SKETCHING AND CREATIVITY
OF INTERIOR DESIGN STUDENTS

by

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the

thesis of KATHLEEN RYAN find it satisfactory and recommend that it be accepted.

Chair

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OF INTERIOR DESIGN STUDENTS

Abstract

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Sketching is evidence of how a designer thinks through an idea. This research aims to answer the question: in the preliminary stage of concept generation for interior design, do the quantity of sketches produced predict creativity? What is the correlation between the number of concept development drawings generated and creativity, aesthetics, or technical quality? Is there a phase in the design process in which the actual number of process sketches produced predicts creativity for a design?

This study investigates the relationship between a measurement of creativity and the quantity of concept development process sketches a student produces, by exploring the connection between the evidence of process (the sketches) and a representation of creativity through a final product (the process poster). Using the Consensual Assessment Technique (Hennessey and Amabile, 1999) measurement of creativity is determined by assessment of project posters created by students. Linear regression is utilized to determine the relationship between the two variables: measurement of creativity and number of process sketches produced. Learning styles assessments and a self-evaluation of creative achievement support understanding of assessed creativity and the creative process. The relationship between sketching and creativity within this group of students is not clearly defined. Changes in the rating system and creative product may be warranted to yield a more conclusive result.

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Chapter 1 Introduction

Visual Thinking Ability and Creative Outcomes

Sketching is evidence of how a designer thinks through ideas. A single sketch or a series of sketches provides evidence of the designer's visual reasoning process. Identifying the process by which a student designer thinks and sketches has useful implications for the development of teaching methods, and predictions for success in practice. Understanding the nature of visual reasoning and assessing student performance in this area would clarify, justify and support educational activities. The development of visual reasoning skills is an important grounding base for design instruction. CIDA (2006) advises that students must demonstrate "the ability to rapidly visualize concepts through sketching" (p.II-11). Clearly industry and education value concept sketching. Goldschmidt (1991) asks "what is it that happens when one sketches, and why is it so helpful to sketch when starting to design?" Sketching is noted as ubiquitous behavior for designers, and has been studied in many forms in the search for understanding of the cognitive processes that result in a conceptual sketch (Goldschmidt, 1991; Arnheim, 1993; Purcell & Gero, 1998; Verstijnen & Hennessey, 1998; Bilda, Gero & Purcell, 2006; Menezes & Lawson, 2006).

Sketching, as a demonstration of thinking, has been described by many as evidence of how we reason through a problem (Laseau, 1989; Goldschmidt, 1991; Arnheim, 1993). Laseau (1989) uses the term graphic thinking to express the process a designer undergoes to develop and illustrate an idea. Laseau describes the visual reasoning process as a closed network between the brain, the eye, the hand and paper, and the continuous cycle therein that produces ideas, which are considered, reconsidered, reshuffled, and recombined until this process of internalized and externalized thinking results in a workable design solution. Visual thinking as described by Arnheim (1969) is the interaction of our memories, perceptions and thinking, when we are able to transform our cognitive perceptions (mental imagery) into physical manifestations as drawings.

This process of thinking, drawing, reasoning, and re-drawing defines the process of concept development in interior design. Graphic and visual thinking are methods by which designers formulate their ideas. Sketching is the communication evidence of the process of thinking for designers. The circuitous process of sketching, then reconsidering, and sketching again provides a small window into the spatial problem solving and cognitive processes of a designer. The sketch acts as communication of visual thinking.

Cognitive mapping provides a structure for considering the process of sketching as thinking (Downs & Stea, 1973; Kitchin, 1994). Cognitive mapping is a theory that begins to describe the cognitive processes that support spatial problem solving. Downs and Stea define cognitive mapping as how "an individual acquires, stores, recalls and decodes information about the relative locations and attributes of the phenomenon in everyday spatial environments" (1973, p. 7). This concept is related to the spatial abilities of visualization and orientation through and the process of transferring mental images into 2D and 3D representations. Spatial cognition and environmental cognition are connected as two parts of cognitive mapping. The process of creating a cognitive map involves our perception of spatial qualities as well as our perception of the physical environment. The ability to develop a cognitive map depends upon spatial awareness; both are necessary in understanding the relationship between a mental image of space and the graphic presentation of an idea for an interior space. The process of transforming 2-dimensional drawings into 3-dimensional representations is supported by our cognitive map perceptions, and our spatial and cognitive abilities. The use of 2-dimensional and 3-dimensional sketches to communicate ideas forms the basis for this study.

Predicting creative outcomes through sketching

Educators have looked at student attitudes and ideas about design in the pursuit of understanding student motivation and focus (Brunner, 2007; Portillo, 1996). Students express the

view that creative ideas are developed through sudden inspiration commonly known as a eureka moment (Portillo, 1996) rather than achieved by working through multiple iterations or revisions of an idea. Does the perception that creativity manifests instantaneously, affect a student's ability in the early phase of concept development to develop ideas and skills necessary to accomplish creative tasks? Understanding how a student develops an idea through 2-dimensional and 3-dimensional sketching, and assessing the creative outcome may reveal the effectiveness of instructional processes. From the student's perspective preconceived notions on the nature of creativity and the how they implement ideation may influence performance in the design studio environment. Drawings produced in the studio environment provide evidence of the ideation process.

Brunner (2007) found that design students place less value on abstract thinking activities, and more value on understanding the problem and sketching ability. Design students considered the conceptual areas of abstracting, synthesizing, making tradeoffs and decomposing less important than understanding the problem, making decisions and using creativity. The areas of abstract thinking and synthesis are critical to concept development as indicated by Laseau (1989), Arnheim (1986) and others. Neglect of the areas of abstraction, synthesis and decomposition by students will likely impact the integration of essential skills required to be successful and creative. Students do value understanding the problem, using creativity, making decisions, sketching and visualization (Brunner, 2007). However, if design students discount abstraction, synthesis and decomposition, it may follow that their visual reasoning skills and work produced will be negatively impacted. Both Arnheim (1969) and Laseau (1989) indicate that abstraction and synthesis are essential parts in the process of spatial thinking. Students who do not value abstraction or synthesis may spend less time engaged in expanding their skill in these areas. Spatial reasoning and visual reasoning including abstracting and synthesizing are key skills identified by interior design professional organizations (Martin & Guerin, 2006), and are developed in the instructional environment (CIDA, 2006).

Problem-solving and visual reasoning skills are vital to success in design and are identified by

Martin and Guerin (2006) in the Interior Design Profession's Body of Knowledge (BOK). The BOK identifies the knowledge that currently exists in the profession of interior design, and presents a knowledge framework valuable for practitioners and educators. In addition the Council for Interior Design Accreditation (CIDA) Professional Standards (2006) provides a structure for ensuring that interior design students are prepared for practice. These two documents quantify and qualify the current state of interior design education, and provide structure for educational development. Nussbaumer and Guerin (2000) reveal to what extent interior design students use visual reasoning skills to solve design problems, and conclude that learning styles are related to visualization skills. CIDA Professional Standards also identify the visualization of concepts and problem solving as two essential areas that demonstrate advanced student learning. CIDA (2006) defines creative thinking as "exhibit a variety of ideas, approaches, concepts with originality and elaboration" (p.II-9), and frequently refers to evidence of "2 and 3-D basic creative work" in determining program outcomes.

Arnheim (1986) believed that creativity is related to our ability to reason visually, and that ability can be taught and directed through development of perceptual ability. The creative nature of sketching provides the evidence for this study. This study proposes to determine the relationship between conceptual sketching and creativity at the student level. Understanding aspects of conceptual sketching related to creativity may provide further direction for the development of effective teaching methods in this domain.

Chapter 2: Review of literature

Creativity and creativity assessment techniques

Defining creativity has long been a matter of discussion in the areas of art, design and psychology (Guilford, 1950; Arnheim, 1969; Hocevar, 1981; Goldschmidt, 1991) with many theories and little consensus. Creativity has been assessed in a number of ways: through determination of personality traits using the Torrance Tests of Creative Thinking or the Myers-Briggs Type Indicator; through outside rating of a product or through thinking tests (Amabile, 1982; Hocevar 1981); and by attempts to uncover the process by which an individual creates through various types of observations (Goldschmidt, 1991). Several studies have looked at imagery created, and quantified the sketches with coding schemes in an attempt to uncover the cognitive processes performed during the sketching as thinking process (Goel, 1995; Kavalki & Gero 2001). Others have used "think-aloud" protocol analysis combined with content analysis of the product (Menezes & Lawson, 2006; Goldschmidt & Weil, 1998, Suwa & Tversky, 1996) to document the thinking process as the individual sketches.

Assessing the process that yields a creative outcome is intrinsically difficult to study. Analyzing personality traits is an attempt to understand the process of producing creative product by understanding how an individual prefers to work but does not provide evidence about how an individual cognitively processes information and creates a sketch. Reviewing the creative product and the physical evidence of cognitive processes may illuminate a link between sketching and a final creative product.

The Consensual Assessment Technique (CAT) was selected for this study to assess the evidence of creativity in student work because of its reliable use in previous examinations of creative assessment of a product (Carson, Peterson & Higgins, 2005; Chen et al, 2000; Dollinger, Clancy Dollinger, & Centeno. 2005). Amabile (1982) uses the following consensual definition of creativity

for application with the CAT method of evaluating creativity:

> A product or response is creative to the extent that appropriate observers independently agree it is creative. Appropriate observers are those familiar with the domain in which the product was created or the response articulated. Thus, creativity can be regarded as the quality of products or responses judged to be creative by appropriate observers, and it can be regarded as the process by which something so judged is produced. (p. 1001)

The CAT method has been used reliably to assess a variety of end-products, simple and complex, including abstract visual compositions, poetry, essays, designs using geometry, design of computer programs, and design of a structure (Hennessey & Amabile, 1996). In the CAT method it is critical to assess separately between the areas of creativity, aesthetics and technical quality. Aesthetic judgments can interfere with judgments of creativity (Amabile, 1982). The aesthetic quality of a final product has aspects of graphic design and composition that distract from the individual imagery that may reveal creativity, innovation or novelty (Goldschmidt and Weil, 1996). Amabile (1982) clusters several criteria to evaluate in order to fully consider creativity as separate from aesthetic value and technical quality on assessment of a product. The products of sketching provide physical evidence of thinking and offer the potential to discover links between sketching and creativity through the evidence of process sketches as compared to final idea presentation.

A companion method to assessment of creativity is the self-assessment. The Creative Achievement Questionnaire (CAQ) (Carson, Peterson & Higgins, 2005) is based on the assumption that creativity is usually expressed within a particular domain, such as art, music, dance and others, and achievement is usually related to the training or experience in the domain. Achievement in these fields has a history of recognition at the local, regional, national and international level. The CAQ also assumes that recognition by "experts" in the domain is one of the most valid measures, and that recognition in more than one domain will indicate greater achievement, which equates with greater creativity. This method was successfully used by Carson, Peterson and Higgins (2005) to predict

CAT scores based on the results of the self-assessed CAQ.

Sketching related to creativity

Sketching is an activity commonly used by designers in the early stages of concept development (Menezes & Lawson, 2006) and is essential in the full realization of an idea (Bilda, Gero & Purcell, 2006). Verstijnen and Hennessey (1998) found that students who were allowed to sketch during an exercise performed significantly better on development of novel approaches than counterparts who were not allowed to sketch in the same circumstances. Menezes and Lawson found that designers with more past experience and a more extensive knowledge base were more adept at ideation through sketching. Sketching was used to record ideas as well as to generate ideas through "emergence" of an idea and "reinterpretation" of an idea (p. 572). Learning how to sketch develops student skill in moving through iterations of conceptual ideas (Bilda, Gero & Purcell, 2006) although sketching may not be as helpful for novices during ideation, the repeated explorations of ideas through sketching undertaken in design courses are the basis for development of this expertise. This study assesses the current state of student sketching performance related to creativity.

Thinking Visually-Visual Reasoning: Discussion of theoretical context or logical framework

A designer's success in abstract and concept sketching is an area worth investigating to expose the translation of cognitive imagery to a visible expression on paper. Goldschmidt and Weil (1998) have explored facets of design reasoning in an attempt to describe the cognitive processes involved in the early phase of seeking a design solution. Understanding design reasoning is particularly useful in the early stages of the design process. The process of developing an idea, as Laseau (1989) explains, is cyclical. Sketching, reflecting, revising and sketching and development of

a support system for this early stage may benefit from incorporation of spatial visualization and problem-solving skills. Arnheim (1969) quotes Aristotle "the soul never thinks without an image" to clarify the position that spatial perception is essential to translating cognitive information (mental imagery) to a two- or three-dimensional sketch. Spatial visualization skills permit effective transfer of cognitive information to a sketch.

A recent survey of interior design practitioners expressed that the ability to sketch quickly in three-dimension was a necessary skill for new professionals (Pable, 2007). Pable surveyed interior design educators and practitioners on their attitudes towards quick sketching. Educators and practitioners were adamant that the ability to create quick sketches is essential to communicating early ideas. Educators teach the skills necessary to sketch, methods of concept development and visual reasoning at all levels, but the volume of sketching has not been linked specifically in relation to measuring creativity. Sketching is a key component in communicating ideas, and is the physical expression of visual reasoning. Exploring and understanding the links between visual reasoning, sketching and creativity may demonstrate where connections between these aspects can be strengthened in education.

The U.S. Department of Labor has identified "thinking skills' as essential foundation skills, and elaborate in the following definition "Uses imagination freely, combines ideas or information in new ways, makes connections between seemingly unrelated ideas, and reshapes goals in ways that reveal new possibilities" (U.S. Department of Labor, 2000). These thinking skills are essential to the education process as well as the professional design process. Determining how interior design students think while developing concept sketches may shed light on what methods or interventions would encourage success by interior design students.

The basis for this study is the premise that visual reasoning is at the center of the design experience, and is influenced by spatial ability, learning style and personality traits (Figure 1). Abstract thinking ability is influenced by spatial ability, learning style and personality traits. Abstract

thinking ability in turn influences fluency in concept development, which influences creative product, all through the filter of visual reasoning. This map of the theoretical framework describes the relationships between the key cognitive aspects that influence sketching and creativity. Our spatial cognition (our ability to transform between 2-dimensional and 3-dimensional representations) influences our visual reasoning and abstract thinking skills.

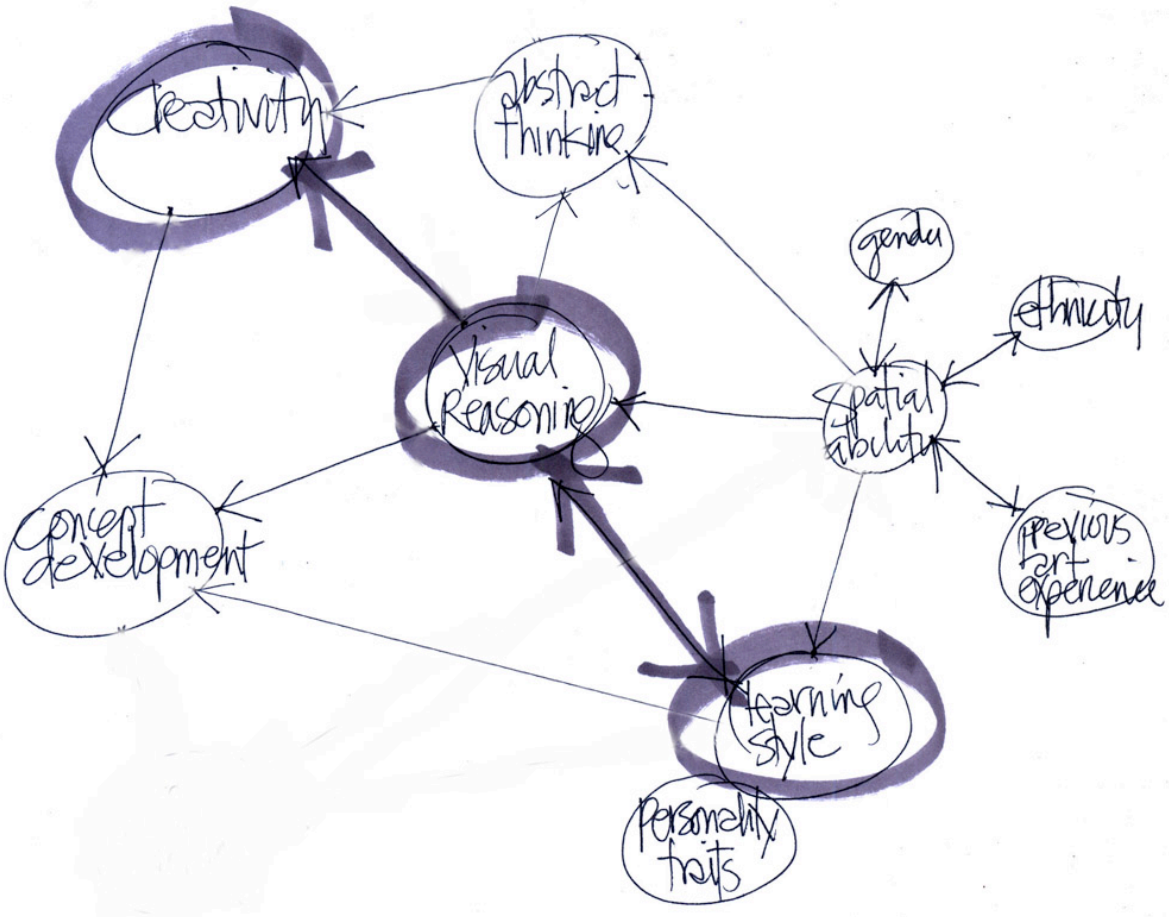

Figure 1: Diagram of logical framework for thesis study.

Concept Development in Design Disciplines

Concept development is a distinct early phase of exploration in the design and engineering disciplines. It has been identified as the occasion for generation of multiple and varied ideas, some of which will be developed further, and other ideas to be discarded (Bilda, Gero & Purcell, 2006). Sketches are considered to be the primary method for recording these early conceptual ideas (Lawson, 1988; Goldschmidt & Weil, 1998; Menezes & Lawson, 2006). Novices and experts alike engage in conceptual sketching activities. Early in this stage sketches are notable because of their abstract and often ambiguous nature (Goel, 1995; Goldschmidt, 1991) that encourages a dialogue between the designer and the sketch. This dialogue is described as evidence of the process of reasoning out an idea, or a series of ideas (Goldschmidt & Weil, 1998). Goldschmidt (1991, p. 190) describes this process as sketch-thinking, Verstijen, et al. 1998 & Hennessey (1998, p. 520) as idea sketches, and Arnheim (1993) describes the sketch as the "tangible" evidence of thinking (p. 19). The many terms used to describe the cognitive process of sketching are descriptive of the fluid nature of sketching.

In order to understand the process of sketching and thinking, Goldschmidt (1991) looked at sketching in terms of the number of designer "moves" exhibited through sketching and verbal dialogue (p. 125), but did not discuss the quantity of sketches produced. Many studies have looked at sketching activities in engineering in order to develop a computational method to generate ideas (Hwang & Ullman, 1990; Chakrabati & Bligh, 2001; Suwa & Tversky, 1996, 1997). Song and Arogino (2004) counted sketches by engineering students and determined that the volume of total sketches produced during the concept development phase had a positive effect on the design outcome. The measurement of design outcome was determined by instructor's evaluation, but specifically did not assess creativity or originality. Song and Arogino (2004) also evaluated sketches by level of detail and variety by using Shah and Vargas-Hernandez's (2003) measure, which indicated that the generation of similar ideas indicates low-variety, and the generation of diverse

ideas indicates high-variety. This deeper review of each sketch also correlated with higher grade outcome.

Thinking Styles and Thinking Styles Analysis

Relationship of learning styles to design process and instruction

The design process is described by Nussbaumer and Guerin (2000) as working "through several solutions of the design problem." This process of ideation is influenced by an individual's cognitive style, experience, and learning style. Practitioners in interior design use critical, analytical and strategic thinking to develop creative design solutions. Practitioners create representations that follow a path of increasing elaboration through the design process from abstraction towards a "structured and more concrete representation" (Pereira, 1999). In the conceptual development phase of design, designers generate multiple ideas and select ideas to transform and develop further. Lawson (1983) describes this process as balancing between divergent and convergent thinking. Multiple original ideas are formulated during divergent thinking, and those ideas are further developed and transformed during convergent thinking. These two styles of thinking are diametrically opposed, but inextricably linked by their usefulness in concept ideation. Identifying links between thinking styles, concept sketching and creativity are the goals of this study.

Relationship of learning style to creativity

Two cognitive style characteristics; convergent and divergent, were proposed by Guilford in the 1950's. Divergent thinkers are defined by their ease in ideation and comfort outside of the known and predictable. The divergent thinker generates a multitude of ideas that are possible for further consideration and exploration. Riding and Cheema (1991) describe the convergent thinker as accomplished at developing a correct answer based on the information at hand, while the

divergent thinker will generate a number of solutions, all equally acceptable. Convergent thinkers are characterized by a single-minded production of one definitive solution. Durling, Cross and Johnson (1996) postulate that designers' creativity is linked to intuition. They attribute this characteristic to the intrinsic differences between divergent and convergent thinking as they relate to problem-solving (Figure 2).

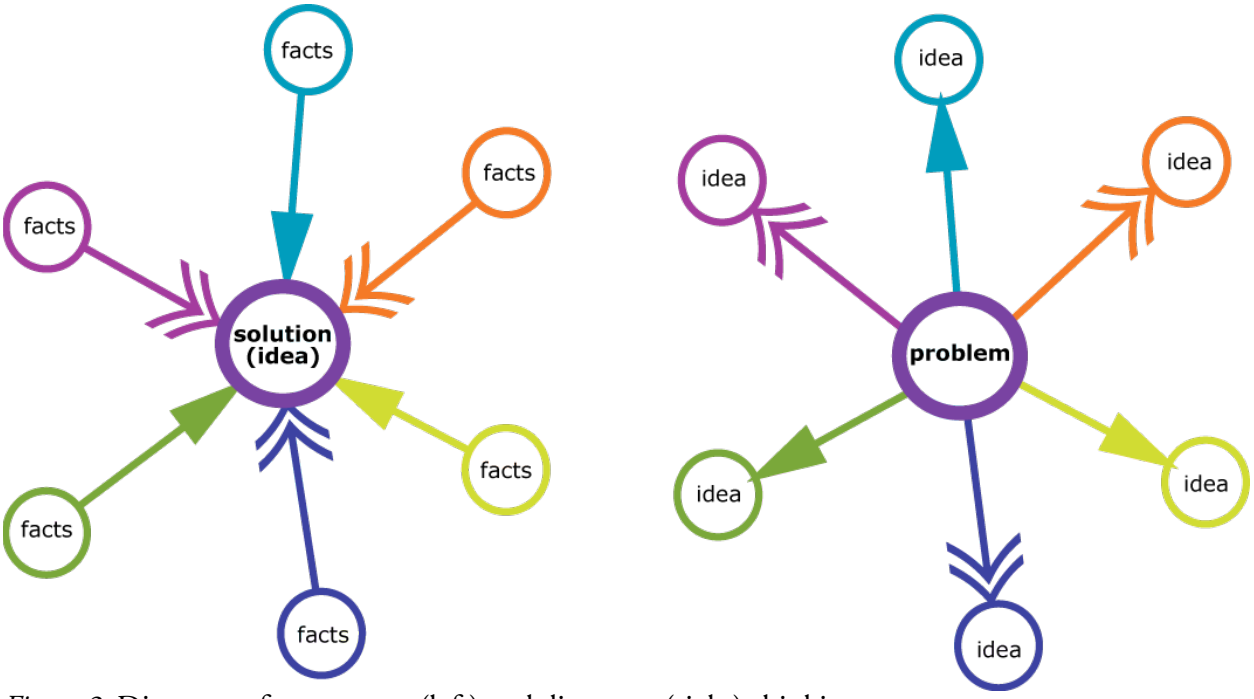

Figure 2: Diagrams of convergent (left) and divergent (right) thinking.

Pereira (1999) hypothesizes that creativity in design occurs at an experiential level, where ideas are imagined, then represented typically through sketching. Creativity in design is recognized as the generation of ideas, not necessarily the representation of solutions. Pereira (1999) describes the design process as developing progressively more detailed representations that move from the abstract to eventually more concrete depictions. The early abstract phase is equated with more creative ideation and 2-dimensional sketches, and the later phase more structured and solution oriented, as shown by 3-dimensional sketches (Goel, 1995). Goldschmidt (1991) describes design sketching as a visible representation of design reasoning, depicting the dynamic nature of ideation. If

sketching represents "inherent reasoning patterns" (p. 124) as Goldschmidt conveys, then the theory of convergent versus divergent thinking may be evident in sketches.

Liu and Bligh (2003) explain that conceptual design process relies on our ability to employ divergent and convergent thinking in tandem. During divergent thinking a designer is generating multiple abstracts ideas. In this stage Liu and Bligh (2003) have stated that quantity is important in order to have sufficient raw material or abstractions to refine into a workable solution. However Liu and Bligh did not specify the quantity of sketching considered sufficient. Determining how convergent and divergent thinking relate to sketch evidence may provide clarification on how successful students are at navigating between divergent and convergent thinking.

Goldschmidt (1991) outlines the dynamic nature of sketching as testing and verifying thoughts. The difference between divergent thinkers and convergent thinkers in the sketching process may become evident by analyzing sketch content. Liu and Bligh (2003) consider the ability to move between divergent and convergent thinking valuable in order to effectively generate conceptual ideas (divergent) and to evaluate those ideas for further development (convergent). Pereira views the ideation process as a designer searching for concrete forms to identify a problem, and defines creativity as "the capacity to perform mental work that leads to an outcome both novel and applicable"(1999, p. 1). Sternberg (2006) supports the belief that the creative process is essentially about decision-making. The creative designer actively decides to generate new ideas, and then proceeds to analyze and revise those ideas. The ability to switch between modes of thinking is critical for creativity. Sternberg (2006) also believes that an individual with a preference for thinking, and the ability to think globally as well as locally will be more creative by being able to recognize what is a problem and what is not. The experiential nature of ideation and creativity as described by Pereira (1999) and Sternberg (2006) are well-suited to the learning styles dimension defined in the next section, and of relevance to this study in understanding the relationship between sketching, creativity and thinking style.

Specific Learning Style assessment tool

Felder and others believe that identifying a student's primary learning style does not imply that learning can only be achieved by that preferred style. Felder (1996) refers to "teaching around the cycle" indicating that teaching and learning should be inclusive to the spectrum of learning styles. This inclusion enables the learner to both acquire information in their preferred style and to begin to expand their abilities to acquire information through less familiar methods. Sternberg (2006) believes that more creative individuals are able to move between styles as the occasion warrants, and this flexibility is demonstrated through creative outcomes. The design process has been described as a cyclical process involving identification of a problem, testing perceptions, development of solutions, and reinterpretation of problem and solutions until an acceptable result is derived (Zeisel, 2006).

The determination of one learning preference should not be the definitive task of completing learning style assessment. The assessment is but a part of an individuals' overall learning strategy. The assessment allows an individual to be conscious of their preference, yet demonstrates alternate strategies available to an individual that enable expansion of their ways of learning. Enabling individuals to understand their learning strengths and develop learning strategies less utilized. Generating ideas and analyzing ideas occupy different dimensions in learning style assessment. Divergent and convergent thinking have been suggested as the primary thinking styles employed during concept development (Liu & Bligh, 2003; Durling, Cross & Johnson, 1996). In this initial study of student sketching and thinking the Felder-Silverman index provides assessment in the areas of divergent and convergent thinking through the assessment domain of sequential and global thinking.

Felder-Silverman Index of Learning Styles

Felder-Silverman Index of Learning Styles (ILS) is a 44-question self-scoring instrument that assesses preferences on the Sensing/Intuiting, Visual/Verbal, Active/Reflective, and Sequential/Global dimensions[1]. It was developed in 1987 to facilitate a better match between teaching styles and learning styles in the engineering classroom. Felder defines learning styles as "characteristic strengths and preferences in the ways they (students) take in and process information" (Felder 1996, p. 18). Felder and Silverman (1988) are interested in development of teaching methods that provide a multi-sensory approach in order to accommodate all learning styles. Felder (1996) describes these characteristics more specifically as:

- sensing learners favor information that comes in through their senses and tend towards facts
- intuitive learners favor information that arises internally through memory, reflection, imagination and through discovering relationships
- visual learners acquire more information from visual images (pictures, diagrams, graphs, schematics, demonstrations)
- verbal learners gather information through written and spoken words and formulas
- inductive learners prefer to learn a body of material by seeing specific cases first (observations, experimental results, numerical examples) and working up to governing principles and theories by inference
- deductive learners prefer to begin with general principles and to deduce consequences and applications.
- active learners tend to learn while doing something active, trying things out, bouncing ideas off others
- reflective learners do much more of their processing introspectively, thinking things through

[1] The web-base version of the Index of Learning Styles is available at http://www.ncsu.edu/felder-public/ILSpage.html

before trying them out.

- sequential learners absorb information and acquire understanding of material in small connected chunks
- global learners take in information in seemingly unconnected fragments and achieve understanding in large holistic leaps.

The Felder-Silverman Index of Learning Styles has been used in interior design related research by Cruz-Perez (2003) and Watson (2003). Cruz-Perez was primarily interested in teaching styles and selected the Felder-Silverman Index because of Felder's extensive development of both a learning style assessment and companion teaching style techniques. Cruz-Perez assessed teaching methods of interior design instructors and concluded that instruction was most frequently organized in a multi-modal style, rather than in a specific modality. This result confirms Felder's assessment of learning through several modes, although one may dominate for an individual. Watson (2003) applied Felder's learning style model to create several strategies for design instructors to include when developing instructional materials in a narrative format, rather than experimental. The Felder-Silverman model has all the necessary components to assess learning styles in a range of areas, and is straightforward to administer and evaluate.

The continuum of global to sequential learning is related to divergent and convergent thinking by the nature of how an individual responds to and processes information. Sequential thinkers respond to logical and ordered content, that gradually becomes more complex. Sequential thinkers employ linear mental methods, convergent and analytic processes to solve problems. Global thinkers are divergent and employ synthesis in their thinking. Multiple and unrelated sources are preferred by global thinkers. Sequential learners pursue linear reasoning methods when working through a problem; global learners prefer accessing a wide variety of inputs in order to understand the larger picture (Felder & Silverman, 1988). Felder and Silverman also suggest that exercises that

involve generating multiple solutions to a design problem are beneficial for students of either sequential or global learning style. Sequential thinkers display their convergent tendencies by excelling at analysis, the process of breaking down an element or idea into smaller parts in order to gain a more complete understanding of the element or idea. Global thinkers display their divergent tendencies by excelling at synthesis, the process of combining disparate or different ideas into a novel construction. The process of analysis is essential to concept development in design (Menezes & Lawson, 2006) and integral to the cognitive process of the sequential-convergent thinker. The process of synthesis is also essential to concept development (Menezes & Lawson, 2006) and integral to the cognitive processes of the global divergent thinker. The relationship between sequential and global thinking and concept development adds another level of support to the notion that sketching evidence relates to creative outcome. Divergent and convergent thinking are the companions to global and sequential learning because of the nature of how an individual responds to and processes information. Convergent thinkers are sequential learners and apply analytic processes to solve problems. Divergent thinkers are global learners and employ synthesis in their thinking.

Divergent and convergent thinking skills are useful in both the concept generation phase and in refinement of ideas as one works to a solution by transforming 2-dimensional to 3-dimensional representations. Learning style and cognitive abilities can influence sketching and creativity. This study investigates the connection between sketching and creativity.

Chapter 3: Research Design and methods

This study investigates the relationship between a measurement of creativity and the quantity of concept development process sketches a student produces. Sketching is evidence of how a designer thinks through an idea and this research aims to answer the question: in the preliminary stage of concept generation for interior design do the quantity of sketches produced predict creativity? This study seeks to determine if there is a measurable relationship between the number of concept development drawings produced and creativity, aesthetics, or technical quality.

Students produced sketches and created a poster summarizing the project. Student project posters were reviewed by outside raters using the Consensual Assessment Technique (Hennessey and Amabile, 1999) in order to measure creativity. Students also completed learning styles assessments and a self-evaluation of creative achievement to support understanding of assessed creativity and the creative process.

Thesis Study, January 2008

This study compares the measurement of creative outcome to the number of sketches produced by students for a specific design project. This study builds on the pilot study by increasing the number of subjects and by defining a simplified project that is executable by 1st, 2nd, and 3rd year interior design students.

Pilot study –testing of methods

A pilot study was undertaken in October 2007 to test the instruments and proposed process for student and rater participation, and demonstrated that a poster format was appropriate for use in rating the creative outcome, and that sketches collected from the subjects were feasible to count.

The pilot project was an artifact of the 2nd year studio assignment with thirty-six participants. Students were directed to develop thumbnails sketches derived from an analysis of the elements and principles of design of a found object. The students created a concept model to describe their *parti*, or essential nature of their concept. Students then applied their *parti* to the design of the residential entry space. The final poster illustrated each student's design process.

Graduate students in interior design evaluated the pilot study posters using the Consensual Assessment Technique (Amabile, 1982). The raters were introduced to the project and instructed on how to complete the assessment form through a verbal presentation by the researcher. Assessment entailed using a Likert scale survey rating for creativity, technical quality and aesthetics within the projects presented (Appendix A).

No requirements were stated for quantity of sketches to be completed. Students were asked produce as many drawings as they felt necessary to develop a concept *parti*. Sketches are defined as individual drawings (Figure 3). The sketches were counted in one of two categories: concept development or application of the concept to the space. Concept drawings are defined as 2-dimensional abstract sketches with no apparent link to a physical space (Figure 4). Application drawings are defined as 3-dimensional sketches that show an aspect of the concept applied to the physical setting (Figure 5).

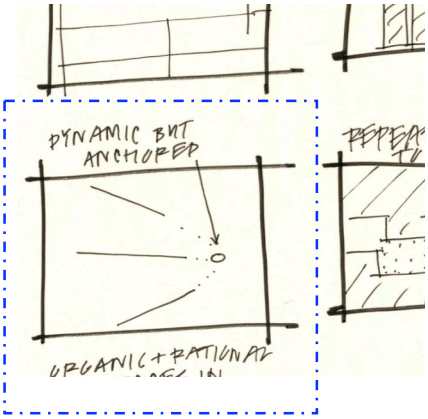

Figure 3: Sketches are defined as individual drawings as identified by dashed outline.

Figure 4: Concept drawings are defined as 2-dimensional abstract sketches with no apparent link to a physical space.

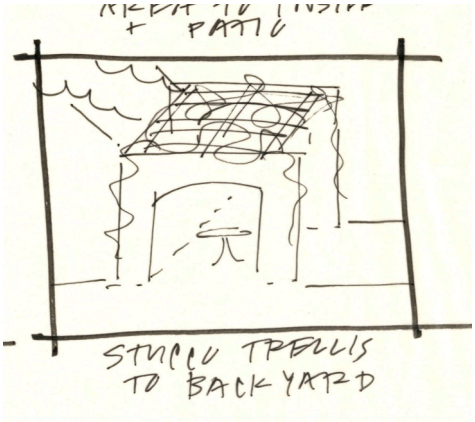

Figure 5: Application drawings are defined as 3-dimensional sketches that show some aspect of the concept applied to the physical setting. Annotations, written notes, are evident.

The Consensual Assessment Technique (CAT) results were tallied and averaged for each student. In addition the CAT scores were subtotaled within the subsets of creativity, technical quality and aesthetics. The CAT scores were evaluated as the dependent variable, the number of concept and application sketches as the independent variable (Table 1).

Table 1. CAT scores for pilot study where N=36.

CAT total score	4.8	
CAT aesthetic score	4.9	
CAT creative score	5.0	
CAT technical score	4.6	
average number of concept drawings	48	standard deviation 29
average application drawing produced	35	standard deviation 23

Although the sample size of thirty-six is insufficient to definitively correlate CAT scores and the number of drawings produced there are some preliminary indications of a relationship. A higher number of 2-dimensional concept sketches produced appears to correlate with a lower technical quality score, and a higher number of 3-dimensional application drawings appears to correlate with a higher creativity score as well as a higher technical quality score. In this limited pilot study it appears that 3-dimensional application drawings may contribute more to an understanding of creativity and technical quality than 2-dimensional concept sketches. A larger sample should allow a more definitive analysis and interpretation in considering the independent variables. Based on these results it was determined that a study with a larger sample should be conducted.

Following the pilot study, a larger project was conducted on student development of a "memory vessel" described in the project description (Appendix A) as an abstract representation of personal memory. The students completed a series of process sketches in 2-dimensions and 3-dimensions, created three-dimensional models and presented their work in the form of a poster.

Measures used in this study were:

1) physical count of the drawings (2D and 3D) completed by each student
2) measure of creativity determined by independent review of student posters through CAT
3) learning styles assessment completed by each student
4) self-assessment of creative achievement completed by each student

Sampling

Participants recruited for this study were enrolled in interior design studios at one university during the second semester. Studios for 1st and 2nd year students were on the main campus; studios for 3rd and 5th year students are located 70 miles away at a branch campus. The 5th year students are graduate students in their first year of a three-year interior design graduate program and enrolled in the 3rd year design studio. The subjects included thirty-four 1st year students, thirty-three 2nd year

students, twenty-seven 3rd year and eight 5th year students for a total of 102.

The Project

Students were instructed to select a found object[2] as an inspiration for concept development for design of a "shelter for their memories." The abstract nature of the project was developed to better accommodate the differences in skill development across the 1st, 2nd, 3rd and 5th year interior design studios (Appendix B). In order to accommodate the inclusion of 1st year students in this study, the project culminated in the application of a conceptual idea to an abstract vessel, rather than application to an interior space. At this point in the academic year, 1st year students have not been introduced to the design of interior space, but have studied the elements and principles of design, have begun development of two-dimensional and three-dimensional sketching and model-building skills, and have produced a number of creative and technical projects. The essential phases of analysis, concept generation in sketch and model form, and application of concept to a physical space have been completed by the 2nd, 3rd and 5th year students in previous projects. Thus they were familiar with the essential task and had the basic skills required to complete the project.

Students were directed to develop thumbnails sketches derived from an analysis of the elements and principles of design of the found object. They were also directed to sketch abstract concept ideas derived from their analysis of the found object, and develop those sketches into 3-dimensional sketches of a concept model. Students created a concept model to describe the *parti*, or essential nature of their concept. The poster was required to illustrate the found object, concept sketches, concept model and application of concept to the shelter for memories.

[2] A found object is identified as an item that is intriguing because of shape, form, texture and color, and also has an identifying feature that is memory-driven.

Objectives for the project were described in terms familiar to interior design students from previous project descriptions:

Use sketching to think visually about communicating an abstract idea.

Create a visual story, an interpretation, about a found object.

Interpret an object by abstracting the form using the elements & principles of design.

Develop a *parti* using the elements & principles of design from a found object.

Use the *parti* to drive a design.

The project was comprised of three phases:

abstract concept development

the application of concept to object design

poster composition depicting the design process and outcome

The project required students to draw 2-dimensional conceptual sketches generated through their analysis and interpretation of a found object using the elements and principles of design. Students also drew 3-dimensional sketches of the found object and 3-dimensional sketches of the application of the concept into a 3-dimensional concept model. The researcher presented the process of sketch development to the 1st year students during a studio session prior to the project. The 2nd, 3rd and 5th year students had prior experience in this idea development process, so introduction to this procedure was not necessary. Students were asked to produce as many drawings as they felt necessary to develop a concept *parti*. No requirements are stated for quantity of sketches to be completed.

Students were introduced to the project with a verbal script, read by the researcher for 1st and 2nd year interior design studio students and read by studio faculty for the 3rd and 5th year students (Appendix B). Experienced studio faculty for 3rd and 5th year students were given a brief

training on the project and process prior to implementation. Training involved reading through the script and discussing the timeframe for each phase of the project.

To ensure that all aspects of the design process were represented and to minimize raters judging graphic design of posters versus content, the students were given a template for completing the poster. Students were given the option of creating the poster through digital print or physical boards. A workshop in preparing a digital presentation using relevant software was presented by the researcher on each campus. The students were asked to collect all of their process drawings into a bound packet, and submit with completed posters.

The posters were rated for creativity by independent raters, and the process sketches were evaluated by the researcher for type and quantity.

Analysis: Counting and Coding concept development sketches

The sketches were tabulated and categorized for each student within the following categories:

2-dimensional concept idea sketches

3-dimensional object analysis sketches

3-dimensional application of concept idea to vessel form

Additional sub-categories were counted but not considered in the analysis:

2-dimensional concept idea sketches with annotations

3-dimensional object analysis sketches with annotations

3-dimensional application of concept idea to vessel form with annotations

Definitions:

Found object: object used by student as an idea generator

2-dimensional concept idea sketches: a sketch that is clearly drawn in 2-dimensions,

using abstract imagery to illustrate an idea (Figure 6)

3-dimensional object analysis sketches: sketch that is clearly a direct representation of the 3-dimensional quality of the found object (Figure 7)

3-dimensional application of concept idea to vessel form: sketch that shows 3-dimensional exploration of vessel form, showing some aspect of the 2-dimensional concept applied to the vessel form (Figure 8), typically located on a separate drawing sheet, dated at the end of the drawing phase of the project.

Annotations: notes associated with a particular drawing, in some cases a single word in other instances a series of words. The number of words was not considered, a single word or a series of word have the same value.

The annotated (written) aspects of the drawings were not considered in this study. A total count for the primary categories of 2-dimensional, and 3-dimensional sketches was created for each student.

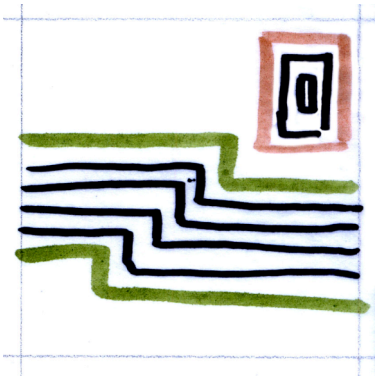

Figure 6. Example of a 2-dimensional concept idea sketch.

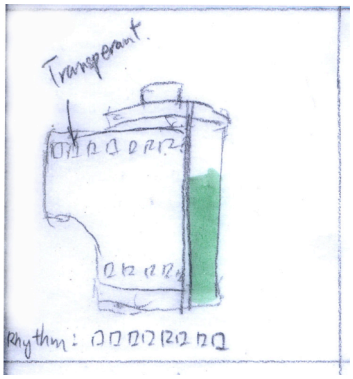

Figure 7. Example of a 3-dimensional object analysis sketch, that also includes annotations.

Figure 8: Example of a 3-dimensional application of concept idea to vessel form.

Analysis: Consensual Assessment Technique

The measure of creativity was assigned through use of the Consensual Assessment Technique (CAT) developed by Hennessy and Amabile (1999). The technique was modified from the CAT to address the specifics of this project. The CAT assessment as developed by Amabile is used for assessment of abstract paper compositions. This project utilized a more complex composition that exhibited a student's design process from analysis to synthesis to fabrication of an end product. Several questions on the CAT refer specifically to paper collages, these references were modified to reflect the nature of this project, the design of a "vessel". Modifications to the CAT to relate more directly to a product, without compromising the reliability of the result are common (Dollinger, Clancy-Dollinger, & Centeno, 2005) and have not been shown to influence effectiveness.

Sixteen raters were recruited from interior design graduate students and 4th year interior design students. Raters were given written instructions (Appendix C), definitions (Appendix D), and standardized review forms (Appendix E). Raters were instructed to look at all the posters prior to starting the review, and to review the posters in a pre-determined order, as designated on their review sheets. Each rater looked at 19 of the 102 posters. Eight items were assessed on a seven-point Likert scale, indicating agreement descriptions such as "low" or "high", "not at all" or "is apparent" depending on the item. Assessment entailed using a Likert scale survey rating for creativity, technical

quality and aesthetics within the projects each rater reviewed. Raters worked independently, and ranked posters based on their personal interpretation of creativity.

The posters created by the students were numbered using a random sort, and placed on the walls in a large public gallery space in numbered order. Hennessey and Amabile's (1999) essential criteria for valid procedure were met, including that the raters have a similar level of experience with the topic, they were instructed to come to conclusions independently, they were instructed to rate the posters relative to each other rather than to an external standard of creativity, and they viewed the posters in a random order as determined by the researcher. In addition to creativity the raters also evaluated the posters for technical quality and aesthetic appeal. Raters worked independently, and ranked posters based on their personal interpretation of creativity, as directed by Amabile (1982).

The CAT scores were totaled within three categories: creativity, technical quality and aesthetics, as prescribed by Hennessey and Amabile (1999). The creativity score was derived from the reviewer's personal subjective definition of creativity, the degree to which the idea was novel or unusual, and the consistency of the concept throughout the display. The aesthetic score was derived from reviewer judgment of overall aesthetic appeal, and pleasing poster composition. Technical quality was assessed by review of drawings and images indicating achievement of skill and craft, how well the vessel achieved the stated concept, and clarity in that the concept was clearly explained throughout the poster.

Analysis: Inter-rater reliability

Inter-rater reliability was analyzed using Cronbach's alpha to assess the internal consistency of the rater's responses. Analysis indicated that after assessment of the alphas for the three domains of creativity, aesthetics and technical quality, that the internal consistency (intra-rater reliability) is

fairly strong. This indicates that each rater was consistent in their judgments of their select posters. However, the inter-rater reliability suggests that the raters do not agree on a definition or assessment of creativity, aesthetics or technical quality.

Five raters had inter-rater agreement on twenty-nine of one hundred and two posters (28%), using a standard deviation of 3 or less. Of the five raters within this group with the highest alignment, four were 4th year students with 3.5 years of experience in the same academic environment. The fifth rater was a graduate student with 2.5 years of experience in the same academic environment. The remaining raters who were not in agreement were in distinct groups according to their experience in the same academic environment: three were graduate students with half a year experience, two had 1.5 years experience, five had 3.5 years of experience, one was a staff person with over 5 years in the academic environment. In multiple studies using the CAT tool the inter-rater reliability has proven to be aligned for both raters who have expertise in the realm field and those who have no expertise (Dollinger, Urban & James 1994; Carson, Peterson, & Higgins, 2005; Verstijen, et al. 1998 & Hennessey, 1998).

Analysis: Assessing Thinking Style

Student participants completed an on-line learning styles assessment through the Index of Learning Styles [3] and submitted results. The distribution of Sequential preference and Global preference are displayed in Figures 9, 10, and 11. The Index of Learning Styles (ILS) assessment regards those scoring between 5 and 7 on the ILS scale as having moderate preference for that dimension. Scores between 9 and 11 suggest a very strong preference for that dimension of the scale. All years showed a slight preference for Sequential learning. Student preferences are shown in Table 2.

[3] The web-base version of the Index of Learning Styles is available at http://www.ncsu.edu/felder-public/ILSpage.html

Table 2. Learning style preference overall by year, n=77.

	1st year students	2nd year students	3rd year students
Sequential overall preference	45%	19%	20%
Global overall preference	9%	30%	20%
Moderate to strong preference for either sequential or global	54%	40%	40%
Sequential moderate to strongly preferred	77%	57%	68%
Global moderate to strongly preferred	23%	43%	32%

These learning style preference results indicate that Sequential learning is generally preferred by a majority (66%) of the students assessed. The Sequential learning style is moderately to strongly preferred by 23% of the students assessed. The Global learning style is moderately to strongly preferred by 21% of the students assessed.

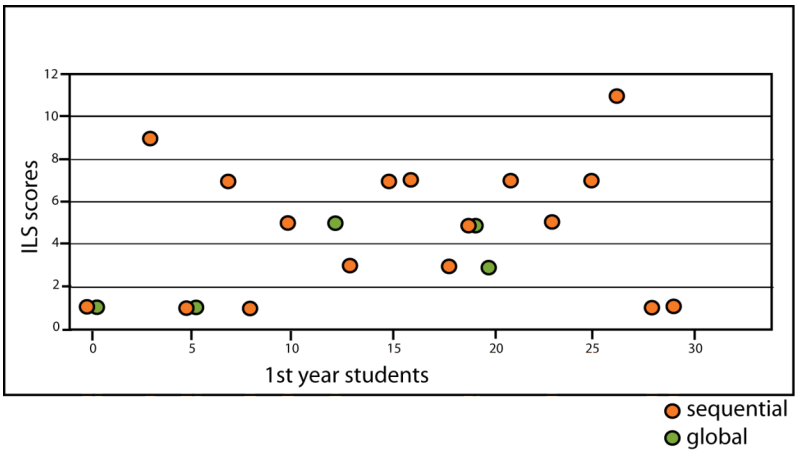

Figure 9. 1st year student preferences for Sequential versus Global thinking. 78% generally prefer sequential thinking; 23% generally prefer global thinking; 54% show a moderate to strong preference to one side; 45% show a moderate to strong preference for Sequential thinking.

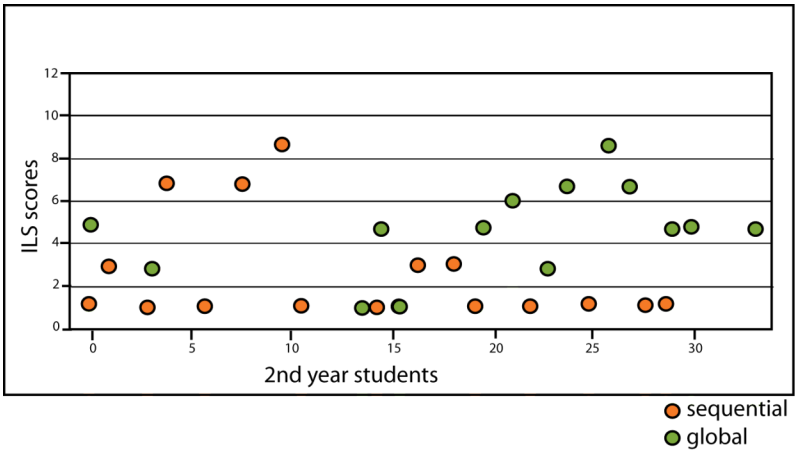

Figure 10. 2nd year student preferences for Sequential versus Global thinking. 57% generally prefer sequential thinking; 43% generally prefer global thinking; 40% show a moderate to strong preference to one side; 30% show a moderate to strong preference for Global thinking.

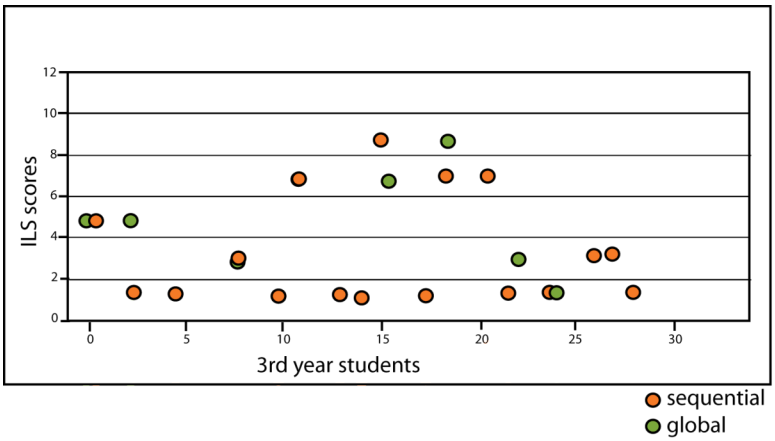

Figure 11. 3rd year student preferences for Sequential versus Global thinking. 68% generally prefer sequential thinking; 32% generally prefer global thinking; 40% show a moderate to strong preference to one side; moderate to strong preference is 20% for Sequential, 20% for Global thinking.

Analysis: Creative Achievement Questionnaire

Eighty-five students completed the Creative Achievement Questionnaire (CAQ) self-assessment. The mean CAQ score for all students was 1.8 (SD=1.4, with a high of 5.6, and a low of

0). In a T-test comparison of the CAQ score and the CAT creative score indicated a .0001 P-value. The mean CAT Creative score for all students was 4.87 (SD =0.850, with a high of 6.3 and a low of 2.7). The distribution of self-assessment is shown in Figure 12.

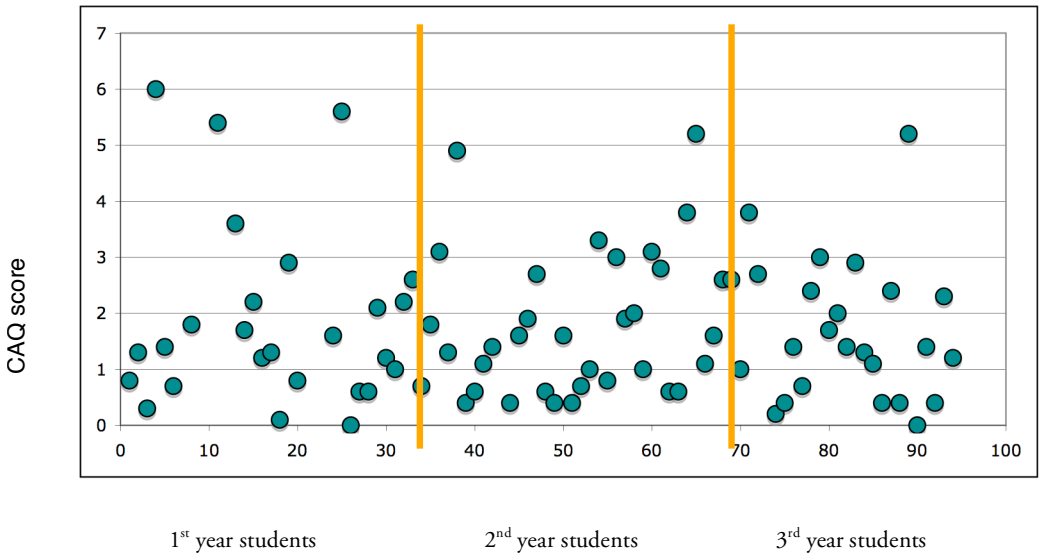

Figure 12. The CAQ self-rating between years in school shows fairly even distribution.

A higher CAQ score would indicate significant self-assessment of creativity. Few students indicated significant achievement through the CAQ assessment.

Sketches were counted in the categories of 2-dimensional or 3-dimensional representation, the CAT score measures were tabulated, and the learning style assessments and CAQ ratings were recorded for each student. Inter-rater reliability among the raters indicated that there was little agreement between the raters on the definitions of creativity, aesthetics and technical quality. Student learning style assessment indicated that Sequential learning is preferred by a majority of the students who completed the assessment regardless of year in school. Student self-rating on creative achievement indicated an even distribution through the years in school.

Chapter 4: Results

The results were tabulated within the categories of the CAT score, number of sketches produced, learning style preference, and CAQ self-assessment. Results were analyzed using linear regression and the reliability function with SPSS.

Descriptive statistics

Sketches: 2-dimensional and 3-dimensional

The mean number of 2-dimensional and 3-dimensional sketches were determined for each student year. Initial results showed two significant outliers in the 3rd year at 3.29 standard deviation from the mean in the number of 3-dimensional sketches. The Z score was determined and the outlier's scores were replaced with the mean, and factored to create a normal distribution (Table 3). Generally the 1st and 2nd year students generated more 2-dimensional sketches than the 3rd year and 5th year students. The 3rd year students generated more 3-dimensional sketches than 1st, 2nd and 5th year students. Overall the 2nd year students generated more total sketches (Figure 13).

Table 3. distribution of number of sketch drawings by year.

	Mean	1st year	2nd year	3rd year	5th year
2-dimensional sketches	35 std dev 25	37	52	16	13
3-dimensional sketches	18 std dev 19	10	10	31	16
Total number of sketches	53 std dev 22	47	62	47	29

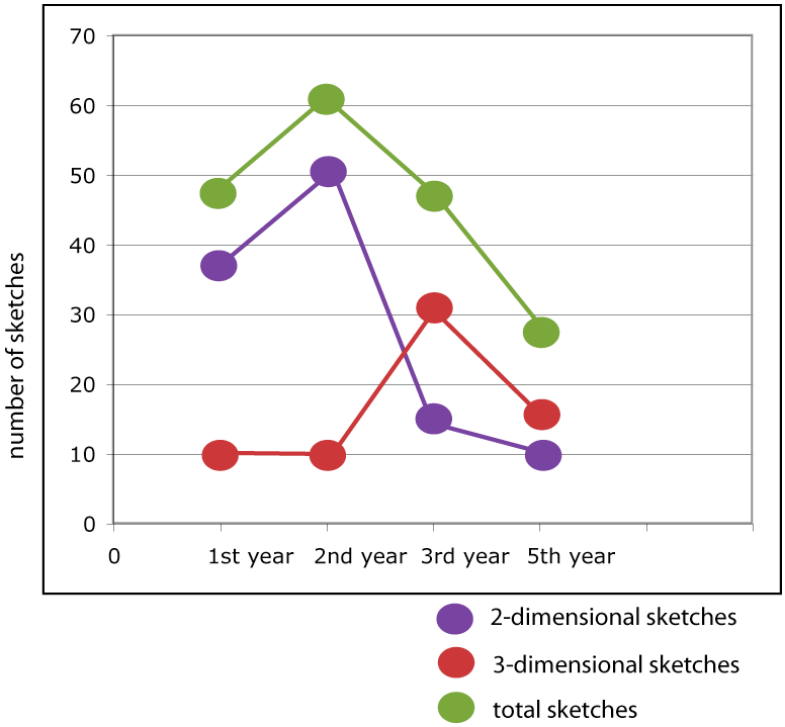

Figure 13: Distribution of mean number of sketches over 1st, 2nd, 3rd and 5th year students.

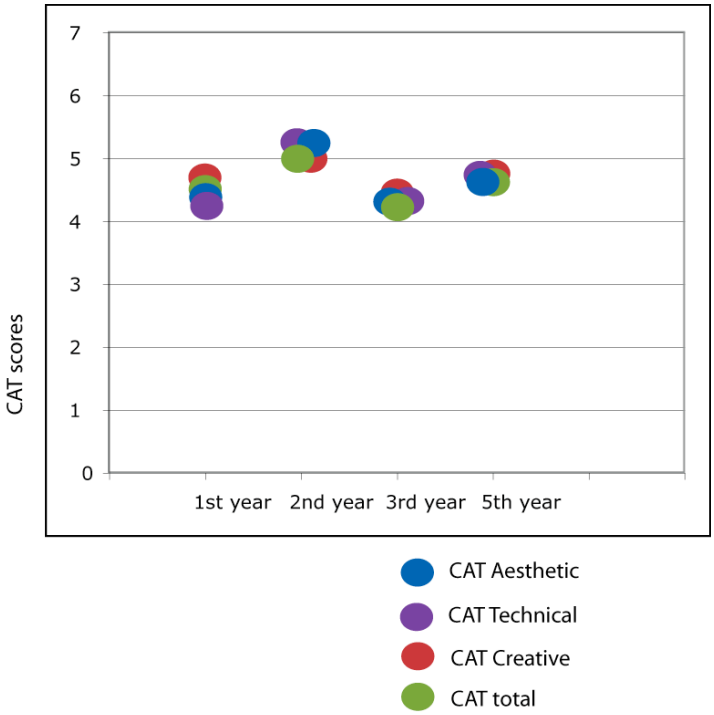

Figure 14: Distribution of mean CAT scores over 1st, 2nd, 3rd and 5th year students.

The distribution of mean number of sketches over 1st, 2nd, 3rd and 5th year students has greater variance than the distribution of mean CAT scores. Although the scale for CAT scores allowed ratings from 1 to 7, the raters primarily used the center of the scale (Figure 14). The student

sketches showed greater distribution between the groups of students. The distribution frequency is normal for the total number of 2-dimensional sketches, and has a slightly negatively skewed distribution, indicating that fewer students drew over fifty 2-dimensional sketches (Figure 15).

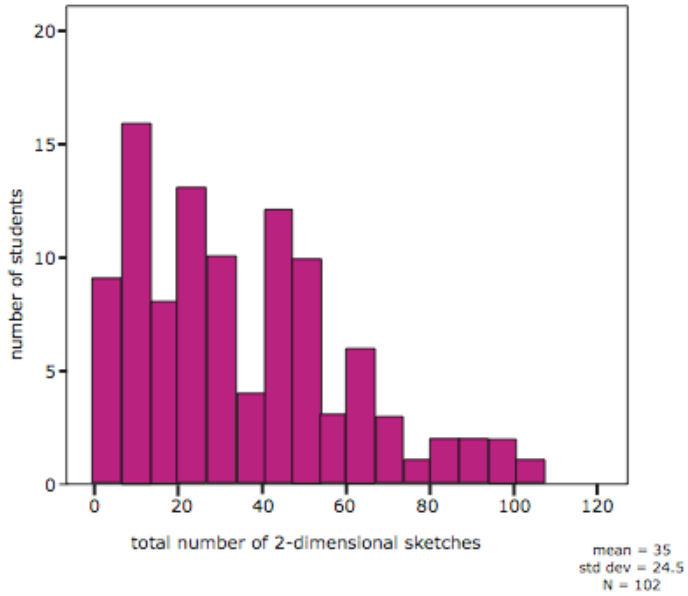

Figure 15.

Distribution frequency of 2-dimensional sketches.

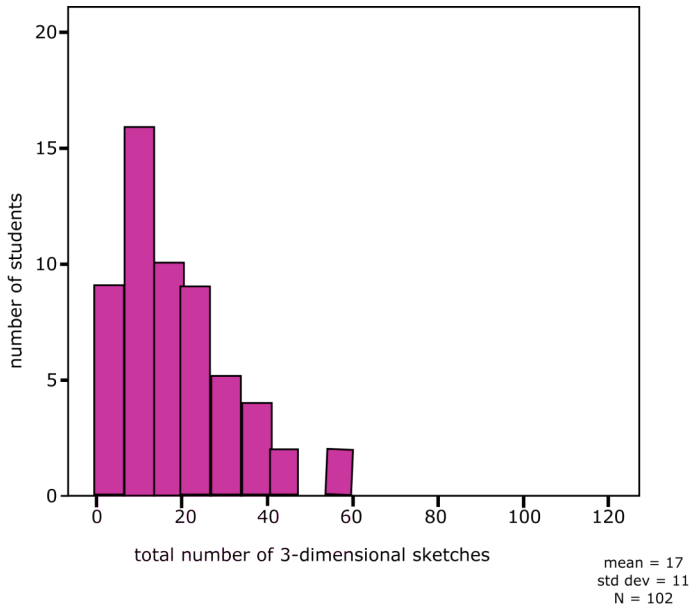

Figure 16.

Distribution frequency of 3-dimensional sketches.

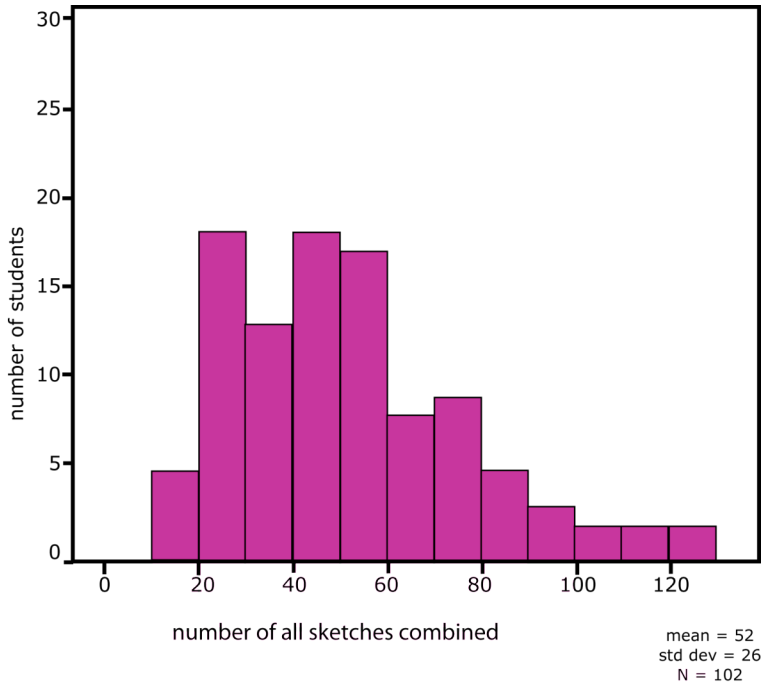

Figure 17.

Distribution frequency of 2-dimensional and 3-dimensional sketches combined

Distribution frequency of 3-dimensional sketches shows a normal distribution of 3-dimensional sketches (Figure 16) while the distribution frequency of 2-dimensional and 3-dimensional sketches combined shows a normal, slightly negatively skewed distribution, indicating that fewer students drew over 75 sketches (Figure 17). In summary, the 1st and 2nd year students generated more 2-dimensional sketches than the 3rd year and 5th year students. The 3rd year students generated more 3-dimensional sketches than 1st, 2nd and 5th year students. Overall the 2nd year students generated more total sketches.

Results: Consensual Assessment Technique

The CAT categories of creativity, aesthetic, and technical quality scores were calculated using linear regression for all 102 students. On a scale of 0 to 7, the overall mean score was 4.7 and varied from 1st year to 5th year students between 4.4 and 5.0 with the 3rd year students having the

lowest score. Creativity, aesthetic, and technical quality scores showed similar variation. CAT scores are tabulated and shown with total number of sketches by year in Table 4. The highest scores in all categories were for 2nd year students. Generally the scores improved from 1st year to the 2nd year, decreased in the 3rd year, and went back up in the 5th year. The 2nd year students generated more sketches overall, and had higher CAT scores overall.

Table 4. CAT scores in all categories and number of sketches by year in school.

	Mean	1st year	2nd year	3rd year	5th year
CAT overall score	4.7	4.5	5.0	4.4	4.8
CAT Creative score	4.8	4.7	5.0	4.6	4.9
CAT Aesthetic score	4.6	4.4	5.2	4.2	4.9
CAT Technical score	4.5	4.3	5.2	4.3	4.8
2-dimensional sketches	35 std dev 25	37	52	16	13
3-dimensional sketches	18 std dev 19	10	10	31	16
Total sketches	53 std dev 22	47	62	47	29

Distribution frequencies of the CAT scores by creativity, aesthetics and technical quality generally followed a standard bell curve, showing fairly normal distribution of scores (Figures 18, 19, 20). Distribution frequency of CAT creative score showed slightly positive distribution, indicating a higher number of high scores (Figure 18). Distribution frequency of CAT technical quality score showed normal distribution (Figure 19).

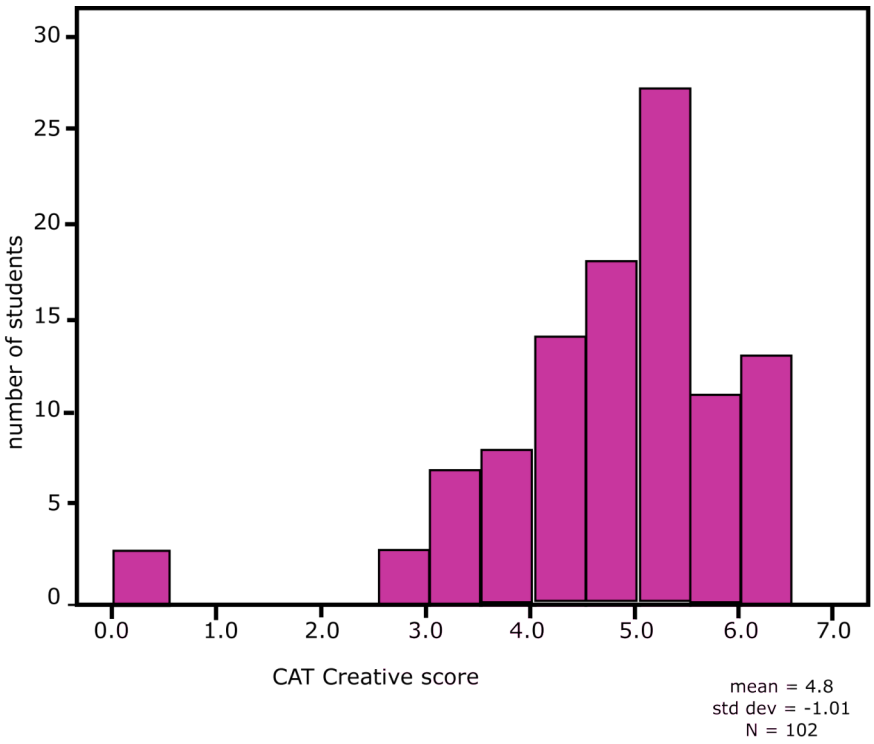

Figure 18. Distribution frequency of CAT Creative scores.

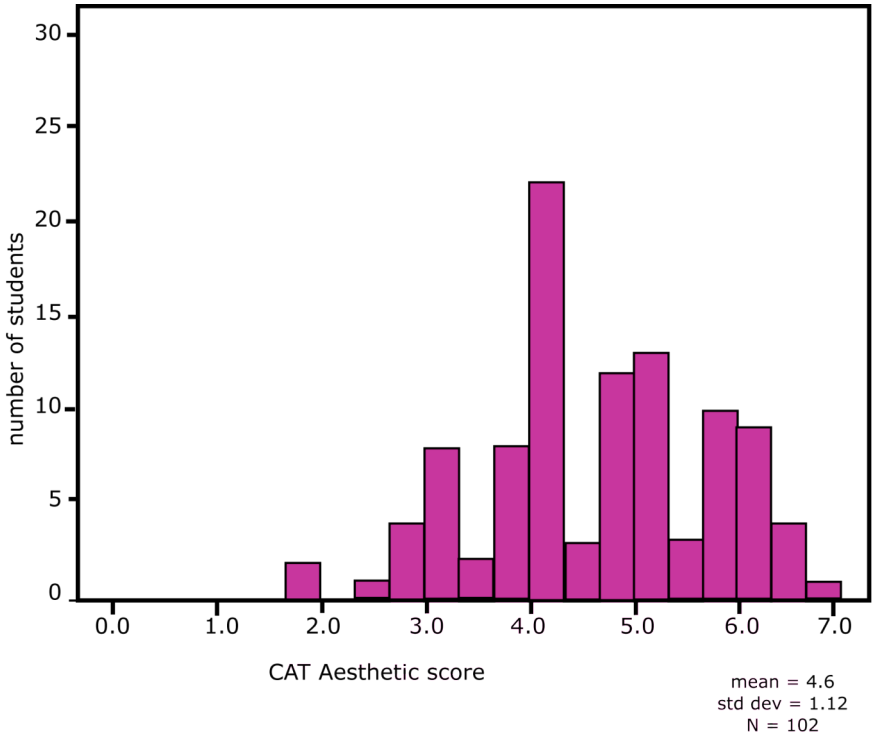

Figure 19. Distribution frequency of CAT Aesthetic scores.

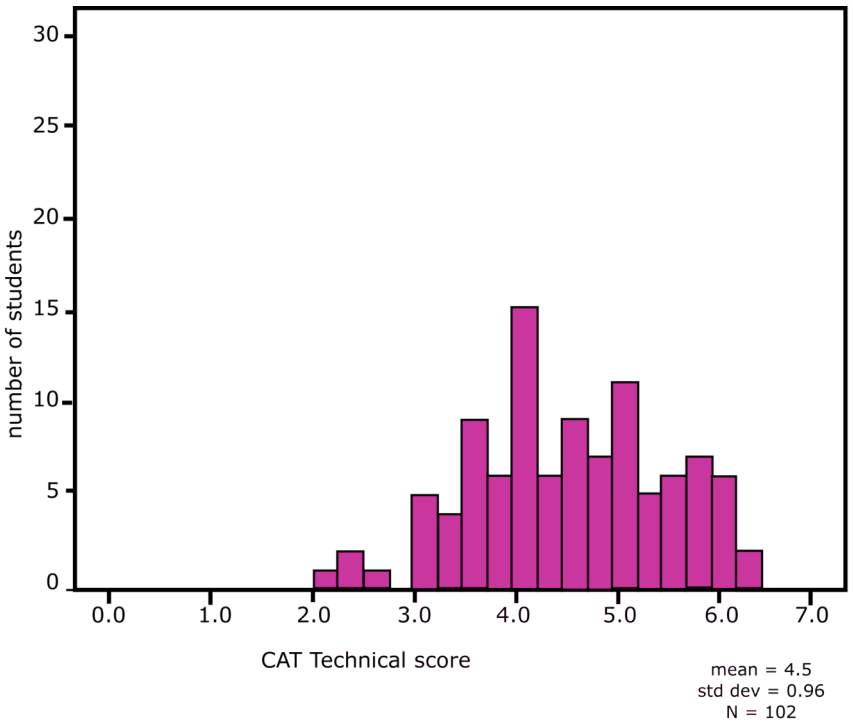

Figure 20. Distribution frequency of CAT Technical scores.

Scatter plots were developed to observe the relationship between the number of sketches by an individual and their CAT scores. The plot showing the relationship between the CAT creativity score and the total number of sketches (Figure 21) shows a slightly positive relationship between a higher CAT creative score and a higher number of sketches produced, indicated by the trend line. However the slightly positive relationship is subject to interpretation, as a significant number of high scores also cluster on the low end of the sketches produced, shown in the circled area on Figure 20. There are no strong indications that there is a relationship between the CAT creativity score and the total number of drawings produced. Initial indications also showed a slightly positive relationship between the CAT technical score and the number of 3-dimensional drawings (Figure 22) shown by trend line. However this relationship is also subject to interpretation, as a significant number of high and low scores cluster on the low end of the sketches produced.

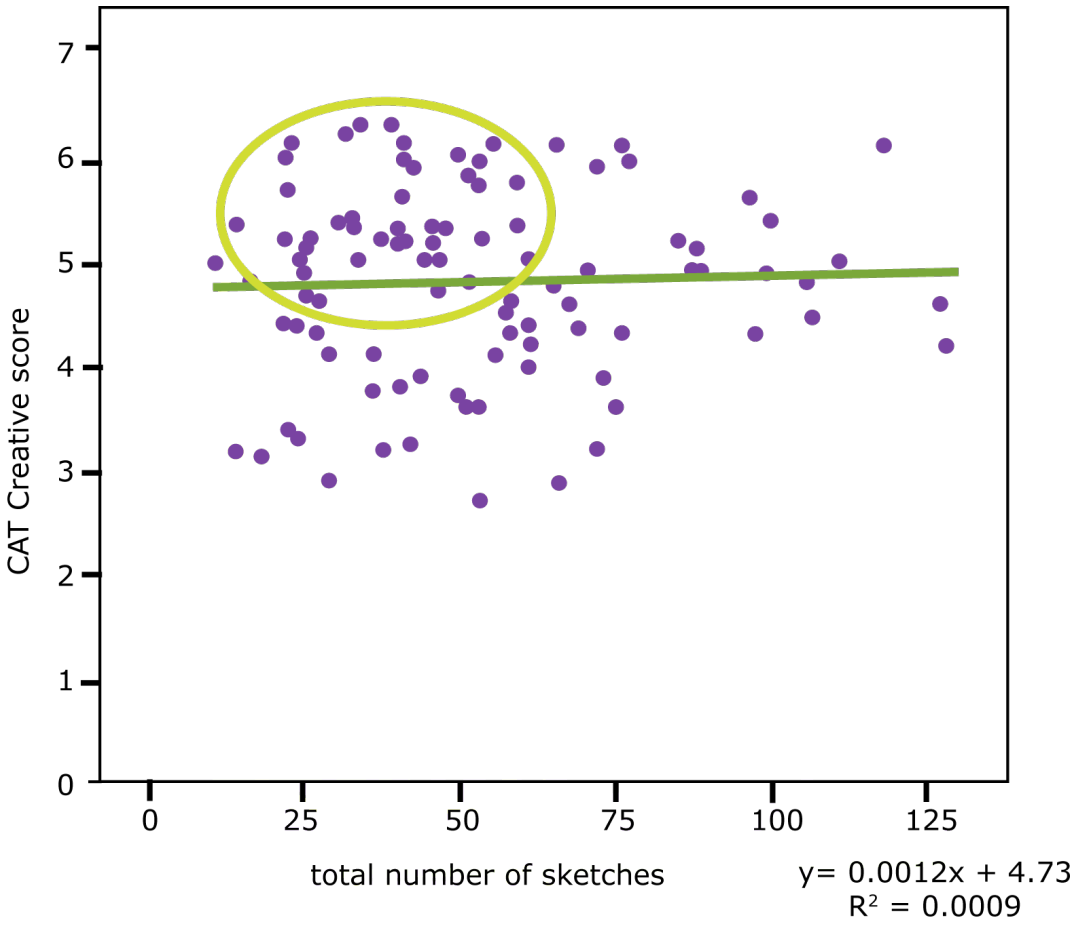

Figure 21: Higher CAT creative score shows a positive relationship (indicated by trend line) with the total number of sketches. Circled area indicates significant cluster on the low end of sketches, while maintaining a higher CAT creative score.

Correlations attempted between the dependent variable, the CAT scores, with the independent variables, the number of sketches produced showed no relationships. Chance observations indicate that there is a positive relationship between the number of 3-dimensional sketches and CAT Creative score, but the observation is not significant.

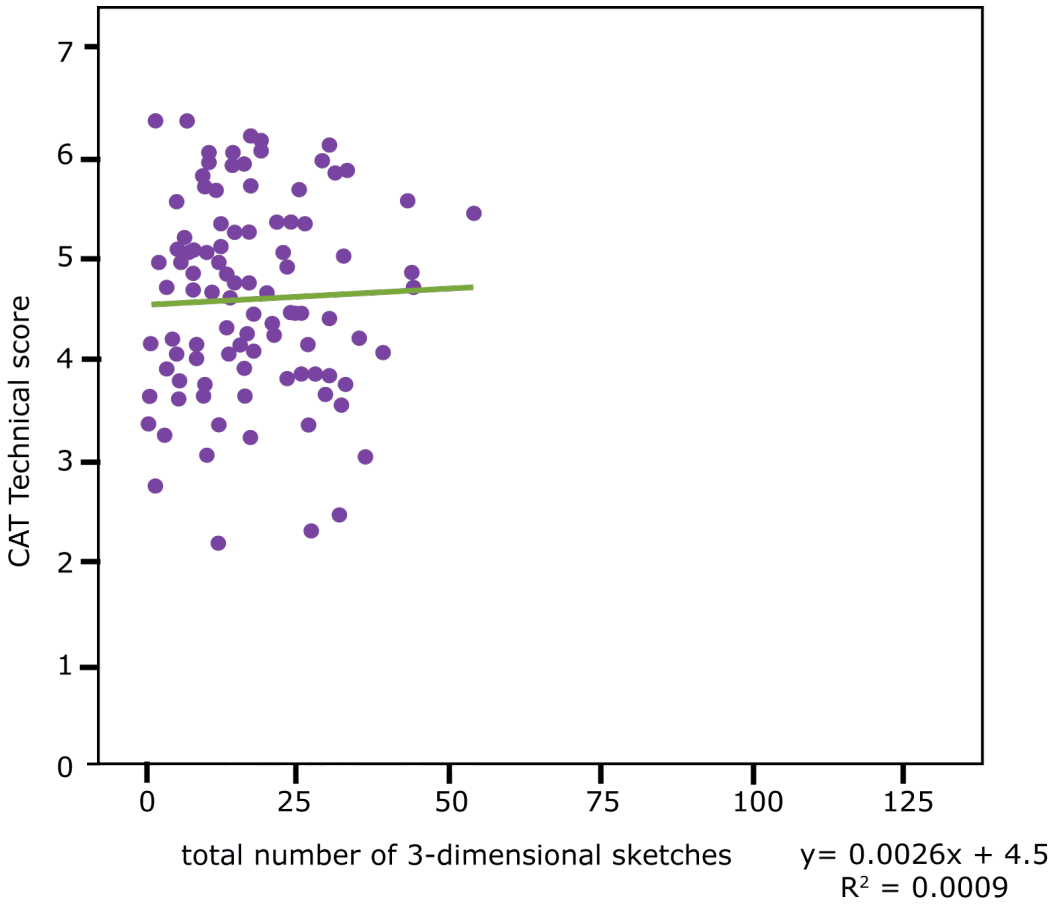

Figure 22: Slightly positive relationship between the CAT technical score and the number of 3-dimensional sketches produced indicated by trend line.

A positive relationship between the CAT aesthetic score and the number of 2-dimensional drawings was noted when the 1st years were removed, and the 2nd, 3rd and 5th years were compared. In an attempt to get a more homogeneous sample it was determined that the 5th year students have a diverse educational background and since their score norms were closer to the 1st and 2nd year students these scores were removed from the total, bringing the total number of students from 102 to 94. Once the 5th year students were removed, the analysis of 1st, 2nd and 3rd year students indicates that the year students are in school correlates with their creativity score. A variance of 3.3 percent was noted in the CAT creative score. The CAT creative score decreased from 1st to 2nd to 3rd

year students (Figure 23). Sixty-three percent of 3rd year, fifty-one percent of 2nd year students, and forty-seven percent of 1st year students scored below 5.0 on the CAT scale. More 3-dimensional sketches produced by the 3rd year students resulted in significantly lower CAT creative scores.

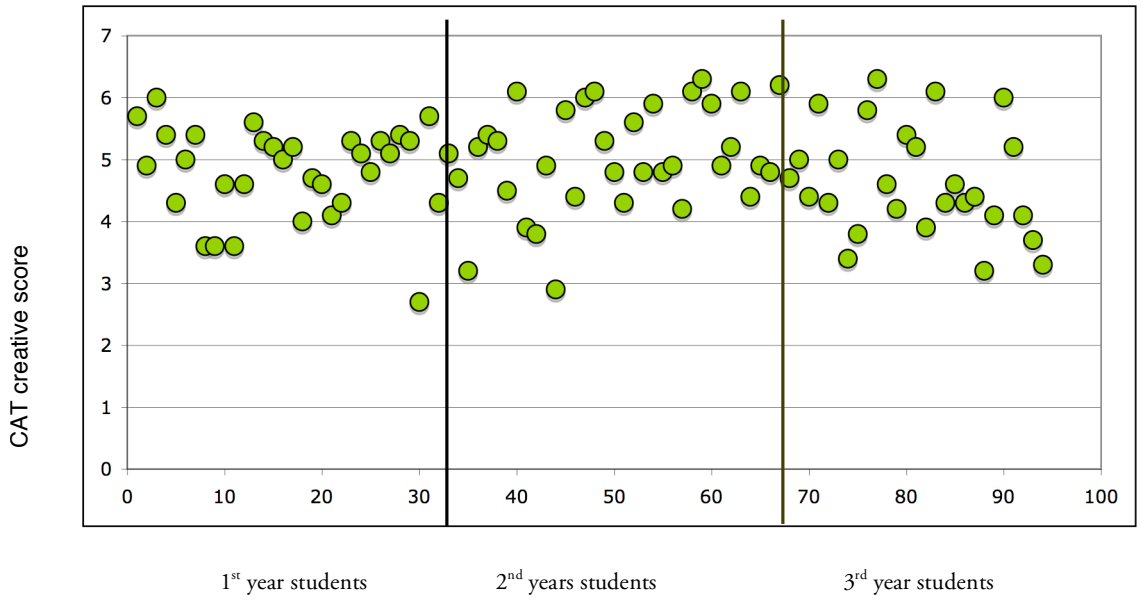

Figure 23: CAT creative score across the year in school.

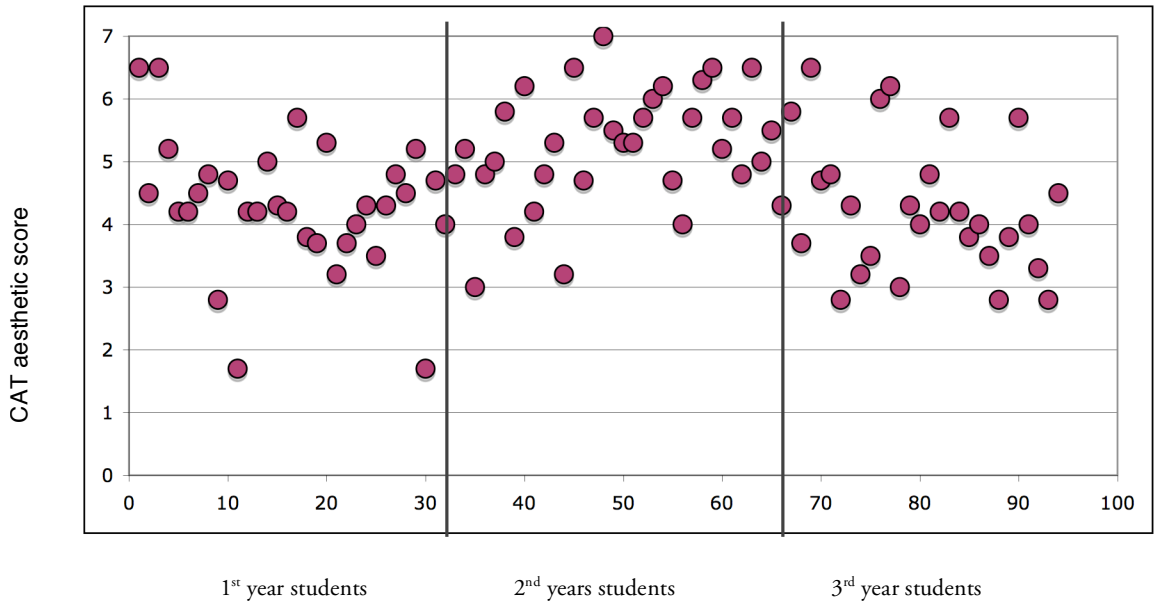

Figure 24: CAT aesthetic scores across the year in school.

A variance of seven percent was noted in the CAT aesthetic score of 1st to 2nd to 3rd year students. The CAT aesthetic score also decreased from 1st to 2nd to 3rd year students (Figure 24). The 3rd year students had 81% scoring below 5.0, 2nd year students had 33% scoring below 5.0, and the 1st year students had 71% scoring below 5.0 on the CAT aesthetic score. The number of 3-dimensional drawings had a positive relationship with the CAT aesthetic score, the more 3-dimensional drawings produced, the lower the CAT aesthetic score. In this respect the year in school contributes more to the CAT aesthetic score than to the CAT creative score.

Results: Thinking Styles

Learning styles assessment completed by each student

Seventy-seven students completed the Learning Style Scales (Felder and Solomon, 1988). Seventy-one students (92%) assessed on the visual learner side, six students (8%) assessed on the verbal learner side. Fifty-one students (67%) assessed on the sequential learner side, twenty-six (33%) students assessed on the global learner side. The Learning Style Scales assessment regards those scoring between 5 and 7 on a scale as having moderate preference for that dimension of the scale. Scores between 9 and 11 suggest a very strong preference for that dimension of the scale. This cohort showed a strong preference for visual over verbal learning, thirty-two students (40%) scored above 9, and twenty-eight students (35%) scored between 5 and 7. In the sequential learning style eighteen students (23%) scored above 5, indicating a moderate preference in the group for sequential thinking, and 21% indicated a moderate preference for global thinking.

Results: Self-assessment of creative achievement

Eighty-five students completed the Creative Achievement Questionnaire (CAQ) self-assessment. The mean CAQ score for all students was 1.8 (SD=1.4, with a high of 5.6, and a low of 0). In a T-test comparison of the CAQ score and the CAT creative score indicated a .0001 P-value. The mean CAT Creative score for all students was 4.87 (SD =0.850, with a high of 6.3 and a low of 2.7). A higher CAQ score would indicate significant self-assessment of creativity. Few students indicated significant achievement through the CAQ assessment.

Results: Summary

Analysis indicates that 2nd year students generated more 2-dimensional sketches, and more sketches overall. The 3rd year students generated the most 3-dimensional sketches and fewer 2-dimensional sketches. The 5th year students generated the fewest sketches in both categories. Overall all years the CAT scores were within a tight range of between 4.3 and 5.2, with a slight rise from 1st to 2nd year, and a slight decrease from 2nd to 3rd year. The 3rd year students had the lowest CAT scores, fewer 2-dimensional sketches, and more 3-dimensional sketches. The 2nd year students had higher CAT scores, fewer 3-dimensional sketches, and more 2-dimensional sketches.

Chapter 5: Discussion

The relationship between the number of sketches produced and subsequent creativity assessment as analyzed is inconclusive. There were no clear indications that a relationship exists between the number of sketches produced and the CAT scores. There is a clear indication of the number of sketches produced by each class and the variation from class to class, and a preference for 2-dimensional sketches by 1st and 2nd year students, and a preference for 3-dimensional sketches by 3rd year students. The 2nd year students also produced more overall sketches than the other two years.

The lack of agreement by raters, as shown by the inter-rater reliability analysis, indicates that there is little agreement among this group of raters on definitions of creativity, aesthetics and technical quality. Five of sixteen raters had agreement on 28% of the posters evaluated. Typical inter-rater reliability with the CAT method is all raters at above 50% in agreement (Amabile, 1996). Raters in this study agreed on only nine of the posters in the top 25% when sorted for highest scores in CAT creativity, then aesthetics, then technical quality. The raters agreed on seven of the lowest scoring 25% when sorted for lowest scores in CAT creativity, then aesthetics, and then technical quality. The lack of agreement could be caused by several factors. The raters were self-trained by reading a description of the process they were to complete. A training session was scheduled, but the raters were not able to attend due to varying circumstances. Four of the raters did participate in the pilot study, but only one of this group was in the group of raters who had agreement. This analysis indicates that each rater was consistent in their judgments of their select posters. However, the inter-rater reliability suggests that the raters do not agree on a definition or assessment of creativity, aesthetics or technical quality.

In multiple studies using the CAT tool the inter-rater reliability has proven to be aligned for both raters who have expertise in the realm field and those who have no expertise (Dollinger, Urban

& James 1994; Carson, Peterson, & Higgins, 2005; Verstijen, et al. 1998; Hennessey, and Amabile, 1999). The inconsistency of inter-rater reliability in this study is not clearly explained. There are two distinct groups of raters who have had a similar experience in the academic environment, yet had clearly different interpretations of creativity, aesthetics and technical quality.

The posters created were complex and displayed multiple images and text. This complexity may have affected the rater response. Future study should consider reducing the complexity of the product. Amabile (1996) has used a simple paper collage as the product to be rated. The simple nature of the product may improve the CAT raters ability to make a definitive assessment.

The indication that CAT scores decrease with year in school may be explained by this particular cohort of 3rd year students. The 3rd year students may have lacked motivation for this particular project. The 3rd year students are working on larger, more complex design projects at this point in their education. Having just completed a project that concentrated on a 15,000 sf commercial space, this abstract project may have seemed too basic for the 3rd year students. A 3rd year student observed that the students in studio did not seem to take this project seriously, and many spent minimal time on the project (student SA, 2008). The 2nd year students are also focused on an upcoming portfolio review, a requirement in order to be accepted into the 3rd year design program, thus every project takes on significance, increasing their motivation to perform.

The researcher had limited contact with the 3rd and 5th year students, who are on another campus, and the students may not have felt compelled to exert effort due to motivational factors, whereas researcher interaction with the 1st and 2nd year students was significantly higher. The Hawthorne Effect implies that workers will respond positively to novel changes in the work environment, and typically results in worker improvement based on worker desire to participate. This effect does not seem to be as significant in the instructional studio environment because each project, at all levels, is novel, as that is the basis for instruction. Motivational factors may have included the grading parameters. The grading on the project was based on completion of the

essential steps, but was not graded on aesthetics or quality of work produced. This may have implied the need for minimal effort on the student's to maintain an adequate grade. Although that would not explain the higher scores by 1st and 2nd year students who were also graded on the same basis.

Future studies should consider independent introduction and oversight of the project. Development of the project into a compact, easy to administer and complete, would remove the limitations imposed by requiring the researcher present during all contact with project presentation.

More 2-dimensional sketches were completed by 1st and 2nd year students, than by 3rd and 5th year students. This may be a result of the emphasis placed on concept development in the 1st and 2nd year studio assignments. A majority of time in 1st and 2nd year studio is spent developing analysis and interpretation skills. In this regard the divergent mode of thinking is very relevant to 1st and 2nd year students in their skill development, and central to the memory vessel project. The 3rd year students have had an additional year of skill development, as well as an introduction to more technical aspects and more complex projects. The 3rd year students may be focused on skill development in other areas, including more convergent thinking skills, as they develop projects that require significantly more complex and detailed solutions. The 3rd year students have completed two years of extensive sketching and concept development activity, and are moving forward with skill development in other areas. The 3rds year students completed more 3-dimensional sketches that related to the solution. They may be developing their convergent thinking skills at the expense of their divergent abilities. The 3rd year students may spend less time on the 2-dimensional aspects of concept development as they are expected to develop more complex projects in an equal amount of time.

Could concept development and extensive sketching be considered a luxury? The 3rd year students complete a journal as part of their studio experience. The journal reflections indicated that some had not focused on concept development to such an extent in some time, and reflected on how while concept development is a valuable process they had not devoted much time to this phase

for recent projects. The 3rd year students may focus on how to get an idea, any idea into 3-dimensions, in order to proceed with the more developed nature of their studio projects. One student reflected, "The most challenging part of the creative process for me is transferring between two dimensional and three dimensions thinking" (student SB, 2008). This student also expressed concerns with "letting logical constraints mold the design" and how this concern impacted the concept development process. A second student (student SC, 2008) stated that further exploration was not necessary because an early idea was the most promising. This observation may reflect the constraints of attempting an abstract-focused project at this phase in design education.

The 1st year students are learning both 2-dimensional and 3-dimensional sketching techniques, their projects are much less complex, and there is greater focus on abstract expression in instruction. The 2-dimensional sketches require fewer spatial skills. A single room design is the culminating project in the 1st year studio, compared to spaces ranging from 2000sf to 15,000sf for the 3rd year students. The 1st and 2nd year students may feel they are more facile at 2-dimensional representation rather than 3-dimensional, as they are still developing 3-dimensional and perspective drawing skills. Does this explain the greater number of 3-dimensional sketches produced by the 3rd year students, and greater 2-dimensional sketches produced by both 1st and 2nd year students? The 1st and 2nd year students are in the midst of developing 2-dimensional abstract expression skills, the 3rd year students are refining 3-dimensional drawing skills and applying their efforts to greater amounts of detail in studio projects. Looking at groups of students over the course of their four year experience may identify the nature of 2-dimensional and 3-dimensional sketching and any changes that occur in focus by year.

All years favored sequential thinking over global thinking: 1st year at 77%, 2nd year at 57% and 3rd year at 68%. Further study that identifies the relationship between thinking style and 2-dimensional and 3-dimensional sketching from year to year may clarify a relationship between these two measures. Divergent thinking ability is critical in order to fully develop an idea. Felder and

Silverman (1996) strongly suggest that an outcome of determining one's learning style is to evaluate the areas where one is successful, and to develop success on the other side of the continuum where one is not focused. If you are successful and prefer sequential thinking, then in order to achieve at a higher level you should explore the nature of global thinking and improve your skill set in that area. Learning styles are not to be considered static personality traits, but should evolve with time and experience (Felder and Silverman, 1996).

The self-assessment through the Creativity Achievement Questionnaire did not seem to identify strong creative tendencies among this group. An alternative to the CAQ for self-assessment would be directing the students to do a self-rating using the Consensual Assessment Technique. The use of CAT as self-assessment has been shown to correlate moderately with the scores from independent raters (Amabile, 1996). The self-assessment would provide opportunity for the students to become engaged in the discussion of "what is creativity" and become more informed about their design process.

Chapter 6: Conclusion and Recommendations

Sketching is evidence of how a designer thinks through an idea. This research attempted to answer the question: in the preliminary stage of concept generation for interior design do the quantity of sketches produced predict creativity? Is there a correlation between the number of concept development drawings generated and creativity, aesthetics, or technical quality?

This study investigated the relationship between a measurement of creativity and the quantity of concept development process sketches a student produces. The current analysis produced no significant correlations between a measurement of creativity and the quantity of concept development process sketches. The relationship between the number of sketches produced by students and creativity assessment by independent raters is inconclusive. The raters lacked agreement on the definitions of creativity, aesthetics and technical quality, and therefore did not rate the posters consistently. There were no clear indications that a relationship exists between the number of sketches produced and the CAT scores. There is a clear indication of the number of sketches produced by each class, the variation from class to class, and a preference for 2-dimensional sketches by 1st and 2nd year students, and a preference for 3-dimensional sketches by 3rd year students. The 2nd year students also produced more overall sketches than the other two years. The relationship between the measures of sketching and creativity has yet to be defined with any certainty.

All measures explored in this study are essential to design education. Sketching in all forms is essential to success in interior design according to educators and practitioners (Pable, 2007; CIDA 2006). Creativity and critical thinking is valued (Martin and Guerin, 2006; CIDA 2006), although materials have yet to be fully developed that identify instructional methods in the area of concept development and creativity. The merit in this study is in the experience gained in designing a relevant project for a range of student experience, in testing methods available for assessing thinking

style and self-assessment of creativity, in development of a project that focuses on divergent and convergent thinking in concept development, and in testing procedures across two campuses.

Future work will include revising the creativity assessment instrument to allow for more precise measurement. The product parameters will be revised and reduced in complexity to assure focused attention by raters and student subjects alike. The project could be revised to culminate in an interior space, and tested at the end of 1st year studio when 1st year students have adequate training in drafting conventions. Or could culminate in a single concept model format rather than process poster that contains complex and time-consuming information. Training procedures will be revised to assure that raters, instructors and students understand the project parameters. Future work will include participation of a greater number of students, from varying institutions, and may include students from related disciplines: architecture, and fine arts.

Future analysis will include protocol analysis of sketching behavior, content analysis of annotations and ideation. Measurement of drawing skills, and evaluation of the quality, variety and complexity of the concept sketches would allow for more depth in the results.
Does creative success increase by requiring a minimum number of drawings? Testing multiple parameters, such as no instruction on quantity, and specific quantity required may show a relationship.

Gender of the student participants may influence the results. The majority of interior design students are female (McCoy, Guerin & Portillo, 2007), how does this affect the number of drawings produced? Spatial and cognitive abilities play a role in visualization and differ between women and men (Halpern, 2005; Nussbaumer & Guerin, 2000). The ability to recognize and reinterpret spatial relationships in interior space is essential to design (Postma et al., 2003) and inherent spatial ability could impact the success of translating two-dimensional representations into three-dimensional representations. Adapting spatial awareness measures to the design and conceptualization process may result in better-informed instructional process. Spatial ability differences have been identified

between women and men, favoring men, particularly in understanding 2- and 3-dimensions (Halpern, 2000) although the results depend on the type of test administered. Cognitive mapping and spatial visualization skills are essential to problem-solving and Purcell & Gero (2006) argue that there are two types of transformations in the problem-solving phase of the design process. Lateral transformations typify moving from one idea to a different idea (divergent thinking), and vertical transformations embody one idea converting into another (convergent thinking). Cognitive mapping and spatial visualization skills facilitate both types of transformations by enabling the designer to mentally visualize the transformations, and shift the ideas to physical form, through a series of drawings. Understanding gender differences in spatial skills may inform the discussion of 2-dimensional and 3-dimensional sketching ability among interior design students.

Although the consensus among educators and practitioners is that sketching is essential to successful design projects, this research could not find a correlation between the number of sketches and the creativity assessment. This may have been due to lack of inter-rater reliability, the complexity of the project, or other factors. New approaches should be developed in order to support the conventional thinking that sketching is essential to creativity in design.

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Appendix:

Appendix A –pilot study rating form using Consensual Assessment Technique.

Rating sheet for entry project posters.
The posters you will review have been created as part of an interior design sophomore level residential project. These particular posters focus on concept development. The starting point for development is a found object. The student then develops a parti (the basic scheme or concept of an architectural design) based on the found object, utilizing the elements & principles of design. The poster should contain an image of the found object, one or more parti drawings, a three-dimensional concept model based on the parti and a series of design possibilities for a residential entry. Thnak you for taking the time to review these posters. The review parameters are described on each question below.

Judge:

Poster number:

Creativity- using your own subjective definition of creativity, the degree to which the overall space design is creative:
low "creativity" 1 2 3 4 5 6 7 high "creativity"

Novel idea- the degree to which the design itself is original or striking especially in conception or style:
low "novelty" 1 2 3 4 5 6 7 high "novelty"

Consistency of concept- the degree to which a consistent theme/concept/parti is expressed throughout the drawings and text:
not at all consistent concept/parti 1 2 3 4 5 6 7 concept/parti is apparent throughout

Overall aesthetic appeal- In general, the degree to which the spatial design is aesthetically pleasing:
low level of artistic sensibility 1 2 3 4 5 6 7 high level of artistic sensibility

Pleasing poster composition- the degree to which there is a pleasing placement of images and text:
not pleasing 1 2 3 4 5 6 7 **very** pleasing

Technical quality- The degree to which the drawings and images good technically:
shows **low** technical achievement 1 2 3 4 5 6 7 shows **high** technical achievement

Useful- how well did is the problem of entry solved?
not useful 1 2 3 4 5 6 7 highly useful

Clarity- Does the poster clearly explain the parti-concept idea?
I have no idea what this concept means 1 2 3 4 5 6 7 I understand this concept completely

Appendix B –Study Student Project Assignment

Memory is a complicated thing, a relative to truth, but not its twin. It's surprising how much memory is built around things unnoticed at the time. Barbara Kingsolver

Some memories are realities and are better than anything that can ever happen to one again. Willa Cather

Memory Vessel
Think about your life memories in the language of design; are they about rhythm or balance? Does your personal history appear as linear or as points of emphasis? Where have your journeys taken you? Is there a particular moment that can be illustrated through the creation of a small volume, a memory vessel? Tell your story through the creation of a personal enclosure that celebrates the people, places or events that are important to you.

Find an object that reminds you of some aspect of your life. Does a chipped dinner plate remind you of a home-cooked meal at your grandmother's, does a curling ball of wire remind you of the many courses you have taken in college? Find an object that is a reminder of a memory, but is not itself embedded with memory (no stuffed animals etc).

Objectives:
Use sketching to think visually about communicating an abstract idea.
Create a visual story, an interpretation, about a found object.
Interpret an object by abstracting the form using the Elements & Principles of design.
Develop a parti using the Elements & Principles of design from a found object.
Use the parti to drive a design.

Monday 01/14/08 Explore sketching of concept ideas. Develop abstract drawings to reflect personal history. Use 17" lengths of trace to begin "thumbnail" sketching.

As you are tearing sheets think about your life history. What was your family life like? Is there a particular time that you recall when very young? Is there a time when you had a vision of your future? What memories come to mind? Illustrate those memories using the E&P of design. A memory that evokes ritual such as a wedding ceremony might be reflected by symmetry. A memory that evokes chaos such as an all-night concert might be shown by a contrast. Continue sketching,

as you sketch you will think of variations to a sketch, start another sketch to explore a series of variations. You may think of a completely new idea, draw a series of sketches that explore that idea. As you work you may notice you are drawing in a particular style, such as only one color, or one line weight. Use this opportunity to try several line weights, or use only ink, or use only graphite, then combine graphite and ink. Make notations next your drawings that briefly describe what you are thinking using the language of design (E&P).

First observe your found object from all angles, top, bottom, and all sides. Complete an object analysis (see last page for an example). Draw the shapes you see represented. Draw from all angles. What is the relationship between the shapes that comprise your object and the negative area around the object? Draw the patterns and textures that are noticeable. As you complete your sketched analysis begin to reinterpret the shapes, textures and patterns you have observed and drawn. Reinterpret these aspects into abstractions, sketches that resemble the found object in terms of the E&P of design.

Next analyze your found object through a series of concept sketches. Analyze the object using the Elements and Principles of design (E&P) as reference points. Sketch many thumbnails (small 2" or 3" drawings) to fully explore the possibilities. What Elements and Principles of design do you perceive in the object? Sketch on 12x17" pieces of trace, using drawing media and drawing style of your choice. Use of multiple media and varied drawing styles is encouraged. Create loose or tight drawings, multi-color or line, use wide or thin strokes and combine them, mix drawing media (color pencil and marker etc). What are you thinking of when you draw? Are you thinking of the contrast or symmetry of your sketch? Write a note near the drawing. Be inventive. Refine your work to create a definitive concept parti (sketch of the essence of your idea).

In the end you are creating a visual representation of a memory vessel that is based on your sketch interpretation of your found object.

After 40 minutes of sketching layout all of your sketches and walk around the room to see the work of your classmates. This is an opportunity to see how other people sketch.

Using your definitive concept parti or several of them, begin to draw a three-dimensional concept model. The concept model is a representation of your sketch, but now has dimension. Do not simply use the sketch as a base and extrude a model, but express the sketch in all directions. There won't necessarily be a bottom to the concept model, although you may prefer to have it stand on a particular side. The bottom should not be a flat side. Use negative space within the concept model to reinforce your idea.

There will be a strong connection between your parti sketch and your concept model, but they should not look the same. Each step of this process will show evolution of your idea.

Wednesday 01-16-08 Develop a concept model or detailed 3D concept drawings that represents your most creative exploration, as shown through the concept parti. This model should be constructed of simple materials that are true to their nature. Cardstock, cardboard, chipboard, fomecore, balsa, wire, and paper are suitable materials for a concept model. Other materials you might consider are pieces of metal, wood, plastic pieces, found objects of a non-specific nature. Feathers, pipecleaners and specific products are not suitable, and will diminish the effect of your concept.

Construct a model of your memory vessel based on your concept model and parti. Use materials of your choice, that best represent your concept, construct the vessel to fit within 12"x12"x12". Suitable model materials are similar to those for the concept model.

Develop a concept statement that describes the idea generator (found object), form-giver (describe the concept sketches-parti, the abstractions of the found object representing E&P), and application (how you applied the parti to the shelter). Use bullet points or prose. See handout on Design Writing.

Attend an InDesign workshop if you would like to produce a digital poster. Tuesday, Jan 15, 12:00-2:00 in South Campus computer lab.

Friday 01-18-08 Create a poster 18"x24" (digital or board) that clearly describes your concept and vessel. Use the template provided. Include the following: series of part-concept sketches that informed your design, image of the concept model or 3D sketches, image of final vessel model, concept statement, written descriptors for sketches to clearly explain your creative approach.

Wednesday 01-23-08 Submit board poster or one print of digital poster, name on back only. Submit Process drawing packet that includes all concept development sketches, dated, bound on one edge, name and date on cover or bound edge. Submit digital photograph of board or jpeg file of poster on CD.

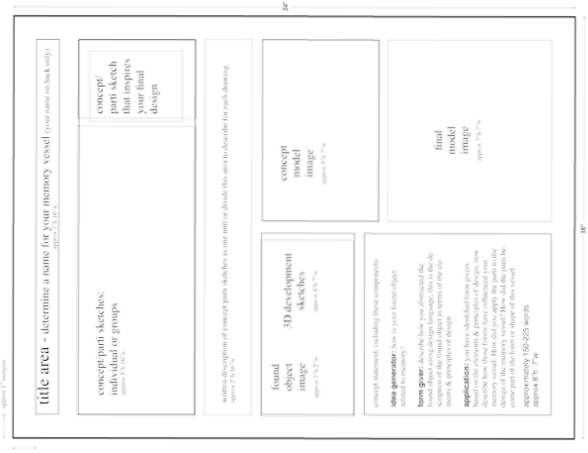
use layer - template, as your reference point - your base drawing.

HIDE or DELETE layer - template before you print

HIDE by clicking in the eye next to the red box-template.

DELETE by choosing "delete layer - template" in the dropdown menu at the tiny arrow on the layers palette.

the blue layer - layer 1 contains a few text boxes, and a few image boxes, you may adjust those, or place images into those boxes. The outer box has a 1-stroke black border, that can be adjusted or removed



Appendix C. script to raters using Consensual Assessment technique (CAT)

01-26-08

Thankyou for agreeing to assist me with this review. This activity is an aspect of my Master's thesis. I am interested in the relationship between a measure of creativity, and visual reasoning style of students.

You will be reviewing concept development ideas created by 1st, 2nd and 3rd year interior design students working on a concept development project.

I am asking you to review this work to assess creativity, novelty, consistency, aesthetics, composition, technical aspects of the design and clarity using a method called Consensual Assessment Technique. Essentially creativity can be effectively evaluated using a group of reviewers who have had some formal training in the area to be reviewed. In this study you will use your own subjective definition of creativity, the degree to which you consider the design to express original or innovative thinking.

An important component of this technique is that each reviewer work independently, and not confer with another reviewer on scoring. I would also like you review the designs in the order listed on the back of the last review sheet of your packet. The score sheets are ordered to match.

To orient yourself to the project please look at each design on your list prior to starting the scoring. In this review I am interested in individual differences, so you are rating your selected projects as a whole, relative to one another.

These particular posters focus on concept development. The starting point is a found object. The student then develops a parti (the basic scheme or concept of a design) based on an analysis of the elements & principles of design discovered in the found object. Each poster should contain an image of the found object, one or more parti drawings, a three-dimensional concept model based on the parti, a concept statement and a model of their memory vessel also based on the parti.

You are primarily reviewing the content of the poster. There is one question that relates to the composition of the poster itself, however the rest of the questions are focused on the content, the individual sketches, image and supporting text and their relationship to one another. I found myself somewhat distracted by the overall graphic organization, so I am emphasizing that the primary focus of this review is evaluating the ideas generated and their relationship to creativity, novelty, consistency, aesthetics, composition, technical aspects of the design and clarity.

Definition of the terms used are on the reverse of each review sheet. I would like you to review these posters before January 31. When you have completed the review sheets, please clip or staple them together and leave in the envelope outside Janetta's office door or with Kristie in the IDI office.

Please feel free to call or email me with any questions. I live in Pullman, and will be back in Spokane next week.

Thank you for taking the time to review these posters.

Kathleen Ryan
509-592-3901
karyan@wsu.edu

Appendix D– definitions to raters

Definitions 01-2008

Creativity: the degree to which you consider the poster to express original or innovative thinking.

Novelty: the degree to which the design is unusual or has components of the unexpected.

Consistency of concept: the degree to which the theme or parti is apparent (or pervades) the drawing or text.

Overall aesthetic appeal: the degree to which artistic sensibility is expressed

Pleasing poster composition: the degree to which the placement of images and text indicates understanding of the principles of design.

Technical quality: the degree to which the drawings and images indicate achievement of skill and craft.

Useful: the degree to which the solution is practical, and the vessel functions well.

Clarity: the degree to which the poster clearly explain the parti-concept idea.

Parti: the basic scheme or concept of a design.

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Appendix E – Consensual Assessment rating form

Rating sheet for memory vessel project posters. 01-2008

The posters you will review have been created as part of a concept development project by 1st, 2nd and 3rd year interior design students. The starting point is a found object. The student then develops a parti (the basic scheme or concept of a design) based on the found object, utilizing the elements & principles of design. The poster should contain an image of the found object, one or more parti drawings, a three-dimensional concept model based on the parti and a final model of their interpretation of a memory vessel

You are reviewing these posters to assess creativity, novelty, consistency, aesthetics, composition, technical aspects of the design and clarity. Thank you for taking the time to review these posters. The review parameters are described in each question below. Definitions for terms are on the reverse.

Reviewer number: _____ reviewer name: _____ (please initial)

Poster number: _____

Creativity- using your own subjective definition of creativity, the degree to which you consider the poster to express original or innovative thinking:

low "creativity" 1 2 3 4 5 6 7 **high** "creativity"

Novel idea- the degree to which the design is unusual or has components of the unexpected:

low "novelty" 1 2 3 4 5 6 7 **high** "novelty"

Consistency of concept- the degree to which the theme or parti is apparent (or pervades) the drawing or text:

concept/parti **is not at all** consistent 1 2 3 4 5 6 7 concept/parti **is apparent** throughout

Overall aesthetic appeal- the degree to which artistic sensibility is expressed:

low level of artistic sensibility 1 2 3 4 5 6 7 **high** level of artistic sensibility

Pleasing poster composition- the degree to which the placement of images and text indicates understanding of the principles of design:

not pleasing 1 2 3 4 5 6 7 **very** pleasing

Technical quality- the degree to which the drawings and images indicate achievement of skill and craft:

shows **low** technical achievement 1 2 3 4 5 6 7 shows **high** technical achievement

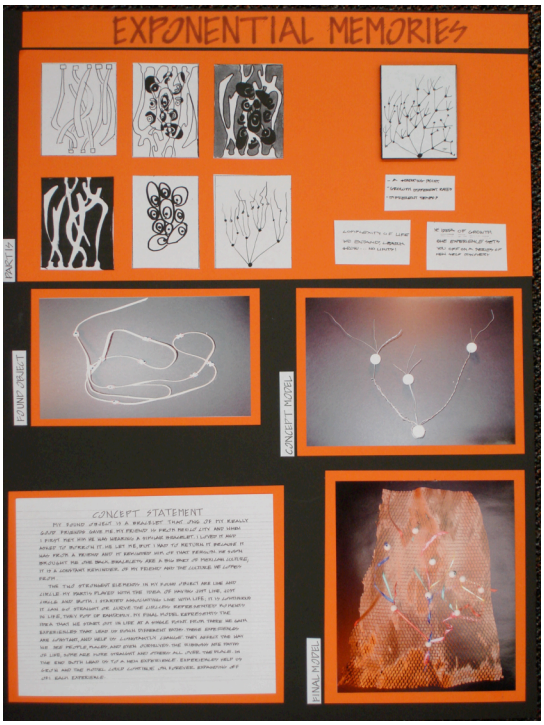
Useful- how well is the problem of vessel solved, is this practical?

not useful 1 2 3 4 5 6 7 **highly** useful

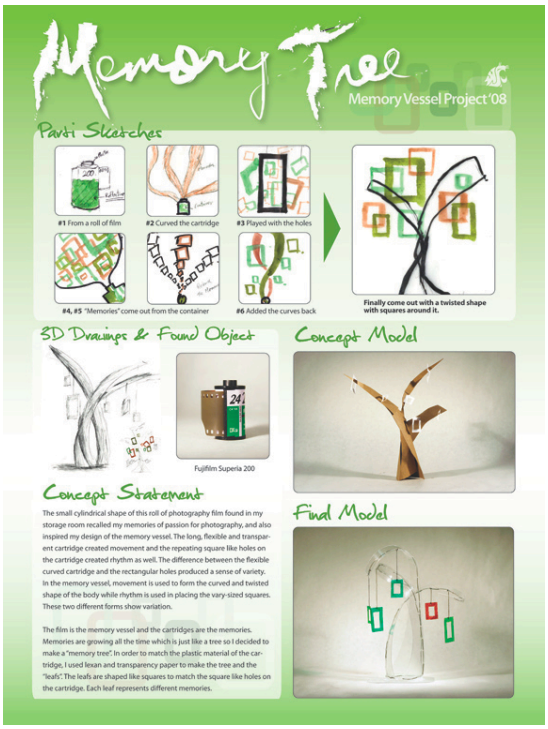
Clarity- Does the poster clearly explain the parti-concept idea throughout?

I have no idea what this concept means 1 2 3 4 5 6 7 **I understand** this concept completely

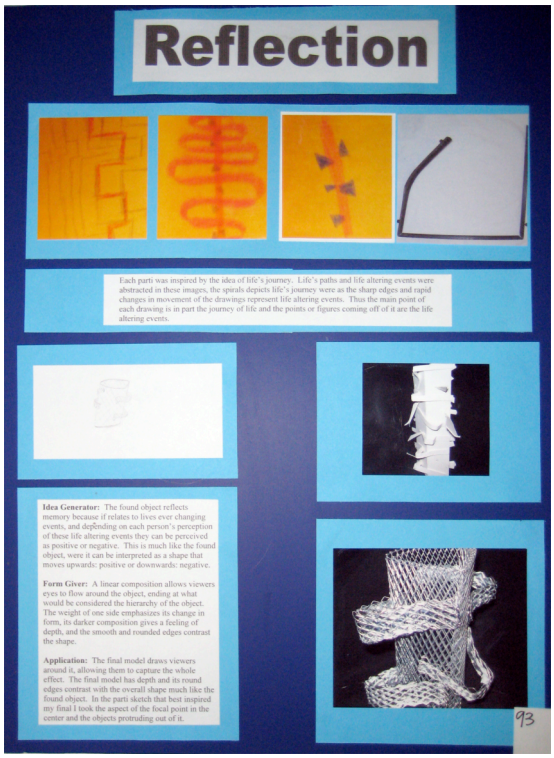
Appendix F – memory vessel posters created by students



068-2



002-2



093-1

027-2