3D voice and chat capabilities provide upper levels of communication interactivity and responsiveness amongst learners and between learners and instructors. In general, the virtual world platform offers a sense of presence and shared experience due to embodiment and the 3D qualities of that environment.

Immersion. According to Heeter (1992), *immersion* is the impression that one is participating in a realistic experience. Dede (2005) asserts that virtual worlds allow for this sense of immersion. Virtual world participants feel immersion by experiencing things with what Jarmon (2009) identified as virtual *bodily presence,* (the feeling that you are there), that allows for experiential and embodied reality. The virtual body allows for "virtual face-to-face

interaction . . . virtual movement and alignment, virtual gaze direction, virtual touch, virtual proximity and a whole range of multimodal communicative resources" (Jarmon, 2009, p. 4). Virtual world participants also feel immersion as a result of virtual *place-presence* or the sense of being immersed in a specific location. Jarmon (2009) asserted that 3D virtual worlds create an enriched sense of place. According to Prensky (2001), the sensory furnishings or ambience information of virtual worlds creates an immersive experience that encourages sustained interest.

Another aspect of immersion that can be experienced in the virtual world is the embodiment of knowledge. Sanchez, Barreiro, and Maojo (2000) claimed that virtual worlds' enhanced interfaces particularly attend to the concept of embodying the knowledge to be taught. They stated, "most of our knowledge relies on basic metaphors derived from our bodily experiences" (p. 345). Lakoff and Johnson (1999) argued that the mind and the body cannot be conceived of separately:

> Reason . . . arises from the nature of our brains, bodies and bodily experience.
> This is not just the innocuous and obvious claim that we need a body to reason;
> rather, it is the striking claim that the very structure of reason itself comes from
> the details of our embodiment. The same neural and cognitive mechanisms that
> allow us to perceive and move around also create our conceptual systems and
> modes of reason. Thus, to understand reason we must understand the details of
> our visual system and our motor system. (p. 4)

> According to Sanchez et al. (2000), "Our learning and our understanding, then, are

structured in terms of concepts framed by our bodies" (p. 359).

Virtual bodily presence allows participants to conceptualize knowledge in ways that are unavailable (due to cost, time, safety, or feasibility) in the physical world. Johnson and Levine

(2008) described such conceptualization of knowledge in a physics lesson taught in the virtual world:

In a world where scale and form can be manipulated at will . . . where setting can be modified and adjusted endlessly, it is possible to imagine entirely new learning experiences that are not possible in any other medium. . . . Imagine a lesson in particle physics being delivered by Einstein—at the scale of a photon! (pp. 163–164)

Thus we see that immersion (the impression of being in a realistic experience) and presence (the feeling of being there) are part of the virtual world experience; that presence and place-presence occur as a result of rich environments and realistic virtual bodily functions; that knowledge is framed through bodily understandings; and that virtual worlds allow knowledge to be embodied as in the participant becoming a part of the object to be understood such as a photon. Overall, immersion and presence allow for 3D experiences and 3D visualization that are not easily reproducible in the traditional classroom.

Influence on environment. Students learning in virtual worlds have the power to immediately influence and interact with an extensive environment. Virtual worlds offer the capability of navigation of environment that gives an awareness of space and allows exploration of various terrains and natural settings (hillsides, beaches, mountains). This capability was an important feature in the River City Project, a virtual world created by Harvard researchers. Ketelhut, Dede, Clark, and Bowman (2006) studied student data-gathering in a realistic virtual setting (a replicated 19th-century city) to provide authentic scientific inquiry for middle school students. As part of a science unit, students were tasked to solve the problem of contamination of the city's water supply. The city had a river running through it and different types of surrounding terrain that would influence water runoff. Navigation and exploration of an

authentic environment were integral to the effectiveness of the student learning process. The virtual world setting allowed students to experience situated learning in an authentic, complex environment where students interacted with that environment and conducted scientific inquiry effectively.

An additional feature of virtual worlds is the capability of modifying the environment (or the participant) to better understand complex concepts. For example, avatars can scale to any size to acquire knowledge about spatial relationships. Additionally, the environment may be modified by use of the building tool that allows various objects to be created important to learning. For example, architecture students can use the building tool to design 3D buildings, allowing them to visualize the spatial requirements of their objects. As was discussed earlier, these virtual world tools may have a positive effect on spatial abilities that might positively influence creativity.

In summary, participants can transact with the virtual world environment in a number of ways that are conducive to positive learning and potentially creativity, including navigation, communication, observation, creation, and modification.

Choice and choices. As previously noted, one of the factors that might facilitate creativity in educational settings is the presence of choices (Amabile, 1989; Nickerson, 2009).

Amabile (1989) discussed the importance of both choice and choices. To foster creativity, she recommended giving students choice, or agency, whenever possible. She also recommended providing as many different kinds of choices as possible in terms of materials or objects for accomplishing tasks. Amabile cautioned that students do need some guidance in their choices, perhaps in the form of a general outline of how to accomplish the task. Amabile and Gitomer (1984) found that children who were given choice in terms of which task materials to

use in creating a collage, produced collages that were evaluated as being more creative than those produced by children who were given no choice. In a model of creativity and innovation for organizations, Amabile (1988) suggested creativity was hindered where choices were restricted in terms of approach or working materials. Additional evidence of the importance of choice and choices was found in the preschools in Reggio Emilia, Italy. In this city, children are surrounded by Italian masterpieces and a rich artistic heritage, and some of the best preschools in the world. A system for education with an emphasis on creativity grew out of this tradition and became known as the Reggio Emilia approach to education. Edwards and Springate (1995) reflected on the principles employed in this system, including the importance of choice and choices. In all, they recommended offering children rich resource materials that were self-chosen.

Chua and Iyengar (2008) proposed a caution regarding choices. They warned that too many choices might cause choice overload, thus hindering creative behavior. They asserted that two factors seemed to influence creativity regarding number of choices offered: the prior experience of the participant and the explicit instruction to be creative. They found that if a large set of choices was given to an individual inexperienced in the task at hand and if the individual was not instructed to be creative, that creative behavior was not induced. However, if a large set of choices was given to an individual with previous experience and the instruction to be creative, creative behavior was produced. In summary, student creativity appears to be impacted by both the choice of activity and the provision of optimal materials within limits.

As choice was investigated in traditional and virtual world learning environments, some fundamental differences were found. The physical classroom offered the following: (a) hands-on choices, such as physical manipulation of objects; (b) direct physical application of choices onto

objects; (c) sense of touch when working with objects; and (d) various real-world experiences. By contrast, the virtual classroom offered (a) greater numbers of choices and immediacy of transformations that can be applied to those choices; (b) more rapid creation and deletion of choices; (c) the ability to immediately apply scale and various gravity properties to choices; and (d) the ability to interact in multiple ways with choices unique to virtual environment capabilities (flight and circumnavigation, for example).

In the virtual world setting, digital functions allow for a wide array of choices with immediate creation and deletion capability that may facilitate student experimentation. The unlimited nature of digital materials may also facilitate students taking more risks than they otherwise would with classroom materials that may be limited in supply. According to Loveless (2002), opportunities to take risks and make mistakes in a non-threatening atmosphere was a key consideration in stimulating creativity. He further remarked that digital technologies offer a wide range of activities and tools for learners, from interactive whiteboards to virtual spaces in which students can exchange ideas and collaborate on projects, assisting in producing conditions favorable to creative behaviors.

One of the tools found in the virtual space is the builder tool. Students can use it collaboratively or individually. The building tool is used for the creation and modification of objects. Participants are given choices of shape, color, scale, and rotation with this tool and can use it to create objects for the environment and then interact with that object (fly over it, walk upon it, lift it up, etc.). This tool allows for many choices that might enhance creativity. As previously noted, Chua and Iyengar (2008) asserted that the confluence of three factors, prior experience, the instruction to be creative, and many choices resulted in creative behavior. Because typically, students participating in the virtual environment have had prior experience

with technology and can be instructed to be creative, creativity might be enhanced rather than dampened with the multitude of digital choices. In addition, because these choices appear in a one-at-a-time format and participants continue making additional choices only as interest prompts them, this may allow conditions favorable to creative behavior. Kalyuga (2007) suggested that "step-sizes and rates of presentation . . . learner controlled [are important] to ensure that the capacity of the Working Memory is not exceeded" (p. 398).

In synthesis, it was determined that choice and choices were foundational elements in fostering creativity; that rich resource materials and guidance in their use was important; that the intersection of prior experience, directives to be creative and the option of many choices produced creative behavior; that the physical classroom and virtual classroom offered qualitatively different kinds of choices; and that learner-moderated choices regarding size and rate of choices were important considerations in ensuring effective learning conditions.

Creativity constructs and virtual world education. The creativity constructs of originality, fluency, flexibility, multiple perspectives, and play might be positively influenced in the virtual world setting.

Originality. As previously noted, one exhibiting originality has been characterized by Guilford (1953) as having the ability to generate clever responses or produce responses of low frequency in the population. One affordance that is offered in the virtual world that may encourage originality is avatar customization, an example of the "mini-c" creativity explained by Beghetto & Kaufman (2007). Students are able to use various digital resources to create an original, unique persona. For example, students can design their appearance using a wide array of qualities (eye color, skin tone, hair color and style, various types of clothing), and freely combine them to produce clever, one-of-a-kind representations. Because the number of avatar

traits is numerous and can be combined with exponential effect, few avatars will look exactly alike, resulting in products that are of low frequency in the population. Additionally, since this creation process is rapid, iteration is facilitated and possibly fluency. Originality may be increased as a result, as fluency is highly correlated with originality since the likelihood of producing an original idea increases proportionate to the number of ideas generated (Simonton, 1990).

As indicated by Graham et al. (1989), playfulness has been linked to the increase of originality. The activity of designing and customizing the avatar might be considered playful and therefore might have a positive effect on originality. When participants experience the outcomes of their experimenting efforts immediately, this may act as a positive reinforcement agent, as described by Maltzman (1960) as having beneficial effects on originality.

Fluency. Fluency has been described as the ability to produce a large quantity of ideas (Torrance, 1979). The creation of a large quantity of ideas might be facilitated in the virtual world environment through at least five affordances: the builder tool, the avatar customization tool, movement options, landscape options and communication options.

The virtual world builder tool used in this study presents participants with a wide array of digital building materials; several shapes; and 255 different shades each of red, blue and green, and as many degrees of opacity to apply to these shapes. The builder tool scale capability offers 50 different sizes of objects that can scale along 3 different axis points, x, y, and z coordinates, and a rotation capability that allows all objects to be rotated 360 degrees in three different directions.

In addition to the options contained in the builder tool, participants in the virtual world environment are also offered multiple options using the avatar customization tool (as previously

detailed) and many options of which landscapes, movements, and communication methods they will use. For example, movement options include flying, hovering, walking, running (and completing those movements backwards), jumping, sitting, raising the hand, and teleporting. Communication options include chat (typing text in a chat window), live 3D positional voice, (allowing participants to navigate amidst sound cues), global voice, and writing on a collaborative whiteboard. Landscape options include beaches, museums, rural areas, mountainous areas, classrooms, amphitheaters, outdoor art exhibits, and so forth. The multiple items included in the initial set of elements in each of the mentioned categories provides raw material for an increase in ideational fluency. In addition to providing ample fodder for ideas, the virtual world's digital affordances produce a quick response from the time a participant requests an action to the realization of that request. This allows for a corresponding rapid iteration process. Participants are able to generate many ideas rapidly which might well increase ideational fluency.

Flexibility. Snyder et al. (2004) noted that a creative act would "link seemingly disparate ideas into a novel synthesis." They connected the categories of fluency and flexibility in their analysis, and stated that creativity would be benefited not only with more ideas (fluency) but more ideas in different categories (flexibility). This might be accomplished in the virtual world environment by both the many numbers of possibilities available and the many different categories of possibilities available, as noted in the previous discussion.

Chua and Iyengar (2008) gave added insight into flexibility as it relates to choice:

The larger the choice set of initial elements, the more flexibility there is in the generation of different combinations. This gives rise to a richer set of potential solutions from which one can later choose. For example, when a chef is given 10

possible ingredients from which to create a new dish, he or she will have greater

combinatorial flexibility than when given just three ingredients. (p. 165)

Simonton (1999) stated that the more combinations one can generate from the initial elements,

the higher the chance that a new a useful (creative) product will emerge (p. 86).

Studies by Vosburg (1998) examined flexibility in relationship to mood and found that

providing a positive, relaxed atmosphere for learning might increase the qualities of flexibility in

students. Since virtual worlds provide environments including expansive landscapes with

soothing ambient sounds, it is possible that students would find this to be a positive, relaxed

atmosphere in which to learn, thus increasing ideational flexibility.

Multiple perspectives. As noted in a prior discussion, creative problem-solving methods

have incorporated the practice of viewing a problem from different intellectual vantage points or

perspectives (de Bono, 1992). In considering how to increase creativity via the virtual world

setting, it might also be appropriate to consider improving creative success by viewing things

from different virtual physical vantage points or perspectives. It is hypothesized in the current

study that creative thought might increase in an environment that supports multiple virtual

physical perspectives and develops spatial skills.

Salzman and Dede (2010) found that incorporating appropriate FORs (Frames of

Reference or perspectives) into visualization tools aids student learning. Virtual world

environments allow students via their avatars to experience these different FORs (egocentric,

exocentric and bicentric). This setting allows students to view many different perspectives,

different angles, and vantage points of the physical landscape by flying around, above,

circumnavigating objects.

Torrance (2000) incorporated unusual perspectives as one of his measures of creativity. In a study involving 144 high school students who were tested in 1950 for their creativity and then were later tested as adults to assess their Quantity of Creative Achievements, Quality of Peak Creative Achievements and Creativeness of Aspirations, Torrance (1972) found that unusual visual perspective responses were statistically significantly correlated with all three areas at better than the .001 level, whereas common perspectives showed no statistical correlation to adult creativity.

Karlins et al. (1969) found spatial abilities to be linked to creativity. Virtual world capabilities allow students to experience space in three dimensions, near and far, and from different types of perspectives, such as from an ant's perspective or looking up from underneath objects, to a bird's eye perspective or looking at the tops of buildings and sculptures. Students can also understand the scale of items in relationship to the scale of their avatar. For example, a student avatar is able to stand next to the painting "The School of Athens" by Raphel and immediately experience the enormity of that work by comparing the scale of their representation to the scale of the work, whereas, a student in the traditional classroom viewing the same painting in a book would not be able to experience the difference in scale from person to painting.

Zavotka (1986) found that spatial skills important to student creativity included such things as mentally seeing two-dimensional elements in a three-dimensional setting. The virtual world allows students to experience this 3D effect, as well as to concretize this concept via the builder tool. Students can design their idea and build it in three dimensions. Since virtual world capabilities have the potential of amplifying stated spatial skills, this may in turn amplify students' creative efforts

McKim (1972) noted as important spatial skills the perception of height in plane, the perception of relative sizes of objects, and the perception of focus (qualities of atmospheric and linear perspective). Because spatial skills are closely associated with creativity (Karlins et al. (1969), it is possible that advanced virtual world graphics that depict these qualities of atmospheric and linear perspective might facilitate an increase of creativity.

Play and serious games. As noted previously, research findings point to the importance of the relationship between creativity and play (Amabile, 1996; Dansky, 1980; Csikszentmihályi, 1996; John, 1976; Lieberman, 1965; Pepler& Ross, 1981). The play and exploration important to fostering creativity has also been investigated in the video game setting. In 2002, the Serious Games Initiative declared that video game technologies should be focused on productive uses in the fields of education, training, health, and public policy. Michael and Chen (2006) defined serious games as "games that do not have entertainment, enjoyment or fun as their primary purpose" (p. 21). Susi, Johannesson, and Backlund (2007), expanded that definition, stating "serious games allow learners to experience situations that are impossible in the real world for reasons of safety, cost, time, etc., but they are also claimed to have positive impact on the player's development of a number of different skills" (p. 1).

Researchers characterize intrinsically motivating learning environments as having challenge, curiosity, fantasy, and control, qualities generally acknowledged as part of creative environments (Lepper & Malone, 1987; Malone, 1981). According to Rieber (1996), "games represent the instructional artifact most closely matching these characteristics. Fantasy is used to encourage learners to imagine that they are completing the activity in a context in which they are really not present" (p. 1). Virtual world settings allow participants to visit locations that do not actually exist, but in which they feel fully immersed and present.

Goor and Rapoport (1977) studied the effects of games on creativity, providing additional evidence of the strong association between creativity and games. These researchers involved 94 disadvantaged students who spent 4 hours per day in creativity games (experimental group) and 48 students who participated in regular recreational activities for 4 hours per day (control group). Results showed the experimental group as having significantly higher creativity scores than the control group. These results might indicate both the efficacy of training in creativity and the efficacy of using games in advancing creative thought. Interestingly, long-range follow-up testing showed significantly higher results for creativity in the experimental group than in the control group, and experimental group students noted that they continued to enjoy playing the games long after the camp had ended. Evidence seems to indicate that games influence students' creativity.

de Freitas (2006) forged a strong connection between serious game play and immersive virtual world education. In an extensive report detailing learning in virtual worlds, de Freitas called these environments "games for learning" and defined them as "applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences" (p. 9).

Hamlen (2009) investigated the connection between video game play outside of class and in-school creativity. Hamlen surveyed two groups of upper elementary students as to their outside-of-class video game habits. The Torrance Test of Creative Thinking Figural and Verbal were used to analyze the connection between amount of time spent, and with whom participants played video games outside of class, with the stated measures of creativity. Although this particular study found neither a negative nor a positive effect of outside-of-class video game playing on in-school creativity, Hamlen suggested the following:

Even if children's general creativity and video game play are not related, there

may be relationships between their ability to solve problems in creative ways and

the types of video games they play. In addition, because of variation in strategies

used, future research should investigate differences in approaches to learning

based on video game play habits. (p. 19)

The video game play habits that Hamlen (2009) suggested studying included (1)

connecting to other participants via computers and the Internet, (2) representing themselves by

an avatar or character, (3) participating in game or game-like activities, (4) navigating space and

exploring terrain, and (5) solving problems or completing tasks. These activities are common to

both online video gaming and virtual world education. Hamlen concluded that while there is as

yet tentative evidence of the relationship between video game play and creativity, since video

game play has been shown to have a significant influence on other forms of cognition, this

"allows for the possibility that video games may also influence additional cognitive constructs …

such as creativity" (p. 19).

Efficacy of Virtual World Education

Given the relatively recent advent of virtual world education, few studies have been

conducted on the specific topic of creativity in the virtual world setting. However, the literature

did reveal several studies about virtual world education in general, overall learning outcomes in

the virtual world and a few touched on creativity.

Learning outcomes. The literature revealed both negative and positive outcomes of

virtual world education. Although a great deal of information was found regarding the negative

effects of excessive recreational gaming in virtual worlds (Tazawa, Soukalo, Okada, & Takada,

1997), less literature was found on the negative effects of virtual world education. Some of the

potentially negative aspects of virtual world education included possible biased cultural perceptions might occur in the virtual world setting that pass on stereotypes to young learners (Jung, 2002). Kirriemuir (2002) described additional teacher workload that occurs from learning new technologies as a negative aspect of virtual world education. According to Grohol (1999) students who spend too much time in the virtual world may retreat from the real world into a social isolation. These possible negative effects must be considered when using virtual world technology for education.

Researchers also discussed the positive aspects of virtual world education and its desirability for overall learning outcomes. Vogel's 2006 meta-analysis of 32 empirical studies showed that the use of interactive simulations and games resulted in higher cognitive gains when compared to traditional instruction. An extensive survey conducted by Kim and Bonk (2006) showed that of the technologies most likely to significantly affect the university sector, simulations and [virtual] games are seen as being increasingly important.

Barab et al. (2005) reported another positive finding for virtual world education in their 3D multi-user virtual environment (MUVE) video game called Quest Atlantis. These researchers designed a virtual world that incorporated hundreds of quests for student learning and asserted that transformational play was at the center of these quests. Barab noted, "The fact that we found statistically significant learning gains with respect to science, social studies, language arts, and meta-cognitive skills does indeed suggest that academic learning was occurring alongside of or in the process of the experience of playing" (p. 19). Arici (2008) conducted an experimental study involving sixth grade students and their use of Quest Atlantis. The treatment group studied water quality through the MUVE, while the comparison group used more traditional learning strategies. The results from this randomized controlled trial indicated a

statistically significant gain in achievement by the MUVE treatment group in comparison to the control group. The gain was sustained over time as evidenced by a delayed posttest.

In another study, Esteves, Fonseca, Morgado, and Martins (2009) found that learning computer programming languages in the virtual world Second Life was particularly efficacious in that environment. Esteves et al. (2009) noted that certain aspects of programming require a higher degree of abstraction and because virtual world technology supports metaphors, concrete visualization and immediate visual feedback, SL became a positive environment for students learning programming skills. Researchers also found that student success was facilitated in SL since that environment allowed for persistent, synchronous or asynchronous situated collaboration using 3D objects. Students experienced an additional benefit by using the SL virtual world technology to collaborate with other students internationally.

Another positive finding was reported in the virtual world environment called *Supercharged!* co-developed by award winning NASA physicist John Belcher (2003) and researchers from MIT. This environment was designed to help students better understand electromagnetic concepts. Belcher asserted, "Animations help my students visualize vector fields and other electromagnetic phenomena that they have a hard time conceptualizing from just the mathematics" (p. 515). Belcher conducted a study involving 90 middle school students. Students took a pretest prior to the presentation of the content, and then a posttest. A two-way ANOVA was calculated and a significant difference was found at $F(2,89) = 4.8$, $p < 0.05$. The experimental group who played the virtual *Supercharged!* game outperformed the control group, who had hands-on experience, demonstrations, and videos in the physical classroom.

Creativity. In contrast to the foregoing articles that discussed possible negative aspects of virtual worlds and also positive learning outcomes for students in various subjects, the next two studies were primarily concerned with the enhancement of creative skills or creativity.

In terms of art curriculum, Sun, Chan, and Meng (2011) developed a virtual sketch classroom to train fifth and sixth grade students in Taiwan to effectively shape, recreate and shade objects. Subjects included 140 male students and 175 female students. Over the course of 8 weeks, with 80 minutes of instruction per week, students in the control group received conventional classroom instruction and the experimental group used the virtual sketch lab. Using a pre-post-test format, Sun et al. (2011) found comparable learning outcomes for both groups with no significant difference between the VR technology and conventional education groups at $p = .335 > .05$ with F = .949. By using VR technology, researchers hoped to "Attract students' attention and learning motivation . . . resolve the disadvantage of lack of interaction that conventional media has, bring out e-learning's advantage of breaking through the restrictions of time and space and [use] the advantages of VR in space, shade and material simulation presentation" (p. 239).   They also hoped to decrease teacher workload, "fire up learners' imagination" and offer their research as a reference for 3D material rendering and virtual reality education development on painting and creativity. Since the study proved to be positive for learning outcomes the program was implemented into the elementary schools.

The next study specifically addressed the topic of creativity in a game-like setting. Hutton and Sundar (2008) found that under certain conditions, creativity increased as a result of video game play. The study examined both the effect of valence (or the mood of the participant) and arousal (as calculated by the amount of skin conductance responses recorded while playing a video game) on creativity scores. The evidence indicated that, "media-generated emotion

significantly affects creativity through the interaction of arousal and valence. Lower arousal levels resulted in higher creativity scores when coupled with a negative mood. At high arousal levels, a positive mood resulted in greater creativity" (p. 294). When certain students were given low levels of arousal and told they had received a failing grade, (inducing negative valence), their creativity scores were higher than students who had a moderate level of arousal and valence. Researchers hypothesized that the combination of valence and arousal in the low group produced an analytical and contemplative approach to the ensuing creativity tests and thus higher scores. Students with high arousal and high valence also received higher creativity scores than the middle group, perhaps due to the energy that transferred into creative thought. Researchers concluded that since today's students are interacting with a variety of media that elicit emotion and arousal (such as the video game used in the study) and since most students consider the experience of playing a video game as pleasant, that the emotions elicited thereby can be very influential in fostering creativity.

In summary, from the foregoing studies that examined the positive and negative effects of video games or virtual world education on learning or creativity enhancement, several significant ideas were discovered. Negative aspects of virtual world education can include the transfer of negative cultural stereotypes, social isolation and additional teacher workload. Positive aspects of virtual world education can include higher achievement levels for students. Findings indicated that individuals participating in simulations and games achieved higher cognitive gains than those participating in traditional education. Researchers who developed the virtual world game Quest Atlantis found statistically significant learning gains in several academic areas such as science, language, and social studies. Learning programming languages was deemed efficacious in the virtual world platform Second Life. The experimental group who played the

virtual game, *Supercharged!* out-performed the control group who had hands-on experience, demonstrations and videos in the physical classroom. A virtual sketch classroom proved helpful and showed positive learning outcomes for students. Finally, emotions produced by video game play were found to be important to creativity.

Virtual world art experience. Although some of the previous studies touched on creativity, a study found closely aligned with the present study of virtual worlds and creativity was one conducted by Antonietti and Cantoia (2000). These researchers developed a study wherein an experimental group of students was allowed to "walk inside of a painting" in a 3D, virtual reality setting, while a control group observed the same painting in a 2D setting. The researchers attempted to assess what kind of thinking processes were activated in the learner in a virtual reality setting. They evaluated the experience by asking participants to create titles that explained their experience and exposure to the painting.

The different exposures elicited different responses and revealed several significant points. For example, the virtual reality group tended to spontaneously offer a deeper analysis of the artwork than the control group, trying to investigate "how" elements of the painting were created and "why" the artist chose to represent those elements in a particular way. This analysis would be considered a meta-cognitive activity, as students thought about the artist's thinking. The control group, on the other hand, asked questions that reflected an interest in describing "what" was directly in front of them. The meta-questions (those focused on thinking about the artist's thinking) were significantly more numerous in the experimental group than the control group, reflecting a deeper level of cognition (Bloom, 1999) than the control group.

Although not statistically significant, the experimental group produced more abstract responses and more free and imaginative elaborations than the control group. Virtual reality

seemed to promote abstract thinking as evidenced by the production of more abstract titles in the experimental group than the control group. The researchers concluded that, "The notion that virtual reality elicits thinking process different from those activated by a non-immersive static, fixed perspective experience is empirically supported" (p. 222).

Although the virtual platform that was used in the current study differed from the Antonietti and Cantoia study in that it was able to take advantage of the technological advances of the last 10 years, the similarities between the two studies are substantial enough that some correlations might be drawn. It would appear that abstract thinking and possibly creativity was increased in the virtual reality task of the Antonietti and Cantoia study. Using empirical research methods, the author found this study to be the only one that significantly correlated with the present study's stated research objectives. It is therefore advisable to update and extend the existing research by conducting additional experiments in this area in order to reach more current and definitive conclusions.

In summation, the literature regarding the fusion of creativity and virtual world education led to several observations that guided this study. First, the idea of universal creativity appropriately framed this study, allowing for the encouragement of creativity for all students. Second, the constructs of originality, fluency, flexibility, multiple perspectives, and play formed the theoretical basis for the study and aligned with teacher observations as bridges to creativity; and additional bridges to classroom creativity included exploration, imagination, space, and time to reflect and experiential learning. Third, physical and virtual world classrooms offered different capabilities for choice in the encouragement of creativity. Further, virtual education and virtual world education were found to differ qualitatively: virtual classrooms incorporated web-based, 2D solutions, while virtual world classrooms provided 3D solutions with

synchronous collaboration, immersion and presence in realistic settings, and influence on the environment, including the presence of choices for appearance, movement, and communication. This difference is of particular importance, given that choice (agency) and choices (resources) have been found to be integral to the enhancement of creativity. Specifically, the literature review suggested that virtual world capabilities have the potential of influencing creativity positively within each of the stated constructs of originality, fluency, flexibility, multiple perspectives and play. Fourth, according to empirical studies, virtual world platforms appear to have some negative effects (teacher workload) and some positive effects (improved student learning outcomes).

CHAPTER 3: METHODS

Research Questions

Given the current upward trajectory of technology and the downward trend in creativity,

investigating the potential of virtual worlds to foster creativity is timely. This study sought to

shed light upon the effect of virtual world education on creative thought, specifically on the

creative attributes of originality, fluency, flexibility, multiple perspectives, and play. By testing

virtual world pedagogies, this study addressed two questions, (1) Using the TTCT Verbal as a

metric, do students from virtual world classroom environments show more, less, or a similar

amount of originality, fluency, and flexibility than students in comparable face-to-face classroom

environments? and (2) How do students from virtual world classrooms and face-to-face

classrooms compare in their representations of originality, fluency, flexibility, multiple

perspectives, and play in art critiques?

Research Design

This study was designed to be quasi-experimental. According to Vockell and Asher

(1995), a quasi-experimental study is one that is not based on random assignment. This type of

experiment uses other strategies such as pre-posttest design with manipulation of the treatment.

Since the participants are not randomized, one cannot be sure that they are as comparable as if

they had been chosen at random. This makes them nonequivalent groups. Although quasi-

experimental designs are limited in that they cannot unequivocally establish causal connection

without randomization, they can establish a correlation between groups.

For this particular study, the quasi-experimental design was chosen to achieve three

goals: (1) accommodate and meet immediate needs of students by avoiding disruption in student

schedules from randomization; (2) strike a balance between a strictly controlled setting and a

naturalistic setting, the broadly generalisable versus the locally usable information, and (3) capitalize on the ability of quasi-experimental designs to provide evidence for educational programs.

This investigation can be described as a quasi-experimental, pretest-posttest, nonequivalent groups design. The following graphic illustrates the two non-equivalent groups, test/retest with equivalent forms, and intervening treatment format used in the study. Both groups were measured by taking the TTCT pretest before the program or treatment occurred and the TTCT posttest after treatment. In column three, the "a" and "b" following the "O's" refer to the different but equivalent forms of TTCT that were given (See Table 3).

Table 3

Format: Two Non-Equivalent Groups, Test/Retest with Equivalent Forms and Intervening Treatment

Group title	Group type	Pretest	Treatment	Posttest
In-world (experimental)	Non-equivalent	Oa	X	Ob
Traditional (control)	Non-equivalent	Oa		Ob

Note. Adapted from *Research Methods Knowledge Base,* 3rd ed., by W. M. Trochim, K. Donnelly, and P. James (Mason, OH: Atomic Dog and Cengage Learning, 2008).

Research Context

One predominant virtual world, Second Life, offers education but also entertainment such as gambling and adult content. Other than Second Life, there are very few virtual worlds in which to teach. As a result, the researcher designed a values-based virtual world strictly devoted to education—the V.I.E.W.—Virtual Immersive Educational World. A company of the same name was created, and animators and programmers were employed to create this virtual

educational world. The study was conducted in this particular virtual world (see Figure 3). Since

the researcher was also the designer of the V.I.E.W., there is a possibility of researcher bias.

This is discussed later in the document (see Appendix E).

Figure 3. Female avatar in museum setting in the V.I.E.W.

The V.I.E.W. is a valuable platform for this study since it has been designed with

multiple visual elements and many opportunities for students to be creative. For example,

immediately upon entering the world, students can customize their avatars. Additional tasks

requiring creative thought such as such as painting and creating buildings in perspective are

included throughout the environment.

Research Setting

This study collected data from one location, Brigham Young University-Idaho (BYU-I). Professor Deanna Hovey, full-time faculty member, participated in the study. The art methods course for preservice teachers was the testing ground for this study. Professor Hovey had extensive experience teaching this course (over 10 years) and a high interest in improving learning for her students. After seeing a demonstration of the V.I.E.W. given to the university's instructional technology department, Professor Hovey responded positively to a request to participate in the study. The researcher attempted to control for curricular confounding by providing the same course content and assessments (TTCT Verbal and art critique assignment) to all students involved in the study, regardless of their treatment condition. Participants

The subjects who participated in this test were primarily Caucasian preservice elementary teachers, ages 19–24. They were junior- or senior-level students enrolled in the three-credit course, Art for the Elementary Teacher, at a private university in the United States. All but three were female students. This is usual in this particular major, since more females than males typically enter the field of teaching at the elementary education level. According to Synder, Hoffan, and Geddes (1996), nationally, only 14.6% of elementary teachers are male. Gamble and Wilkins (1997) reported that this lack of males in elementary teaching is due to tradition (females usually enter this field), low salary, and low prestige. Additionally, students entering this course typically had very little training in art. It would be unlikely to find participants randomly that were so similar in background, ethnicity, and general socio-economic status. Since students shared these similar characteristics, the quasi-experimental design fits well with the research agenda at hand.

Over the course of two semesters that ran from January 2011 to July 2011, there were 51 student participants during winter semester and 46 participants during spring semester for a total of 97 participants. During each semester, there was one experimental group and one control group participating in the experiment.

Data Collection

For the first research question, the TTCT Verbal instrument was used to assess originality, fluency and flexibility. For the second research question, a rating scale was used to quantify student responses to an artwork represented in 2D and 3D formats.

Torrance Test of Creative Thinking. The TTCT Verbal was the instrument used in the current study to quantify student creative thought. Torrance's TTCT has a figural and verbal form that are equivalent and are the most widely used test of creativity (Colangelo & Davis, 1997).

Description. Torrance developed his test as part of a long-term research program emphasizing experiences that stimulate creativity (Swartz, 1988). The original Torrance Test for Creative Thinking made its debut in 1966, and although there have been changes through the years in the modes of scoring, the test itself has remained unchanged (Kim, 2002). The TTCT Figural requires examinees to draw various answers whereas the TTCT Verbal allows for written answers. The TTCT Figural is recommended for ages Kindergarten through adult and lasts 30 minutes and has particular equity benefits for persons who have language or cultural issues. The TTCT Verbal is recommended for first grade through adult and lasts 45 minutes. Since students enter this course with some trepidation about drawing, the TTCT Verbal appeared to be more appealing to students who felt uncomfortable with drawing skills. In addition, since the TTCT Verbal includes flexibility as one of its three main constructs, the researcher determined that it

was a more important construct to measure for this study than the construct of resistance to premature closure contained in the TTCT Figural (see Table 4).

Torrance (2000) constructed the TTCT over a period of more than 25 years and suggested several uses for the test. One suggested use for the assessment was "to evaluate the effects of educational programs, materials, curricula, and teaching procedures" (Torrance, 1966). This study aligns most closely with that purpose.

This instrument satisfied several needs. First, the results from the TTCT Verbal pretest provided information on both student creative thinking abilities in the areas of originality, fluency, and flexibility upon entering the experiment and acted as a covariate to control for initial student knowledge for overall test results. The TTCT Verbal posttest results provided information on students' overall creativity gains. Second, these data results allowed the researcher to make practical judgments about student performance by comparing TTCT Verbal scores with the rating scale scores. This allowed the researcher to identify aspects of student experience that might have brought about a difference in their creativity scores. Third, the quantitative data from this study added to the body of statistical information and literature informing institutional understanding of the role of virtual world education as it relates to creativity. Statistics of overall creativity scores from both groups can provide data points for administrators in assessing the value of virtual world education.

Validity and reliability. The TTCT is a valuable measure of creativity both in terms of validity and reliability. Trochim, Donnelly, & James (2008) defined validity as "the best available approximation to the truth of a given proposition, inference, or conclusion" (p. 20); or another way of stating it, validity requires that the construct in question is measured in actuality.

Table 4

Creativity Measures in Torrance Tests of Creative Thinking: Figural and Verbal

Test Measure	Description or definition
Figural	Emphasizes creating unique drawings from prompts or existing shapes and telling stories through titles for drawings.
Fluency	The number of ideas a person expresses through interpretable responses that use the stimulus in a meaningful manner.
Originality	Uniqueness of responses based on statistical infrequency and unusualness of the response.
Resistance to premature closure	Ability to keep open or delay closure long enough to make the mental leap that makes possible original ideas.
Verbal	Emphasizes thinking of solutions to problems, questions about scenarios, consequences of a pretend situation, uses of an object.
Fluency	The total number of relevant responses, with relevancy being defined in terms of the requirements of the specific task or activity.
Originality	Uniqueness of responses based on statistical infrequency and unusualness of the response.
Flexibility	The number of different categories represented by a response.

Note. Adapted from The Torrance Tests of Creative Thinking Norms-Technical Manual Figural (Streamlined) Forms A &B, by E. P. Torrance, 1990.

The TTCT offers evidence of construct validity. In a study conducted by Artley, Horn, Friedrich, and Carroll (1980), construct validity of the TTCT was confirmed. One important element of creative problem solving is the ability to identify problems. Arlin (1975–1976) discussed problem finding and designed a task to differentiate between individuals based on their problem finding abilities. Artley et al. (1980) set out to determine whether creativity as measured by the TTCT Verbal was correlated to Arlin's problem finding task. Test results from 84 university-level undergraduate students revealed that numbers of questions generated in problem finding correlated significantly with the TTCT Verbal.

As for predictive validity, TTCT Verbal scores showed a high correlation between initially identified high originality in preservice teachers and a composite index of creative teaching behavior. Torrance, Tan, and Allman (1970) developed a checklist of creative behaviors of elementary teachers that was correlated with two measures of verbal creativity. Torrance et al. (1970) conducted a study that included 325 elementary education majors who were tested in 1958 and then tested again in 1966. The composite index of creative teaching behavior was found to correlate with the TTCT Verbal .62 with the originality score and .57 with the overall creativity score. The results from this follow-up study of 220 subjects suggested that preservice teachers initially identified as highly original, were found to demonstrate greater creativity in the classroom six years later than their less original counterparts.

As for concurrent validity, or the degree to which results from one test agree with results from other, Alston conducted a study of 50 economically-disadvantaged children incorporating the Wyrick Test of Motor Creativity and found that it correlated positively and significantly with the TTCT verbal (Torrance, 2000, p. 13).

Scoring inter-rater reliability for the TTCT Verbal was found to be high at 0.90 or higher in tests of 125 gifted and 428 non-gifted elementary school children (Rosenthal, DeMers, Stillwell, Graybeal, & Zins, 1983, p. 10).

As far as test-retest reliability, both the TTCT Verbal and Figural had coefficients that ranged from 0.59-0.97 (Torrance, 2000). Treffinger (1985) determined that the TTCT can be seen as a reasonably reliable test for group and research applications.

Implementation. Students participating in the study took the Torrance Test of Creative Thinking Verbal that has both a pre- and a posttest that are different but *equivalent forms* of the test. Students agreed to participate by signing a consent form prior to the study. There were 27 students in the control group and 24 students in the experimental group. Existing course curriculum was modified to align with virtual world affordances. Curriculum and tasks were the same for both groups, though the way the tasks were accomplished varied depending upon the environment, traditional or virtual world. Winter semester began on January 5, 2011, and ended on April 7, 2011. During this semester, both the experimental and control groups met for approximately one hour in class. Each group met on Mondays and Wednesdays but in different sections. The experimental group met in their regular classroom on Mondays and in the V.I.E.W. on Wednesdays. All students took the TTCT Verbal Form A Pretest on January 12, 2011.

On January 26, 2011, experimental group students met as a class in the virtual world (V.I.E.W.) following four weeks of attending the regular classroom and participating in a training session involving downloading the program onto computers, setting up microphones, customizing avatars, and learning to navigate in the virtual world. Since the V.I.E.W. program could not be freely accessed everywhere on campus due to firewall restrictions, a campus

computer lab was set-up for students whose schedules necessitated them remaining on campus. For this semester, 15 students accessed the V.I.E.W. from their homes and the remaining nine students accessed the V.I.E.W. from the campus computer lab. Experimental group students then met in the virtual world for seven class sessions of approximately one-hour duration ending on March 23, 2011. A period of twelve weeks separated the pretest from the posttest. Both the experimental and control group students took the TTCT Verbal Form B Posttest on April 6, 2011.

Spring semester ran from April 20, 2011, to July 20, 2011. There were 24 students in the control group and 22 students in the experimental group. All students took the TTCT Verbal Form A Pretest on May 9, 2011. As in the previous semester, the curriculum and tasks were the same for both groups. Both the control and experimental groups met in the regular classroom for the first three weeks of the course on Mondays and Wednesdays in different sections. The control group completed all of their lessons in the physical classroom. The experimental group began attending the regular classroom on Mondays and the V.I.E.W. on Wednesdays, according to the same pattern followed winter semester. The experimental group began these V.I.E.W. class sessions on May 18 after a brief training session and ended their V.I.E.W. experience on July 6, 2011.

Due to university firewall issues, students were unable to access the V.I.E.W. on campus, so approximately half of the class met in the physical classroom, and approximately half were able to access the program from off-campus locations. Although instruction was planned to replicate the winter term seven-week schedule, class meetings in the virtual world were inconsistent due to port issues. Ports were finally opened for the final two class sessions planned for the V.I.E.W. Up until that time, for three class sessions, about half of the students came to

the physical classroom and watched the V.I.E.W. projected on a screen in the front of the class, while the other half got into the V.I.E.W. at off-campus locations; two class sessions were accomplished in the V.I.E.W. asynchronously; and the final two sessions were open to students in an easily accessible manner. Both experimental and control group students took the TTCT Verbal Form B Posttest on July 20, 2011.

Art critique rating scale. The second quantitative instrument used in the study was a rating scale that assessed student responses given in an art critique. (The rating scale is reproduced in Appendix A.)

Description. The rating scale designed for this study attempted to capture student creative thought processes in terms of the previously stated creativity constructs. According to Trochim et al. (2008), scaling is a branch of measurement that connects a qualitative construct with a quantitative measure. Usually a scale derives a single numerical score for that construct. For this study, raters worked from a scale of 1-7 where 1 represented low perception, 3-slight perception, 5-moderate perception, or 7-high perception of a creativity construct within the art critique. The numbers 2, 4, and 6 were also shown on the scale allowing raters to understand that alternative options to the designated numbers were available. The researcher included a description of each of the rating levels (see Appendix B) and sample student responses to guide raters in their evaluation process (see Appendix D).

Each question on the rating scale addressed a creativity construct. Question 1 of the art critique rating scale addressed the construct of play. Raters were given the following words to guide them in assessing this construct: playful, imagination, humor, adventure, exploration, and fantasy. Questions 2 and 6 addressed the construct of multiple perspectives. Keywords provided for Question 2, regarding vantage points, included above, beneath, inside, outside, on top, and

below. Raters chose a score between 1 and 7 (low, slight, moderate, and high) that indicated

student awareness of vantage points in the art critique. Question 3 addressed the construct of

originality. Keywords for this category included novel, unusual, or vivid ideas, approaches or

descriptions. For originality, fluency, and flexibility, raters chose between very weak, somewhat

weak, moderately strong, and strong as levels of evidences of these constructs in the student art

critiques. Question 4 focused on the construct of fluency. The key idea offered to guide raters

for this category was to observe if students exhibited one idea spilling off of another idea or the

rapid fire of many ideas about one topic. Question 5 focused on the construct of flexibility.

Guiding ideas for raters for this category included multiple ideas in different categories and

seeing things from different intellectual or physical vantage points. Question 6 focused on

spatial awareness. Keywords for Question 6 included near, far, beyond, 3D, distance, around,

and space, and raters chose between the descriptions of low awareness, slight awareness,

moderate awareness, and high awareness in this category.

 Validity and reliability. The researcher designed the rating scale in collaboration with an

assessment expert to incorporate procedures that would result in instrument validity.   To

establish construct validity prior to implementation, the researcher evaluated the rating scale.

The researcher has had 11 years of experience in teaching university level students to critique art

and brought this expertise to bear in assessing the rating scale. As for reliability, raters were

trained prior to the rating task, and the researcher checked every 10th paper during the procedure

to assure inter-rater and intra-rater reliability. Raters provided justifications for each of the

scaled answers on all student papers. The scale offered a total of nine questions so as to avoid

rater fatigue.

Implementation. The physical world group was able to view a 2D painting in person while the V.I.E.W. group virtually walked through a virtual 3D replica of the same painting. Then both groups of students evaluated the artwork in a one to two page art critique using the Feldman Model of Art Criticism (See Appendix B). According to Clements (1979), art criticism is "a creative act of the mind" (p. 76). Blandy and Congdon (1991) described art criticism as meant to "encourage new ways of seeing, to give us new perspectives on possibilities and suggest new directions for imagining and constructing reality" (p. 1). This art critique was designed to answer the second question of the study. Students' responses were analyzed according to the rating scale questions to determine what differences in perception and description existed between the two groups.

The quality of *flexibility* was of particular interest. It was hypothesized that allowing students to view an artwork from multiple virtual physical perspectives might have a facilitating effect on increasing flexible thinking.

Virtual views allow participants to see and experience objects and locales from every conceivable angle. Not only are participants able to fly above environments, facilitating a bird's-eye perspective, participants are also able to scale their avatars to ant or giant size in relationship to that environment or object observed. Participants can even become the object in the environment (Salzman & Dede, 2009).

Views obtained from these scales are qualitatively different than views obtained in the physical world environment. In the art classroom, for example, a student in the virtual world could choose to scale his avatar to the size of an ant to observe a 3D statue. The participant via his avatar would see an object as going from exceptionally large to exceptionally small at its apex and could see detail of angles, shapes, and textures that could only be discerned at that scale

size. A student in the traditional classroom looking up from the ground at that same statue would not have those same vantage points or perceptions of the statue and its details.

Further, if the virtual world participant used the flight and hover capabilities, the participant could both see the statue from the top down and hover and observe the statue from any height above the ground. Depending upon the circumstances, safety and feasibility might prevent these sorts of views for physical classroom students.

Virtual world participants can also fly up to heights above a bird's eye view, allowing one to see an expansive view and layout of an entire environment from space. This capability might prove useful to architecture students for designing a comprehensive setting.

Finally, students can actually become a part of experiences unavailable to the traditional classroom, such as traveling back in time and walking around the Colosseum in ancient Rome (Guidi et al., 2005) or, as in this study, entering the painting "Some Moon" and running along its lunar landscape. Clearly, different types of views give different information to the viewer. Views specific to the virtual world might have a facilitating effect on the creativity constructs of flexibility and multiple perspectives.

Raters used the rating scale to analyze student response to the artwork. The rating scale included various categories of creative thought, namely, originality, fluency, flexibility, multiple perspectives, and play. This quantitative instrument allowed raters to choose rank between 1 and 7 the levels of inclusion of creativity constructs in student art critiques. This instrument facilitated understanding about how students in different environments responded to an artwork. This rating scale represented a second measurement aimed at quantifying student creative thought.

Data Analysis

Two instruments were used in this study, the TTCT Verbal and a constructed rating scale. The data derived from the TTCT Verbal was scored and then statistically analyzed in the SAS program using an ANOVA (analysis of variance). For the rating scale, a total score was derived from the completed scales for each critique. These scores were treated as continuous variables and an ANOVA was used to yield the results in the SAS program.

Torrance Test Analysis. Scholastic Testing Service, Inc. scored the TTCT. This service's analysis included the standard descriptive statistics and frequency distribution table, and the creativity raw scores, standardized scores, and national percentiles for each student for each of the TTCT subscales.

Treatment. The treatment or intervention that distinguished the experimental group from the control group included the following: (1) exploring the virtual world setting and (2) using its functions. Although both groups had the same curriculum and learning tasks, one group inhabited the virtual world and used its functions to complete learning tasks, and the other group inhabited the physical classroom and used its materials to complete learning tasks.

Statistical analysis. The dependent variables for this analysis were TTCT Verbal subscales of originality, fluency, flexibility, and overall average. The independent variables were treatment, pre-post tests, and the interaction of these two variables. For the statistical analysis, a repeated measures analysis of variance (ANOVA) was conducted since means between groups was the focus. This type of analysis takes into account the correlation in the repeated measures on each subject. This same statistical analysis was performed on each of the dependent variables (subscales).

The interaction between treatment and pre-post was the term of primary interest. This interaction was examined to see if the gain from pre to posttests was significantly different for the two groups. For all statistical tests, an alpha level of < .05 was used. A repeated-measures ANOVA was used since it is designed to handle studies with a larger structure and several variables.

Scale analysis. Raters scored student art critiques. Raters were chosen from individuals uninvolved with the study so that scoring reflected an unbiased and balanced outcome. Two raters were chosen both for their artistic sensibility and for their experience with evaluating student artwork. Both raters have taught at the university level and have had several years of experience grading student work. Both raters are currently professional artists participating in juried exhibitions. They received 5.5 hours of training and completed practice exams prior to processing the student responses. Raters provided justifications for each of the scaled answers. Ongoing checks of every ten papers were conducted to assure rater consistency over time.

CHAPTER 4: RESULTS

Purpose of Study

The main purpose of this study was to better understand the potential impact of virtual world education on creative thought. The study addressed five creativity constructs—originality, fluency, flexibility, multiple perspectives, and play—using two quantitative instruments: the TTCT and a constructed rating scale. Both of these metrics provided comparative statistical data from traditional classroom students and from virtual world students. Because the experiences of students in Semester 1 varied from the experiences of students in Semester 2 (as described in the Methods section), the results below are described separately for each semester.

Semester 1 Results

During Winter Semester 2011, 52 students at Brigham Young University–Idaho took TTCT pre- and posttests and submitted an art critique for study. The 27 students in the control group met in the regular classroom environment for all 14 weeks, while the 24 students in the experimental group met in the virtual world (V.I.E.W.) via home computers or an on-campus computer lab for 7 of the 14 weeks, and in the regular classroom environment for the other 7 weeks.

Research Question 1—Changes in TTCT Verbal scores. Using the TTCT Verbal as a metric, students who participated in the virtual world increased their overall creativity scores more than students who participated in the regular classroom. The experimental group reported larger gains in the categories of originality, flexibility, and fluency, and overall scores although not all of the differences were statistically significant, as described below.

Overall scores. In the overall scores category (representing the average of all categories combined), the control group's average for overall pretest scores was 82.407, and the

experimental group's average for overall pretest scores was 62.440. The control group's average

for overall posttest scores was 85.407, and the experimental group's average for overall posttest

scores was 73.000. In the overall scores category, score gains for the control group were 3.000

points, and score gains for the experimental group were 10.560 points, a difference of 7.560

points. With significance at $p = .033$ ($F_{1,50} = 4.79$), the experimental group's average overall

score gains were statistically significantly higher than the control group's average overall score

gains (see Table 5). Four students, two in the experimental group and two in the control group,

exhibited greater gains or losses than members of their group. All four students were contacted.

Three students, two from the control group, and one from the experimental group, responded to

the contact. All three students affirmed that the pre- and posttest conditions were alike and that

any differences might be attributable to learning effects (Hartley, 1973).

Evaluating the number of students who experienced gains, maintenance, or loss between

pre- and posttest revealed that 19 students in the experimental group had higher posttest scores

than pretest scores, compared to 15 in the control group. Scores for one experimental group

student and two control group students stayed the same. Four experimental group students

experienced losses, whereas 10 control group students experienced losses (see Figure 4).

Further, a graphical representation of the distribution of the overall gains between the control and

experimental groups is shown as a box plot (see Figure 5).

Originality. For originality, the control group's average pretest score was 88.925, and

the experimental group's average pretest score was 75.720. Posttest scores for the control group

averaged 88.333, and the posttest scores for the experimental group averaged 79.400. The gain

(loss) experienced from pretest to posttest scores for originality for the control group was -0.592

points, whereas the gain from pretest to posttest score for the experimental group was 3.680
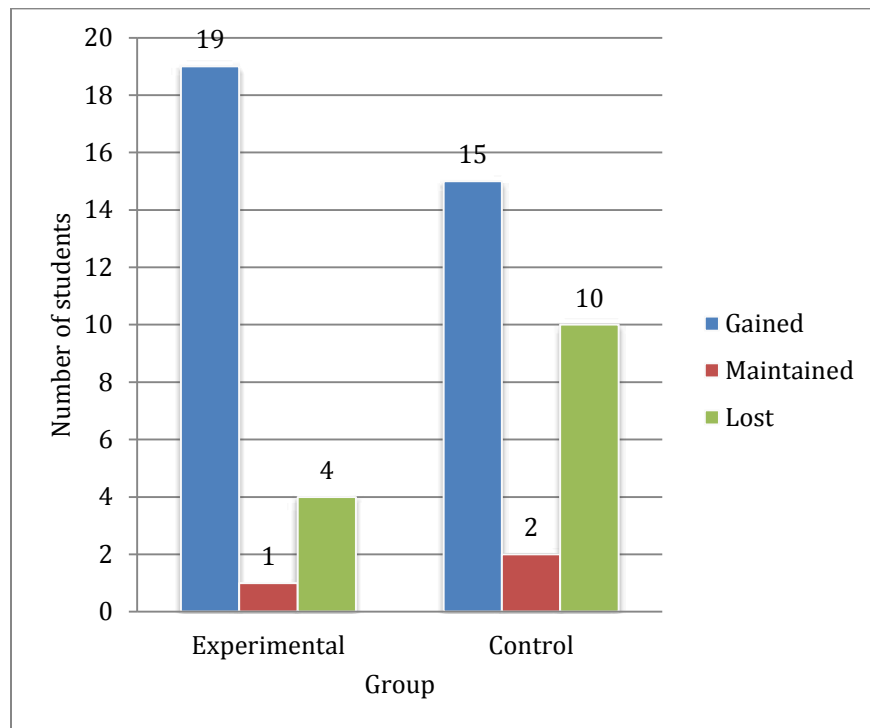
Figure 4. Winter Semester 2011 TTCT overall gains, maintenance, and loss, pretest to posttest, by group.
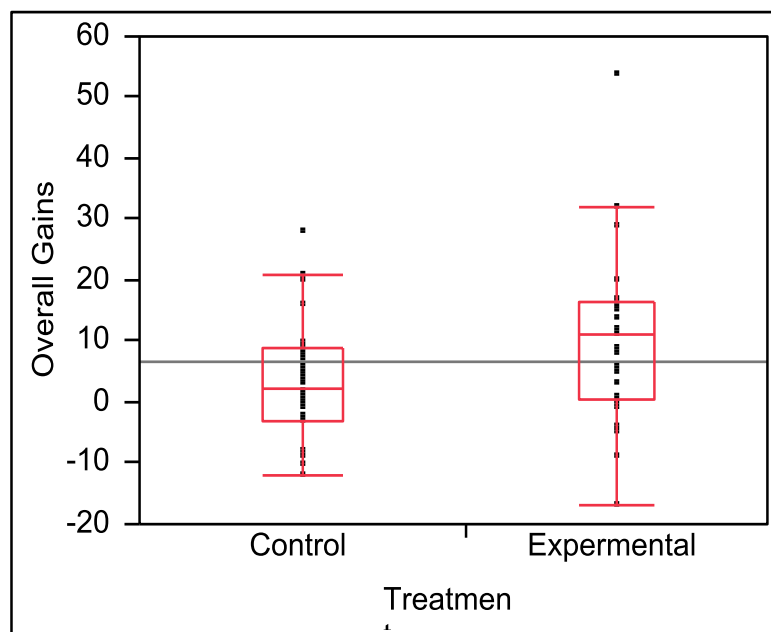
Figure 5. Winter Semester 2011 TTCT overall gains, shown by box plot of pretest to posttest by group.

points, a difference between groups of 3.088 points. Although the gains for the experimental

group were more than the gains (loss) of the control group at $p = .160$ ($F_{1,50} = 2.03$), the

differences did not reach the level of statistical significance (see Table 5).

      Fluency. For fluency, the control group's average pretest score was 76.851, and the

experimental group's average pretest score was 57.000. Posttest scores for the control group

averaged 84.296, and posttest scores for the experimental group averaged 73.080. Gains for the

control group averaged 7.444 points, whereas gains for the experimental group averaged 16.080

points. The experimental group gained 8.636 points more on average than the control group.

The score gains for the experimental group were statistically significantly higher than those of

the control group at $p = .036$ ($F_{1,50} = 4.62$) (see Table 5).

      Flexibility. For flexibility, the control group's average pretest score was 75.814, and the

experimental group's average pretest score was 52.320. Posttest scores for the control group

averaged 78.666, and the posttest scores for the experimental group averaged 63.200. Gains for

the control group averaged 2.851, while gains for the experimental group averaged 10.880, a

difference of 8.029 points. The score gains for the experimental group were statistically

significantly higher than the gains of the control group at $p = .043$ ($F_{1,50} = 4.29$) (see Table 5).

      Summary. For within-group data, we see that the control group reported gains in every

category except originality, where a slight loss was noted. However, the control group measured

statistically significant gains in only one of the four categories, the category of fluency. The

control group achieved an overall average gain of 3.00 points, taking all categories into account.

This overall gain was not statistically significant at $p = 0.597$. The experimental group reported

gains in all categories and achieved statistically significant gains in three of the four categories,

including overall scores. The group achieved an overall gain of 10.560 points, taking all

categories into account. This gain was statistically significant at $p = <.001$. The experimental

group gained an average of 7.560 more points than the control group in the overall combined

scores. In summary, compared to the control group, the experimental group achieved greater

score gains in originality and statistically significant higher score gains in fluency, flexibility and

in the overall average category, with the latter category achieving the statistical significance of

$p = .033$ (see Table 5).

Research Question 2—Art critique. To answer the question of how students from

virtual world classrooms and face-to-face classrooms compare in their representations of

originality, fluency, flexibility, multiple perspectives, and play in art critiques, a rating scale was

created to measure student creative thought as expressed in their written art criticism paper (see

Appendix A).

Students were given the assignment to write an art critique using the Feldman Model of

art criticism (see Appendix C) about an oil painting entitled "Some Moon" by artist Abe Day

(see Appendix E). Students in the traditional classroom observed the actual original painting in

person; students in the virtual world classroom only saw a digital copy of the painting, but they

were able to virtually walk inside of a 3D replica of it that was placed in the virtual world.

Originality. The control group scored 2.888 in the originality category compared with

2.555 for the experimental group, a difference of .333 with a standard error of .308. With a

result of $p = .450$ ($F_{1,34} = .58$), no significant difference in originality was found between the

experimental and control groups (see Table 6).

Table 5

Semester 1 TTCT Scales: Mean (and SE) of Group Scores by Category with Significance Within and

Between Groups

Category/group	Pretest (*SE*)	Posttest *(SE)*	Gains in points	Significance (*p*)
Originality				
Control group	88.925(2.779)	88.333(2.779)	-0.592	.991
Experimental group	75.720(2.888)	79.400(2.888)	3.680	.332
Difference in gains between-groups			3.088	.160
Fluency				
Control group	76.851(3.496)	84.296(3.496)	7.444	.048*
Experimental group	57.000(3.633)	73.080(3.633)	16.080	.0001*
Difference in gains between-groups			8.636	.036**
Flexibility				
Control group	75.814(3.199)	78.666(3.199)	2.851	.714
Experimental group	52.320(3.324)	63.200(3.324)	10.880	.001*
Difference in gains between-groups			8.029	.043**
Overall combined score				
Control group	82.407(3.210)	85.407(3.210)	3.000	.597
Experimental group	62.440(3.336)	73.000(3.336)	10.560	.0005*
Difference in gains between-groups			7.560	.033**

*Denotes statistically significant gains *within* the group for this category.
**Denotes statistically significant gains *between* the two groups for this category.

Table 6

Semester 1 Art Critiques: Group Scores by Category with Significance Between Group

Category/group	Score (*SE*)	Between-groups Difference in points	Significance (*p*)
Originality			
Control group	2.888 (.308)		
Experimental group	2.555 (.308)		
Difference between-groups		.333	.450
Fluency			
Control group	2.833 (.330)		
Experimental group	2.611 (.330)		
Difference between-groups		.222	.637
Flexibility			
Control group	2.500 (.353)		
Experimental group	2.111 (.353)		
Difference between-groups		.389	.441
Play			
Control group	2.222 (.315)		
Experimental group	2.333 (.315)		
Difference between-groups		.111	.805
Multiple Perspectives-Vantage Pt			
Control group	1.833 (.263)		
Experimental group	2.000 (.263)		
Difference between-groups		.167	.657
Multiple Perspectives-Spatial			
Control group	2.222 (.293)		
Experimental group	3.111 (.293)		
Difference between-groups		.889	.039**
Overall Score			
Control group	14.500 (1.365)		
Experimental group	14.666 (1.365)		
Difference between-groups		.166	.931

**Denotes statistically significant gains *between* the two groups for this category.

Fluency. The control group scored 2.83 in the fluency category to the experimental group's 2.61, a difference of .222, with a standard error of .330. With a result of $p = .637$ ($F_{1,34} = .23$), no significant difference between the experimental and control groups was detected (see Table 6).

Flexibility. The control group scored 2.50 in flexibility to the experimental group's 2.11, a difference of .389 with a standard error of .353. No significant difference between the experimental and control groups was detected at $p = .441$ ($F_{1,34} = .61$) (see Table 6).

Multiple perspectives (vantage points/spatial awareness). In the category of vantage points, the experimental group scored 2.000 to the control group's 1.833, a difference of .167 with a standard error of .263. There was no significant difference detected between the groups at $p = .657$ ($F_{1,34} = .20$). As for spatial awareness, the experimental group scored 3.111 to the control group's 2.222, a difference of .889 with a standard error of .293. At an alpha level of < .05, the experimental group had a higher score than the control group in spatial awareness, with statistical significance at $p = .039$ ($F_{1,34} = 4.57$) (see Table 6).

Play. The experimental group scored 2.333 points to the control group's 2.222 points, a difference of .111 points with a standard error of .315. No significant difference was found between the experimental and control groups at $p = .805$ ($F_{1,34} = .06$) (see Table 6).

Overall results. The experimental group achieved an overall score of 14.666 to the control group's 14.500, a difference of .166 with a standard error of 1.365. The totals that resulted from including all six questions showed no statistical difference between the experimental and control groups at $p = .931$ ($F_{1,34} = .01$) (see Table 6).

Summary. Scores from the art critique assessment reflected a similarity between the groups. The control group scored slightly higher than the experimental group in originality,

fluency, and flexibility while the experimental group scored slightly higher than the control group in play, vantage points, spatial awareness and overall total scores. For originality, the control group scored .333 of a point more than the experimental group with no statistical significance indicated. For fluency, the control group scored .222 of a point more than the experimental group yielding no statistical significance between the groups. The control group scored .389 of a point more than the experimental group in the category of flexibility detecting no statistical significance between the groups. In the play category, the experimental group gained .111 of a point more than the control group yielding no statistical difference between the groups. For the category of vantage points, the experimental group scored .167 of a point more than the control group yielding no statistical difference between the groups. In the category of spatial awareness, the experimental group scored nearly one point more than the control group, yielding a statistically significant difference between the groups at $p = .039$. This question, which reached statistical significance, allowed the experimental group to have a slightly higher overall score than the control group. The experimental group achieved an overall score of .166 of a point more than the control group, but this yielded no significant difference between the groups (see Table 6).

Semester 2 Results

During Spring Semester 2011, 46 students at Brigham Young University–Idaho took TTCT pre- and posttests and submitted an art critique for study. The 24 students in the control group met in the regular classroom environment two days a week, while the 22 students in the experimental group met in the regular classroom once a week and in the virtual world (V.I.E.W.) once a week. As discussed in the Methods section, problems with the campus Internet firewall meant that students had to participate via home computers off campus or watch the V.I.E.W. on a

projector screen at the front of a classroom. No campus computer lab was available. The 11 students who watched the V.I.E.W. in a passive role in class did not experience the program as intended.

Research Question 1—Changes in TTCT Verbal scores. As in Semester 1, the first research question used the TTCT as the metric to ascertain whether students from virtual world classroom environments showed more, less, or a similar amount of originality, fluency, and flexibility than students in comparable face-to-face classroom environments. In contrast to the statistically significant gains by the experimental group in Semester 1, the experimental group in Semester 2 did not exhibit statistically significant between-group or within-group differences in score gains.

Originality. For originality, the control group's average pretest score was 90.500, and the experimental group's average pretest score was 86.764. Posttest scores for the control group averaged 87.791 and the posttest scores for the experimental group averaged 85.375. Both groups reported a small loss, with the experimental group's loss slightly less than the control group's loss. The loss experienced from pretest to posttest scores for originality for the control group was 2.708 points, whereas the loss from pretest to posttest score for the experimental group was 1.389 points. Although the difference between groups of 1.319 points indicated a slightly smaller loss for the experimental group at $p = .728$ ($F_{1,44} = 0.12$), there was no statistically significant difference shown between the two groups' scores (see Table 7).

Fluency. For fluency, the control group's average pretest score was 81.375, and the experimental group's average pretest score was 79.240. Posttest scores for the control group averaged 82.458 and posttest scores for the experimental group averaged 80.250. Gains for the control group averaged 1.083 points whereas gains for the experimental group averaged 1.009

points. Although the control group gained an average of .074 points more than the experimental group, at p = .987 ($F_{1,44}$= 0.00), the slight score gain for the control group was not statistically significant (see Table 7).

      Flexibility. For flexibility, the control group's average pretest score was 74.166, and the experimental group's average pretest score was 69.828. Posttest scores for the control group averaged 69.583, and the posttest scores for the experimental group averaged 68.375. Losses for the control group averaged 4.583 points, while losses for the experimental group averaged 1.453 points. Although the experimental group experienced less average loss by 3.130 points, at p = .597 ($F_{1,44}$ = 0.28), the average experimental group score losses were not statistically significantly lower than those of the control group (see Table 7).

      Summary. From the statistical data, we see that the control group reported losses in every category except fluency, where a slight improvement of 1.083 points was noted. Taking all categories into account, this group experienced an overall average loss of 2.250 points. The experimental group reported gains in two categories and losses in two categories, with an overall gain of .087 points.   Overall, the experimental group achieved an overall average gain that was 2.416 points higher than the gain of the control group, but these gains did not result in statistical significance (see Table 7).

      Research Question 2—Art critique. Second semester students were also given the assignment to write an art critique about the painting "Some Moon." The conditions, however, were different from the first semester. As described in the Methods section, students had very little exposure to the V.I.E.W. technology and were unable to use it as it was intended. Student art critique scores reflected this condition.

Table 7

Semester 2 TTCT Scales: Mean (and SE) of Group Scores by Category with Significance Within and

Between Groups

Category/group	Pretest (*SE*)	Posttest (*SE)*	Gains in points	Significance (*p*)
Originality				
Control group	90.500(3.127)	87.791(3.127)	-2.708	.731
Experimental group	86.764(3.208)	85.375(3.127)	-1.389	.956
Difference in gains between-groups			1.319	.728
Fluency				
Control group	81.375(4.036)	82.458(4.036)	1.083	.987
Experimental group	79.240(4.134)	80.250(4.036)	1.009	.990
Difference in gains between-groups			.074	.987
Flexibility				
Control group	74.166(4.381)	69.583(4.381)	-4.583	.678
Experimental group	69.828(4.515)	68.375(4.381)	-1.453	.985
Difference in gains between-groups			3.130	.597
Overall combined score				
Control group	84.250(3.877)	82.000(3.877)	-2.250	.882
Experimental group	80.379(3.969)	79.833(3.877)	-.545	.998
Difference in gains between-groups			1.705	.700

*Although the experimental group experienced less overall losses between the groups than the control group by 1.705 points, these scores were not statistically significant.

Results by category and overall results. For the six constructs of originality, fluency, flexibility, play, vantage points, and spatial awareness, there was no significant difference found between the experimental and control groups, and the overall score between the control group and the experimental group yielded no statistical difference (see Table 8).

Summary. Both the control group and the experimental group were very close in their scores for each question. The control group scored slightly higher than the experimental group in originality, fluency and flexibility and spatial awareness while the experimental group scored slightly higher than the control group in play and vantage points. For originality, the control group scored .273 of a point more than the experimental group with no statistical significance indicated. For fluency, the control group scored .591 of a point more than the experimental group yielding no statistical significance between the groups. The control group scored .682 of a point more than the experimental group in the category of flexibility, showing no statistical significance between the groups. The experimental group scored slightly higher than the control group on question one regarding play and question two regarding vantage points. In the play category, the experimental group gained .682 of a point more than the control group yielding no statistical difference between the groups. For the category of vantage points, the experimental group scored .136 of a point more than the control group yielding no statistical difference between the groups. The control group achieved an overall score of 1.091 of a point more than the experimental group that yielded no significant difference between the groups at *p* = .457 (see Table 8).

Table 8

Semester 2 Art Critiques: Group Scores by Category with Significance Between Groups

Category/group	Score(*SE*)	Between-groups Difference in points	Significance (*p*)
Originality			
Control group	2.727(.250)		
Experimental group	2.454(.250)		
Difference between-groups		.273	.445
Fluency			
Control group	3.545(.276)		
Experimental group	2.954(.276)		
Difference between-groups		.591	.137
Flexibility			
Control group	2.636(.294)		
Experimental group	1.954(.294)		
Difference between-groups		.682	.108
Play			
Control group	2.181(.363)		
Experimental group	2.863(.363)		
Difference between-groups		.682	.191
Multiple Perspectives-Vantage Pt			
Control group	1.454(.182)		
Experimental group	1.590(.182)		
Difference between-groups		.136	.600
Multiple Perspectives-Spatial			
Control group	2.000(.243)		
Experimental group	1.863(.243)		
Difference between-groups		.137	.693
Overall Score			
Control group	14.500(1.028)		
Experimental group	13.409(1.028)		
Difference between-groups		1.091	.457

CHAPTER 5: DISCUSSION

This study examined the role that virtual world education might play in promoting student creativity. This chapter begins with a short overview of the study and results. I will then discuss how these results connect to creativity theory in the areas of immersion/presence, multiple viewpoints (visualization and spatial awareness), play, and choices. A discussion of the technical and methodological limitations will follow, and then implications for institutional adoption. The chapter will close with recommendations for future research and concluding remarks.

Study Overview

To add to the literature on virtual world pedagogies and environments, this study sought to compare changes in creativity between two groups of university students: those who spent half of their art class experience in the virtual world, and those who participated solely in face-to-face environments. The creativity constructs of originality, fluency, and flexibility were measured through the TTCT Verbal (Scholastic Testing Service, 2007) pre- and posttests. Those same three constructs, along with the additional constructs of multiple perspectives and play, were compared through students' representations in art critiques and assessed by a constructed rating scale.

It is significant that this study examined virtual world creativity through two lenses yielding two perspectives: one global, and the other more specific. The first lens, the TTCT Verbal, aided in viewing the virtual world classroom in an overall way; students took a pretest, experienced seven weeks of instruction, and then took the posttest. This was the primary tool used in this study to measure student creativity. The second lens, an art critique rating scale, was used to focus in on a one particular activity experienced in the virtual world classroom. After

this activity—viewing a piece of artwork in either the virtual or traditional classroom —students wrote a critique of that experience. Raters then assessed student art critiques according to a scale constructed by the researcher to assess their application of various creativity principles. Results from the TTCT Verbal showed statistically greater gains in creativity in the experimental group as compared with the control group. Results from the rating scale, showed no overall significant difference between groups except in the category of spatial awareness where the experimental group's scores were statistically significantly higher than the control group's scores.

Connections between Results and Theory

Interesting connections to creativity theory emerged from this analysis. Instructor and student observations also provided insights that connected to creativity theory. Four major themes developed that might provide some explanation for the experimental group's greater gains in creativity for overall scores, fluency, flexibility, and multiple perspectives as compared to the control group: (1) The virtual world environment might have evoked a feeling of presence that positively impacted student interest or engagement in the course and thereby increased creativity; (2) Virtual world 3D capabilities may have increased student visualization and spatial awareness and flexibility that may have increased creativity; (3) The virtual world environment may have elicited some positive, playful responses to learning but not enough to significantly impact originality and play scores; (4) The virtual world gave students many choices and the ability to rapidly iterate, which may partly explain the statistically significant increase in experimental group fluency scores.

It is also possible that the Hawthorne effect (the influence of novelty) may explain the higher gains in creativity scores. The novelty of the virtual world experience, with its choice and choices, may have led to increased engagement and motivation that resulted in greater gains

(Pink, 2009). Studies in the literature reveal a lack of agreement on the issue of novelty effects. Although it is possible that an effect occurs as a result of the participants' interpretation of the situation, Adair (1984) cautioned that there may not be an effect of any kind and that post-experiment interviews would be a way to investigate this.

Immersion/presence. It is possible that one of the reasons that the experimental group experienced statistically significant overall creativity gains was the immersive nature of the 3D environment, and the co-presence and shared experience of its participants (Jarmon, 2009). Some student comments seemed to confirm this hypothesis. One student observed, "It felt real. I was able to walk around and see the beautiful artwork and study art as a class." This student reiterated the importance of a shared experience with classmates. Prensky (2001) asserted that the sensory furnishings and ambience of virtual worlds creates an immersive environment that encourages sustained interest. Records indicate that some students routinely stayed in the V.I.E.W. environment 25-30 minutes after class; some students logged back into the V.I.E.W. even after the entire course was finished. Students appeared to enjoy the virtual world environment; one student commented, "This is so awesome; the learning tree is especially cool!" The instructor's comments confirmed student interest: "I think the V.I.E.W. made the class something special and brought life to some of those [otherwise disinterested] students." Another explanation for positive results for the experimental student group might be due to student immersion in a very visual, imagery rich environment. Shaw and DeMers (1986) found creativity constructs (originality, fluency, and flexibility) correlated with visual imagery and that visual memory of images was important to fluency for children of average IQ. It is possible that the vivid imagery contained in the virtual world setting might partly explain the significant gains in the experimental group's fluency and flexibility scores.

Multiple viewpoints (visualization/spatial awareness). Torrance (Millar, 2002, p. 31) specified "unusual perspectives" as one of his listed creativity strengths. The instructors participating in the European Commission multisite study observed that activities involving multiple perspectives and spatial awareness built bridges to creativity (Cachia et al., 2010). In the current study, it was hypothesized that the added dimensionality of the virtual world and the capabilities of flight, building in 3D, and navigating in the 3D environment might have an effect on student multiple perspectives and spatial awareness, which might lead to an increase of flexibility of thought. In the TTCT results, the experimental group experienced five times the gains of the control group for flexibility. In the art critique assessment, the experimental group experienced higher scores in the spatial awareness category, with significance at ($F_{1,34} = 4.57$, $p = .039$). It might seem intuitively that students would have achieved a higher score on the spatial awareness construct in the virtual world environment, but it is to be noted that these scores would only have occurred if the students who had gone into that environment had become psychologically immersed and believed that they were in a 3D environment. In reality, they were looking at an image on a 2D computer screen.

For flexibility, the experimental group reported a statistically significant gain of $p = .001$ within their group as compared with the control group at $p = .714$ yielding a statistically significant difference of $p = .043$ between the groups. Since spatial skills have been linked to creativity (Karlans et al., 1969) it is possible that the increase of flexibility for the experimental group came as a result of the visualization of space offered in the virtual world environment.

The experimental group also exhibited statistically higher scores in spatial awareness in the art critique assessment. The experimental group was able to use the bicentric FOR as they walked in and out of the virtual painting; at once becoming part of the lunar landscape, then

walking back out of the painting into the art museum. According to findings by Salzman and

Dede (2010), students who experienced the bicentric point of view, alternating between

egocentric and exocentric Frames of Reference, reported greater mastery of abstract concepts.

Since experimental group scores were higher than the control group's scores in the spatial

awareness category of the art critique assessment, it is possible that walking in and out of the

virtual world painting using the bicentric FOR may have allowed students to better understand

the abstract spatial aspects of the painting and increase in their spatial awareness.

Students may have increased in their spatial skills by experiencing atmospheric and linear

perspective (Mckin, 1972) in the virtual world environment that included various lighting

graphics that simulated these principles.

Additionally, Zovotka (1986) noted several visualization tasks that might contribute to

student creativity, for example mentally seeing two-dimensional elements in a three-dimensional

surrounding. Experimental group students were able to concretize these visualizations though

the use of the builder tool that allowed for creating, scaling, and rotating objects to another plane.

Finally, although not statistically significant, the experimental group scored slightly

higher than the control group on the question relating to multiple perspectives/vantage points in

the rated art critique assessment. This indicator might also suggest potentially greater spatial

awareness in the virtual world setting.

Play. Lieberman (1965) demonstrated that playfulness significantly correlated with

originality, fluency, and flexibility. Graham, Sawyers, and DeBord (1989) found that students

who scored high on originality also scored high on playfulness and conversely those who scored

low on originality also scored low on playfulness. The results from the TTCT and the art

critique assessment seemed to track with the latter findings of Graham et al. (1989). The

experimental group showed a small gain in creativity of 3.680 points to the control group's loss

of -0.592 points but this was not a statistically significant difference. Interestingly, the same

pattern emerged in the rated art critiques; the experimental group experienced a small gain in the

category of play on the rated art critique more than the control group, but it was not statistically

significant. Much larger differences in scores were found in the TTCT between the experimental

and control groups in fluency, flexibility, and overall scores categories than in the originality

category.

Although the V.I.E.W. appears to offer the challenge, curiosity, fantasy, and control that

researchers characterize as intrinsically motivating and useful for creative learning environments

(Lepper & Malone, 1987; Malone, 1981), significant gains in originality and play scores did not

result. Although some students routinely remained in the V.I.E.W. environment after class and

some students returned to the V.I.E.W. after the course was finished might indicate some

intrinsic motivation to revisit an enjoyable or fun environment, this apparently was not sufficient

to create a significant increase of originality and play in creativity scores. Further research into

the inclusion of more specific games or quests within the environment might reveal important

information regarding the connection between virtual world education, games, and creativity.

Choice and choices—A comparison between Semester 1 and Semester 2. Amabile

(1989), Amabile and Gitomer (1984), and Edwards and Springate (1995) found deep connections

between choice (agency), choices (resources) and the enhancement of creativity. The following

comparison of semester one and semester two results highlights the importance of choice and

choices.

Semester 1. Chua and Iyengar (2008) noted the connection between flexibility with

regard to choices and asserted that the larger the choice set of initial elements, the more

flexibility there is in generating different combinations. Rate and amount of choices given are also important considerations in decision-making (Kalyuga, 2007). Since virtual world digital choices are offered one at a time, students were able to make choices about navigation, communication, creation, and modification based on their own time allocation and personal preferences. These decisions provided opportunities for the agency and pacing important to creativity. According to teachers who participated in the European Commission study (2009) this sort of iteration was a bridge to building creativity in students. The TTCT results for winter semester reflected high gains in the flexibility and fluency categories for the experimental group. As previously mentioned, fluency scores within the experimental group were statistically significant at $p = <.001$ and impacted the overall combined score of $p = <.001$. Flexibility scores were also statistically significant at $p =.001$ Choice and choices appropriately offered may have positively impacted these score outcomes.

  Semester 2. Spring semester results appeared to have lent strength to the importance of choice and choices for the development of flexibility and fluency. Although the spring semester at BYU-Idaho was not a true test of the V.I.E.W. technology and was not a primary focus of this discussion, the results of the TTCT and the art critique from spring semester were included in this document for the sake of comparison, particularly in the area of choice and choices. Since students in spring semester were relegated to watching the V.I.E.W. projected on a screen for several weeks without choice and choices (i.e., students were unable to control movement, speech, or creation), their ability to dictate their own learning was severely limited.

  This passive visualization was found to be less beneficial for student learning than interactive visualization (Naps et al., 2003; Schweitzer & Brown, 2007). Amabile and Gitomer (1984) found that children who were given choice were evaluated as being more creative than

those produced by children who were given no choice, and Amabile (1989) later observed that restricted choices were creativity barriers for students. Edwards and Springate (1995) asserted that students need rich resource materials that are self-chosen to increase in creativity. Although the V.I.E.W. contained rich resource materials and a myriad of choices, students in spring semester were not able to choose amongst them for learning purposes or for transacting with the virtual world due to their role as passive observers.

This appears to have had a negative impact on student scores. For example, in spring semester both the experimental group and the control group experienced very small gains in fluency. For flexibility, the control group lost an average of 4.5 points and the experimental group 1.5 points. Although the experimental group experienced less overall losses on the TTCT than the control group, it was not significant and did not match the strong gains in fluency and flexibility reported by the winter experimental group. For the art critique assessment, the control group reported 1.091 points more than the experimental group, which was not statistically significant. In comparing the statistically significant, large gains of the experimental group as compared to the control group in flexibility and fluency during winter semester with the flat, non-statistically significant scores of spring semester, it appears that the choice (agency) that was absent in spring semester may have negatively impacted experimental group student scores. Even art critique scores from spring semester showed no difference between the groups. This might indicate that immersion and choice (agency) are necessary to creativity enhancement in the virtual world platform.

Study Limitations

Technical. Some of the limitations of this study were technical in nature. Two issues in particular were problematic: (1) loading the application and (2) securing adequate Internet

connection. All students were required to download the V.I.E.W. application onto their

computers in order to access the virtual world classroom; the V.I.E.W. team traveled to BYU-I

and spent considerable time working with students in person to help with the download process.

When certain students were unable to download the program, it was discovered that students

with PC computers were required to perform the additional step (different than the Mac users) of

giving themselves permission to download the program. This was a continuing problem since it

was discovered that this additional authentication process was required each time a student

attempted to enter the V.I.E.W. Once this issue was communicated to all PC users, this loading

problem was generally solved. Some students experienced lengthy loading times, and so the

V.I.E.W. team was able to offer an installer that shortened loading times. As for Internet

connection, initially students were unable to access the V.I.E.W. on campus due to a blocked

Internet connection. A campus computer lab was set up for students that preferred to stay on

campus for the virtual world class and this resolved the issue. Some students preferred to meet

for class in the V.I.E.W. from their home, but if sufficient Internet speeds were not available,

they had to find a more suitable location. Students were able to locate areas of sufficient Internet

access from friends' apartments and this issue was resolved. Both application loading and

Internet connection problems were resolved in a couple of weeks and students were able to settle

into a weekly routine of meeting with ready computers and adequate Internet access.

Methodological. According to Runco and Okuda (1991) explicit instructions

encouraging originality, fluency, and flexibility improved student scores in those areas of

creativity. In the current study of creativity in virtual world education, the instructor who

administered the TTCT gave the explicit instructions included in the TTCT manual that

encouraged creativity. However, for the art critique assessment, students were not given explicit

instructions encouraging these behaviors. Raters observed that students might have performed better and might have been more creative on their art critique if they had been explicitly encouraged to incorporate originality, fluency, flexibility, multiple perspectives, and play in their critiques. Raters also observed that the use of the Feldman model of art criticism, although helpful in giving a common structure to all students, might have inhibited student creativity because of that structure. It was also observed that student writing styles and skills may have influenced raters to assess students with better writing skills more positively. To avoid the preceding limitations, it is recommended that future studies using a similar rating scale give students explicit instructions to be creative, require less structure in the writing assignment, and instantiate greater safeguards again the influence of writing skills on rater evaluations. If incorporated, these improvements might aid in a more accurate assessment of student creativity.

Population sampling was also a possible limitation in this study. Since the researcher was interested in studying a population of university-level students and in maintaining stability in their schedules, purposive rather than random sampling was used. Since the sample selected in this study was not random, these results may or may not be generalizable to the broader population. Also, the population was primarily female, and this may have had an impact on the outcomes of the experiment. Testing with a more equal gender representation would be advisable for future investigation of creativity and virtual world education.

As for limitations with regard to sample size, across two semesters, the total sample size was 97 participants. There was a total of 51 participants in the control groups, and a total of 46 participants in the experimental groups. However, 22 of the 46 experimental group students were unable to experience the virtual world platform in an adequate manner. Although this circumstance allowed for a contrast between the groups from semester to semester, especially in

regards to active participation with choice, it would have been optimal to have had all 46 experimental group participants able to fully participate. When replicating this study, it would be advisable to include a larger population sample that consists of relatively equivalent groups for a more complete estimation of the impact of virtual world education on creativity.

Initial differences in the control and experimental groups' pretest scores presented some limitations. Although the experimental group made significantly greater gains than the control group, their ending scores did not reach as high a level as the control group. This disparity may have been due to factors that were not obvious such as lower or higher creativity or IQ of the groups as a whole. In a recent study, Tateishi (2011) suggested that groups that tested low in creativity seemed to show greater gains than those groups who began with a normal creativity score. Further research in this area might prove helpful to understand the possible difference of intervention impact between students of low and normal creativity scores.

Implications for Institutional Adoption

This study's results indicate some initial positive findings for virtual world education that may prove valuable for educators and administrators. These results may have implications for not only creativity, but for overall student performance. According to this study's findings, the virtual world platform might enhance student creativity or overall student performance as a result of an increase in the following three areas: (1) engagement, (2) spatial skills, and (3) choice/choices.

First, an increase in student engagement might be one explanation for students' higher creativity scores. The instructor noted that the V.I.E.W. brought "life to otherwise disinterested students" in the experimental group. Amabile (1996) suggested that highly gifted and creative underachievers may become energized as a result of playful engagement. Students may have

perceived the virtual world platform as a more playful environment than the traditional classroom. It is possible that these Net Generation students responded well to the virtual world technology and thus experienced greater gains on the creativity tests.

Second, results from this study suggested that spatial skills were heightened as a result of the 3D capabilities and environment of the virtual world. Educators who teach in disciplines that require advanced spatial skills such as architecture, interior design, art, 3D animation, programming, and STEM (Science, Techology, Engineering and Math). might benefit from the adoption of virtual world platforms that facilitate visualization and heightened spatial awareness. Fiore, Rodriguez, and Carstens (2012) and Esteves et al. (2009) suggested that the capabilities offered in the virtual world environment of concrete, 3D object visualization and movement with immediate visual feedback were beneficial to individuals for collaboration and learning.

Third, the results of the current study indicated a sharp rise in the creativity constructs of fluency and flexibility in the experimental group, which may be attributable to the freedom of choice and multiple choices (Chua and Iyengar 2008) offered in the virtual world. Fluency and flexibility may have been increased due to the ability to rapidly iterate in this environment. The rapid iteration capabilities indigenous to the virtual world environment help students practice the iterative process in a non-threatening, risk-free environment with unlimited digital materials. This skill of rapid iteration might also prove beneficial to students entering the field of business (Kelley & Littman, 2000).

Future Research

In evaluating the directions that future researchers might take in studying creativity in the virtual world environment, six recommendations have come to the forefront.

The first recommendation for research would be to replicate the current study with some modifications and under improved conditions. Modifying the study to include a qualitative instrument such as discussions with students about their learning experiences in the class (rather than the art critique assessment), paired with the TTCT Verbal, might provide deeper understanding of student perspectives, especially in regard to novelty effects (Adair, 1984). As for improved conditions, adequate support from administrative policy makers in advance of the study would eliminate technology access issues. The improvement of the tool itself to be web-based rather than application-based would better assist students in using the tool without undue difficulty. It also would be useful to implement a tool that monitors student activity in the virtual world and would provide useful analytic data for additional perusal. Broadening the study to include a multi-site format, increasing the number of student participants, and using random selection might help to substantiate the reliability of the study and generalizability of its results.

It might also prove beneficial to study time of day effects and their possible impact on student creativity scores. Since the experimental group's initial and ending scores were less than the control group's scores, and the former group met at 8:00 a.m and the latter group met at 2:00 p.m.—and since there is some evidence that university-level students do less well in the morning (Allen et al. 2008)—it is possible that the time of day may have affected the experimental group's overall creativity levels. In future studies it might be advantageous to control for the time of day that the TTCT is given.

Other interesting iterations of this study would be to include longitudinal studies testing students over a period of years. In addition, it would be helpful to study the effect of amount of time spent in the virtual world—a quarter, a semester, a year—or the way the time is divided between the virtual world and the physical classroom. For example, one group might consist of

students who would attend class in the virtual world for three weeks without attending the physical classroom, and then attend the physical classroom for three weeks, and so on, in that pattern. A second group might alternate by attending the virtual world every-other class session, and a third group might spend the entire course in the virtual world.

The second recommendation would be to direct research focus toward one specific area of the current study, such as spatial awareness and creativity. This topic could be expanded and explored in a number of different ways. For example, students could be given tasks and assessments that would specifically examine (a) creating and moving 3D objects in the virtual world, (b) exhibiting an understanding of linear and atmospheric perspective, (c) understanding abstract spatial concepts, such as scope and size of artworks, and (d) viewing objects from different virtual physical vantage points. An investigation of these topics would add to this underdeveloped area in the creativity research literature.

The third recommendation for research would be to include IQ as a factor in studying creativity in the virtual world. Shaw and DeMers (1986) found that creative abilities are more likely to exist above an IQ threshold of about 115. They also found that overall creative thinking in terms of originality, fluency, and flexibility were linked strongly or moderately strongly with imagery, and these links occurred more often and more strongly with the high-IQ group than with the comparison group. Curiously, they also found that images for memory appeared to be more influential for average intelligence children than for high-IQ children. It would be interesting to revisit the Shaw and DeMers (1986) study using virtual world imagery as the basis for the assessment metrics rather than the conventional imagery that would have been used in 1986. It may be that the rich 3D imagery found in the virtual world environment might trigger

greater gains in creativity for average- to low-IQ students and level the playing field for these students for creativity gains.

The fourth recommendation for research would be to investigate the relationship between the inclusion of more quests and game-like activities in the virtual world to see if they might increase originality scores on the TTCT. Since play was a primary factor for overall learning for students who experienced statistically significant gains in the virtual world platform Quest Atlantis (Barab 2005), it is possible that students might experience greater gains in originality if more specific play events (quests and games) were included in virtual world platforms. Future research is needed to determine the strength of connection between an increase of game-like activities in the virtual world environment and increased creativity.

The fifth recommendation for research would be to study special populations in regard to creativity in the virtual world environment. In conducting research on simulated motion in virtual worlds, a report emerged that articulated the benefits of virtual world environments for stroke victims. One individual in particular found that participating in virtual movements aided in recovery (Stein, 2007). In addition, a student using the V.I.E.W. expressed appreciation for the virtual world educational platform that allowed for attendance and normal participation in class activities during sickness. These accounts gave rise to the idea of investigating the benefits of virtual world classrooms for special populations like handicapped students. International students may also benefit from virtual world environments as previously noted (Esteves, Fonseca, Morgado, and Martins, 2009).

The sixth recommendation would be to investigate the impact of virtual world education as an intervention for groups of varying creativity levels. Researchers might accomplish this by administering the TTCT pre- and posttests and then, based on those results, divide participants

into high and low creativity groups. Virtual world lessons would then be given to both groups and then an alternate creativity assessment would be administered. These results might produce further information about the possible difference of impact interventions might have on groups of varying creativity levels.

Conclusion

In this study, we investigated the connection between virtual world education and creativity using two different quantitative measures, the TTCT Verbal and a constructed rating scale. From these two metrics, 177 data points from 97 participants were collected and statistically evaluated. In addition to this quantitative information, several instructor and student qualitative observations were reviewed. In analyzing this study from a global perspective, winter semester experimental group students who experienced virtual world instruction and took the TTCT achieved greater gains than the control group in nearly every category, though their overall gains did not reach the level of the control group students. More students in the experimental group achieved overall gains than control group students and had less overall losses than the control group students. For the art critique assessment, both groups seemed relatively equivalent except for the statistically significant positive difference that the experimental group experienced in the area of spatial awareness compared to the control group. In this study, some instructor comments affirmed increased student interest and engagement in the virtual world setting; some student comments were positive and some were negative. According to this study's test results, it preliminarily appears that something about the virtual world experience may have positively impacted the experimental group students' creativity scores.

Although the tests, assessments, and observations derived from this study may be helpful for educators investigating virtual world education, more research is required. In the final

analysis, these results are only an initial attempt at learning more about the possible impact of virtual world education on creativity. There are still many questions left unanswered.

As researchers conduct investigations in this area, they will encounter classrooms—both real and virtual—comprising student populations that exhibit a wide range of intelligence, inclinations, motivations, physical and emotional issues, and creativity levels. Data from the current study may help researchers better understand how to work with complex student populations and may become a springboard to additional studies about creativity and the intriguing area of virtual world education. It is hoped that research in this area will continue to move forward, keeping pace with student needs and establishing benchmarks to inform and guide the path of education toward a successful and more creative future.

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Appendix A: Subjectivities Statement

During the first semester of my PhD program, I was introduced to virtual world education. I was immediately struck by the possibilities of that platform and through a set of unusual circumstances I began to create my own virtual world. The virtual world, the V.I.E.W., came into existence as a result of a need for a safe and virtuous teaching environment in which to conduct my study. Because of my inherent interest in and bias toward virtual world education, I took precautions to preserve objectivity.

These precautions extended protection against subjectivity from the beginning of the study until the end. For example, the study itself was conducted at BYU-I rather than BYU Provo where I teach. A professor at BYU-I was the instructor in the virtual world and the traditional classroom, and I remained out of state and was simply a support to the instructor online. Also, to avoid the perception of undue influence on students by either myself or the professor, the professor's teaching assistant at BYU-I administered the student consent forms. The TTCT Verbal, both the pre- and posttest, were administered by the BYU-I professor and Scholastic Testing Service graded the TTCT Verbal pre- and posttests. A party uninvolved with the study conducted the statistical analyses. As for the rating scale, I sought counsel from an expert in the department that was not connected to this study to guide its creation and sought input from my co-chairs to confirm the design. I made copies of all student art critiques and removed student names to maintain student anonymity. Although the raters reside in Utah and were evaluating critiques from students from BYU-I, on the chance that they might recognize a student, the removal of the names was done to aid raters in maintaining objectivity. The raters were professional colleagues and after initial training, I remained uninvolved in the evaluation process.

Since I am the creator and designer of the virtual world the V.I.E.W., which has now become a company, I acknowledge that there is possibility of benefitting from positive results from the study. Although that possibility exists, it would not be the primary selling point for the V.I.E.W. My intent is to present the information gathered in this study in the most fair and honest way possible.

Appendix B: Scale for Assessing Student Responses to Artwork

ART CRITIQUE RATING SCALE

Rater Instructions:

Please rate the student's critique on six dimensions, as described in the rubric below.

---

1. PLAY: Uses a playful approach, showing imagination, humor, adventure, exploration, fantasy

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

1 = *Low perception*
Little or no mention of play elements

3 = *Slight perception*
Passing mention of play or elements

5 = *Moderate perception*
Several mentions of play or elements; noted enjoyment of this construct

7 = *High perception*
Repeated focus on play; strong affinity/enthusiasm for exploration or adventure

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2. VANTAGE POINTS: Describes perspectives like above, beneath, inside, outside, on top, below

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

1 = *Low awareness*
Little or no mention of vantage points

3 = *Slight awareness*
Brief mention of place or perspective

5 = *Moderate awareness*
Notes personal location or unusual perspective

7 = *High awareness*
Obvious attention to place, angles, and frames of reference

---

3. ORIGINALITY: Employs novel, unusual, or vivid ideas, approaches, or descriptions

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

1 = *Very weak*
Very bland or mundane approach to describing artwork

3 = *Somewhat weak*
Limited evidence of unique thought in description

5 = *Moderately strong*
Some colorful description; some use of literary elements; simile, metaphor

7 = *Strong*
Effective use of adjectives, simile, metaphor

---

4. FLUENCY: Explores one idea spilling off of another idea; rapid fire of many ideas about one topic

1	2	3	4	5	6	7

1 = *Very weak*	3 = *Somewhat weak*	5 = *Moderately strong*	7 = *Strong*
Shallow discussion of artwork with predictable, plodding execution; little or no evidence of a flow of many ideas	One-dimensional ideas offered; finite or chopped ideas without much elaboration; occasional use of a longer train of thought or series of several ideas	Regular use of elaboration and evidence of thoughts in a series; thought pathways explore ideas with depth	Strong evidence of flow of ideas throughout critique; writer explores topics with a rapid fire of many ideas; expansive view of topic due to number of ideas generated

5. FLEXIBILITY: Offers multiple ideas in different categories; sees things from different intellectual or physical vantage points

1	2	3	4	5	6	7

1 = *Very weak*	3 = *Somewhat weak*	5 = *Moderately strong*	7 = *Strong*
Focus on the same idea without diverging into other idea categories; repetition of the same idea; intellectually flat	Many phrases seem cliché or trite; thoughts seem closed and less diverse; occasional use of outside-of-the-box thinking	Good variety of ideas; many thoughtful insights; care was taken to think through ideas and diverge in thought	Vibrant thought processes; ideas intellectually stimulating; a wide range of ideas and new ways of thinking of familiar topic

6. SPACIAL AWARENESS: Includes descriptions like near, far, beyond, 3D, distance, around, space

1	2	3	4	5	6	7

1 = *Low awareness*	3 = *Slight awareness*	5 = *Moderate awareness*	7 = *High awareness*
Little or no mention of space, distance, or dimension	Allusion to background or foreground as art vocabulary; rare use of other spatial terms	Multiple evidences of spatial thinking; discusses near and far; relates many ideas to spatial elements	Abundant allusion to space, distance, direction, dimension, near and far

Appendix C:

Scale Questions with Related Creative Thought Categories and Examples

QUESTION/ CATEGORY	KEY WORDS OR PHRASES	SAMPLE RESPONSE
1 -PLAY	PLAYFUL, IMAGINATION, HUMOR, ADVENTURE, EXPLORATION, FANTASY	"A lone bird flew across the dappled sky, surveying the desert below"
2 -VANTAGE POINTS	ABOVE, BENEATH, INSIDE, OUTSIDE, ON TOP, BELOW	"Dancing stars tumbled down the single moonbeam that lit the black velvet sky, almost as though they wanted to reach Earth to play with the night creatures"
3 - ORIGINALITY	NOVEL, UNUSUAL, VIVID IDEAS/APPROACHES/ DESCRIPTIONS	"As I viewed the artwork, I imagined that I was that star in the sky, falling Earthward…trying to brace myself before crashing into the lunar landscape"
4 -FLUENCY	ONE IDEA SPILLING OFF OF ANOTHER IDEA…RAPID FIRE OF MANY IDEAS ABOUT ONE TOPIC	"If I were to have to list the various colors that are represented in this artwork, I would say that vermillion, cadmium red light, dioxazine purple, rose madder, lamp black, cobalt blue, Payne's grey and several other colors are part of the landscape"
5 - FLEXIBILITY	MULTIPLE IDEAS IN DIFFERENT CATEGORIES; SEEING THINGS FROM DIFFERENT INTELLECTUAL OR PHYSICAL VANTAGE POINTS	"If I were the star, the scene below would seem small and far away…if I were the rock on the lunar surface, I would be looking skyward, hoping that the star would not fall to crush me"
6 -SPATIAL AWARENESS	NEAR, FAR, BEYOND, 3D, DISTANCE, AROUND, SPACE	"The hot orange lava stretched back for miles, as far as the eye could see then melted around the tall violet structures that stood like sentinels in the dark"

Appendix D: Feldman Model of Art Criticism

MATRIX: Introduction to Feldman's Method of Art Criticism

	TITLE:	ARTIST:	MEDIUM:	DATE:
DESCRIPTION	**GOALS:** To describe objectively what you see; to delay judgment. List title; artist; date; medium; size. Is work representational, abstract, or nonobjective? Can you identify a subject? If not, are there objective "hints" about a subject? Describe how the elements are used: line; shape; form; space; color; light & dark; texture; time; motion.			
ANALYSIS	**GOAL:** To describe behaviors of what you see. Describe how the elements above use the principles of design (balance, scale & proportion, emphasis & focus, repetition & rhythm, & unity & variety).			
INTERPRETATION	**GOAL:** To find meaning in what you see. What does the work remind you of? How does the work make you feel? Why? What do you think the artist was trying to do? What is the intended use of the object? Are there symbols in the work? What do they mean?			
EVALUATION	**GOAL:** To evaluate what you see. Does the work have value through formal qualities (use of elements & principles of design)? Value through expression of emotion or feeling? Value through purpose? Are materials appropriate? How could it have been more successful? Who might value this work?			

ARTS 2001-Art Appreciation. ©Betty Oliver Seabolt Matrix: Intro to Feldman's Method of Art Criticism

Appendix E: "Some Moon" Artwork by Abraham Day used for Art Critique