A Q-METHODOLOGICAL STUDY OF STUDENT BELIEFS ABOUT THE CHARACTER OF CREATIVITY IN THE EMERGING DISCIPLINE OF COMPUTER GRAPHICS

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CHAPTER I

INTRODUCTION TO THE STUDY

During the Middle Ages and the Renaissance, the sciences and the humanities were conceived as a single philosophical enterprise. Since the time of the Scientific Revolution, however, the two cultures, as Snow (1998) described them, have existed in opposition to one another. The arts and humanities are separated from the sciences and mathematics by a substantial ideological gulf and members of the opposing cultures are hostile to one another, seldom crossing disciplinary lines to communicate. Snow believed this to be particularly problematic because he saw the sciences as an empowering agency, but the arts as a moral agent of sorts, helping us apply power appropriately. Lindauer (1998) argues that even today, "the relation between science and the humanities is marked more by opposition than by cooperation. The sciences, for example, proudly insist on objectivity, quantification, and control. The humanities just as strongly promote the virtues of subjectivity, intuition, and narration" (p. 1). He further notes that, "the virtues of science are therefore judged as vices by scholars in the humanities and vice versa" (p. 2).

Two Cultures in Creativity

The view that the sciences and humanities stand apart as two differentiated cultures likewise frequents much of the literature on creativity and creative expression. This difference is expressed in a variety of ways; for instance, analytic versus synthetic thinking, left- versus right-brain hemispheric dominance, divergent versus convergent thought processes, logical/mathematical versus spatial intelligence, and most broadly, scientific versus artistic creativity. While scientific and artistic creativity, and the various other expressions of the differences between the creative interests, cognitive processes, products, skills, and intelligences of those aligned with either the sciences or the arts, are not always considered oppositional, they are considered different and distinguishable from one another.

The perceived division between the two cultures of the sciences and the arts, as well as their corollaries in creativity and creative expression, are also manifest in debates regarding the intersection of technology and aestheticism. Many in the fine arts community have seen technology as antithetical to creative expression. It has been argued that the introduction of technology into the process of creating—and learning to create—art marginalizes other more important concepts such as imagination and a patient, thoughtful approach to design. While the fine arts engage the artist and the art student through critique and self-reflection, technology inhibits engagement, distorting the relationship between artist and art (Spaid, 1998). Commercial applications of art, such as digital design, have been seen as a selling out of higher ideas by many artist-academicians (Von Proyen, 2000). Sherman (1990) points to a frequent concern that the integration of technology into creative activities results in an emphasis on training—how to do something—at the expense of larger issues about whether or not to do something.

We are challenged, then, to adequately conceptualize the underpinnings of creative activities and expressions in those areas that, with increasing regularity, seem to fuse aestheticism and artistic views with highly technical tools and media, demanding engagement across contrasting creative types, orientations, and intelligences. Interestingly, Snow (1998) writes that it is here, at this intersection of the two cultures, that the greatest opportunities for creative production exist. Likewise, Meggs (1983) proposes that while technology contributed to the separation of the arts from their connection to people's social and economic lives, there is a growing awareness of the need to reconnect the aesthetic and the technological.

Computer Graphics: A Third Culture

With increasing frequency, artists are using the tools of science, computers, for expression and communication. Science informs art and art informs science. The result is a triangulation, an emerging third culture characterized by an interdisciplinary approach with communications into each of the other two cultures (Vesna, 2001). This third culture is defined by previously impossible or unimaginable products and curricular emphases and is most active at colleges and universities, where demands for profit are not especially compelling allowing freedom for experimentation, where members of both the scientific and artistic cultures are close at hand, and leading edge digital technologies are often made available for innovative applications (Jackson, 1999; Vesna, 2001). Eber (2000) notes that computers allow traditional art students to create unique art forms such as digital paintings, 3D models and animations, and varied interactive products. At the same time, traditional computer science students are being introduced to aesthetics and the expressive potential of computer graphics.

The evolution of the computer graphics field has taken place across three stages beginning in the mid 1970s (Spalter, 1999). In this first period, those interested in utilizing computers for graphics production were required to learn computer programming. The extreme costs of digital equipment made access to suitable hardware, to include the most rudimentary output systems, difficult and only an exclusive few were able to participate in this principally experimental time in the field (Mak & Degennaro, 1999; Spalter, 1999).

The second phase ran roughly from the late 1970s through the late 1980s. Lucrative design firms and production facilities began to procure expensive computing systems that required little or no programming on the part of digital artists. Still, the costs of hardware and software were too high to support widespread adoption and computers were still considered by most to be the exclusive tools of scientists, mathematicians, and skilled technicians. Most of those experimenting with computer graphics at that time were self-taught, perhaps after a few years in a technically oriented college or vocational program. The few personal computing systems available to the general public lacked the power to run software applications suitable for serious graphic work. Output was typically black and white and the few color systems available were especially expensive and limited to low resolution (Mak & Degennaro, 1999; Spalter, 1999).

The third stage began soon after 1990. Since that time, computing power has grown substantially while costs have decreased. Unprecedented computing power is finally available to hobbyists, small production companies, individual contractors, other interested individuals, and even public and private K-12 and higher education institutions. It cannot be assumed, however, that the widespread adoption of digital technologies indicates that the technical barriers to quality production have been eliminated. On the contrary, it is highly likely that power and flexibility in digital design tools will always demand some level of technical prowess, and it is this technical skill-set that has become a prerequisite for most of today's commercial design jobs (Mak & Degennaro, 1999; Spalter, 1999).

The proliferation of digital technologies has had a tremendous impact on our culture. Freedman (1997) notes, "Visual forms of culture have become more accessible than literary forms" (p. 6). The increasing availability of computers in recent years has meant that young adults entering college today are very familiar with these assets and are not hesitant to engage the technology for a wider array of purposes (Rubin, 1995). That is, computers are not strange or unfamiliar to today's college-bound students and, as with every other artifact common to the culture, they seem less likely to limit their applications. These students are not hamstrung by visions of punch cards, bright green text on the black background of a cathode-ray tube, command-line user interfaces, or an understanding of computers that limits their applicability to the realms of science and math. On the contrary, as Harris (1999) notes, "We are living in a world in which the arts, sciences, and technology are becoming inextricably integrated strands in a new emerging cultural fabric" (p. viii). Students entering college today, especially those who seek to integrate technology and aestheticism, are crafting a new reality (Sherman, 1990) and they expect to enjoy an educational experience that prepares them for this new reality. Likewise, employers are looking beyond technically trained candidates for employment to meet market demands for creative, as well as technically functional, content. Consequently, colleges and universities are creating programs to support this demand. Unfortunately, they often do so without an adequate understanding of the challenges involved.

Schreiber (1998) notes that established faculty members often doubt the validity of these new programs, seeing them as part of a pop culture that will pass with time. Administrators and departmental peers frequently underestimate the additional time required of a faculty member teaching in a discipline that is constantly evolving with new software upgrades, each with new features and capabilities, coming every 12 to 18 months. Faculty members teaching these courses often find themselves the de-facto point of contact for program maintenance and budgetary issues (Rubin, 1995). Existing academic structures based on closed departmental boundaries and the traditional separation of the arts and the sciences make establishing a home for inherently interdisciplinary studies difficult (Chandler, 1999; Schreiber, 1998). Different institutions have taken a variety of approaches. Both graduate and undergraduate degrees are offered in digital media, new media, computer graphics, computer arts, electronic media, multimedia information systems, inter-media, and/or media arts out of art departments, computer science departments, communication departments, film and theater departments, or, in rare instances, interdisciplinary studies programs (Eber, 2000; Gardner, 1999; Harris, 1999). Most notably, few understand that traditional models of teaching and learning must give way to pedagogical practices better suited to the unique demands of these new programs and the needs of the students they attract (Nielsen & Trias, 2000; Schreiber, 1998; Sherman, 1990).

Problem Statement

The exceptional demands of today's computer graphics field, both aesthetic and technical, set it apart as a unique enterprise. Educators, curriculum developers, and program administrators will benefit from an appreciation of how students understand and engage in creative design and development in this highly technical field.

Colleges and universities, and the faculty members they employ to create, manage, and teach in such programs, are not only being challenged to reconsider the relationship between the two cultures as manifest in academic organizations, but also their understanding of how students might utilize what have often been considered as disparate forms of creativity: scientific versus artistic, analytic versus synthetic, convergent versus divergent, etc. As a step toward understanding, it should prove beneficial to study students' beliefs regarding creativity and the influence digital technologies have on creative expression. Mace (1997) writes, "It is likely that there are patterns of similarity between the working processes of creative people working in particular fields. These patterns might reveal pervasive factors underlying creative production" (p. 266). Runco and Bahleda (1986) note that given the extreme difficulty in defining creativity, implicit theories may be helpful in establishing definitions that are most practical. It is from their implicit beliefs regarding creativity that students will engage course materials and experiences (Katz & Thompson, 1993; Sternberg, 1985). This study employed Q methodology to describe the understandings of college students in computer graphics courses with regard to creativity and how creative expression might be influenced by digital technologies.

Theoretical Framework

This study into students' understandings of creativity, creative expression, and the influence that technology has on both extends from the researcher's ontological and epistemological assumptions that situate truth and knowledge with the individual. The goal of this study was to uncover how participants in the emerging discipline of computer graphics understand the construct of creativity. Rather than proceeding from the researcher's construct of creativity and in some way measuring it in the population of those actively engaged in computer graphics, this study sought students' own constructs of creativity. From an observed phenomenon, students' arrangements of diverse statements regarding the broader field of creativity, patterns of beliefs were collated describing students' manifest constructs.

In broad terms, the dialogic expressions of creativity as a concept rest on a few principal themes. These include understandings of the determinants of creativity as either in the person, product, process, or creative-ogenic environment (Davis, 1992) and the often-expressed view of creativity as scientific or artistic or perhaps an intersection between these two (Feist, 1991; Runco & Bahleda, 1986).

Purpose of the Study and Research Questions

"Research questions arise out of practice, out of a sense that unsolved problems, unresolved conflicts, and contradictions in beliefs and actions in some way block us from being better at what we do" (Carroll, 1997, p. 183). This study reflects the researcher's passion for his work as an instructor at the intersection of aestheticism and technology and the desire to better understand how students frame their efforts in the emerging discipline of computer graphics.

The purpose of this study was to investigate the patterns of beliefs students hold about the field of computer graphics and their understandings regarding the character of creativity in the field. The questions guiding this study were a) What patterns of beliefs do students hold about the field of computer graphics? b) What is the character of creativity represented among students' beliefs about the field of computer graphics?

Significance of the Study

The significance of this research rests on the growing demand for skilled adults to work in career fields requiring both creative abilities and technical expertise, and higher education's interest in preparing students for this work. The newness of the digital technologies at the heart of these career fields and their unique capabilities compel educators to consider new pedagogical approaches (Nielsen & Trias, 2000; Schreiber, 1998; Sherman, 1990). Unfortunately, little research has been undertaken on the intersection of creativity and technology and how it might be experienced in educational settings (Howe, 1992; Johnson, 1997).

A number of additional factors suggest that this study is clearly worth pursuing. Simonton (1999) writes,

> While the quality of scholastic performance may be modestly correlated with adulthood success in some domains, it bears no relation with achievement in other domains, especially in those areas requiring creativity....The lack of correspondence between scholastic performance and creative achievement is particularly conspicuous in artistic creativity....Artistic creators are also more likely to have much more negative attitudes about their educational experiences in comparison with scientific creators. (p. 119)

Simonton continues, "Although formal education thus seems to bear an ambivalent relationship to the development of creative talent, it must be stressed that those who later attained status as creators almost invariably engaged in the arduous process of self-education" (p. 120). If colleges and universities are to play a significant role in the education of future digital artists and designers, it is clearly advantageous for students' educational experiences to facilitate successful employment. Similarly, it would be valuable if student performance in college programs correlated in a highly positive manner with student success after graduation. Garnering a better understanding of students' beliefs and expectations about creativity in the field of computer graphics should prove beneficial for course design and implementation.

The proposed research responds to calls by the College Art Association (CAA) (Rubin, 1995) and the National Arts Education Association (NAEA) (1994) for research into the impact of technology on art education, art education across domains, and curricular foundations. Both the CAA and NAEA indicate that such research may improve pedagogical practices and otherwise enhance art education.

Summary

Aesthetics and technology have been seen as being at odds since the Scientific Revolution (Lindauer, 1998; Snow, 1998). Likewise, the effectors of creative production have also been divided such that different processes are assumed to support what in broad terms might be termed scientific creativity, often described as convergent, analytical, controlled, contrasting, rational, constrained, objective, and pragmatic, and that which might be broadly described as artistic creativity, characterized as divergent, integrative, subjective, intuitive, impulsive, emotional, expressive, imaginative, and focused on high ideas (Feist, 1991; Gardner, 1973; Lowenfeld & Brittain, 1987; Simonton, 1999). Several point to the sentiment in the fine arts community that technology inhibits creativity and imagination (Mak & Degenaro, 1999; Sherman, 1990; Spaid, 1998; Von Proyen, 2000). Others suggest that this intersection has especially great potential to encourage creativity (Chandler, 1999; Meggs, 1983; Snow, 1998). This study sought to describe the beliefs of students engaged in studies that require creative production while insisting on highly technical tools and associated skills. Q methodology was employed to capture their beliefs according to the theoretical frame of creativity as located in the person, process, product, or environment (Davis, 1992) and as scientific, artistic, or some combination of these two (Feist, 1991; Runco & Bahleda, 1986).

CHAPTER TWO

REVIEW OF LITERATURE

This study investigated what creativity means to students in computer graphics courses. Students' beliefs regarding the influence of technology on their processes of creative production were also examined. Relevant to this study is literature that addresses a) principal constructs regarding the origin and manifestations of creativity, b) applications of technology to creative activities and the ramifications thereof, and c) the value of implicit beliefs in providing a pragmatic understanding of creativity.

Understandings of creativity vary widely. While Davis (1992) argues that creativity certainly exists, he also notes, "…there are about as many definitions, theories, and ideas about creativity as there are people who have set their ideas on paper" (p. 38). Likewise, Edwards (2001) calls creativity an "amorphous concept" (p. 222) and concludes that although extensively studied,

> There exists no consensus as to what the term *creative* or *creativity* means, what a creative act entails, or how creativity is recognized. It is apparent that creativity has not been adequately defined and that incongruent findings about the nature of creativity are commonplace in the literature. (p. 222)

Piirto (1992) writes, "Every discipline, every field, every person, has a separate definition, and each believes in creativity as something that really exists" (p. 6). Boden (1994) describes creativity as a paradox, mysterious, and apparently unpredictable. The challenge, then, is to organize the expansive body of research and literature on creativity in such a way that meaningful themes and concepts can be extracted for consideration.

Before doing so, however, it is probably important to consider the value that we place on creativity.

While little consensus exists regarding how to best define creativity, it is generally acknowledged that its study is important as it is assumed to contribute to quality of life and positive mental health. For instance, Maslow (1976) notes that the universal characteristic of creativity—as opposed to the relatively rare special-talent creativity—is positively correlated with psychological health. Creative, psychologically healthy individuals are less inhibited and self-critical. They are more spontaneous, happy, open to new ideas and understandings, more comfortable with ambiguity and uncertainty, and less likely to see life in terms of dichotomies. Maslow writes, "the creativity of my subjects seemed to be an epiphenomenon of their greater wholeness and integration" (p. 90). So, Maslow correlates these attributes of creativity, and creativity itself, with health and what he has notably come to refer to as "self-actualization." More than this, however, he writes, "it is as if [self-actualizing] creativity were almost synonymous with, or a *sine qua non* aspect of, or a defining characteristic of, essential humanness" (p. 92). Likewise, Carl Rogers (1976) identifies creativity as an innate urge associated with self-actualization. He asserts that creative expression is indicative of health and maturation, a growing toward constructive human potentialities. According to Rogers, the creative individual is playful, open, and expressive. Torrance (1962) notes that creativity is linked to stress management and satisfaction in life. For many, creative expression is a positive coping mechanism that not only reflects but also facilitates mental health. Those who repress their innate tendencies for creative expression often become overly conforming and overly dependent on others. They may develop learning disabilities, the result of repressed curiosity and the child's natural tendency to explore. In some instances, neurosis or psychosis may ensue. Beyond benefits to the individual, creativity is also essential to social progress (Barron, 1968; Csikszentmihalyi, 1993; Guilford, 1967; Lowenfeld & Brittain, 1987; Piirto, 1992; Torrance, 1962). Society benefits from creative engagement, imaginative diversity, and novel solutions to shared problems.

Novelty and Creativity

Any discussion of creativity would be incomplete without some reference to novelty, widely accepted as the defining characteristic of creativity (Barron, 1988; Davis, 1992). Unfortunately, while novelty is accepted by most as a distinguishing characteristic of creativity, what is meant by novelty is often debated. Some suggest that a notion or product needs to be novel only for that person conceptualizing the notion or creating the product (Johnson-Laird, 1987). For others, the concept of novelty is understood within a broader context, such that a creative idea or product is only novel when it is new to society. For instance, Csikszentmihalyi (1988) argues, "without a group of peers to evaluate and confirm the adaptiveness of the innovation, it is impossible to differentiate what is creative from what is simply statistically improbable or bizarre" (p. 326).

The Domain Specificity of Creativity

It is rare for an individual to exhibit creative abilities across a number of diverse disciplines and so creativity is often conceptualized as domain specific. That is, it is argued that creative expression is only possible when it extends from a foundation of experience and an adequate skill-set within a particular domain (Edwards, 2001). An artist might be recognized as creative only after many years of work and study concentrated in a particular discipline or craft. Past experience is essential in that it forms the basis for evaluating solutions to problems and situates creative expression acceptably within its domain (Weisberg, 1988). Novel solutions are frequently novel combinations of previously available materials or ideas. So, time and a substantial collection of experiences and skills within a domain are the building blocks of novelty and creative expression.

Csikszentmihalyi (1988), Gardner (1993a), and Li (1997) also argue that creativity is domain specific but expand upon the notion that it simply requires knowledge and experience in the domain. They suggest that creativity can best be understood as a system of interacting elements: the person, the domain, and the field. Gardner (1999) defines a domain as a "socially constructed human endeavor, ...an organized set of activities within a culture, one typically characterized by a specific symbol system and its attendant operations" (p. 82). It is essentially a discipline or a practiced craft. Gardner contrasts this with a field, which he defines as the broader set of agencies and individuals that set standards and place value on works created within the domain. So, creative expression is domain specific not only because it demands substantial experience with the tools of the domain, but also because of the interplay between the individual, the domain, and the field. An individual's work within a domain is shaped by the symbol system of the domain. That work is either appreciated by the field—composed of critics, educators, peers, and significant others—in which case it is retained and becomes a part of the domain's evolving cultural fabric, or it is discarded as ineffectual or unimportant. The evolving cultural fabric informs a new generation of individuals and the interplay continues. It is especially important, then, to understand that opportunities for creative expression vary from domain to domain influenced by the symbol system and operational character of the domain and by the influential members of the field (Csikszentmihalyi, 1988; Gardner, 1993a; Li, 1997). Mace (1997) writes that the processes associated with creativity are unique to specific disciplines. In this way, a discipline may be defined based on its unique set of creative processes. The significance of this study is derived, in part, from this presumption that creativity is domain specific. Given variability among domains, their symbol systems, their tools, and their processes and products, it is likely that, for instance, students enrolled in academic programs in computer graphics will conceptualize creativity differently than those enrolled in fine arts, music, computer programming, or any other particular domain or discipline.

Special-Talent and Self-Actualized Creativity

A few uncommon individuals manifest creativity in the extreme. This is a rare group and the foundations of their creative expressions are unclear (Maslow, 1976). This type of creativity is referred to as "special-talent creativity" (Davis, 1992, p. 6), "eminent creativity" (Edwards, 2001, p. 221; Richards, 1990, p. 302), "high-creativity" (Cropley, 1990, p. 167), or "big-C" creativity (Stein, 1987, p. 420). It is often characterized as precocious, idiosyncratic, disruptive, highly complex, and somehow more a product of inheritance than education or upbringing (Albert, 1983). Although there is substantial debate regarding the validity of such claims, many have linked this extreme form of creativity with psychological disorders such as mania (Becker, 1983; Cropley, 1990; Davis, 1992; Guilford, 1967).

The corollary to special-talent creativity is "everyday creativity" (Cropley, 1990, p. 168; Edwards, 2001, p. 221; Runco & Bahleda, 1986, p. 93), "self-actualizing creativity" (Davis, 1992, p. 59), or "little-c" creativity (Stein, 1987, p. 420). As noted above, everyday creativity is often considered a component of the self-actualizing individual (Cropley, 1990; Lowenfeld & Brittain, 1987; Maslow, 1976; Rogers, 1976; Torrance, 1962). It is present at least as a potential in all humans. In those individuals for whom everyday creativity is not manifest, it is theorized that their creative potential has probably been blocked by psychological disturbance (Maslow, 1976; Rogers, 1976) or by cultural pressures to conform, perhaps as a part of public schooling (Davis, 1992; Steinberg, 1967; Sternberg, 1988).

Determinants of Creativity

A number of authors (Davis, 1992; Kneller, 1965; Mace, 1997; Rhodes, 1961) note that many of the published works on creativity extend from presumptions about its principal determinant: most often the creative person, the creative product, the creative process, or those environmental conditions that facilitate creativity. Davis (1992) calls this last category "press" while Mace (1997) calls it the "creative-ogenic" environment.

Theory that positions the loci of creativity with the person typically assumes specific personal traits that lead to creative production. For instance, Perkins (1988) notes, "creativity is more a matter of values and personality than particular ways of deploying activities" (p. 379) and further argues that although some set of skills within a particular domain are probably beneficial, this skill-set is insufficient to ensure creativity and we must, therefore, look to personal attributes to explain the source of creative expression. Smith, Ward, and Finke (1995) admit that while culture, individual abilities, and environment may influence creative expression, it is ultimately a person's cognitive processes that are "the essence and engine of creative endeavors" (p. 1). Steinberg (1967) and Hodges (1999) also see specific personal attributes as being the source of individual creativity. They indicate that these include cognition, beliefs, values, attitudes, and emotions. Likewise, Sternberg (1988) sees creativity as "a peculiar intersection between three psychological attributes: intelligence, cognitive style, and personality/motivation" (p. 126).

Kneller (1965) notes that creative products have traditionally provided the most available means to understanding creativity. They are far more accessible than personalities. Likewise, Simon (1967) writes that the processes used in what comes to be identified as creative expression are probably no different than those used by everyone else, whether in artistic or scientific endeavors. Creativity, then, is manifest in products that are novel, unconventional, and valuable. McKinnon (1987) also cites the creative product, and how it is differentiated from other non-creative products, as "the bedrock of all studies of creativity" (p. 120). Interestingly, for McKinnon, the creative product can be a creative person; that is, someone who manifests novel interpersonal abilities as might be applied in a leadership role.

A number of researchers espouse a principally process-centered model of creativity. Torrance (1962), for instance, conceptualizes the creative process as a series of steps or stages not unlike the scientific method. Specifically, he defines creative thinking as "the process of sensing gaps or disturbing, missing elements; forming ideas or hypotheses concerning them; testing these hypotheses; and communicating the results, possibly modifying and retesting the hypotheses" (p. 16). Wallas (1926) also proposed a process-oriented model of creativity. His popular four-step model includes preparation, incubation, illumination, and verification. In the preparation stage, the problem or situation is explored and relevant information is collected. Incubation can be understood as a mulling over or reflection on the problem or situation. Typically, this occurs at an unconscious or preconscious level (Davis, 1992). Illumination occurs when insight into a solution occurs. The final stage, verification, includes testing the insights of the illumination stage for their suitability as a solution.

Still others see the environment as playing an especially significant role in the manifestation of creativity. For instance, Hennessey and Amabile (1988) note that social and environmental factors can have a significant impact on motivation and, in-turn, creativity. For example, their research indicates that when motivation is intrinsic, opportunities for creative expression are enhanced but when extrinsic rewards, such as money, are introduced, intrinsic motivation and creativity are diminished. Hennessey and Amabile cite other environment factors that influence creativity such as deadlines, surveillance, awards and recognition, external evaluations, and criticism. As has been noted previously, environments that demand or reward conformity can also adversely affect creativity (Davis, 1992; Steinberg, 1967; Sternberg, 1988).

While examining each of these loci as the possible seat of creativity is helpful, it may be that considering each in isolation leaves us with an incomplete understanding of this complex characteristic. Mace (1997) notes, "Any truly useful account of creativity will consider variables from each locus, and how they influence and are influenced by their wider environment, or domain of issue" (p. 265). Out of Mace's statement come two important concepts to be considered: a possibly multivariate stimulus for creativity and, again, the connection between creativity and the specific domain in which it is expressed. It should be noted that Mace sees much of recent research pointing to a multivariate influence on creativity, especially the combined influences of the person and the environment. Likewise, Csikszentmihalyi (1988) sees the interplay between the environment and the individual as critical to our understanding of creativity. Specifically, Csikszentmihalyi argues that it is only when we appreciate the interplay between an individual's creative expressions, when valued by social institutions, and subsequently adopted into a stable culture, that we understand the complete and true picture of creativity. To make this point, he notes that one cannot judge on first sight the creativity of a thing. It is only later, when considered with the knowledge of its impact on the culture into which it was borne, can we begin to value something as creative. Johnson-Laird (1987) notes, "creativity is like murder—both depend on motive, means, and opportunity" (p. 208).

Artistic Creativity versus Scientific Creativity

Gardner (1994) differentiates between scientific and artistic creativity and creative production in several respects. In terms of their products, both artists and scientists strive to communicate through the use of symbolic forms, but the artist employs these forms to communicate subjective experience in a way that elicits an affective response. The scientist uses symbolic forms to explain, appealing to the audience's intellect through explicit means. While the communicative forms of scientists are amenable to translation into other media and other symbolic systems—another language or some restructured form—the communicative forms of artists are not. That is, a scientist's findings may be easily translatable across languages, between scientific notation and text, and between text and some diagrammatic representation; while an artist's manifestation of feelings, thoughts, or ideas are almost certainly bound by the medium used. Translating a poem, for example, from one language to another may destroy the rhythm and, consequently, the mood or emotion the creator intended to elicit. Consequently, while the products of artistic creativity must be experienced firsthand to be appreciated, the products of scientific creativity can be experienced secondhand with little or no depreciation. Further, it may be that an artistic work allows for, or even embraces, ambiguity or multiple meanings. The creative products of scientists, conversely, are most valued when free from ambiguity. An observer's appreciation of an artistic piece is difficult, if not impossible, to validate, while the understanding of a scientific creation, grounded in objective truth, can be assessed for accuracy. Artistic creativity often yields a product that is the embodiment of its creator, while scientific products reveal aspects of an objectified world, apart from and unbiased by its creator/discoverer.

Gardner (1994) also makes a distinction between the goals associated with scientific and artistic creativity. Scientific creativity aims at describing the world of natural phenomena. Artistic creativity seeks to provide commentary and illustrate, characterize, or recreate some subjective experience or phenomena. Gardner writes, "Aspects of life that appear inexplicable or ineffable to scientists dominate the aesthetic realm" (p. 34). Also, the goals of scientists are most often to add to the broader body of knowledge, building on the work of others, while artists, who may be aware of the traditions of their medium, seek not to answer problems of their field, but of themselves, their culture, or their society at large. Gardner also notes that there is a linearity of sorts associated with the goals of science. To be successful, scientists must understand their domain as it has evolved throughout time. This is not necessarily the case for artists. Gardner writes, for instance, that a painter need not study sixteenth century painting in order to be judged creative, but might, instead, focus on contemporary works. That is, the broader scientific community creates by building on earlier works and understandings, while the artistic community is not similarly bound to an evolutionary progression. Interestingly, Gardner notes that this means that scientists' work can be continued after their death, but the same is not possible for an artist's interrupted work.

In terms of the creative processes employed, Gardner (1994) notes that artists employ a personally sensuous process. The detachment that may characterize scientific research cannot be tolerated in artistic work. Writing of Wallas's four stages in the creative process—preparation, incubation, illumination, and verification—Gardner notes that the key stage for scientists is illumination. Having reached an understanding of the problem and its solution, scientists can turn their work over to assistants. The key stage for artists is the last, which Gardner reconceptualizes as "execution" (p. 280). In this stage, artists may feel as if they are no longer in control, but that the process has taken them over and somehow takes on a will of its own. Scientific creativity frequently emanates from a theoretical understanding that yields possible explanations and questions that are tested through a system of formalized operations. Provided that they are technically competent, artists need not employ reason in the creative process. Scientific creativity is most often bound by rules and a relentless structure, while the rules associated with artistic creativity are "there to be imaginatively transformed, deliberately violated, or subtly altered" (Gardner, 1994, p. 312). In similar fashion, Chandler (1999) writes, "science is perceived as devoid of the stages of conceptualization, incubation, and creativity thought to be only the province of the arts and the arts are perceived as devoid of the methodological and theoretical rigor associated with scientific process" (p. 169).

Runco and Bahleda (1986) studied the implicit theories of undergraduate students and artists regarding scientific, artistic, and everyday creativity. In their study, artists most frequently described artistic creativity as expressive, imaginative, humorous, open-minded, unique, emotional, and exciting. Conversely, they described scientific creativity as perfectionist, intelligent, curious, patient, and thorough. Non-artists in the study described scientific creativity as intelligent, logical experimenting, curious/inquisitive, intuitive, and problem solver. These non-artists most commonly associated the words imaginative, expressive, intelligent, original, and perceptive with artistic creativity. In his research of how creativity is most often conceptualized, Feist (1991) finds that scientific creativity is commonly said to be "rational, analytical, objective, non-emotional, and controlled" whereas artistic creativity is most often characterized as "nonrational, intuitive, subjective, emotional, and impulsive" (p. 146). Simonton (1999) also differentiates between the creativity demonstrated by scientists and that of artists: scientific creativity being more constrained, divorced from everyday life, and dependent upon convergent thought processes, while artistic creativity can be more expressive, imaginative, and more dependent upon divergent thought processes. Lowenfeld and Brittain (1987) conceptualize creativity and intelligence as uniquely different characteristics, each possibly having little to do with the other. Intelligence is the ability to think rationally and employs convergent production. Creativity, on the other hand, takes advantage of divergent production, originality, and flexible thinking patterns.

Convergent versus Divergent Thinking

Although the relationship is debatable, divergent thinking is frequently seen as a key component of creativity (Papalia & Olds, 1978; Piirto, 1992; Russ, 1993). Divergent thinking includes fluency, which is the ability to produce a large number of ideas within some limited amount of time; flexibility, the ability to embrace change; and originality, which refers to an ability to generate novel concepts and products (Guilford, 1967). Convergent thinking involves the selection of the expected answer from among many possibilities (Piirto). This type of thinking is evaluative and related to the individual's sensitivity to problems (Dudek & Côté, 1994). It is not uncommon to see divergent thinking associated with artistic creativity and potential while convergent thinking is more closely associated with intelligence (Hartley & Greggs, 1997). While extreme care needs to be taken in interpreting the results given that definitions of creativity and intelligence vary substantially from person to person, there is some evidence for this view. For instance, Hartley and Greggs find that on some tests of divergent thinking, students enrolled in art programs score significantly higher than science students. Likewise, a study of mathematically gifted students by Kajander (1990) showed no relationship between mathematical ability and divergent thinking, leading her to conclude, "mathematical creativity appeared to be a special kind of creativity not necessarily related to divergent thinking ability" (p. 254). The research of Getzels and Csikszentmihalyi (1976) also indicates that art students depend to a greater degree on visual perception than those abilities assessed by traditional intelligence tests, and while intelligence seems to relate to problem solving, the aesthetic work of artists is based, instead, on a questioning nature, a rejection of established cultural values, and a willingness to challenge convention.

Spatial versus Logical/Mathematical Intelligence

Gardner (1999) conceptualizes creativity as a co-concept associated with intelligence, but unique in a number of respects. Gardner notes that creativity is domain specific. That is, creative expression for any particular individual will not be demonstrated across a range of domains but only a very few, and often, only one. So, while some type of intelligence, as defined by Gardner, might prove beneficial to some individual in a number of domains, it is highly unlikely that the individual would demonstrate creativity in all of those domains. Put another way, any intelligence, or group of intelligences, may be foundational for work within a domain and, likewise, participants from a number of domains may benefit from a specific intelligence or set of intelligences. That said, intelligence alone is insufficient to result in creative activity. Gardner also understands intelligence to be differentiated from creativity in that the latter is characterized by novelty; more than that, novelty that in some way alters the domain with which it is associated. So, while both intelligence and creativity involve problem solving and production, the latter is domain specific and novel to the point of changing its domain.

Logical-mathematical intelligence (Gardner, 1983) is characterized by a fluid use of analogy and heuristics to solve problems. Common heuristics include solving problems by working backwards from possible solutions to see if they might fit the problem at hand. Alternatively, individuals who capitalize on their logical-mathematical intelligence may solve problems indirectly by working with a possible solution they assume to be false in order to establish a negative case. These individuals delight in finding solutions and they are adept at deconstructing complex problems into component parts. They are mindful of the logic underlying problem solutions and value the communicability of that logic. Logic is the language of their profession. On occasion, their skills in patterning may carry over to an interest in, for instance, music; but while these interests may benefit from the orderedness of logical-mathematical intelligence, Gardner argues that this intelligence is clearly not foundational to these areas of interest.

Gardner (1983) identifies the ability to accurately perceive the world as characteristic of spatial intelligence. Yet, beyond that, those who capitalize on their spatial intelligence are able to mentally transform this perception, to imagine a scene from varied angles and vantage points, even when separated from the scene. The perception of these individuals extends beyond a simple seeing of an object and, instead, captures the subtleties of light, shape, and color. While many artists will benefit from fine motor skills, Gardner writes that the quintessential prerequisite is spatial intelligence. Gardner also notes that while both logical-mathematical and spatial intelligence are grounded in physical realities, the former soon takes its task into abstraction while the latter remains rooted in the concrete.

Analytic versus Synthetic Thinking

Feist (1991) conceptualizes the differences in creative types to be along distinguishable approaches to problem conceptualization and solution finding: what he describes as analytic versus synthetic thinking. Analytic thinking searches out differences, unique dimensions, and contrasting features. Conversely, the synthetic mode of thinking features a principally integrative process that seeks to unify conceptual features. Feist's research with undergraduate art and science students suggests that while both types of students use similar modes of thinking at some points in problem solving situations, at other times there are differences in the methods employed. Fidelman (1991) further indicates that these thinking types, analytic and synthetic, are peculiar to the left and right hemispheres of the brain, respectively.

Hemispheric Specialization

A great deal of research and speculation about hemispheric specialization has followed Sperry's work with split-brain epileptic patients. The corpus callosum connecting the two hemispheres of the human brain was cut away in each of these patients as a means of managing epileptic seizures. Studies have followed these patients and observations have led to assertions that unique characteristics can be ascribed to each hemisphere and these characteristics are frequently associated with creative production (Al-Sabaty & Davis, 1989; Hoppe, 1990, 1994; Lii, 1986). The left hemisphere seems to be managed by logical, sequential processes. This hemisphere is often characterized as realistic, objective, and critical and seems to be essentially verbal. The right hemisphere is managed by holistic processes and seems to be responsible for humans' spatial orientation. It is characterized as synthetic, analogical, and nonverbal. The assumed connection to creativity varies from researcher to researcher, most often due to varied definitions of creativity. If our definition of creativity emphasizes a spatial orientation, often the foundation for work in fine art areas such as painting and sculpting, it can be argued that the right hemisphere is the seat of creative expression (Al-Sabaty & Davis). If our definition of creativity is broadened to include works in, for instance, poetry, science, and math, it can be seen that the right hemisphere alone cannot be assumed to be solely responsible for creative expression, but the left hemisphere must also be involved (Hoppe, Lii).

Gowan (1978) offers a particularly interesting way of thinking about the combined influence of both hemispheres on creativity. He suggests that each stage of Wallas' four-stage model of creativity can be associated with one or the other hemisphere and that a complete model of creativity involves a back-and-forth process of handling creative challenges: the preparation stage dominated by the left hemisphere as the problem is first confronted and analyzed; the incubation stage dominated by the right hemisphere as the problem is considered at a seemingly unconscious, but probably nonverbal, level; the illumination stage, also dominated by the right hemisphere as a new solution is synthesized; and the verification stage, during which the problem is returned to the left hemisphere for critical analysis. Likewise, Hoppe (1990, 1994) argues that creativity is best understood as a dialogic relationship between the two hemispheres of the brain—what he calls hemispheric bisociation. In considering the synergistic relationship between the two hemispheres of the human brain as espoused by Gowan and Hoppe, one cannot help but be reminded of Snow's (1998) suggestion that the intersection of the two opposing cultures, the sciences and the humanities, should yield the greatest opportunities for creative production.

Of interest, Saleh (2001) studied the influence of hemisphericity on students' choice of academic major and found significant correlation. The study's results indicated that students majoring in art, literature, education, nursing, communication, and law tended to be right-brained while students majoring in business, commerce, engineering, and science were left-brained.

Technology and Aesthetics

Although it is expressed in a variety of ways, the preceding paragraphs make clear that the literature on creativity is replete with references to sometimes opposing and sometimes counter-balanced forces that contribute to creative production. The goals, orientations, symbolic systems, interests, and possibly even cognitive structures of artists and scientists are frequently characterized as uniquely different. We return, then, to our research questions and give thought to how creativity might be understood at the intersection of these forces, systems, and structures in the emerging discipline of computer graphics.

Reflecting on the character types that typify the disparate career fields, Knowlton (1972) writes that programmers are restrained, logical, methodical, and cautious. He notes that programmers can always explain their actions. Conversely, he characterizes artists as intuitive, impulsive, and sensitive and notes that they may have trouble verbalizing the reasons for the steps they have taken in creating some work of art. Our challenge, then, is to understand that individual who is part programmer and part artist or the individual who chooses to work in computer graphics where logic and intuitiveness meet or cautiousness and impulsiveness are both valued.

Schreiber (1998) chronicles the challenges faced by instructors recruited to teach new media courses at many colleges and universities. She notes that colleges and universities increasingly feel the need to offer computer graphics, interactive multimedia, and similar digital media programs given student interests and new employment opportunities, but she explains that few institutions are prepared to deal with this new discipline. Schreiber argues that many fine art instructors see computer graphics as having little to do with aesthetics. She notes that students and instructors with experiences in the fine arts often see new media programs as part of a passing fad and antithetical to the tried and true approaches of traditional arts education. Computer graphics are seen as push-button, devoid of the emotional investment of fine arts. Schreiber's insistence that educational programs in new media require uniquely different pedagogies gives us some insight into how computer graphics stands apart as a new discipline, out of harmony with many existing art programs.

Spaid (1998) is one of many artists who argue that the application of technology to arts and arts education perverts aestheticism. She believes that technology subjugates the higher ideas of art—such as imagination and creativity—to modernist concepts such as mass-production and expediency. Spaid frames this tension in the ongoing debate over the purposes of higher education. She sees the introduction of technology into the arts curriculum as being driven by a philosophy that understands education as a means to immediate employment. Traditional fine arts programs, on the other hand, teach students how to think. They prepare students for lifelong learning and a lifetime of work rather than teaching only those skills necessary to enter today's job market. Spaid further differentiates between the fine arts education for aestheticism and technology-based education for employment noting that the former is about social issues, moral consequences, compassion, and personal sensitivities while the latter is about overcoming technical barriers, media exploitation, mediated experience, and disenfranchisement. Spaid sees computer graphics and traditional approaches to art as distinctly different, requiring very different skills and attracting very different personality types.

Research by Mak and Degennaro (1999) seems to support their hypothesis that the tendency to exclude technology from educational programs aimed at aesthetic production is based on cultural biases. Specifically, they chronicle the history of computer graphics and point to its pioneering days in research and military settings. Because early applications of computer graphics, well into the 1980s, were exclusive to scientific, engineering, and military programs, many still see computer graphics as sterile, highly technical, and requiring an advanced understanding of mathematics and programming, concepts antithetical to aesthetic production. "The concepts of 'computer' and 'art' seem to be incongruent….To many artists, computer artwork is mediocre and has no artistic value" (p. 421). Interestingly, the increasingly widespread use of computer graphics in business and advertising in recent years has only exacerbated the problem, fusing computer graphics with concepts of commercialism and crass technical novelty in the minds of many artists and art educators. While their research has focused on these biases in educational settings, Mak and Degennaro argue that evidence exists that these same biases are prevalent throughout the broader fine arts community. Moreover, they find that many of those who make use of computers in an attempt to generate aesthetic works find themselves ostracized from the broader artistic community.

Chandler (1999) also points to the disparate aims and orientations that have separated technology and the arts for the last half-century. Over the course of time, the two cultures have been divided by disagreement on what counts for legitimate knowledge and which ways of knowing are considered acceptable. She writes that art has been built upon critical theory and craftsmanship, oriented on humanistic outcomes, while science utilizes as its support, law and the experimental method and focuses on utilitarian goals and objectives. That said, Chandler sees many similarities between artists and technologists. These include mental giftedness, the need for substantial time alone to work through problems and create, and the need for support and supplies, often from sponsors, agents, and promoters. She also notes that art, in the main, follows culture and, consequently, will need to incorporate technology as that technology increasingly defines who we are. She points to business' investment in visual communications as an attempt to engage a younger audience most comfortable with information presented in graphic, visual form and suggests that art will also have to move toward a middle ground. "The arts and sciences are like twins separated at birth, sharing chromosomal identities and shared values, sensing one another's affect, communicating nonverbally across dimensions, and seeking reconciliation" (Chandler, 1999, p. 165). Chandler sees this intermediate ground as especially fertile for creative applications and achievements. She notes, "The more successful projects in interdisciplinary study and research occur and go on to spawn anomalies and revolution when one field and its practitioners are willing and enthusiastic about exploring the theoretical, methodological, and practical procedures of another field" (p. 170). Chandler identifies computer graphics as such an interdisciplinary field.

Bertoline (1998) also believes that graphic communication increasingly characterizes our techno-centric culture. Furthermore, he argues that a unique set of tools, a specialized body of knowledge, and a distinctive research agenda define an emerging discipline that he initially termed "visual science" (p. 181) and later identified as "computer graphics" (Association for Computing Machinery Special Interest Group on Computer Graphics [SIGGRAPH], 2001). That said, Bertoline notes that the discipline of computer graphics frequently goes unnoticed in academia because it appears to rely more on hand skills than serious thought and reflection; and thought has historically been valued more than hand skills and craftsmanship in higher education. However, he argues against this view of computer graphics and notes that expertise in the domain requires an understanding of cognitive psychology, geometry, imaging technologies, and those philosophical foundations that have traditionally been taught in computer science and art. Bertoline further argues that now is an appropriate time to recognize computer graphics as a unique domain in that we are moving from a culture dominated by print to one dominated by visual imagery.

Edwards (2001) believes that technology is essentially devoid of inherent value. That is, he argues that technology "is poised to both facilitate and retard the development of creativity both in society and the individual" (p. 221). If computers are used principally as a means of gaining efficiency, creativity will be inhibited. If they are used to enhance opportunities for exploration, creativity can be advanced. Edwards argues that in the right circumstances and environment, the right technology can foster creativity.

Freedman (1997) also emphasizes the exploratory possibilities inherent in most computer graphics software. He notes that students are able to simultaneously have present onscreen their original image along with several other images, each a slight variation in color, contrast, hue, or saturation, allowing students to pick the one they find most pleasing. They can undo changes to images and approach their work in a trial and error fashion. While Freedman sees this as creativity-enabling, Spaid (1998) notes that these same capabilities dissuade students from thoughtful engagement in their work and, consequently, sees technology as creativity-inhibiting.

Eber (2000) argues that computer graphics give new meaning to art and art forms. Referring to the often quoted statement by Marshal McLuhan, "The medium is the message," (as cited in Eber, 2000, p. 920) Eber notes that computer hardware and software are so complex as to make especially great demands on the artist. Learning curves are steep and both hardware and software are in a constant state of evolution. Consequently, technology imposes itself on the digital artist and the media does, indeed, mediate, and possibly even supercede, the message. Digital artists must, "constantly shift between artistic expression and skill acquisition, *two different ways of thinking* [italics added]" (Eber, 2000, p. 920).

A number of authors (Dyson & Picno-Owiny, 2000; Sherman, 1990) see technology as one of many tools available for aesthetic production. Sherman argues that innovation is unlikely to occur until the user has mastered his/her technology but, thereafter, technology allows for greater freedom and opportunities for experimentation. He cautions, however, that a new aesthetic will be necessary to judge creative expression in this new medium. Still, he is certain that creative expression with technology is, indeed, aesthetic and he writes, "I have discovered that mathematics can be romantic, even mystical. I have learned that numbers & logic can create emotionally satisfying images" (p. 197). Dyson and Picho-Owiny agree that technology has a place in aesthetic production but note that this is a point frequently missed by instructors and students who focus on training for specific skills. Bringing together art and technology requires new understandings. That is, old ways of thinking about art and about technology must give way to new definitions and new conceptualizations (Goodale, 1998).

Role of Implicit Beliefs

Broadly speaking, theories of creativity can be categorized as either explicit or implicit. Explicit theories are based on the empirical research of psychologists, sociologists, or other professionals who share their findings. They extend from the hypothetical constructs of these individuals and what they presuppose to be creativity and creative expression (Runco & Bahleda, 1986; Runco, Nemiro, & Walberg, 1998; Sternberg, 1985). Implicit theories, on the other hand, are conceptually based and derived from individuals'—most often, lay persons'—belief systems (Runco, Nemiro, & Walberg). Because they are rooted in context, implicit beliefs are said to be more "ecologically valid" (Chan & Chan, 1999, p. 185) than purely objective psychometric examinations. They exist as individuals' mental constructs and, consequently, "need to be discovered rather than invented" (Sternberg, 1985, p. 608).

Implicit theories of creativity are important for several reasons. As mentioned previously, a wide variety of definitions and characteristics are frequently applied to the construct of creativity. Implicit theories give us insight into what the term means to those who use it to describe their work, their creative processes and products, and even themselves. Particularly important here, Chan and Chan (1999) note that implicit theories are likely to vary across cultural groups. Consequently, we might expect those engaged in computer graphics to hold uniquely characteristic implicit beliefs regarding creativity when compared to, for instance, those engaged in the traditional fine arts or computer science domains. Also, people regularly make judgments regarding the creative value of products based on their implicit beliefs (Chan & Chan, 1999; Runco & Bahleda, 1986; Sternberg, 1985). Their implicit beliefs help us understand these value judgments. Additionally, implicit theories of creativity may prove beneficial as we develop, evaluate, and possibly modify explicit theories of creativity (Chan & Chan, 1999; Sternberg, 1985). That is, implicit theories may prove beneficial as we consider the social validity—or, validity of context—of explicit theories (Runco & Bahleda; Sternberg).

Summary

Understandings regarding the nature of creativity vary substantially. Some see it as it an exceptionally rare phenomenon found only in a very few individuals or culture-changing products, while many others see it as a potential available to all human beings. While the former view often finds a correlation between high creativity and mental instability, the latter finds creativity to be indicative of positive mental and emotional health. While novelty is common to most definitions of creativity, other espoused attributes are regularly disputed. Many theoretical assumptions of creativity are extensions of their proponents' assumed determinant of the valued characteristic. Quite frequently, the determinant is said to be the creative person, creative product, creative process, creative environment, or a multivariate determinant composed of two or more of the others. Creativity is also commonly characterized as either scientific—logical, linear, convergent, left-brained, and analytical—or artistic—intuitive, nonlinear, divergent, right-brained, and synthetic.

Of particular importance for this study, creativity is often described as domain specific. That is, creative expression may require a substantial knowledge base and skill-set. That creativity is conceptualized as domain specific also reflects the specific symbol system, attendant operations, and cultural constraints of a particular creative domain; factors which set limitations on opportunities for creative expression. Consequently, what counts for creativity and creative expression varies from domain to domain. Computer graphics constitutes a distinctive domain by virtue of its unique knowledge base, particular set of tools and operations, highly visual symbol system, and distinguishable research agenda.

In order to gain an understanding of creativity that might be most beneficial to those teaching and studying computer graphics in higher education, this study endeavored to capture the implicit beliefs of students in computer graphics programs. Given that creativity is frequently considered domain specific, it is not surprising that implicit beliefs about creativity vary from domain to domain.

As Sternberg (1985) notes, "The data of interest in the discovery of people's implicit theories are people's communications, in whatever form, regarding their notions as to the nature of the psychological construct under investigation" (p. 608). The following chapter describes Q methodology as a means of studying the "flow of communicability" (Brown, 1993, p. 94) and, consequently, the implicit beliefs of college and university students about the field of computer graphics and the character of creativity.

CHAPTER THREE

METHOD

The purpose of this study was to investigate the patterns of beliefs students hold about the field of computer graphics and their understandings regarding the character of creativity in the field. To this end, Q methodology was employed as a means of accessing the implicit beliefs of college and university students, the research participants. This chapter begins with an overview of Q methodology's foundational assumptions and continues with an explanation of procedures employed in Q methodology studies. The chapter also presents details of the research participants, the research instrument, procedures employed in this study, and the framework for data analysis.

Q Methodology

The choice of Q methodology as the preferred approach to investigating students' beliefs about creativity in computer graphics comes nearer the end of a long process of reflection and serious consideration, taking into account the research problem, research questions, the assumed role of research participants, and the ontological and epistemological views held by this researcher. That these should influence the methodology a researcher chooses to employ is supported by much of the foundational writings on qualitative research, such as that by Crotty (1998), Denzin and Lincoln (1994a, 1994b), Erlandson, Harris, Skipper, and Allen (1993), and Guba and Lincoln (1994).

The philosophical foundations associated with Q methodology are most closely aligned with what is commonly identified as interpretivism (Goldman, 1999). Q methodology seeks to understand constructed meanings in context as opposed to discovering isolated and objectified realities. Observer and observed are not separated, but engaged in the process of interpretation. By way of further explanation, it may be helpful to note that Q methodology is frequently compared to quantum mechanics by its proponents (e.g., Brown, 1999); the analogy being that just as quantum theory holds that particular attributes of individual particles of matter cannot be understood in isolation and without regard to other attributes, neither can human experience be understood in terms of isolated variables apart from their broader context. Both need to be studied as systems. This study, then, was designed to understand students' constructs of creativity as characteristic of the field of computer graphics.

It is interesting to note that Goldman, who writes in great detail about the philosophical common ground shared by Q methodology and interpretivism, assumes that the former's statistical methods constitute a "sharp division" (p. 595) between the two. I would suggest that this is not the division Goldman believes it to be but, instead, adds weight to claims that Q methodology is indeed aligned with the historical intentions of interpretivism. Schwandt (1994) describes a historical tension within interpretivist goals to "develop an *objective* interpretive science of *subjective* human experience [italics added]" (p. 119). So, the statistical methods of Q methodology may not be the point of departure from interpretivism, but the resolution of this foundational tension.

Q methodology employs statistical manipulation of collected data through factor analysis and correlation. In this regard, it might be considered procedurally quantitative.

However, the principal focus for Q methodology is the lived experiences and subjective understandings of research participants, an interest most often associated with qualitative research. Consequently, Q methodology can be seen as a bridge between the research practices and broadly conceived philosophies traditionally employed by the two cultures of positivism, on the one hand, and post-positivism, or anti-positivism, on the other, combining the strengths of each (Brown, 1996; Dennis & Goldberg, 1996; Sexton, Snyder, Wadsworth, Jardine, & Ernest, 1998). In this regard, it becomes an appropriate method for this particular study in that it not only allows for quantitative manipulation of participants' implicit understandings of the broadly defined construct of creativity, but on another level mirrors the research interest, the intersecting cultures of technology and the aesthetic. Not unlike the creative expression manifest through technical media by research participants in this study, Q methodology supports an interest in subjective experiences with a mathematical substructure (Brown 1996; Stephen, 1985).

Q methodology stands apart from the mainstream of factor analysis and correlation methods in that it factors persons instead of tests (Avery, 1990; Brown, 1993; Carr, 1992; Sexton et al., 1998; Stephenson, 1935). That is, rather than beginning with a predefined characteristic or attribute and measuring it in a sample of subjects, Q methodology allows research participants to define the characteristic or attribute and then factors participants—or more accurately, their network of beliefs regarding the issue being investigated—into correlated groups based on their responses (Rogers, 1995; Schlinger, 1969; Stephen, 1985). So, Q methodology is often understood to be an inversion of R methodology (Avery; Rogers). Writing regarding his study of creativity, Johnson-Laird (1987) notes, "a priori definitions do not advance science, but impede it.

The advance of science, however, enables us to frame superior a posteriori definitions" (p. 202). This study extends from the assumption that our understanding of creativity in the emerging discipline of computer graphics will benefit not from sampling characteristics defined in advance of the research but will, instead, be most instructive when we are able to consider the construct through the lenses provided by participants later in the research process.

Concourse Development

An initial step in any Q-methodological study is to consider the concourse, or dialogic space, associated with the phenomena of interest. Brown (1993) defines concourse as, "the flow of communicability surrounding any topic" (p. 94). He adds, "Concourse is the very stuff of life, from the playful banter of lovers or chums to the heady discussions of philosophers and scientists to private thoughts found in dreams and diaries" (p. 95). These subjective, or person-centered, dialogic elements are self-referent yet their communicability makes them available for observation, study, and factor analysis (McKeown & Thomas, 1988). They are not facts or objective truths—since Q methodology like similar interpretivist philosophies rejects the idea of objective truths—but accessible aspects of socio-cultural constructs (Goldman, 1999).

Q methodology is best suited to the study of subjective understandings in those areas bound by some degree of limited diversity (Rogers, 1995). That is, the concourse should reflect an ordered dialog about which participants could be expected to argue or otherwise differ in opinion. In this study, creativity is presented as a social construct about which opinions vary but can be generally placed into a finite set of categories:

determinants of person, process, product, or environment and types as scientific, artistic, or some intersection thereof. The concourse for this study, then, is the set of collected statements that defines the area of dialogic space regarding creativity's determinants and types.

There are a variety of ways to build a concourse such that useful stimuli—that is, Q-sort items—can be subsequently generated. These include interviewing members of the target population and selecting key statements from those interviews; collecting items from sources such as newspaper clippings, documents, reports, and other written narratives; gleaning pertinent statements from television or radio talk shows; or asking experts to provide items (McKeown & Thomas, 1988; Stephen, 1985). The wealth of scholarly information available that details the aforementioned determinants of creativity as well as those that characterize the two cultures of scientific and artistic creativity were selected as a primary source for concourse representation and, subsequently, Q-sort item generation in this particular study. Additionally, a small number of statements were collected during open forum discussions at the 2002 Annual Conference of the Association for Computing Machinery Special Interest Group on Computer Graphics (SIGGRAPH) and were included in the concourse. These open forum discussions were a part of the SIGGRAPH Educators' Program, focusing on the emerging discipline of computer graphics and associated implications for education and educators (SIGGRAPH, 2001, 2002).

Research Instrument

Frequently, the concourse is populated by far too many items to be put before research participants. So, a subset of items needs to be extracted from the larger population of collected statements. As Stephen (1985) notes, the goal for item generation or selection should be

> to develop a well rounded set of items which provides a fair representation of the larger, theoretical set of all possible items which relate to the dimension being studied. Although the item set may be unable to represent any particular dimension perfectly, it should be able to represent most of the dimension's important facets. (p. 195)

To facilitate adequate representation of the concourse, Q-sort items can be generated and organized based on principal categories identified during development of the concourse. This process can be inductive, meaning that the researcher discovers themes and patterns during interviews or readings, or deductive, meaning that the themes and patterns are based on a priori theoretical propositions (McKeown & Thomas, 1988). For this study, a deductive approach was principally employed in that theories of creativity's determinants and types were already addressed in detail in numerous journals and texts. However, as concourse items were being considered for utility as Q-sort items, a few did not fit well into either the scientific type or artistic type categories. These have been sorted into a "hybrid" category. Of interest, most of these concourse items were collected during SIGGRAPH open forum discussions on the emerging discipline of computer graphics. A few others were taken from articles that argue in favor of a view that positions computer graphics as an interdisciplinary discipline situated between the arts and sciences, such as Bertoline (1998) and Vesna (2001), and from those few articles that describe creativity as a mix of types, such as Gowan (1978) and Hoppe (1990, 1994) who consider creativity to be a synergistic effort involving both the left and right hemispheres of the brain. So, Q-sort items were developed based on the theoretical framework of creativity as determined by (a) person, (b) process, (c) product, or (d) environment and the type as either (e) scientific, (f) artistic, or situated at the intersection of these two as (g) hybrid. This 4 x 3 design is presented at Figure 1.

Main Effects	Levels
A. Determinants of Creativity B. Types of Creativity	(a) Person (b) Process (c) Product (d) Press (e) Scientific (f) Artistic (g) Hybrid
Q-Sample (N) = (Main Effects) (Replications) = ([A] [B]) (m) (A) (B) = (4) (3) = 12 combinations ae be ce de af bf cf df ag bg cg dg Replications (m) = 4 N = (12) (4) = 48 statements	

Figure 1: Factorial Design of Creativity Determinants and Types

It must be understood, however, that this framework serves as a guide, as is the case for similar conceptual frames employed in other qualitative studies. It cannot be understood to be a precise and objective structure. As Stephenson (1953) writes, "it is a mistake to regard a sample as a standardized set or *test* of statements, any more than one can hope to regard a particular set of children as a standardized sample for R-technique purposes" (p. 77). Additionally, as Brown (1993) points out, few of our Q-sort items ever belong exclusively to one category or another and it would not be unheard of for participants to interpret statements in a manner different from that which was imagined by the researcher. More to the point, "meanings are not to be found solely in the categorical cogitations of the observer, but as well (and even more importantly) in the reflections of the individual as he or she sorts the statements in the context of a singular situation" (Brown, 1993, p. 101).

Still, the framework serves to facilitate selection of Q-sort items and generally improves the quality of the selection. As Brown (1980) points out, the process of selecting statements for identification with a particular cell in the framework compels the researcher to consider statements for their relative likeness, or "homogeneity" (p. 189), to other items associated with that cell. Conversely, the reductive process of ensuring adequate representation within a particular cell compels the researcher to consider the difference between statements of that cell, or "heterogeneity" (p. 189). Brown argues that this helps the researcher extract a comprehensive set of Q-sort items. He writes, "selecting the most unalike statements from those which are alike in kind serves to minimize the constraining effects of the design and tends to produce a sample of stimuli more nearly approximating the complexity of the phenomenon under investigation" (p. 189). This process of first fitting concourse statements to categories and then reducing their number through a series of comparisons that yield within-category diversity was employed in this study. Statements were grouped based on their fit to one of the twelve aforementioned categories, duplicates within categories were removed, and then each category's statements were considered for their representation of diversity within that particular category.

Brown (1980) notes that Q-sort items are to be formatted in the language of the research participants. They are not to be constructed as facts, but opinions. Ambiguity is certainly appropriate as the objective is not to limit the participant to the researcher's a priori assumptions regarding the Q-sort items but, instead, to allow participants to project onto the Q-sort their own constructed meanings. As Brown argues,

> We are uninterested in the logical properties of the Q sample, but in learning how the subject, not the observer, understands and reacts to items....In Q methodology, the meaning and significance of items is determined by the subject, so that the observer acquires knowledge of their meaning a posteriori, i.e., after the subject has sorted them. (p. 191)

Two hundred fifty-six statements were initially generated in response to the review of literature and comments collected during sessions of the 2002 SIGGRAPH Conference. No limits were established beforehand regarding the number of concourse items to be generated, and viewpoints corresponding to all of the differentiated categories were purposely sought out to ensure adequate representation of the possible dialogic space. Also, in the process of generating Q-sort items from the broader concourse of statements, there was no attempt to reflect proportionality of concourse statements regarding a particular determinant or type in the subsequent Q-sort item set. That is, a particular determinant or type, because of its popularity in scholarly literature, may have been represented by a greater number of statements in the concourse than some other determinant or type. This disproportional representation is not present in the final set of

Q-sort items, for which the aim is to represent possible constructs and not their frequency of appearance in the concourse. On the contrary, in the process of generating Q-sort items for consideration by research participants, each intersection of determinant and type was represented by the same number of statements—four statements for each of the 12 quadrants in the factorial design presented at Figure 1.

Opinions vary concerning the optimal number of Q-sort items, referred to as *n* in Q methodology studies, that should be made available to research participants for sorting. Schlinger (1969) indicates that there need to be enough to ensure statistical reliability and stability. She recommends between 55 and 75 items. Rogers (1995) notes, however, that even with very few Q-sort items, the number of possible combinations quickly reaches the thousands and, consequently, quite distinctively arranged sets. He recommends a range of 10 to 100 items. So, the set of Q-sort items needs to be large enough to adequately describe variability within the concourse but not so large as to overwhelm participants as they mentally manage and arrange them. From the original set of 256 concourse statements, four statements were generated for each of the 12 creativity categories. These 48 Q-sort statement items are available at Appendix A.

Participants react to and arrange Q-sort items representative of the concourse. Each participant's arrangement—as the manifestation of his or her understanding—along with the arrangements of other research participants are then subject to a factor analysis. Consequently, the phenomena under investigation can be understood in its constructed context, related to the broader set of interrelated and interactional constituents that define the phenomena as opposed to aggregate elements in isolation. Conceptual constructs, such as creativity, can be investigated for what they mean to individuals who employ these constructs in everyday living.

Ranking of Q-sort items need not take the form of a perfectly linear distribution of 1 through n, but prove more than suitable for statistical analysis when arranged by the research participant in a quasi-normal distribution such as that shown in Figure 2. This format allows participants to place items that are neither like nor unlike their beliefs or conceptual frameworks near the middle of the distribution where they lose their statistical, as well as descriptive, significance, while items that are more characteristic of the participants' beliefs or understandings fall closer to the tails of their distributions (Rogers, 1995; Sexton et al., 1998; Stephen, 1985).

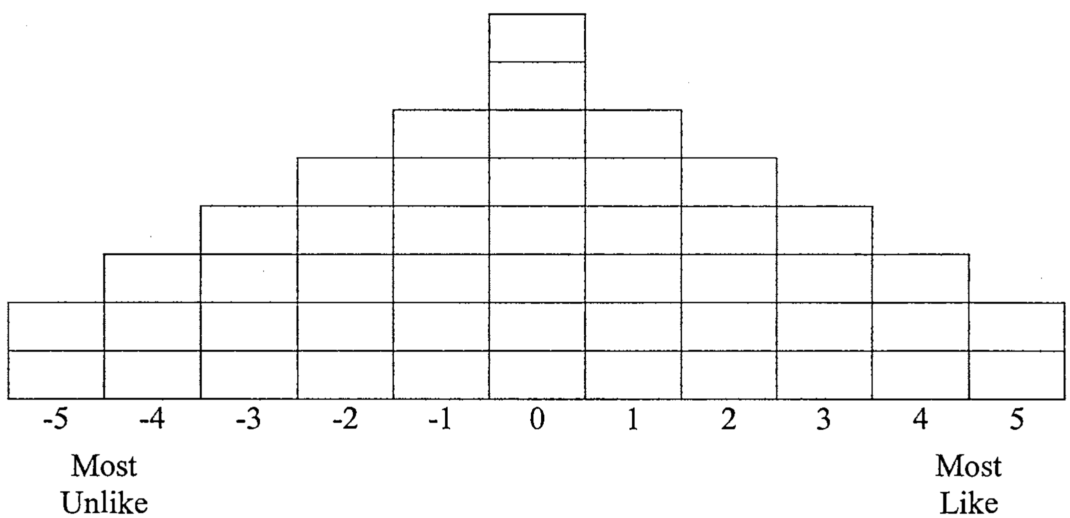

Figure 2: Q-Sort Distribution Template

Q-sort statements are typically provided to participants on small slips of paper that can be fitted to boxes along the distribution. Participants are asked to sort items into two or three piles. One pile is to be comprised of those items that most closely reflect their beliefs, character, or preferences, or in some other way might be conceptualized as positive in nature. A second stack is comprised of items most unlike them or their beliefs or might be conceptualized as negative. A third stack can be used for items that are perceived to be neutral in nature. Then, working from the stack of positively rated items, participants select those few that are most positive or most like their beliefs and place them in the boxes at the far right of the template. Participants can complete the distribution either one column at a time, moving back and forth to fill spaces at the opposite ends of the distribution (Schlinger, 1969) or they may arrange all cards from one stack and then all cards from the other (Rogers, 1995). In all cases, participants are instructed to reorganize cards as they think appropriate until the distribution best represents their thoughts, feelings, or beliefs about the construct under investigation.

For this study, most Q-sort sessions were arranged to engage one student at a time. A "Researcher's Script" for these sessions is presented at Appendix B. When students' limited availability required Q-sorting by more than one student at a time, no more than five students were engaged in the process and an alternate researcher's script for multiple participants, at Appendix C, was used. Of interest, Sexton et al. (1998) and Stephen (1985) report that the process of sorting items is enjoyable for most participants: novel and even game-like and, therefore, encourages engagement.

It is important to note that the number of Q-sort items equals the number of spaces available in the distribution. That is, when the participant has finished sorting, all cards are used and all spaces are filled. Consequently, every item has some degree of influence on others because items must be prioritized in relation to others (Stephen, 1985). Unlike some other measures, such as Likert scales, participants cannot strongly agree, or strongly identify, with every stimulus put before them.

As an aid to understanding participants' beliefs about their Q-sorts and items within the sorts, each sort should be followed by a brief interview (Brown, 1980, 1993). The interview should focus on those aspects of the participant's Q-sort that seem to hold the most meaning for the participant; that is, those items at the extreme ends of their sort. Still, items at the center of the sort can be addressed as well as they seem to lack significance for participants. Variability of participants' Q-sorts precludes a heavily structured and fixed approach to interviewing and so a full set of interview questions cannot be prepared beforehand. Instead, a few general questions can be crafted in advance of the session and posed early in the interview. Then, a brief dialog between researcher and participant can follow as a means of clarifying points or perceptions as necessary. Initial interview questions are provided as a part of the researcher's scripts at Appendixes B and C.

Data Analysis

Relationships among participants' Q-sorts are factored into a correlation matrix representing correlations between participants. That is, as mentioned previously, Q methodology is often considered the inverse of R methodology in that it factors persons instead of tests (Avery, 1990; Brown, 1993; Carr, 1992; Sexton et al., 1998; Stephenson, 1935). Typically, an R methodology correlation matrix would pair variables, in columns as factored elements, with persons in rows. Conversely, a Q methodology correlation matrix pairs persons, in columns, with variables in rows (Carr, 1992).

Correlation reveals similarly arranged Q-sorts and, therefore, common constructs regarding the issue or phenomenon under investigation. These constructs can stand alone or be related to participants' demographic data to associate findings with attributes or characteristics (Sexton et al., 1998).

It is essential that we understand that each participant's arrangement of the Q-sort items is what we are interested in, and not the value of any single specific statement. This aspect of Q methodology is what makes it an especially valuable approach for studies of constructs in context and the broader complexity of human beliefs and behaviors. Rogers (1995) writes,

> The other beauty to ranking as an alternative methodology is, of course, that it breaks one away from thinking of individual datum (say the rank given by a participant to element B of a five-element set) as a *measurement*. It is not. Statistically, each set of rankings is properly only worked upon as a whole; for example, correlated as a variable, with another parallel set of rankings as the other variable. (p. 180)

As Goldman (1999) notes, the factored and correlated arrangements "create structures of significations, and place them into an intelligible framework" (p. 595). This is the objective for a Q methodology study.

As an aid to managing the complexities of factor analysis and the generation of correlation coefficients for the Q-sorts of participants, the PQMethod 2.11 (Schmolck, 2002) software application was utilized. Significance of correlation is determined by multiplying the standard error, which is computed as $1/\sqrt{n}$ where n is the number of Q-sort items, times 2 to 2.5 (Brown, 1993; McKeown & Thomas, 1988). So, with 48

Q-sort items and, consequently, a standard error of 0.14, significance was indicated where correlation was equal to or greater than .28 to 0.37, in either direction.

Research Participants

The number of participants in a Q methodology study, referred to as the *p-sample*, while not unimportant, is secondary to the number of Q-sort items, *n*, put before each participant. This is because, as noted previously, Q methodology can be conceptualized as the inverse of R methodology (Avery, 1990; Rogers, 1995). That is, while a number of participants are applied to a test in R methodology, the test, in the form of Q-sort items, is applied to participants in Q methodology. Four to six similarly arranged Q-sorts are sufficient to indicate a noteworthy factor (Brown, 2002). Of course, there is no way to know in advance how many factors will surface. Likewise, there is no way to know which participants will sort for one factor or another. So, given that the concourse contains a finite degree of diversity, the number of participants need not be especially large but only sufficient to represent the possible combinations of principal factors (Rogers, 1995). Between 30 and 50 participants is frequently sited as adequate (Brown, 2002; McKeown & Thomas, 1988; Rogers, 1995; Schlinger, 1969) and very small p-sample sizes, even single case research, is not uncommon (McKeown & Thomas, 1988; Stephen, 1985). It may be noteworthy that Borg (1989) indicates that 30 participants are sufficient in other types of correlational research and Mertens (1998) indicates that 30 to 50 are appropriate for grounded theory research.

Because the aim of Q methodology studies is not to report population statistics or frequency of occurrence, the selected set of research participants need not reflect proportionally the variability of the population, but only ensure that sub-classes are indeed represented (Rogers, 1995; Schlinger, 1969). Consequently, participants in a Q-method study are not necessarily selected as they might be in a typical empirical and quantitative study. Participants are, instead, selected as they would be in a qualitative study, with an intent to provide ample diversity. Selection is purposive in that it seeks those who hold an opinion about the topic to be studied. This takes the form of multiple participants selected from varied settings or participants with varied backgrounds, interests, and knowledge (Rogers, 1995).

For this study, it was predetermined that 30 to 60 participants would perform the Q-sort. Plans called for participants to be stratified by their school type: 10 to 20 from a Carnegie-classified Private, For-Profit, Associate's College with a preparatory program clearly oriented to creative arts and design; 10 to 20 from a Carnegie-classified Public, Associate's College with a fast-paced, hands-on orientation; and 10 to 20 from a Carnegie-classified Public, Master's I University with a liberal arts orientation.

Each participant was asked to complete a demographic data sheet (Appendix D). This information may be useful as common structures emerge among participants' Q-sorts (Stephen, 1985) and, in this instance, as an aid to considering what other patterns are manifest in computer graphics students' beliefs about creativity. Each participant was asked to provide details of gender, age, educational experience, and academic concentration within their computer graphics discipline. Gender may be especially important as some (e.g., Freedman, 1997) note that men and women may approach computer use differently. The back side of the demographic data sheet included a representation of the Q-sort form. This was used to record participants' Q-sort arrangements.

When circumstances allowed the researcher to engage one participant at a time, each participant was asked to participate in an exit interview after completing his or her Q-sort. These participants were asked to elaborate on their Q-sort, with particular attention to those items placed at and near the extremes of the distribution, and asked if they had any additional thoughts on the field of computer graphics. When participants' availability precluded an interview, these participants were asked to comment on their Q-sort in the space provided at the bottom of the Demographic Questionnaire. Every participant was asked to complete a consent form (Appendix E) prior to completion of the demographic questionnaire, sorting of Q-sort items, and participating in the exit interview. Interviews were recorded electronically. Interviewees were kept anonymous and all electronic recordings destroyed after completion of the study.

Reliability, Validity, and Bias

Typically, reliability, the measure of consistency or stability across multiple measurements, is important because it increases confidence in the methodology employed and exists as a necessary support to validity. External validity refers to the generalizability of results to other individuals within the broader population and internal validity refers to elimination of extraneous variables that might threaten or diminish confidence in the measure, especially when causality is of interest (Borg, Gall, & Gall, 1993). Of course, Q-sorts vary from research initiative to research initiative and so any a priori assumption regarding a particular instrument is impossible, and concerns regarding causality yield to an interest in describing and understanding. As Stephen (1985) notes, "in many Q-sort applications questions of internal consistency are not at issue since the q-set is viewed as a means for a subject to express personal opinions rather than as a test of a predetermined trait" (p. 199). That said, research indicates that Q methodology studies are reliable in test-retest situations and demonstrate both internal and external validity (Fairweather, 1981).

For research initiatives conducted from within a positivistic framework, it is assumed that bias can be managed and its influence on research participants and outcomes eliminated (Borg et al., 1993; Guba & Lincoln, 1994). Q methodology and most qualitative approaches to research hold a contrary position; that bias is unavoidable and that research is best served by having the researcher make his or her biases known to readers, illuminating conclusions and interpretations (Erlandson et al., 1993). To that end, details of this researcher's own Q-sort has been provided as an appendix to the study (Appendix F). As Erlandson et al. (1993) note, "The dangers of bias and reactivity are great; the dangers of being insulated from relevant data are greater...Relevance cannot be sacrificed for the sake of rigor" (p. 15).

Summary

Q methodology was used to discover students' beliefs about the field of computer graphics. Students' Q-sorts were examined to determine their beliefs about creativity as it relates to this field. A dialogic concourse on the determinants of creativity and creative types is framed by Chapter Two, the review of literature, and includes statements collected at the 2002 SIGGRAPH Conference. These serve as the basis for Q-sort items.

Research participants were asked to sort these items into a form that takes the shape of a quasi-normal distribution. Demographic information was collected from participants. Participants' Q-sorts were examined for correlation and discovered factors were used to shed light on students' constructs.

CHAPTER IV

RESULTS

The research questions guiding this study were: a) What patterns of beliefs do students hold about the field of computer graphics? b) What is the character of creativity represented among students' beliefs about the field of computer graphics? As a means to discovering participants' implicit beliefs, Q methodology was utilized. Forty-eight statements were generated by the researcher using the theoretical frame presented in Chapter II: the locus of creativity concentrated in the person, process, product, or environment and a creative orientation as scientific, artistic, or some intersection of these two. Research participants sorted these statement items onto a form board resembling a quasi-normal distribution with statement frequencies, column numbers, and array positions as detailed in Chapter III and as represented in abbreviated form in Figure 3 below. Participants' arrangements of Q-sort items were subjected to correlation and factor analysis. The results of this data collection process and statistical analysis are detailed in this chapter, with significantly correlated factors described in terms of participants' arrangements of Q-sort items as well as participants' post-sort comments.

Statement Frequency	2	3	4	5	6	8	6	5	4	3	2
Column Number for Sorting	1	2	3	4	5	6	7	8	9	10	11
Array Position/Statistical Values	-5	-4	-3	-2	-1	0	1	2	3	4	5

Figure 3: Statement frequencies, column numbers for sorting, and array positions/ statistical values of the Q-sort form board

This chapter begins with a brief description of the computer graphics programs of each college/university visited, as well as details of research participants' demographics. A description of the statistical analysis of collected data follows. The interpretation of this data is presented first by factor as it points to the patterns of beliefs students hold about the computer graphics field, the first research question, and then by reference to consensus statements as they point to students' beliefs about the character of creativity in the field, the second research question.

Program Descriptions

Data were collected from participant volunteers at each of three higher education institutions with computer graphics programs. Each school was selected purposefully given its distinguishing characteristics in order to ensure a satisfactory degree of population diversity and to ensure that a wide range of orientations—albeit, within the particular discipline of interest—would be sampled.

The Carnegie-classified Public Associate's College, in which 11 participants were enrolled, has been designed to simulate the real-world experience of a computer graphics production facility. During their last 16-week semester at the College, students take nothing but computer graphics courses. That is, they are not concurrently enrolled in general education courses or academic electives during this semester but will have completed all of those and other degree requirements beforehand. This arrangement makes the program attractive to students who already have a degree in some other discipline or from some other institution and wish to enroll in this one semester of the program in order to obtain a focused learning experience in computer graphics. Students attend class between 8 a.m. and 5 p.m. six days a week, Monday through Saturday. However, the computer graphics facility is open to enrolled students 24 hours a day, seven days a week. Each day begins with a meeting of all class members and the instructors. Goals and objectives for the day are detailed at this meeting and students discuss their work, to include challenges and problem areas, with instructors and peers. For the remainder of the day, students and instructors work closely together, each student at his or her own designated computer graphics workstation. Class size is typically between 12 and 18 students, but may be as large as 20. During this researcher's visit to the College, the student to instructor ratio was 4:1. This program is a part of its college's Business Division. The College is accredited by the North Central Association of Colleges and Schools and the Association of Collegiate Business Schools and Programs. Additionally, it is a member of the American Association of Community Colleges and the Council of North Central Two-Year Colleges. Hereafter, this program will be referred to as the Public 2-Year Business program.

The Carnegie-classified Private Associate's College, in which 15 participants were enrolled, has as its mission to provide postsecondary career-oriented education for the creative arts. This institution is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools to award associate of applied art, associate of applied science, and bachelor of fine arts degrees. At present, the institution's computer graphics programs culminate in the award of an associate of applied art degree or an associate of applied science degree only, although development of a bachelor of fine arts program is well under way. The existing computer graphics programs are designed to be completed in 21 months. Unlike the computer graphics program of the

Public 2-Year Business program detailed above, computer graphics courses in this program are fairly well distributed across the whole of the students' educational experience; these courses being taken concurrently with courses in the humanities, social sciences, communications, etc. Students take computer graphics courses that focus on technical skills and associated theory. However, students are also required to take several courses in drawing, color theory, design, typography, and mathematics. They are expected to keep a sketchbook and develop good life drawing skills. Most of the faculty members who teach the computer graphics courses at this institution are or have been working professionals. Henceforth, this program will be identified as the Private 2-Year Arts program.

Twenty participants were enrolled in a bachelor of fine arts (BFA) program at a Carnegie-classified Public Master's I University with a liberal arts orientation. Computer graphics courses in this program are offered out of the Department of Design, situated in a college the main emphasis of which is creative activities such as art, music, and theater. Coursework in the program seeks to balance hands-on experiences with theoretical information considered essential for long-term success in the field. Students earn a BFA degree, completing 64 credit hours in their academic major and another 60 hours in general education requirements. In addition to computer graphics courses, students study drawing, color theory, art history, illustration, and other courses in art and design fundamentals. The University is accredited by the North Central Association of Colleges and Schools. This program will hereafter be referred to as the Public 4-Year Comprehensive program.

Participant Demographics

Table 1 summarizes demographic information for the 46 students who participated in the study. All participants were currently enrolled in upper-division courses in their particular programs.

TABLE 1

DEMOGRAPHIC DESCRIPTION OF RESEARCH PARTICIPANTS

Gender	Male	Female
Public 2-Year Business	9	2
Private 2-Year Arts	11	4
Public 4-Year Comprehensive	11	9
Study	31	15

Age	17-20	21-25	26-30	31-35	36-40	Over 40
Public 2-Year Business	2	6	3	0	0	0
Private 2-Year Arts	3	7	5	0	0	0
Public 4-Year Comprehensive	0	14	3	2	0	1
Study	5	27	11	2	0	1

Current Degree Programs	Associate of Applied Art	Associate of Applied Science	Bachelor of Fine Art
Public 2-Year Business	0	11	0
Private 2-Year Arts	8	7	0
Public 4-Year Comprehensive	0	0	20
Study	8	18	20

Education Previously Completed	High School	Associate's Degree	Bachelor's Degree	Graduate Degree
Public 2-Year Business	8	0	3	0
Private 2-Year Arts	10	3	1	1
Public 4-Year Comprehensive	11	9	0	0
Study	29	12	4	1

Data Analysis

Under the single condition of instruction, each participant was asked to sort the statements (Appendix A), along a scale of most unlike to most like, based on what he or she believed about the field of computer graphics. Collected data was first examined using PCQ for Windows, Academic Edition 1.4 (Stricklin & Almeida, 2000) in order to view the relationships between sorts in an unrotated state using centroid factor analysis. This process yielded three factors, the first defined by 35 of the 46 sorts, the second by 1 sort, and the third by 3 sorts. Seven sorts were confounded; that is, achieved significance on more than one factor. Statistical significance was calculated as .37 by multiplying the standard error, or $1/\sqrt{n}$ where n is the number of Q-sort items, by 2.5 (Brown, 1993; McKeown & Thomas, 1988). All 46 sorts loaded at or above this level of statistical significance on at least one of the three factors. The especially strong loading on Factor 1 of the unrotated data may indicate a common viewpoint for the majority of the sorters (Brown, 1996; Mrtek, 1996).

The process was then repeated using the PQMethod 2.11 (Schmolck, 2002) software application. Q-sorts were intercorrelated and the 46 by 46 correlation matrix was factor analyzed using principal component analysis. A varimax rotation was preformed and a three-factor solution was retained for further study. Other solutions were considered but each failed to offer the fidelity and/or clarity of definition of the three-factor solution. Specifically, a two-factor solution masked the subgroup discovered when a three-factor solution was considered. That is, the two-factor solution resulted in unnecessarily gross generalizations about the participants. When four or more factors were computed, factors beyond the third were represented by three or fewer Q-sorts, considered unstable by many (Brown, 1980, 2002). Additionally, increasing the number of factors resulted in an increasing number of insignificant or confounded sorts. For instance, 8 sorts fail to load at a significant level on only one factor in a three-factor solution. That number rises to 13 when a four-factor solution is computed.

The factor matrix for the three-factor solution is presented at Table 2 and in graphical form at Appendix G. Participants are identified as P01 through P46, each with abbreviated details of their gender (M for male and F for female), their computer graphics program (PUB2 for the Public 2-Year Business program, PRV2 for the Private 2-Year Arts program, and PUB4 for the Public 4-Year Comprehensive program), age category, and highest completed level of education (HS for high school, AD for associate's degree, BD for bachelor's degree, and GD for graduate degree). Defining sorts for each factor are identified with an X. Defining sorts are calculated by PQMethod 2.11 according to the rule: "flag *a* if (1) $a^2 > h^2/2$ (factor 'explains' more than half of the common variance) and (2) a > 1.96 / SQRT(nitems) (loading 'significant at p>.05')" (Schmolck, 2002, Algorithms and Formulas section, ¶ 5). This approach takes into account not only the Q-sort's statistical significance but also its communality, which is the proportion of a sort's variance accounted for by the factors. That is, to be flagged as a defining sort for a specific factor, the load must reach or exceed statistical significance and the square of the load must exceed the sum of the squared loads for that sort divided by two.

The three-factor solution accounted for 53 percent of the variance; Factor 1 for 20%, Factor 2 for 22%, and Factor 3 for 11%. Thirty-eight of the 46 Q-sorts were flagged as defining one of the three factors (Table 2). Of the 38 flagged sorts, 14 were on Factor 1, 19 on Factor 2, and 5 on Factor 3. Eight of the 46 Q-sorts were confounded.

TABLE 2

FACTOR MATRIX WITH AN X INDICATING A DEFINING FACTOR LOADING

Q-sort	Factor 1	Factor 2	Factor 3
P01-M-PUB2-21/25-HS	.2028	.3295	.3726
P02-M-PUB2-26/30-BD	.2820	.5522X	.1338
P03-M-PUB2-21/25-HS	.3877	.5229X	-.0873
P04-M-PUB2-26/30-HS	.3320	.5571X	.2788
P05-M-PUB2-21/25-HS	.4066	.6337X	.2280
P06-M-PUB2-17/20-HS	.1539	.8050X	.0437
P07-F-PUB2-21/25-BD	.5712X	.1087	.3671
P08-M-PUB2-26/30-BD	.3766	.5463X	.2785
P09-F-PUB2-17/20-HS	.1031	.7118X	.1020
P10-M-PUB2-21/25-HS	.0976	.5244	.5505X
P11-M-PUB2-21/25-HS	.3476	.6164X	.0540
P12-M-PRV2-17/20-HS	.2841	.4984	.5312
P13-M-PRV2-17/20-HS	.2797	.5260X	.3944
P14-M-PRV2-21/25-HS	.4799X	.1409	.3478
P15-M-PRV2-21/25-HS	.4012	.6943X	.1307
P16-M-PRV2-21/25-HS	.0420	.3339	.6615X
P17-M-PRV2-26/30-BD	.4316	.4367	.5672
P18-F-PRV2-26/30-HS	.2602	.6665X	.1329
P19-F-PRV2-26/30-HS	.6260X	.3913	.1870
P20-M-PRV2-26/30-HS	.4067	.4803	.3118
P21-M-PRV2-17/20-AD	.0693	.2522	-.5508X
P22-M-PRV2-21/25-AD	.6380X	.3858	.0751
P23-F-PRV2-21/25-HS	.2946	.6097X	.3180
P24-M-PRV2-26/30-AD	.0486	.6035X	.3409

TABLE 2 (continued)

FACTOR MATRIX WITH AN X INDICATING A DEFINING FACTOR LOADING

Q-sort	Factor 1	Factor 2	Factor 3
P25-M-PRV2-21/25-HS	.2310	.6643X	.0225
P26-F-PRV2-21/25-GD	.4251	.4533	.4616
P27-M-PUB4-21/25-AD	.4498	.4560	.3332
P28-F-PUB4-21/25-HS	.4002	.3137	.3818
P29-F-PUB4-26/30-HS	.2681	.5018X	.1969
P30-F-PUB4-21/25-AD	.6451X	.2574	.3864
P31-M-PUB4-26/30-AD	.5344X	.1937	-.3371
P32-F-PUB4-21/25-AD	.6324X	.3921	.0425
P33-F-PUB4-21/25-HS	.4376	.5063X	.2524
P34-M-PUB4-21/25-HS	-.0061	.5901X	-.2678
P35-M-PUB4-31/35-AD	.1829	.0152	.6469X
P36-M-PUB4-40+-HS	.3292	.4797X	.1751
P37-M-PUB4-31/35-AD	.2910	.5432X	.1956
P38-M-PUB4-21/25-HS	.5388X	.1560	.3804
P39-M-PUB4-21/25-AD	.7822X	.1594	-.0633
P40-F-PUB4-21/25-HS	.5130	.2308	.5645X
P41-F-PUB4-21/25-HS	.7244X	.2977	.2117
P42-F-PUB4-21/25-AD	.7376X	.1307	.1152
P43-M-PUB4-21/25-AD	.7643X	.1841	.1856
P44-F-PUB4-21/25-HS	.5032	.4108	.3121
P45-M-PUB4-26/30-HS	.6278X	.4737	.1106
P46-M-PUB4-21/25-HS	.5235X	.3892	.3155
total number of defining sorts	14	19	5
% of variance explained	20	22	11

Note: X indicates loading is significant at p. > .05 and the factor explains more than half the common variance.

Data Interpretations

Descriptive profiles for each of the three factors extracted from this analysis were generated using those Q-sort items with the highest and lowest z-scores, those Q-sort items that distinguished one factor from the other two, and the comments provided by participants when asked to reflect on their arrangements of Q-sort items. Each of the three factors, then, can be understood to represent a shared understanding of the computer graphics field and the nature of creativity in that field. These three understandings, or patterns of beliefs, are described below and identified as: Factor 1, Artistic Creatives; Factor 2, Technological Creatives; and Factor 3, Romantic Creatives.

Research Question #1: What patterns of beliefs do students hold about the field of computer graphics?

Factor 1: Artistic Creatives

The Q-sorts for 14 of the 46 research participants define Factor 1. A subset of the demographic data collected from the 14 is presented in Table 3. The Q-sorts for 1 of the 11 participants from the Public 2-Year Business program, 3 of the 15 participants from the Private 2-Year Arts program, and 10 of the 20 participants from the Public 4-Year Comprehensive program define Factor 1. Factor 1 accounts for 20% of the variance in the sample.

TABLE 3

DEMOGRAPHICS - ARTISTIC CREATIVES

Gender	Male	Female				
	8	6				

Age Range	17-20	21-25	26-30	31-35	36-40	Over 40
	0	11	3	0	0	0

Current Degree Programs	Associate of Applied Art	Associate of Applied Science	Bachelor of Fine Art
Public 2-Year Business	n/a	1	n/a
Private 2-Year Arts	2	1	n/a
Public 4-Year Comprehensive	n/a	n/a	10

Education Completed	High School	Associate's Degree	Bachelor's Degree	Graduate Degree
	6	7	1	0

The 14 participants who loaded on Factor 1 can be characterized as Artistic Creatives. They indicate that computer graphics have as their goal to communicate ideas and opinions and to elicit an affective reaction. They recognize as like their beliefs the idea that computer graphics can be understood in terms of truth and beauty. Artistic Creatives value motivation, imagination, and intelligence as necessary characteristics for those who would succeed in the field. They seem to conceptualize computers as tools available to creative persons and indicate that the truly creative work takes place before you seat yourself at the computer. Artistic Creatives indicate, however, that the field is somewhat closed in that success is not the result of time and education. Specifically, they value a keen eye, an aesthetic sense, and an intuitive feel above education and experience. These inferences are derived from the ordered array of Q-sort items that characterize these participants and distinguish this factor from other extracted factors. This ordered array and the set of distinguishing statements for this factor are presented at

Appendixes H and I respectively. A subset of that data—specifically, the five most like and five most unlike statements—is listed in Table 4. (Data listed includes the column number, array position, z-score, statement number, and Q-sort statement.)

TABLE 4

FACTOR 1, ARTISTIC CREATIVES: HIGHEST (MOST LIKE) AND LOWEST (MOST UNLIKE) RANKED STATEMENTS

Array Position	Z-Score	Statement Number and Statement
Five Most Like Statements		
11 (+5)	2.191	18 The most important factor for success is a person's motivation.
11 (+5)	1.812	12** The CG field is all about communicating ideas and opinions.
10 (+4)	1.787	34 The truly creative work in CG takes place before you ever sit down at the computer.
10 (+4)	1.615	3* Success requires the ability to manipulate objects in your head; mentally see them from different angles and directions.
10 (+4)	1.598	14 Success requires a vivid imagination.
Five Most Unlike Statements		
2 (-4)	-1.203	32** Creative expression depends on mastery of the software.
2 (-4)	-1.208	43** Success is determined by which tools (software applications and hardware) you have available for your use.
2 (-4)	-1.454	22 The need to understand math makes this an impossible career field for many.
1 (-5)	-1.631	27** Anyone can succeed in this field given enough time and training.
1 (-5)	-2.088	40 Technology and creativity are like oil and water; they don't mix.

Note: Based on normalized (z) scores. A single asterisk (*) indicates a distinguishing statement for this factor at significance of $p < .05$; double asterisks (**) indicate a distinguishing statement for this factor at significance of $p < .01$.

Artistic Creatives identify as most like their beliefs statements that frame workers in the field of computer graphics as requiring high motivation and substantial intelligence. They indicate that success mandates an ability to manipulate objects in one's head and that a vivid imagination is highly valued. (Array positions of –5 to + 5 and z-scores appear in parentheses following each Q-sort statement.)

- #18 The most important factor is a person's motivation. (+5, 2.191)
- #3 Success requires the ability to manipulate objects in your head; mentally see them from different angles and directions. (+4, 1.615)
- #14 Success requires a vivid imagination. (+4, 1.598)
- #21 The CG field requires substantial intelligence. (+3, 1.519)

While Artistic Creatives place great value on motivation, it is unlikely they would suggest that motivation might be sufficient to overcome deficiencies in other areas. On the contrary, Artistic Creatives suggest that those personal characteristics essential for success in the field are not learned, but innate. For instance, P32, a female working toward a BFA in the Public 4-Year Comprehensive program, describes the inherent abilities characteristic of successful computer graphics creatives this way:

> Some people just can't necessarily explain why they came to a solution but some people just have the right solution. It just happens in their mind because the switches go on and it's just like, "that's perfect, that's the answer to the problem;" because I think some people just have that talent naturally because of the way their brain works.

As P19, a female student in the Private 2-Year Arts program, adds, "I don't believe just anyone can succeed in this field. We are special people." So, the Artistic Creatives suggest that the field requires, or perhaps attracts, special individuals who have a natural talent and a brain that appears wired for this type of activity. That such characteristics are innate and not the result of motivated study also appears to be reflected in positioning of statements 48 and 27 for this factor. While the Artistic Creatives identify as like their beliefs the idea that success depends more on aesthetic abilities than education or experience, they also indicate as quite unlike their beliefs the statement that anyone can succeed in computer graphics given enough time and training.

- #48 Success depends more on a keen eye, an aesthetic sense, and an intuitive feel than a person's education or experiences. (+3, 0.929)
- #27 Anyone can succeed in this field given enough time and training. (-5, -1.631)

However, Artistic Creatives do not appear to indicate that this innate aptitude is the purview of traditional or fine artists only. As P19 notes, "I believe that it takes all types of artists to have a successful artistic world: programmers and non-programmers alike." It may be noteworthy that she does not indicate that those in the computer graphics field need to be multitalented but, instead, that the broader field itself requires varied types of creatives. So, while programmers might be considered creative by the Artistic Creatives, as per the placement of statement 30 for this factor, statements 16 and 4, regarding a balanced approach to work in the field by each individual, are less like their beliefs.

- #30 Those who spend their time scripting or programming to produce CG really can't be considered "creative." (-3, -0.879)
- #16 Success in the field mandates creative types who are both left-brained and right-brained, rational and impulsive, logical and emotional. (2, 0.905)

- #4 It's like turning a switch on and off. You go back and forth from logical and linear to imaginative and unconstrained. (1, 0.431)

Given that their post-sort comments and their arrangements of Q-sort items point to an understanding of the computer graphics field in which workers are innately endowed with requisite skills, it comes as no surprise that the Artistic Creatives indicate that they are somewhat separated from the technology they utilize. That is, for the Artistic Creatives, tools, such as computers, have little if any influence over the true germ of creativity, that being the aforementioned innate, personal characteristics. Artistic Creatives seem to understand instead that technology exists as a mere tool, externalized and lacking an intimate connection to the creator. That is not to suggest that technology cannot be used as a means of creative expression; only that it is not the focal point for understanding creativity, as reflected in placement of statements 32, 43, and 40. It is also noteworthy that Artistic Creatives indicate that the truly creative work takes place not at the computer, but before sitting down at the computer, Q-sort item 34.

- #34 The truly creative work in CG takes place before you ever sit down at the computer. (+4, 1.787)
- #32 Creative expression depends on mastery of the software. (-4, -1.203)
- #43 Success is determined by which tools (software applications and hardware) you have available for your use. (-4, -1.208)
- #40 Technology and creativity are like oil and water; they don't mix. (-5, -2.088)

Participants' comments also suggest an understanding of the computer as external to the creator. P42, another female working on a BFA in the Public 4-Year Comprehensive program, notes, "You don't have to be a computer whiz to be in CG. The computer is just a tool and in no way should aid in your design; it just helps you accomplish and finish a piece." P41, also a female working on a BFA in the Public 4-Year Comprehensive program, emphasizes the importance of imagination and cognition above that of available tools and mastery of hardware and software. She states,

> I believe that computer graphics is more of a tool than a design solution. Design solutions should begin with the individual's understanding and background in art and aesthetics. The solutions come from your head/imagination. The computer is simply a tool to construct your ideas.

P14, a male enrolled in the Private 2-Year Arts program, and P07, a female in the Public 2-Year Business program, bring an especially interesting view to this aspect of technology as external to the creator. P14 writes,

> With CG, something is lost because, truthfully, there are a lot of different art styles from person to person, but anyone given enough time can create exactly what you did on a computer because all the steps have been done for you. It's all clicks that can be copied, but you can't [copy] someone else's hand movements.

The point seems to be that creative activities can be accomplished with technology, but thereafter the creative activity can be deconstructed into discrete and readily identifiable steps—mouse movements and menu selections—that can be repeated in linear fashion by someone else to reproduce what was originally a creative activity, but is no more. P07 notes in her post-sort interview,

> I do think [CG] is a different kind of art than what we're use to, because it is more like photography in the way that it's married to technology. It's divorced from the hand but it still has an obvious relationship to what people are thinking and the

> culture. So, in some ways it does require a new way of looking at work, but that doesn't undermine the relevance of it. It's just that people have to get up over their romance with the hand—the hand drawn line and all of that stuff.

It may be important to note that P07 does not suggest that the creator is married to technology. That is, it is not the photographer but, instead, photography, that is married to technology.

With regard to computer graphics output, Artistic Creatives seem to favor a balanced view that values both aestheticism and utility. They identify as like their beliefs statements 12 and 10, and unlike their beliefs statement 19.

- #12 The CG field is all about communicating ideas and opinions. (+5, 1.812)
- #10 The goal of CG production is to elicit an "affective reaction." (+3, 1.330)
- #19 CG can't be understood in terms of "truth" and "beauty" like paintings might. (-3, -0.883)

P42, a female in the Public 4-Year Comprehensive program, writes, "Computer graphics is about communicating ideas and opinions. Unlike art, CG has a sense of purpose and direction—communication—not just for aesthetic appeal." P32, another female in the same program, noted during her post-sort interview,

> The reason we develop our concepts is all about what we want the target audience to take from each thing that we show them. We want them to get the message and so that's communicating an idea or an opinion.

Factor 2: Technological Creatives

The Q-sorts for 19 of the 46 research participants loaded significantly on Factor 2. A subset of the demographic data collected from these 19 participants is presented at Table 5. The Q-sorts for 8 of the 11 participants from the Public 2-Year Business program, 6 of the 15 participants from the Private 2-Year Arts program, and 5 of the 20 participants from the Public 4-Year Comprehensive program loaded on Factor 2. Factor 2 accounts for 22% of the variance.

TABLE 5

DEMOGRAPHICS - TECHNOLOGICAL CREATIVES

Gender	Male	Female				
	14	5				
Age Range	17-20	21-25	26-30	31-35	36-40	Over 40
	3	8	6	1	0	1

Current Degree Programs	Associate of Applied Art	Associate of Applied Science	Bachelor of Fine Art
Public 2-Year Business	n/a	8	n/a
Private 2-Year Arts	3	3	n/a
Public 4-Year Comprehensive	n/a	n/a	5

Education Completed	High School	Associate's Degree	Bachelor's Degree	Graduate Degree
	15	2	2	0

Like the Artistic Creatives, Technological Creatives recognize the importance of imagination, motivation, and intelligence for workers in the field of computer graphics. They add to this, however, logic, order, and reason. Also, they suggest that the field benefits not only from varied types of creators, but from multidimensional, multitalented workers. Technological Creatives appear to be more connected to technology and emphasize the importance of problem solving skills. They indicate that the process of creating computer graphics may be sensuous and personally engaging. Technological Creatives recognize the contributions of hardware and software developers to the field and to creative expression. They extend their notion of creative types to include those who program or script computer software. They include in their definition of creative computer graphics those generated mathematically by computers. These inferences about the Technological Creatives are derived from the ordered array of Q-sort items that characterize these participants and distinguish this factor from the other two extracted factors. This ordered array and the set of distinguishing statements for this factor are presented at Appendixes J and K respectively. A subset of that data—specifically, the five most like and five most unlike statements—is listed in Table 6.

Like the Artistic Creatives, the Technological Creatives see motivation, imagination, and intelligence as essential characteristics for those working in the field. However, Technological Creatives add to this list the need for logic, order, and a reasoned approach to computer graphics work. Also, Technological Creatives identify as quite like their beliefs the suggestion that, "the technology compels you to be a problem solver," a distinguishing statement for this factor.

- #1 The technology compels you to be a problem solver. (+5, 1.840)
- #18 The most important factor is a person's motivation. (+4, 1.705)
- #14 Success requires a vivid imagination. (+4, 1.209)
- #39 A logical, orderly, and reasoned approach to work in the field is essential. (+3, 1.069)
- #21 The CG field requires substantial intelligence. (+3, 1.005)

TABLE 6

FACTOR 2, TECHNOLOGICAL CREATIVES: HIGHEST (MOST LIKE) AND LOWEST (MOST UNLIKE) RANKED STATEMENTS

Array Position	Z-Score	Statement Number and Statement
Most Like Statements		
11 (+5)	1.840	1** The technology compels you to be a problem solver.
11 (+5)	1.786	16 Success in the field mandates creative types who are both left-brained and right-brained, rational and impulsive, logical and emotional.
10 (+4)	1.705	18 The most important factor for success is a person's motivation.
10 (+4)	1.209	14 Success requires a vivid imagination.
10 (+4)	1.176	42 There's a difference between mastering the software and using it creatively.
Most Unlike Statements		
2 (-4)	-1.263	44 Creating with a computer lacks intimacy; the technology inhibits personal engagement.
2 (-4)	-1.516	28** The technology reduces color, light, and form to numerical representations and, consequently, suppresses the sensuousness of creative expression.
2 (-4)	-1.548	5 Because they exist as transient images on a screen, most CG images lacks the reality of other art forms like paintings and sculptures.
1 (-5)	-1.730	30** Those who spend their time scripting or programming to produce CG really can't be considered "creative."
1 (-5)	-2.163	40 Technology and creativity are like oil and water; they don't mix.

Note: Based on normalized (z) scores. A single asterisk (*) indicates a distinguishing statement for this factor at significance of $p < .05$; double asterisks (**) indicate a distinguishing statement for this factor at significance of $p < .01$.

References to the importance of problem solving were also common in the post-sort comments of Technological Creatives. For instance, P04, a male in the Public 2-Year Business program, notes,

> If you can't problem solve you can't work your way through this stuff. It's just the way of being on the computer. That's the technical side; that's the switch that's extremely important, because if you don't have that, you don't have the creative. You can't do anything with the creative if you can't problem solve the technical side.

Whereas Artistic Creatives defined the field as comprised of varied creative types, each individual with a particular skill-set, Technological Creatives seem to anticipate, instead, that successful computer graphics creators will, as individuals, possess a broader range of abilities. That is, individuals, and not the broader field, are characterized as diversified. This is inferred from the factor's positioning of statements 16 and 33.

- #16 Success in the field mandates creative types who are both left-brained and right-brained, rational and impulsive, logical and emotional. (+5, 1.786)
- #33 Those who succeed in the field aren't truly artists, but they aren't really technicians either. (-3, -1.059)

This understanding of interdisciplinary and multidimensional creators is also suggested by participants' comments. For instance, P06, a male in the Public 2-Year Business program, said,

> You have to switch back and forth between the right-brain and left-brain…You have to be both technologically intelligent and creatively intelligent. If you're not,

> it's not really going to work for you. You have to solve problems and be creative at the same time.

P02, another male in the Public 2-Year Business program, adds,

> I think you really need to—have to—cover both ends of the spectrum. I mean, otherwise you're going to get stuck in one spot and you just won't be able to work your way out of a problem. You really do need both sides…It's like learning how to use a part of your brain you never had to tap into before; then trying to marry that with a part of you that's always been there. That's what it has been for me; the idea of the technology, realizing that it is an art and that it is a tool, but that it is unlike any tool you've ever used and the possibilities are limitless.

P03, another male in the Public 2-Year Business program, notes,

> It's like, you know, you've got to think one way to use a computer and you've got to think one way to draw something; they're not quite the same but they do incorporate well…It helps to have both the logical and emotional because the logical helps you work through the computer, it helps you put what you want to see on the machine and the emotional helps you to make it look good; helps you to give the impression and that ability to move people with what it is you put on the machine. Without both it becomes a very slow process because then, if you just can't understand the computer to put something on there, you've got a real problem in trying to get what you want people to feel to come out of the machine…It's not entirely logical. There's a lot of creativity involved. At the same time there's definitely a mixing of the two. Ultimately, it can yield much

greater, much more cost effective, much more efficient, much more capable, and in much smaller amounts of time, greater art.

This reference by P03 to efficiency as a goal for workers in the field of computer graphics is also reflected in a distinguishing statement for the Technological Creatives. Contrary to its positioning for Factors One and Three, Q-sort item 45 is characterized as somewhat like the Technological Creatives' beliefs.

- #45 Success is defined in terms of commercial acceptance and marketability. (+2, 0.747)

Technological Creatives also appear to be more connected to their technology than Artistic Creatives. The notion that the field is defined to a large degree by available hardware and software, Q-sort item 36, is quite like their beliefs. Also, statements 44 and 28, which suggest that technology situates itself between the creator and his or her creative expression, are positioned as quite unlike their beliefs. So, Technological Creatives seem to understand creating with the computer to be an interdependent, and possibly intimate and sensuous, experience.

- #36 This field is defined to a large degree by what software and hardware developers make possible. (+3, 0.960)
- #44 Creating with computer lacks intimacy; the technology inhibits personal engagement. (-4, -1.263)
- #28 The technology reduces color, light, and form to numerical representations and, consequently, suppresses the sensuousness of creative expression. (-4, -1.516)
- #40 Technology and creativity are like oil and water; they don't mix. (-5, -2.163)

The positioning of another distinguishing statement for this factor may also provide insight into how the three types of creatives presented here differ in terms of their relationship with the technology. Both the Artistic Creatives and the Romantic Creatives, to be discussed subsequently, identify statement 34, "The truly creative work in CG takes place before you ever sit down at the computer," as quite like their beliefs. For Artistic Creatives, this statement is placed in column 10 (+4) with a z-score of 1.787 and for the Romantic Creatives the statement is located in column 11 (+5) with a z-score of 2.217. Both of those types, then, seem to understand creative thought and reflection as antecedent to engaging the technology. In contrast, Technology Creatives situate this statement in column 6 (0) with a z-score of 0.263. It may be that for Technological Creatives, creative considerations occur in concert with technology engagement at their workstations.

The technical orientation of this group is also indicated by the positioning of Q-sort items 6 and 5 for the factor. They indicate that even computer-generated images, such as fractals, can be considered creative and even though computer graphics exist as transient images on a computer screen, they are no less real than paintings and sculptures.

- #6 CG generated mathematically (e.g., computer-generated fractals) really can't be considered "creative." (-3, -1.248)
- #5 Because they exist as transient images on a screen, most CG images lack the reality of other art forms like paintings and sculptures. (-4, -1.548)

Factor 3: Romantic Creatives

Factor 3 of a three-factor understanding of the Q-sort arrangements accounts for 11% of the variance. Five of 46 participants load on this factor. A subset of the demographic data collected from these five participants is presented at Table 7. The Q-sorts for 1 of the 11 participants from the Public 2-Year Business program, 2 of the 15 participants from the Private 2-Year Arts program, and 2 of the 20 participants from the Public 4-Year Comprehensive program loaded on Factor 2. P21, a 17 to 20 year old male working on an associate of applied science degree in the Private 2-Year Arts program, loads negatively.

TABLE 7

DEMOGRAPHICS - ROMANTIC CREATIVES

Gender	Male	Female
	4	1

Age Range	17-20	21-25	26-30	31-35	36-40	Over 40
	1	3	0	1	0	0

Current Degree Programs	Associate of Applied Art	Associate of Applied Science	Bachelor of Fine Art
Public 2-Year Business	n/a	1	n/a
Private 2-Year Arts	1	1	n/a
Public 4-Year Comprehensive	n/a	n/a	2

Education Completed	High School	Associate's Degree	Bachelor's Degree	Graduate Degree
	3	2	0	0

The arrangements of Q-sort items by the Romantic Creatives seem to point to a more open and inclusive membership of participants in the computer graphics field. That is, unlike the Artistic Creatives, Romantic Creatives do not seem to close the door on many would-be computer graphics professionals. Instead, they support the notion that you don't need to be especially intelligent. You don't need to know how to draw. As long as you are motivated and imaginative, those characteristics that are assumed to be typical of the general population, like the ability to manipulate objects in your head, will be sufficient provided some amount of time and education. Romantic Creatives certainly do not understand themselves as nerds but characterize themselves as "beautiful" people. Their placement of Q-sort items suggests that they believe success is not determined by marketability. Instead, they view incentives and commercial acceptance as possibly detrimental to creative work in the field. They value their work and the work of the field as much as one might value paintings by Picasso, Van Gogh, and Michael Angelo. These inferences about the Technological Creatives are derived from the ordered array of Q-sort items that characterize these participants and distinguish this factor from the other two extracted factors. This ordered array and the set of distinguishing statements for this factor are presented at Appendixes L and M respectively. A subset of that data—specifically, the five most like and five most unlike statements—is listed in Table 8.

TABLE 8

FACTOR 3, ROMANTIC CREATIVES: HIGHEST (MOST LIKE) AND LOWEST (MOST UNLIKE) RANKED STATEMENTS

Array Position	Z-Score	Statement Number and Statement
Most Like Statements		
11 (+5)	2.217	34 The truly creative work in CG takes place before you ever sit down at the computer.
11 (+5)	1.919	27** Anyone can succeed in this field given enough time and training.
10 (+4)	1.864	18 The most important factor for success is a person's motivation.
10 (+4)	1.662	9** Deadlines, salaries, and other "incentives" cripple creative expression.
10 (+4)	1.535	42 There's a difference between mastering the software and using it creatively.
Most Unlike Statements		
2 (-4)	-1.363	5 Because they exist as transient images on a screen, most CG images lacks the reality of other art forms like paintings and sculptures.
2 (-4)	-1.381	17** Although most tasks in CG can be solved in a variety of ways, there is ultimately a single "best" procedure for each challenge.
2 (-4)	-1.475	37** This field attracts nerds.
1 (-5)	-1.641	26** Images produced by computer will never be valued as much as paintings by Picasso, Van Gogh, or Michael Angelo.
1 (-5)	-1.971	40 Technology and creativity are like oil and water; they don't mix.

Note: Based on normalized (z) scores. A single asterisk (*) indicates a distinguishing statement for this factor at significance of $p < .05$; double asterisks (**) indicate a distinguishing statement for this factor at significance of $p < .01$.

Like the Artistic and Technological Creatives, the Romantic Creatives identify motivation and imagination as much needed characteristics for those who would succeed in the field. However, the Romantic Creatives are distinguished from the other two in that they identify as unlike their beliefs the notion that computer graphics requires substantial intelligence.

- #18 The most important factor is a person's motivation. (+4, 1.864)
- #16 Success in the field mandates creative types who are both left-brained and right-brained, rational and impulsive, logical and emotional. (+3, 1.392)
- #14 Success requires a vivid imagination. (+3, 1.171)
- #3 Success requires the ability to manipulate objects in your head; mentally see them from different angles and directions. (+3, 1.088)
- #21 The CG field requires substantial intelligence. (-3, -0.943)

Talking about the role intelligence plays in the career field, P10, a male in the Public 2-Year Business program, notes, "It kind of goes with the math, but even if you don't have a lot of math but you're really creative and you're good artistically, and if you can just get the basic motions down, pretty much anybody can go with this job."

P10's comment that, "pretty much anybody can go with this job," points to what seems to be another defining characteristic of the Romantic Creatives. They seem to understand the computer graphics field to be open to almost anyone and they appear to generalize those capabilities that are essential for success in the field to the broader population. They assume that everyone has the potential to succeed. Specifically, Romantic Creatives identify as quite like their beliefs the statement that, "Anyone can succeed in this field given enough time and training." They also note that drawing skills are not a prerequisite to success.

- #27 Anyone can succeed in this field given enough time and training. (+5, 1.919)
- #46 You can still do quite well in computer graphics even if you don't know how to draw. (+3, 1.118)

Reflecting on his positioning of the aforementioned statement that, "Success requires the ability to manipulate objects in your head," P10 notes,

> I put that in the higher column because if you can't see it in your head then it's not going to come out right; cause just about everybody can see what it looks like in their head even if they can't draw or sculpt it.

So, it is assumed that the ability to mentally manipulate objects is fairly common in the general population. As P10 adds later in his post-sort comments, "Success is pretty much what you make it. If you want to be successful, you're going to."

Also, Romantic Creatives stand in stark contrast to the Technological Creatives with regard to their beliefs about the importance of problem solving skills. As noted in the preceding section, Technological Creatives locate this Q-sort item in column 11 (+5) with a z-score of 1.840. Conversely, Romantic Creatives position this statement in column 4 (-2) with a z-score of -0.620. They also identify as unlike their beliefs the statement that, "The most creative workers in this field are also the most technically savvy."

- #1 The technology compels you to be a problem solver. (-2, -0.620)
- #35 The most creative workers in this field are also the most technologically savvy. (-3, -0.936)

The Romantic Creatives are also distinguished from the Artistic and Technological Creatives with regard to their positioning of statement 37, "This field attracts nerds." P10 notes, "I feel that this field doesn't attract nerds. I think it is open to just about all types of people; the beautiful, everybody." His comments are quite different than those of P32, a female in the Public 4-Year Comprehensive program who loads as an Artistic Creative. She notes, "Everybody that I know that's in this field is a nerd especially Mr. Smith," (a pseudonym for her instructor). She laughs and adds, "I think that it really does attract nerds because I know I'm very nerdy." So, while Artistic Creatives define themselves as "nerdy" and "special," Romantic Creatives characterize themselves as "beautiful" and not nerds and suggest that the field is open to everyone.

- #37 This field attracts nerds. (-4, -1.475)

Beyond these considerations of personality types and characteristics that exemplify the computer graphics field, Romantic Creatives also differ from Artistic and Technological Creatives in terms of how they understand and value computer graphics production and products. They identify as quite like their beliefs the statement that, "incentives cripple creative expression." As P35, a male in the Public 4-Year Comprehensive program, put it, computer graphics is "fun, but not fun when business is added to it." Also distinguishing this factor from the other two is Q-sort item 26 which states, "Images produced by computer will never be valued as much as paintings by Picasso, Van Gogh, or Michael Angelo," which Romantic Creatives position as quite unlike their beliefs. P16, a male in the Private 2-Year Arts program, notes, "Much CG art I have viewed throughout my college career has gone beyond the works of Picasso or any other artist." So, Romantic Creatives value computer graphics as tangibles having the same realistic nature as paintings and sculpture. They value them not just as things but also thoughts. They imagine that they might rival the works of the masters in the fine arts. Yet they see deadlines, salaries, and similar incentives as injurious of creative expression and do not believe that success is determined by commercial acceptance and marketability.

- #9 Deadlines, salaries, and other "incentives" cripple creative expression. (+4, 1.662)
- #45 Success is defined in terms of commercial acceptance and marketability. (-3, -0.936)
- #7 CG output is best understood as things, not thoughts. (-3, -1.113)
- #5 Because they exist as transient images on a screen, most CG images lack the reality of other art forms like paintings and sculptures. (-4, -1.363)
- #26 Images produced by computer will never be valued as much as paintings by Picasso, Van Gogh, or Michael Angelo. (-5, -1.641)

With regard to the processes involved in computer graphics production, Romantic Creatives identify as most like their beliefs the statement, “The truly creative work in CG takes place before you ever sit down at the computer,” Q-sort item 34. Also, Romantic Creatives are distinguished from the other two creative types by placement of Q-sort item 15 as unlike their beliefs; “Although most tasks in CG can be solved in a variety of ways, there is ultimately a single ‘best’ procedure for each challenge.”

- #34 The truly creative work in CG takes place before you ever sit down at the computer. (+5, 2.217)

- #17 Although most tasks in CG can be solved in a variety of ways, there is ultimately a single "best" procedure for each challenge. (-4, -1.381)

Research Question #2: What is the character of creativity represented among students' beliefs about the field of computer graphics?

Some number of statements failed to differentiate between factors. As they are positioned in the arrays of each factor at or very near the same location and with essentially undifferentiated z-scores, these consensus statements, presented at Table 9, may be construed as commonly held constructs. The theoretical frame of creativity as located in the person, process, product, or environment (Davis, 1992) and as either scientific, artistic, or a hybrid of the two (Feist, 1991; Runco & Bahleda, 1986) served to organize material collected and subsequently formatted as Q-sort statements. Students, in their arranging of these statements, manifest their understandings of the character of creativity in the field. Given Bertoline's (1998) assertion that computer graphics constitute an emerging discipline and the claim that creativity is discipline or domain specific (Csikszentmihalyi, 1988; Edwards, 2001; Gardner, 1993a; Li, 1997; Mace, 1997), commonality across all factors should reflect the nature of creativity as it is generally understood by all participants and as it is, therefore, assumed by students to be characteristic of the field. The entire list of Q sort statements are listed in order from greatest consensus to greatest disagreement at Appendix N.

TABLE 9

CONSENSUS ITEMS: THOSE THAT DO NOT DISTINGUISH BETWEEN ANY PAIR OF FACTORS

Statement Number	Statement	Factor 1 Array Position Z-Score	Factor 2 Array Position Z-Score	Factor 3 Array Position Z-Score
4	It's like turning a switch on and off. You go back and forth from logical and linear to imaginative and unconstrained.	+1 0.43	+2 0.81	+2 0.90
7*	CG output is best understood as things, not thoughts.	-2 -0.69	-1 -0.76	-3 -1.11
8	CG is more of a craft than an art.	-1 -0.61	-2 -1.01	-2 -0.68
14	Success requires a vivid imagination.	+4 1.60	+4 1.21	+3 1.17
19	CG can't be understood in terms of "truth" and "beauty" like paintings might.	-3 -0.88	-2 -0.97	-1 -0.43
25*	Understanding the value of CG requires a new aestheticism.	+1 0.40	0 0.40	0 0.10
40*	Technology and creativity are like oil and water; they don't mix.	-5 -2.09	-5 -2.16	-5 -1.97
42*	There's a difference between mastering the software and using it creatively.	+3 1.37	+4 1.18	+4 1.54
47	Using pull-down menus, the "undo" feature, and similar "trial and error" functionality in CG applications makes this a much easier field to be creative in than painting or sculpting.	0 0.03	+1 0.41	+1 0.17

Note: Non-significant at $p > .01$, asterisk (*) indicates non-significant at $p > .05$

Across all three factors, there was strong disagreement with Q-sort item 40, "Technology and creativity are like oil and water; they don't mix." Although it should come as no surprise that students working in the field of computer graphics should hold such an opinion, it was important to include it in the set of Q-sort items given that many in the fine arts community see technology as a serious detriment to creativity and creative expression. Still, it is noteworthy that for all three factors, this statement appeared at the extreme in column 1 with z-scores for Factors 1, 2, and 3 of -2.088, -2.163, and -1.971 respectively. So, this notion was quite clearly dismissed by participants. Although each creative type engages the computer graphics technology to a greater or lesser degree, all view it as contributing to creative expression. Some, such as P32, suggest that technology can even extend creativity. She notes, "A lot of times, you have an idea, and you write it down on paper and it looks good but then you take it into the program and you start putting it together and creating it, it's ten times better because of the technology."

- #40 Technology and creativity are like oil and water; they don't mix. (Factor 1: -5, -2.088; Factor 2: -5, -2.163; Factor 3: -5, -1.971)

Similarly, participants identify as like their beliefs the statement that success in the computer graphics field requires a vivid imagination. Post-sort comments indicate that imagination defines creative activity and that the technology, if it is to be used successfully, is a tool for visualization and manifestation of one's imagination. As P41, a female working toward a BFA degree in the Public 4-Year Comprehensive program notes, "The solutions come from your head/imagination. The computer is simply a tool to construct your ideas."

- #14 Success requires a vivid imagination. (Factor 1: +4, 1.598; Factor 2: +4, 1.209; Factor 3: +3, 1.171)

There is also agreement across all three factors with the statement, "There's a difference between mastering the software and using it creatively." Placement of this statement was in column 9 (+3) with a z-score of 1.37 for Artistic Creatives, column 10 (+4) with a z-score of 1.18 for Technological Creatives, and column 10 (+4) with a z-score of 1.54 for Romantic Creatives.

- #42 There's a difference between mastering the software and using it creatively. (Factor 1: +3, 1.368; Factor 2: +4, 1.176; Factor 3: +4, 1.535)

Of interest, participants were fairly ambivalent across all three factors regarding the notion that technology—specifically pull-down menus, the "undo" feature found in computer graphics software, and the "trial and error" functionality made available through preprogrammed filters and built-in special effects—may make computer graphics an easier field than painting or sculpting. With z-scores of 0.025, 0.413, and 0.170 for Factors 1, 2, and 3 respectively, research participants see this statement as neither like nor unlike their beliefs.

- #47 Using pull-down menus, the "undo" feature, and similar "trial and error" functionality in CG applications makes this a much easier field to be creative in than painting or sculpting. (Factor 1: 0, 0.025; Factor 2: +1, 0.413; Factor 3: +1, 0.170)

Summary

This chapter has presented details of the analysis and interpretation of collected data from 46 student volunteers from three different college/university computer graphics programs. Findings indicate that three identifiable patterns of beliefs about the field of computer graphics are represented in that data.

The pattern of belief characterized by 14 of the 46 Q-sorts and identified as Artistic Creatives recognizes motivation, imagination, and intelligence as essential characteristics for those working in the field. Success is not the result of education and experience but, instead, more dependent on a keen eye, an aesthetic sense, and an intuitive feel. The goal of computer graphics is assumed to be the communication of ideas and opinions and to elicit an affective reaction. It is not characteristic of this pattern to accept that success is determined by available hardware and software. On the contrary, truly creative work is antecedent to engagement of the technology; an externalized orientation of computer graphics tools.

The pattern of belief revealed in 19 of the 46 Q-sorts has been identified as Technological Creatives. While Technological Creatives recognize the importance of imagination, motivation, and intelligence, they also point to the importance of logic, order, reason, and problem solving skills. They value a balanced approach to work in the field by multitalented workers. They also value the contributions of hardware and software developers to the field. Technological Creatives appear to be more connected to their technology and accept that the process may be engaging and sensuous.

The pattern of belief revealed in 5 of the 46 Q-sorts has been labeled as Romantic Creatives. Motivation and imagination are recognized as especially important, but intelligence falls out of the mix for Romantic Creatives. Deadlines, salaries and other incentives are construed as possibly crippling of creative expression, and commercial acceptance and marketability are not the measure by which they judge success. However, they indicate that their work is of great value and may even rival the works of great artists like Picasso, Van Gogh, and Michael Angelo.

Across all three factors, there seems to be an understanding that technology and creative can and do integrate well, although it is accepted that mastering the software is not the same as using it creatively. There is general agreement that imagination is important.

Implications of these findings and recommendations for additional research are presented in the following chapter.

CHAPTER V

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

In summarizing this study, considering implications, and making recommendations for further research, it is especially important to frame the work completed here with reference to the research goals, objectives, and questions. This study was undertaken with the pragmatic interests of the researcher and other computer graphics instructors and curriculum developers in mind. The purpose of this study was to investigate the patterns of beliefs students hold about the field of computer graphics and to gain insight into their understandings regarding the character of creativity in the field. The questions guiding this study were a) What patterns of beliefs do students hold about the field of computer graphics? b) What is the character of creativity represented among students' beliefs about the field of computer graphics?

It is worth emphasizing that the data collected does not necessarily reflect the field as it actually exists or might be understood to exist by computer graphics professionals or other informed and influential contributors. Instead, the data reflects students' understandings of the field and creativity in the field. It is important to keep in mind that computer graphics is a young and fluid field. The technologies that define the field today are substantially different than those that defined the field 10 years ago, assuming that it was even possible to imagine computer graphics as a field 10 years ago. Consequently, there exists no empirical work with which to compare the results of this study. Even issues of aesthetics as they might be used to evaluate work in the field are evolving rapidly. To further complicate the process of identifying implications for the results of this study, the theories of creativity's determinants and characteristics are multitudinous, as noted in Chapter II, and research is available to support a wide variety of competing claims and understandings.

It is anticipated that the information made available here will be of interest to others who are studying the computer graphics field as well as those who have undertaken a study of creativity. As indicated by Chan and Chan (1999) and Sternberg (1985), implicit theories of creativity, such as those communicated by the students in this study, may be especially beneficial as we look to develop new theories of creativity and/or attempt to validate existing explicit understandings. The remainder of this chapter summarizes the study, presents brief details of possible implications of the study, makes recommendations for additional research, and closes with the researcher's comments and reflections.

Summary of the Study

The proposed determinant of creativity has often been conceptualized as existing in persons, products, processes, and/or environments (Davis, 1992). Also, a dichotomy of creative types—scientific and artistic—has been postulated (Feist, 1991; Runco & Bahleda, 1986). Scientific creativity is understood to be logical, intelligent, rational, and directed toward problem solving while artistic creativity is conceptualized as impulsive, imaginative, emotional, and intuitive (Feist, 1991; Runco & Bahleda, 1986). While scientific creativity is often understood to be detached, artists are understood to engage in a personally sensuous process of creation (Gardner, 1994). Art is presumed to require spatial intelligence while science requires analytical thought and abstraction (Feist, 1991; Gardner, 1983). Although there exists some debate regarding such characterizations, art is often conceived as the providence of the right hemisphere of the brain, with its non-verbal, spatial, and visual functioning, while skills and abilities that lead to success in science are presumed to extend from the left hemisphere, said to be logical, sequential, verbal, and objective in its processing of information and experience (Al-Sabaty & Davis, 1989; Hoppe, 1990, 1994; Lii, 1986). The emerging discipline of computer graphics, which seems to draw from both types, challenges us to rethink this dichotomy.

From the dialogic concourse of varied assumptions regarding creativity framed by the aforementioned types and determinants, 48 statements were generated to serve as Q-sort items. Forty-six participant volunteers from three dissimilar computer graphics programs sorted these items, and their arrangements of items were subjected to correlation and factor analysis as detailed in Chapters III and IV. A three-factor representation of students' patterns of beliefs was selected for study, yielding the categories identified here as Artistic Creatives, Technological Creatives, and Romantic Creatives.

Briefly, the arrangement of Q-sort items that characterizes Artistic Creatives positions as like their beliefs a perceived need for workers in computer graphics to be motivated, imaginative, intelligent, and able to mentally manipulate objects. Computers are characterized as "mere tools" by those who load on this factor and it is noted that the truly creative work takes place before one sits down at the computer. Personal characteristics of creative individuals, to include a keen eye, an aesthetic sense, and an intuitive feel, seem to be understood as innate and of greater worth than an individual's education and experience. According to Artistic Creatives, communicating ideas and opinions are among the most important goals for the field.

Technological Creatives also give priority to personal characteristics of motivation, imagination, and intelligence. Of interest, however, spatial intelligence holds far less value for Technological Creatives. Instead, they understand the technology to compel workers in the field to be problem solvers. Also, Technological Creatives stress the need for computer graphics creators to be balanced in their skills and abilities: both logical and emotion, rationality and impulse, and accessing both hemispheres of the brain. Technological Creatives can also be conceptualized as technology engagers. They indicate that creating with technology can be an intimate and sensuous experience.

Romantic Creatives appear to have a more open and global membership in mind for computer graphics professionals. While motivation and imagination remain as important attributes, intelligence is not assumed to be crucial. Also, drawing skills are not seen as necessary. Romantic Creatives indicate that given enough time and education, anyone can succeed in the computer graphics field. Romantic Creatives also propose that computer graphics can be valued as much as one might value paintings by Picasso, Van Gogh, and Michael Angelo.

Aside from these differentiated characterizations, descriptive of the three factors revealed through statistical analysis of collected data, this study also revealed substantial commonality among participants. That is, an initial examination of the unrotated data using centroid factor analysis revealed 35 of the 46 sorts to be associated with a single factor. Likewise, a number of consensus statements were identified when the data was later examined using principal component analysis and varimax rotation. Across all three creative types presented here, imagination and motivation are highly valued. All three locate as quite unlike their beliefs the notion that technology and creativity do not mix. All agree that it is one thing to master technology and something else again to use it creatively. All position as like their beliefs, albeit to slightly different degrees, the idea that computer graphics can be understood in terms of truth and beauty.

Conclusions

The views of participants in this study about the field of computer graphics and creativity in the field, while common in some respects, clearly differ in several important ways. Across all three factors, motivation and imagination are valued as essential personal characteristics. For participants associated with all three factors, it is understood that creativity and technology are integrated in the field of computer graphics. The view that there is a difference between mastering the software and using it creatively also appears as common across all three factors. However, opinions vary with regard to when creativity happens, the value education plays for those in the field, whom the field is open to, thoughts about how technology is engaged, and the importance of specific personal characteristics sometimes deemed necessary for success in the field of computer graphics.

Participants' views differ regarding when creativity takes place. Unlike Technological Creatives, Artistic and Romantic Creatives identify as quite like their beliefs the notion that the truly creative work takes place before one sits down at the computer.

Participants' views differ regarding whom the field is open to and the value of education. While Romantic Creatives understand that anyone can succeed in the computer graphics field given enough time and training, Artistic Creatives indicate that this idea is quite unlike their beliefs. Artistic Creatives identify as like their beliefs the statement that success depends more on a keen eye, an aesthetic sense, and an intuitive feel than a person's education or experiences. Technological Creatives and Romantic Creatives do not.

Participants' views differ with regard to how technology is engaged by those creating computer graphics. Technological Creatives, unlike Artistic Creatives and Romantic Creatives, strongly believe that creating with technology can be sensuous, intimate, and personally engaging.

Participants' views differ with regard to the personal characteristics necessary for success in the computer graphics field. While motivation and imagination are identified as important by participants from all three factors, only Technology Creatives emphasize the need for problem solving. Also, while Artistic Creatives and Technological Creatives identify intelligence as a valued characteristic, Romantic Creatives indicate that intelligence is not a prerequisite for workers in the computer graphics field.

Of interest, a relationship between factors—or more specifically, identified patterns of beliefs—and curriculum seems to be indicated by the data. That 8 of 11 Technological Creatives were enrolled in the 2-Year Public Business program and 10 of the 20 Artistic Creatives were enrolled in the 4-Year Public Comprehensive program seems especially noteworthy.

Implications of the Research Findings

Implications to Theory

It has been proposed that creativity is domain specific (Csikszentmihalyi, 1988; Edwards, 2001; Gardner, 1993a; Li, 1997; Mace, 1997). That is, creativity in a particular domain or discipline will be shaped by the symbol system, tools, operations, and the influential persons and institutions associated with that discipline such that creativity is manifest in ways that characterize and define the discipline and distinguish it from others. It has been further proposed that computer graphics can be conceptualized as an emerging discipline defined by a unique set of tools, a specialized body of knowledge, and a distinctive research agenda (Bertoline, 1998).

It is important to keep in mind that the data and related findings associated with this study reflect students' patterns of beliefs about the field of computer graphics, which may not correlate with the patterns of industry professionals or computer graphics instructors. However, if students' understandings are accurate, the collected data from this study may point to a need for additional research into the understanding of creativity as domain specific and/or the characterizations of computer graphics as a discipline. If creativity is domain specific, we are challenged to explain how collected data results in three differentiated factors. One possible explanation is that computer graphics encompasses multiple domains, and each factor evaluated here is representative of a domain. To clarify, it is of interest to note that Gardner (1999) uses painting (p. 117) as an example of a domain. In contrast, Lii (1997) uses as an example of a domain Chinese ink brush painting (p. 107). One would expect patterns of beliefs about the field and creativity in the field to vary to a greater degree if painting is studied as a domain than might be the case if Chinese ink brush painting is studied. Again, it may be that students' understandings are inadequate. However, it is also possible that computer graphics exists as an overarching structure defined in part by the commonalities of the aforementioned single factor among unrotated data and/or the consensus statements, while the three factors are in actuality true domains, each reflecting more focused interests and emphases among students and possibly curricula.

As noted previously, creativity is frequently characterized as either scientific or artistic. The results of this study suggest that students in computer graphics programs describe themselves in terms that situate them outside of either construct, or perhaps somehow in both. That is, while each of the factors extracted here might be characterized as more scientific than artist or more artistic than scientific, none of the three is clearly one or the other. For instance, the Technological Creatives appear to value logic, order, and reason; engage technology; count among their numbers those who program software; and emphasize problem-solving skills. Based on these characteristics alone, one might be inclined to describe these individuals as scientifically creative. However, they also indicate that the goal for computer graphics is to elicit an affective reaction and indicate that technology does not preclude personal, sensuous engagement as a part of the creative process. So, while some values of Technological Creatives are quite indicative of scientific creativity, others are more aligned with understandings of artistic creativity. Likewise, Artistic Creatives and Romantic Creatives can be understood to point to an understanding of creativity in the field of computer graphics that is neither exclusively scientific nor artistic. It is suggested here that the dichotomous understanding of creative types—which may have been of some utility given the backdrop of the competing and oppositional cultures of the sciences and the humanities as described by Snow (1998) and Lindauer (1998)—may be of diminished worth as science and art are reunited in the Twenty-First Century.

Implications for Practice

Donald MacKinnon (1967) writes,

> Our task as educators is not to recognize creative talent after it has come to expression, but either through insight or through the use of validated predictors to discover talent when it is still potential and to provide that kind of educational climate and environment which will facilitate its development and expression. (p. 227)

Consequently, an appropriate starting place for computer graphics educators is to understand that their students come to higher education with varied understandings of the field and creativity in the field—understandings that may differ substantially from their own. Computer graphics faculty need to seek to recognize and appreciate these varied understandings and implement curricula that allow for students of each type to benefit from their educational experiences.

Students' varied opinions about the value of education as it might contribute to success is computer graphics will be especially noteworthy. For all three types, motivation appears to be valued above education. This idea resonates with the research of many, such as Davis (1992) and Torrance (1967), indicating that motivation is a key factor in all creative endeavors. For instance, Romantic Creatives may engage educational opportunities differently based on how they value computer graphics output. The statement, "Images produced by computer will never be valued as much as paintings by Picasso, Van Gogh, or Michael Angelo," is quite uncharacteristic of Romantic Creatives only. Students' assumptions about the long-term value of their work may factor into their motivation and desire to produce good work.

Artistic Creatives identify as quite like their beliefs the statement, "Success depends more on a keen eye, an aesthetic sense, and an intuitive feel than a person's education or experiences." They also identify as like their beliefs the statement, "The aesthetic aspects of the field can't be taught." At the same time, they identify as quite unlike their beliefs the statement that, "Anyone can succeed in this field given enough time and training." Taken together, these statements may point to a presumption by Artistic Creatives that educational experiences are of limited value to future computer graphics professionals. Romantic Creatives take a contrary position. They identify as somewhat unlike their beliefs that aesthetic characteristics are of greater value than education and experience and they identify as quite like their beliefs the notion that anyone can succeed in this field given enough time and training. It may be that Romantic Creatives are more open to educational experiences and instruction.

However, instructors will want to be aware of Romantic Creatives' understanding that deadlines and similar incentives cripple creative expression. This notion is supported in the literature on environmental influences on creativity (Davis, 1992). It may be helpful to understand the potential for intrinsic motivation as a means of fostering creative expression in this group.

Artistic Creatives view as quite unlike their beliefs the idea that, "Creative expression depends on mastery of the software," and as like their beliefs the statement, "There's a difference between mastering the software and using it creatively." They favor an understanding of truly creative work as an antecedent to work at the computer. Taken together, these statements, along with post-sort comments by Artistic Creatives that situate the computer as a "mere tool," seem to indicate that they distance themselves from technology. Consequently, instructors may find it challenging to foster substantial technical skills in Artistic Creatives. Also, it may be difficult to get students to see beyond the computer's utility as just another design tool and to understand that "computers are also something to design *for*" (Dubberly, 1990). That is, computers exist as a unique medium and so must be engaged on multiple levels. Unlike Artistic Creatives, Technological Creatives can be understood to be technology engagers. They agree with the sentiment that the field is defined by available software. They understand creating with computers to be personally engaging and sensuous. For those instructors who teach students at the computer and emphasize development of technical skills, the Technological Creatives should prove to be an easier group to mentor. However, it is important to note that the differences of opinion among research participants regarding the development of skills as they might be necessary for creative expression mirror differences of opinion among researchers. That is, just as computer graphics students hold different beliefs about the need to master software in order to use it creatively, researchers also debate mastery of the tools and operations of their domain as antecedent to creative expression (Davis, 1992).

Students' varied appreciations of intelligence, logic, reason, orderliness and problem solving skills may also be of interest to instructors. Only Technological Creatives identify as like their beliefs the need for substantial intelligence and a logical, orderly, and reasoned approach to their work. It may be that Artistic Creatives and Romantic Creatives disassociate themselves from these statements, understanding them to be more characteristic of science than art and aestheticism. However, for whatever the reason, instructors will need to be aware that some students will undervalue these attributes.

While understanding the main differences between creative types is important, it is also valuable to understand that the computer graphics students in this study also shared many things in common. Perhaps chief among these commonalities was that they situated themselves between the arts and the sciences. They are both, but they are neither. This has several implications for practicing computer graphics faculty.

Students participating in this study were alike in that they all understood technology to be an appropriate means to creative expression. At first blush, this may seem a rather unimportant observation. It is, however, quite noteworthy. Spaid (1998) argues that technology suppresses imagination and creativity. She writes that a fine arts education fosters an appreciation for the aesthetic, while the use of computers for the production of graphic images in arts education programs disenfranchises student artists. The views expressed by students in this study were clearly different than Spaid's. Participants did not understand technology to be antithetical to creative production.

Vesna (2001) expresses serious concern for those working at the intersection of art and science, describing this as "both a privileged and dangerous position" (p. 121). It is privileged in that it allows those involved in computer graphics to see into both cultures, borrow from both, and bridge the two. It is dangerous in that students and instructors may lack a sense of belonging and they may even be seen as subversive in their crossing of disciplinary boundaries. It is of interest that some of the students in this study describe themselves in terms that set them apart from others. Some described themselves as "special people" (i.e., Artistic Creatives); others as "beautiful" people (i.e., Romantic Creatives). Some see the computer graphics field as closed to all except an innately endowed few (i.e., Artistic Creatives). Schreiber (1998) describes in detail the serious challenges that new media instructors face when they are assigned to existing academic departments in the fine arts for which they are, fundamentally, a poor fit. It is certainly possible, given the information uncovered here, that students may face similar challenges. Instructors and administrators will want to be mindful of this sense of otherness and support students as they deal with it.

Likewise, Van Proyen (2000) makes the point that operating at this intersection of technology and art may leave students without clear understandings of their goals, objectives, and opportunities. Torn between aestheticism and pragmatism, creation as a means of expression and creation for market acceptance, students may not understand what is really expected of them. Issues of what constitutes success may elude them, as seems to be evident in the varied views about what constitutes success uncovered in this study. Also, it is necessary to ensure that students are encouraged to explore the wider range of the computer graphics discipline. In other words, some students will have principally aesthetic aims in mind while others channel their work toward more pragmatic ends. In the longer term, success in the field will mandate workers who are sensitive to both.

Recommendations for Further Research

The dialogic concourse used in this study to frame possible understandings of computer graphics students about their field and about creativity in the field was purposely broad. That is, Q-sort items were generated based on the broadest possible understandings of creativity as it might reflect persons, processes, products, and/or environments as the determinant of creativity, and the creative type as scientific, artistic, or some hybrid of the two. The results have situated students' understandings of the field and of creativity within a relatively small area as indicated by the dominant factor revealed in the unrotated data and by the consensus statements. Further research is needed to add definition to the bounds of this smaller area and to tease out information that will further define students' patterns of beliefs. That is, an appropriate next step would be to repeat this study using a more tightly focused concourse based on statements that allow for greater differentiation of commonalities regarding students' patterns of beliefs. This new concourse could be drawn from participants' written and oral statements during interviews. This approach, characterized as "naturalistic" by McKeown and Thomas (1988, p. 25), has the advantage of framing Q-sort statements in the language of the research participants. Additionally, generating a new concourse based on students' own dialogic space, as opposed to that of the community of researchers and academicians studying the broader field of creativity, should increase definition in the data and preclude a one-factor solution.

Additional studies using additional participants are suggested. As noted previously, students' patterns of beliefs may not reflect the true nature of the field. Engaging those who have demonstrated success as computer graphics professionals and/or educators may add to our understanding of this emerging discipline.

The correlations between students' patterns of beliefs and their instructors' orientations and/or the curriculum they use may be of interest. For instance, 8 of the 11 participants from the Public 2-Year Business program loaded on Factor 2. Of the remaining three Q-sorts from this institution, one was confounded, one loaded on Factor 1, and one loaded on Factor 3. Similarly, 10 of the 20 participants from the Public 4-Year Comprehensive program loaded on Factor 1. A relationship between students' patterns of beliefs and some aspect of their education is suggested. It may be that students understand creativity as they do given emphases in their curriculum; or perhaps students of a particular orientation are drawn to one curriculum as opposed to another. Given the newness of the field, instructor orientations may have some influence over how creative matters are conveyed to students. For instance, an instructor who entered the computer graphics discipline from the fine arts may pass along to students a different set of values than an instructor who entered the discipline from computer science. It might also be that some academic programs envision students applying learned skills and concepts in a technical field, such as computer gaming, while others forecast aesthetic issues to be of greater importance, assuming the greatest demands for graduates to be in areas of advertising and design. Understanding how aspects of the educational setting influence or attract students, especially with regard to creative production, would be helpful.

Given that study findings point a breakdown in the traditional dichotomous understanding of creative types, further research into varied types is warranted. For instance, it may be of interest to repeat Saleh's study that identified significant correlation between hemispheric preferences and students' choices of academic major. In that study, students majoring in art, literature, education, nursing, communication, and law were also identified as right-brained, while students majoring in business, commerce, engineering, and science were identified as left-brained (2001). It may be that if Saleh's study were repeated with computer graphics students added to the pool of participants, these new participants would appear as both left- and right-brained, or in some way fail to fit neatly into either category. Other research away from dichotomous understandings of creativity and hemispheric specialization is also needed. For instance, research into computer graphics students, educators, or professionals as they make synergistic use of brain hemispheres, per the theories of Gowan (1978) and Hoppe (1990, 1994), may be more illuminating.

Research into aestheticism as it relates to computer graphics is also appropriate. It is noteworthy that calls for a new aestheticism frequent the literature on computer graphics, for example Goodale (1998) and Sherman (1990). Curiously, Q-sort item 25, "Understanding the value of CG requires a new aestheticism," was a consensus statement, loading at 0.401, 0.397, and 0.099 for Factors 1, 2, and 3 respectively; indicating that the statement was neither like nor unlike participants' beliefs. This discrepancy needs explaining. Also, it should prove of great value to instructors and others in business and industry to understand how students value aesthetic aspects of computer graphics products.

It is suggested that research into computer graphics students' understandings of the value of education be undertaken. As is indicated here, some students value innate aesthetic abilities above education. Additional research could help to explain this finding and would benefit instructors as they work to craft meaningful educational experiences.

With regard to broader recommendations for further research, it must be noted that Q methodology proved to be a useful and efficient means of discovering the implicit beliefs of research participants. The process of creating a concourse from the full range of understandings of creativity as located in the person, process, product, or environment, and as either scientific, artistic, or a combination of the two seemed to facilitate a broad and balanced view of possible orientations. Participants found the process of sorting Q sort statements enjoyable. Likewise, participants' arrangements of these statements proved to be an excellent starting point for interviews and clarification of participants' understandings. Correlation and factor analysis provided a statistical basis for the identification of patterns among participants' beliefs. Q methodology is highly recommended for similar research.

Closing Remarks

Academic research into computer graphics education may be the best means of understanding the field. As Davis (1990) notes, computer graphics professionals see little benefit in conducting research into how the field is best understood and what really counts for creativity. Clients are already willing to pay substantial sums of money for work without research, professionals do not see tangible benefits in researching the field, and most of those in the field but outside of academia lack the skills necessary to complete research tasks. So, any effort to understand computer graphics and improve educational programs that prepare students for work in the field will come from educators challenged to design, implement, and assess their curricula. This necessity was the impetus for this study.

It has been especially helpful to see, in the colleges and universities visited in the last 15 months, the same diverse sets of understandings about the discipline and about creativity that I have seen in the last seven years of teaching computer graphics courses. It is easy for instructors to become frustrated as they face what seems to be an infinite variety of understandings about the discipline and as they try to understand the creative orientations of their students in light of numerous, and frequently contradictory, books and articles on creativity. However, Q methodology has proved to be especially helpful in this study in finding commonalities among students and coalescing an especially diverse set of orientations into a very few that can be easily understood and used in curriculum development initiatives.

Participants in this study point to an understanding of creativity that is neither wholly scientific nor artistic. Instead, these students see themselves as future practitioners in a field situated at the intersection of aestheticism and digital technologies. They understand technology as an instrument of creative expression. They understand motivation and imagination to be foundational for success in the field. They see as somewhat different issues, mastery of the software used in the field and creative expression. However, their views vary with regard to the degree to which the technology defines the field and accounts for creative expression.

At this point in time, while the modern computer graphics field is still quite young and without clear bounds or constrained direction, it has been especially beneficial to compare and contrast students' understandings with those of myself and my peers. It has been helpful to frame possible curricular considerations against students' expressed interests and needs. As Bertoline (1998) and Freedman (1997) note, our culture is evolving beyond literary forms of information dissemination and toward more visual forms. Few may have the insights into this new culture as do today's computer graphics students, for whom access to, and use of, digital technologies are a defining characteristic and for whom there seems to be a need to reconnect the aesthetic and the technological (Meggs, 1983). Reflecting on the experience, it seems clear that Snow (1998) was correct in his assumption that operating at the intersection of art and science provides substantial opportunities for novelty, innovation, and creativity.

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APPENDIXES

APPENDIX A

Q-Sort Statement Items

1. The technology compels you to be a problem solver.
2. The computer software requires you to proceed step by step.
3. Success requires the ability to manipulate objects in your head; mentally see them from different angles and directions.
4. It's like turning a switch on and off. You go back and forth from logical and linear to imaginative and unconstrained.
5. Because they exist as transient images on a screen, most CG lacks the reality of other art forms like paintings and sculptures.
6. CG generated mathematically (e.g., computer-generated fractals) really can't be considered "creative."
7. CG output is best understood as things, not thoughts.
8. CG is more of a craft than an art.
9. Deadlines, salaries, and other "incentives" cripple creative expression.
10. The goal of CG production is to elicit an "affective reaction."
11. The technology precludes a playful approach to work in the field.
12. The CG field is all about communicating ideas and opinions.
13. The aesthetic aspects of the field can't be taught.
14. Success requires a vivid imagination.
15. The medium is the message.
16. Success in the field mandates creative types who are both left-brained and right-brained, rational and impulsive, logical and emotional.

17. Although most tasks in CG can be solved in a variety of ways, there is ultimately a single "best" procedure for each challenge.
18. The most important factor for success is a person's motivation.
19. CG can't be understood in terms of "truth" and "beauty" like paintings might.
20. CG are, by definition, pragmatic and useful.
21. The CG field requires substantial intelligence.
22. The need to understand math makes this an impossible career field for many.
23. The nature of the technology means that you really can't "feel" your way through a project. You have to "think" your way through.
24. The technology complicates the aesthetic process.
25. Understanding the value of CG requires a new aestheticism.
26. Images produced by computer will never be valued as much as paintings by Picasso, Van Gogh, or Michael Angelo.
27. Anyone can succeed in this field given enough time and training.
28. The technology reduces color, light, and form to numerical representations and, consequently, suppresses the sensuousness of creative expression.
29. The fine arts have a moral foundation that is lacking in CG.
30. Those who spend their time scripting or programming to produce CG really can't be considered "creative."
31. The technology imposes a structure on the creation of CG that makes it difficult to act intuitively.
32. Creative expression depends on mastery of the software.

33. Those who succeed in the field aren't truly artists, but they aren't really technicians either.
34. The truly creative work in CG takes place before you ever sit down at the computer.
35. The most creative workers in this field are also the most technologically savvy.
36. This field is defined to a large degree by what software and hardware developers make possible.
37. This field attracts nerds.
38. An understanding of art history is truly beneficial.
39. A logical, orderly, and reasoned approach to work in the field is essential.
40. Technology and creativity are like oil and water; they don't mix.
41. A lot of what's showcased as CG isn't really creative at all but, instead, reflects the power of today's hardware and software to make anyone look good.
42. There's a difference between mastering the software and using it creatively.
43. Success is determined by which tools (software applications and hardware) you have available for your use.
44. Creating with a computer lacks intimacy; the technology inhibits personal engagement.
45. Success is defined in terms of commercial acceptance and marketability.
46. You can still do extremely well in CG even if you don't know how to draw.
47. Using pull-down menus, the "undo" feature, and similar "trial and error" functionality in CG applications makes this a much easier field to be creative in than painting or sculpting.

48. Success depends more on a keen eye, an aesthetic sense, and an intuitive feel than a person's education or experiences.

APPENDIX B

Researcher's Script: Directions for Sorting Q-sort Items - Single Participant

Step 1 – In a moment, I will give you a stack of 48 cards. You will need to read through the cards and sort them into three piles based on what **you believe about the field of computer graphics**: its people, processes, products, and the environments in which it takes place. After you read each card, place it into one of three (3) piles so that
a) those cards that are **most like** what **you believe about the field of computer graphics** are placed into a pile on your right. We will call this the "most like" pile.
b) those cards that are **most unlike** what **you believe about the field of computer graphics** are placed into a pile on your left. We will call this the "most unlike" pile.
c) those cards that are **neither like nor unlike** what **you believe about the field of computer graphics** can be placed in a third pile directly in front of you. We will call this the "neutral" pile.
Here are your cards. Sort them into most like, most unlike, and neutral piles.

Step 2 – Now that you have three (3) piles of cards, start with the pile to your right, the "most like" pile, and select the two (2) cards from this pile that are **most like what you believe about the field of computer graphics**. Place them in the two (2) spaces at the far right of the sheet in front of you in column 11. The order of the cards within the column—that is, the vertical positioning of the cards—does not matter.

Step 3 – Next, from the pile to your left, the "most unlike" pile, select the two (2) cards that are **most unlike what you believe about the field of computer graphics** and place them in the two (2) spaces at the far left of the sheet in front of you in column 1.

Step 4 – Now, go back to the "most like" pile on your right and select the three (3) cards from those remaining that are **most like what you believe about the field of computer graphics** and place them into the three (3) open spaces in column 10.

Step 5 – Next, return to the "most unlike" pile on your right and select the three (3) cards from those remaining that are **most unlike what you believe about the field of computer graphics** and place them into the three (3) open spaces in column 2.

Step 6 – Now you'll continue placing cards onto the sheet in this same manner until all of the cards have been placed into all of the spaces. Select the cards from the "most like" pile on the right that are **most like what you believe about the field of computer graphics** and place them into available spaces to the far right. Select cards that are **most unlike what you believe about the field of computer graphics** from the "most unlike" pile on the left and place them into available spaces to the far left. Once you have placed all of the cards from either the "most like" or "most unlike" pile, begin to place cards from the middle pile into spaces as appropriate. Again, items from this pile that are **most like what you believe about the field of computer graphics** will be placed into open spaces further right and those **most unlike what you believe about the field of computer graphics** will be placed into spaces further left.

Step 7 – Now that you have filled all available spaces, feel free to rearrange the cards until the sheet best represents what **you believe about the field of computer graphics**: its people, processes, products, and the environment in which it takes place. When you believe your arrangement of cards best represents what **you believe about the field of computer graphics**, let me know.

Step 8 – Now, let me record your sort before I speak with you for a few minutes.

Step 9 – Is it okay with you if I record our conversation about your sort of these items?

a) In broad terms, what do you think the items in columns 1 and 11 say about your understanding of the field of computer graphics?

b) Can you pick one or two other meaningful items from the sort and explain what they say about your understanding of the field of computer graphics?

Step 10 – I really appreciate your time and thank you for sharing your understanding of the field of computer graphics with me.

APPENDIX C

Researcher's Script: Directions for Sorting Q-sort Items - Multiple Participants

Step 1 – In a moment, I will give you a stack of 48 cards. You will need to read through the cards and sort them into three piles based on what **you believe about the field of computer graphics**: its people, processes, products, and the environments in which it takes place. After you read each card, place it into one of three (3) piles so that

a) those cards that are **most like** what **you believe about the field of computer graphics** are placed into a pile on your right. We will call this the "most like" pile.

b) those cards that are **most unlike** what **you believe about the field of computer graphics** are placed into a pile on your left. We will call this the "most unlike" pile.

c) those cards that are **neither like nor unlike** what **you believe about the field of computer graphics** can be placed in a third pile directly in front of you. We will call this the "neutral" pile.

Here are your cards. Sort them into most like, most unlike, and neutral piles.

Step 2 – Now that you have three (3) piles of cards, start with the pile to your right, the "most like" pile, and select the two (2) cards from this pile that are **most like what you believe about the field of computer graphics**. Place them in the two (2) spaces at the far right of the sheet in front of you in column 11. The order of the cards within the column—that is, the vertical positioning of the cards—does not matter.

Step 3 – Next, from the pile to your left, the "most unlike" pile, select the two (2) cards that are **most unlike what you believe about the field of computer graphics** and place them in the two (2) spaces at the far left of the sheet in front of you in column 1.

Step 4 – Now, go back to the "most like" pile on your right and select the three (3) cards from those remaining that are **most like what you believe about the field of computer graphics** and place them into the three (3) open spaces in column 10.

Step 5 – Next, return to the "most unlike" pile on your right and select the three (3) cards from those remaining that are **most unlike what you believe about the field of computer graphics** and place them into the three (3) open spaces in column 2.

Step 6 – Now you'll continue placing cards onto the sheet in this same manner until all of the cards have been placed into all of the spaces. Select the cards from the "most like" pile on the right that are **most like what you believe about the field of computer graphics** and place them into available spaces to the far right. Select cards that are **most unlike what you believe about the field of computer graphics** from the "most unlike" pile on the left and place them into available spaces to the far left. Once you have placed all of the cards from either the "most like" or "most unlike" pile, begin to place cards from the middle pile into spaces as appropriate. Again, items from this pile that are **most like what you believe about the field of computer graphics** will be placed into open spaces further right and those **most unlike what you believe about the field of computer graphics** will be placed into spaces further left.

Step 7 – Now that you have filled all available spaces, feel free to rearrange the cards until the sheet best represents what **you believe about the field of computer graphics**: its people, processes, products, and the environment in which it takes place. When you believe your arrangement of cards best represents what **you believe about the field of computer graphics**, let me know.

Step 8 – Now, we need to record your sorts before continuing. Note that a number on the upper left corner of its card identifies each statement. On the back of your Demographic Questionnaire, you will find a miniature representation of the form board you have sorted items onto. Carefully copy the number of each statement into the corresponding cell on that miniature form.

Step 9 – What would you like to say about your arrangement of these items and what the arrangement means about your understanding of the field of computer graphics? Please take a moment and write your comments on the bottom of the Demographic

Questionnaire in the space provided at item "H." I can provide additional sheets of paper if necessary.

Step 10 – I really appreciate your time and thank you for sharing your understanding of the field of computer graphics with me.

APPENDIX D

Demographic Questionnaire

Directions: Please provide requested demographic information by checking the most appropriate responses:

A. Gender: ___ Male ___ Female

B. Age: ___ 17-20 ___ 21-25 ___ 26-30 ___ 31-35 ___ 36-40 ___ Over 40

<u>Current educational program</u>

C. Currently enrolled in which type of degree program:

___ AA ___ AS ___ AAS ___ BA ___ BS

___ BFA ___ MFA ___ Other: ______________________________

D. Concentration: ______________________________

E. Cumulative grade point average (GPA) for current program: __________

<u>Previous educational experience</u>

F. Highest education level completed:

___ High School ___ Associate's Degree ___Bachelor's Degree

___ Graduate Degree ___ Other: ______________________________

G. Major area of study: ______________________________

H. Comments (please do not complete this section unless instructed to do so): _________

____

____

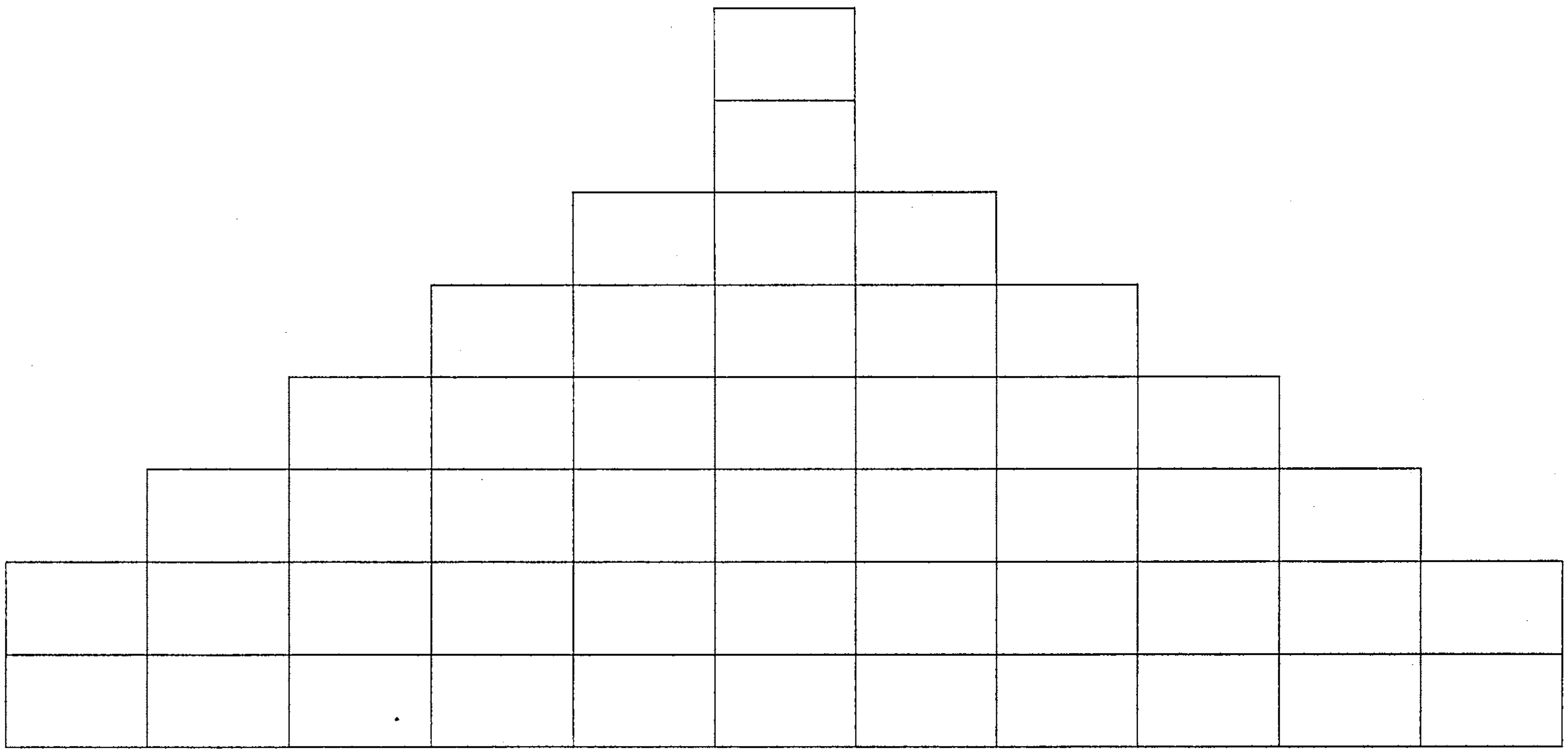
____

____

____

____

what you believe about the field of computer graphics



1	2	3	4	5	6	7	8	9	10	11
(-5)	(-4)	(-3)	(-2)	(-1)	(0)	(1)	(2)	(3)	(4)	(5)

Most Unlike
My Belief

Most Like
My Belief

APPENDIX E

Participant Consent Form

Dear Student of Computer Graphics,

You are invited to participate in a research study. The purpose of the study is to describe what students believe about the computer graphics field. Individuals who agree to participate in this study will complete a short survey describing general demographic characteristics, sort 48 statements about the field of computer graphics, and share thoughts about their arrangement of those statements: a process that typically takes no more than 30 minutes. The knowledge gained as a result of this study may improve our understanding of how work in computer graphics is conceptualized and, consequently, improve academic instruction for those who pursue a career in this field.

If you agree to participate, your responses will be kept confidential. Your name will not be used in reports nor will it be associated with your arrangement of the 48 statements or the transcription of any tape-recorded comments. Only data analysis information as a group will be kept beyond the conclusion of this study; all other materials will be destroyed. The sorting and taped feedback is completely voluntary. Specific details of your participation are not provided to your instructors or school administrators and your grades will not be affected by participation or non-participation. You have the option of stopping the process at anytime you wish. You are also free to withdraw your consent and end your participation in this project at any time. If you agree, you will be one of 30 to 45 participants in the study.

Questions about this research can be directed to me, Tony Alley, 2501 E. Memorial Rd., Edmond, OK 73013, (405) 425-5528, tony.alley@oc.edu; Dr. Bruce Petty, 261 Willard Hall, Oklahoma State University, Stillwater, OK 74078, (405) 744-8007, bap326@okstate.edu; or Sharon Bacher, Institutional Review Board, 203 Whitehurst, Oklahoma State University, Stillwater, OK 74078, (405) 744-5700, sbacher@okstate.edu. A copy of this information is provided and is yours to keep.

If you agree to participate and have your comments tape-recorded, please read and sign the statement below:

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ____________ Time: ____________ (a.m./p.m.)

Name (printed): ____

Signature: ____

I certify that I have personally explained all elements of this form to the subject or his/her representative before requesting the subject or his/her representative to sign it.

Signed: ____

Tony Alley, Researcher

APPENDIX F

Normalized Factor Scores – Researcher's Q-Sort

No.	Statement	Array Position
18	The most important factor for success is a person's motivation.	+5
16	Success in the field mandates creative types who are both left-brained and…	+5
34	The truly creative work in CG takes place before you ever sit down at the…	+4
12	The CG field is all about communicating ideas and opinions.	+4
4	It's like turning a switch on and off. You go back and forth from logical…	+4
42	There's a difference between mastering the software and using it creatively.	+3
14	Success requires a vivid imagination.	+3
35	The most creative workers in this field are also the most technologically…	+3
36	This field is defined to a large degree by what software and hardware…	+3
48	Success depends more on a keen eye, an aesthetic sense, and an intuitive…	+2
15	The medium is the message.	+2
10	The goal of CG production is to elicit an "affective reaction."	+2
9	Deadlines, salaries, and other "incentives" cripple creative expression.	+2
3	Success requires the ability to manipulate objects in your head; mentally…	+2
21	The CG field requires substantial intelligence.	+1
39	A logical, orderly, and reasoned approach to work in the field is essential.	+1
37	This field attracts nerds.	+1
23	The nature of the technology means that you really can't "feel" your way…	+1
32	Creative expression depends on mastery of the software.	+1
17	Although most tasks in CG can be solved in a variety of ways, there is…	+1
6	CG generated mathematically (e.g., computer-generated fractals) really…	0
41	A lot of what's showcased as CG isn't really creative at all but, instead,…	0
25	Understanding the value of CG requires a new aestheticism.	0
8	CG is more of a craft than an art.	0

APPENDIX F - continued

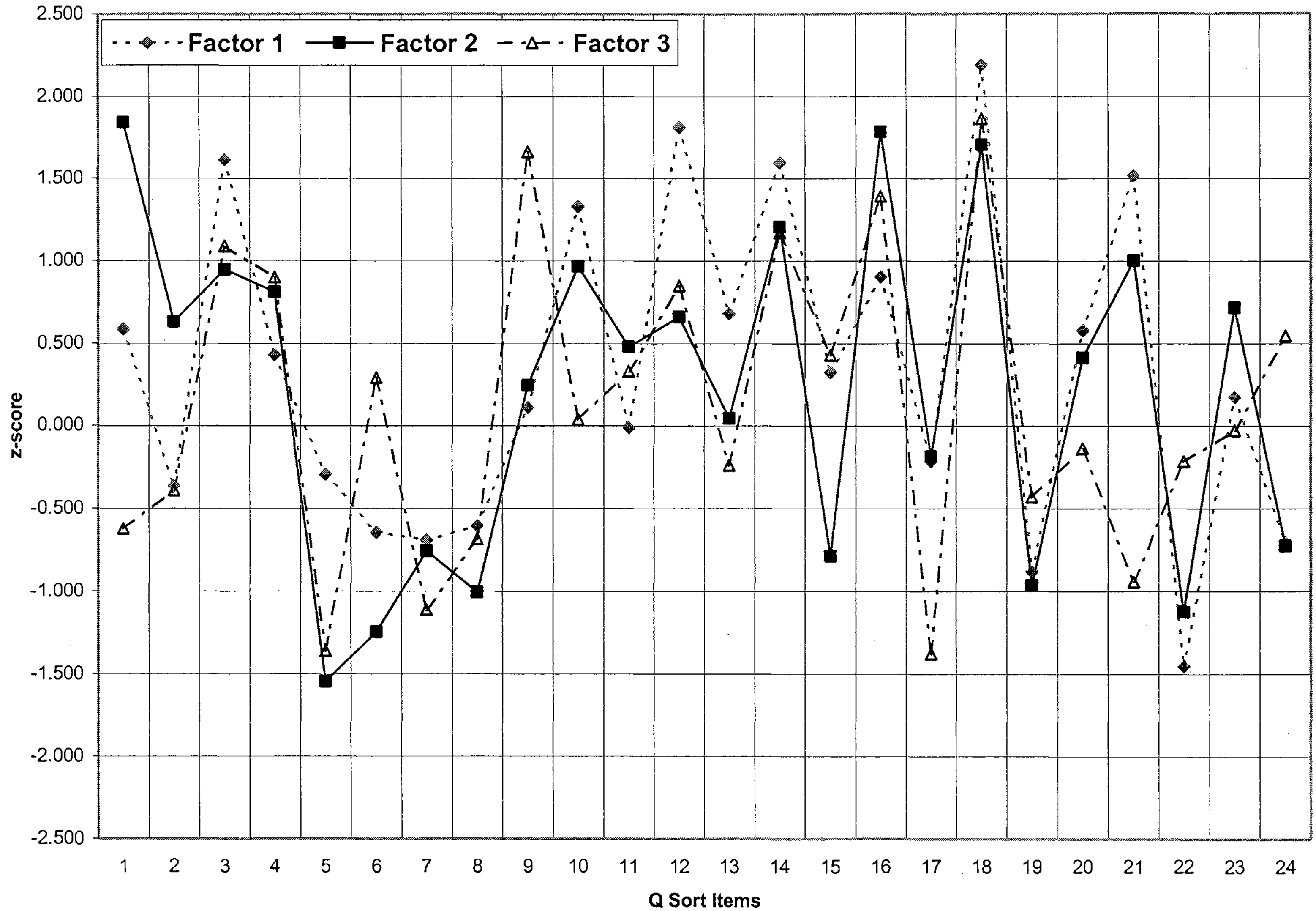
Normalized Factor Scores – Researcher's Q-Sort

No.	Statement	Array Position
2	The computer software requires you to proceed step by step.	0
1	The technology compels you to be a problem solver.	0
46	You can still do extremely well in CG even if you don't know how to draw.	0
26	Images produced by computer will never be valued as much as paintings...	0
33	Those who succeed in the field aren't truly artists, but they aren't really...	-1
47	Using pull-down menus, the "undo" feature, and similar "trial and error"...	-1
22	The need to understand math makes this an impossible career field for many.	-1
38	An understanding of art history is truly beneficial.	-1
7	CG output is best understood as things, not thoughts.	-1
24	The technology complicates the aesthetic process.	-1
31	The technology imposes a structure on the creation of CG that makes it...	-2
5	Because they exist as transient images on a screen, most CG lacks the...	-2
43	Success is determined by which tools (software applications and...	-2
20	CG are, by definition, pragmatic and useful.	-2
13	The aesthetic aspects of the field can't be taught.	-2
30	Those who spend their time scripting or programming to produce CG...	-3
45	Success is defined in terms of commercial acceptance and marketability.	-3
29	The fine arts have a moral foundation that is lacking in CG.	-3
28	The technology reduces color, light, and form to numerical representations...	-3
11	The technology precludes a playful approach to work in the field.	-4
19	CG can't be understood in terms of "truth" and "beauty" like paintings might.	-4
27	Anyone can succeed in this field given enough time and training.	-4
44	Creating with a computer lacks intimacy; the technology inhibits personal...	-5
40	Technology and creativity are like oil and water; they don't mix.	-5

Note: The researcher's Q-sort flags as an Artistic Creative with loadings for Factors 1, 2, and 3 of 0.5951, 0.4107, and 0.2331 respectively.

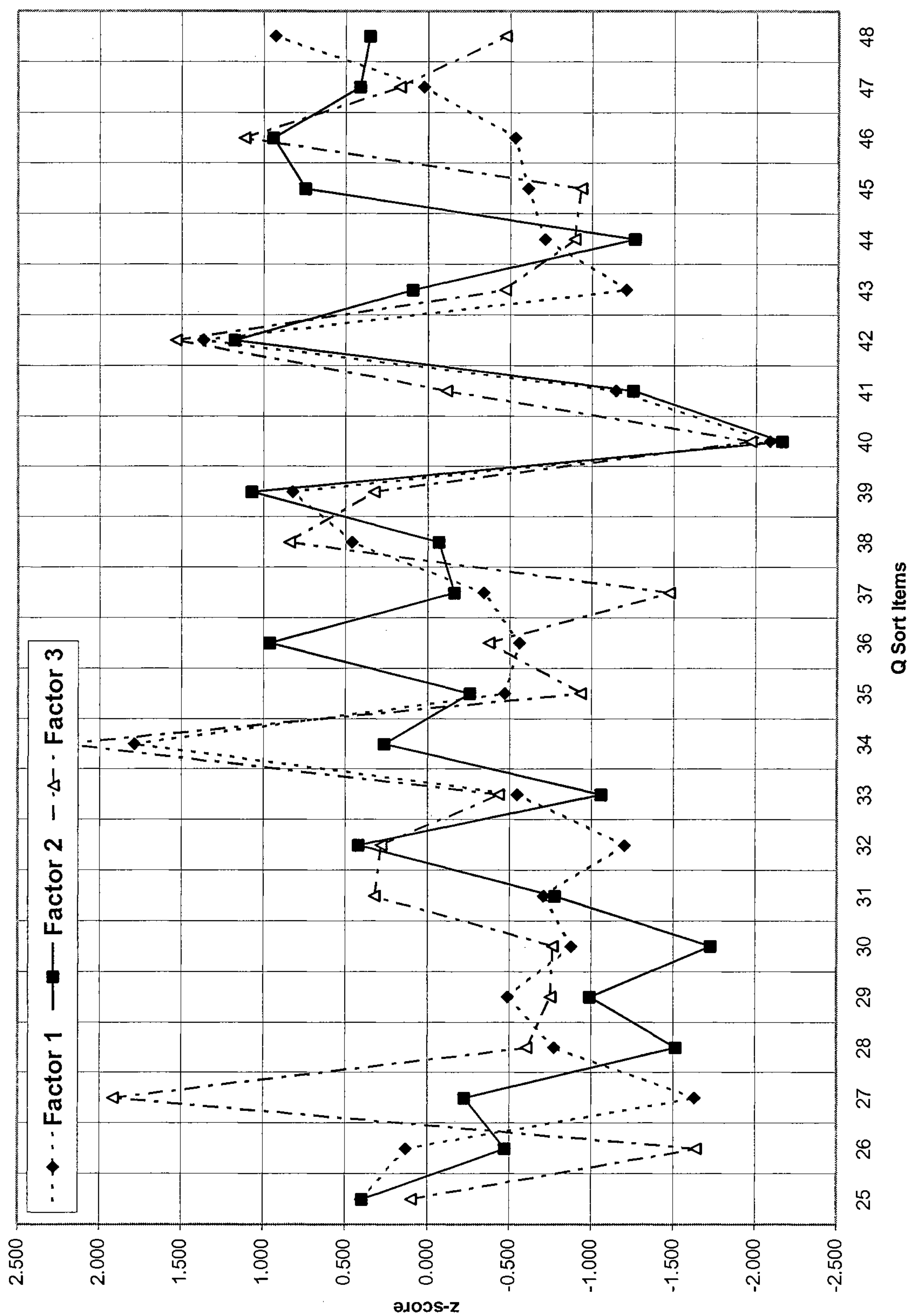
APPENDIX G

Factor Loadings by Q Sort Item – Comparative Plot of Z-Scores



APPENDIX G - continued

Factor Loadings by Q Sort Item – Comparative Plot of Z-Scores



APPENDIX H

Normalized Factor Scores – Factor 1 – Artistic Creatives

No.	Statement	z-score
18	The most important factor for success is a person's motivation.	2.191
12	The CG field is all about communicating ideas and opinions.	1.812
34	The truly creative work in CG takes place before you ever sit down at the...	1.787
3	Success requires the ability to manipulate objects in your head; mentally...	1.615
14	Success requires a vivid imagination.	1.598
21	The CG field requires substantial intelligence.	1.519
42	There's a difference between mastering the software and using it creatively.	1.368
10	The goal of CG production is to elicit an "affective reaction."	1.330
48	Success depends more on a keen eye, an aesthetic sense, and an intuitive...	0.929
16	Success in the field mandates creative types who are both left-brained and...	0.905
39	A logical, orderly, and reasoned approach to work in the field is essential.	0.822
13	The aesthetic aspects of the field can't be taught.	0.681
1	The technology compels you to be a problem solver.	0.584
20	CG are, by definition, pragmatic and useful.	0.578
38	An understanding of art history is truly beneficial.	0.461
4	It's like turning a switch on and off. You go back and forth from logical...	0.431
25	Understanding the value of CG requires a new aestheticism.	0.401
15	The medium is the message.	0.324
23	The nature of the technology means that you really can't "feel" your way...	0.173
26	Images produced by computer will never be valued as much as paintings...	0.132
9	Deadlines, salaries, and other "incentives" cripple creative expression.	0.109
47	Using pull-down menus, the "undo" feature, and similar "trial and error"...	0.025
11	The technology precludes a playful approach to work in the field.	0.013
17	Although most tasks in CG can be solved in a variety of ways, there is...	0.216

APPENDIX H - continued

Normalized Factor Scores – Factor 1 – Artistic Creatives

No.	Statement	z-score
5	Because they exist as transient images on a screen, most CG lacks the...	-0.294
37	This field attracts nerds.	-0.343
2	The computer software requires you to proceed step by step.	-0.363
35	The most creative workers in this field are also the most technologically...	-0.471
29	The fine arts have a moral foundation that is lacking in CG.	-0.491
46	You can still do extremely well in CG even if you don't know how to draw.	-0.531
33	Those who succeed in the field aren't truly artists, but they aren't really...	-0.549
36	This field is defined to a large degree by what software and hardware...	-0.560
8	CG is more of a craft than an art.	-0.606
45	Success is defined in terms of commercial acceptance and marketability.	-0.611
6	CG generated mathematically (e.g., computer-generated fractals) really...	-0.643
7	CG output is best understood as things, not thoughts.	-0.689
24	The technology complicates the aesthetic process.	-0.704
31	The technology imposes a structure on the creation of CG that makes it...	-0.709
44	Creating with a computer lacks intimacy; the technology inhibits personal...	-0.714
28	The technology reduces color, light, and form to numerical representations...	-0.777
30	Those who spend their time scripting or programming to produce CG...	-0.879
19	CG can't be understood in terms of "truth" and "beauty" like paintings might.	-0.883
41	A lot of what's showcased as CG isn't really creative at all but, instead,...	-1.147
32	Creative expression depends on mastery of the software.	-1.203
43	Success is determined by which tools (software applications and hardware)...	-1.208
22	The need to understand math makes this an impossible career field for many.	-1.454
27	Anyone can succeed in this field given enough time and training.	-1.631
40	Technology and creativity are like oil and water; they don't mix.	-2.088

APPENDIX I

Distinguishing Statements Array Positions – Factor 1 – Artistic Creatives

No.	Statement	Factors One	Factors Two	Factors Three
12	The CG field is all about communicating ideas and...	+5	+1	+2
3	Success requires the ability to manipulate objects in...	+4	+2	+3
21	The CG field requires substantial intelligence.	+3	+3	-3
10	The goal of CG production is to elicit an "affective...	+3	+3	0
48	Success depends more on a keen eye, an aesthetic...	+3	0	-1
13	The aesthetic aspects of the field can't be taught.	+2	0	0
1	The technology compels you to be a problem solver.	+2	+5	-2
26	Images produced by computer will never be valued...	+1	-1	-5
5	Because they exist as transient images on a screen...	0	-4	-4
46	You can still do extremely well in CG even if you...	-1	+2	+3
6	CG generated mathematically (e.g., computer...	-2	-3	+1
32	Creative expression depends on mastery of the...	-4	+1	+1
43	Success is determined by which tools (software...	-4	0	-1
27	Anyone can succeed in this field given enough time...	-5	-1	+5

APPENDIX J

Normalized Factor Scores – Factor 2 – Technological Creatives

No.	Statement	z-score
1	The technology compels you to be a problem solver.	1.840
16	Success in the field mandates creative types who are both left-brained and...	1.786
18	The most important factor for success is a person's motivation.	1.705
14	Success requires a vivid imagination.	1.209
42	There's a difference between mastering the software and using it creatively.	1.176
39	A logical, orderly, and reasoned approach to work in the field is essential.	1.069
21	The CG field requires substantial intelligence.	1.005
10	The goal of CG production is to elicit an "affective reaction."	0.966
36	This field is defined to a large degree by what software and hardware...	0.960
3	Success requires the ability to manipulate objects in your head; mentally...	0.948
46	You can still do extremely well in CG even if you don't know how to draw.	0.941
4	It's like turning a switch on and off. You go back and forth from logical...	0.813
45	Success is defined in terms of commercial acceptance and marketability.	0.747
23	The nature of the technology means that you really can't "feel" your way...	0.716
12	The CG field is all about communicating ideas and opinions.	0.660
2	The computer software requires you to proceed step by step.	0.631
11	The technology precludes a playful approach to work in the field.	0.480
32	Creative expression depends on mastery of the software.	0.419
20	CG are, by definition, pragmatic and useful.	0.414
47	Using pull-down menus, the "undo" feature, and similar "trial and error"...	0.413
25	Understanding the value of CG requires a new aestheticism.	0.397
48	Success depends more on a keen eye, an aesthetic sense, and an intuitive...	0.353
34	The truly creative work in CG takes place before you ever sit down at the...	0.263
9	Deadlines, salaries, and other "incentives" cripple creative expression.	0.247
43	Success is determined by which tools (software applications and hardware)...	0.092
13	The aesthetic aspects of the field can't be taught.	0.043

APPENDIX J - continued

Normalized Factor Scores – Factor 2 – Technological Creatives

No.	Statement	z-score
38	An understanding of art history is truly beneficial.	-0.068
37	This field attracts nerds.	-0.164
17	Although most tasks in CG can be solved in a variety of ways, there is…	-0.186
27	Anyone can succeed in this field given enough time and training.	-0.228
35	The most creative workers in this field are also the most technologically…	-0.259
26	Images produced by computer will never be valued as much as paintings…	-0.474
24	The technology complicates the aesthetic process.	-0.723
7	CG output is best understood as things, not thoughts.	-0.755
31	The technology imposes a structure on the creation of CG that makes it…	-0.780
15	The medium is the message.	-0.787
19	CG can't be understood in terms of "truth" and "beauty" like paintings might.	-0.965
29	The fine arts have a moral foundation that is lacking in CG.	-0.993
8	CG is more of a craft than an art.	-1.008
33	Those who succeed in the field aren't truly artists, but they aren't really…	-1.059
22	The need to understand math makes this an impossible career field for many.	-1.126
6	CG generated mathematically (e.g., computer-generated fractals) really…	-1.248
41	A lot of what's showcased as CG isn't really creative at all but, instead,…	-1.252
44	Creating with a computer lacks intimacy; the technology inhibits personal…	-1.263
28	The technology reduces color, light, and form to numerical representations…	-1.516
5	Because they exist as transient images on a screen, most CG lacks the…	-1.548
30	Those who spend their time scripting or programming to produce CG…	-1.730
40	Technology and creativity are like oil and water; they don't mix.	-2.163

APPENDIX K

Distinguishing Statements Array Positions – Factor 2 – Technological Creatives

No.	Statement	Factors One	Factors Two	Factors Three
1	The technology compels you to be a problem solver.	+2	+5	-2
21	The CG field requires substantial intelligence.	+3	+3	-3
10	The goal of CG production is to elicit an "affective...	+3	+3	0
36	This field is defined to a large degree by what software...	-1	+3	0
45	Success is defined in terms of commercial acceptance...	-1	+2	-3
23	The nature of the technology means that you really can't...	+1	+2	0
2	The computer software requires you to proceed step by step.	0	+1	-1
48	Success depends more on a keen eye, an aesthetic sense...	+3	0	-1
34	The truly creative work in CG takes place before you...	+4	0	+5
43	Success is determined by which tools (software...	-4	0	-1
38	An understanding of art history is truly beneficial.	+1	0	+2
27	Anyone can succeed in this field given enough time and...	-5	-1	+5
26	Images produced by computer will never be valued as...	+1	-1	-5
15	The medium is the message.	+1	-2	+2
33	Those who succeed in the field aren't truly artists, but...	-1	-3	-1
6	CG generated mathematically (e.g., computer-generated...	-2	-3	+1
28	The technology reduces color, light, and form to...	-3	-4	-1
30	Those who spend their time scripting or programming to...	-3	-5	-2

APPENDIX L

Normalized Factor Scores – Factor 3 – Romantic Creatives

No.	Statement	z-score
34	The truly creative work in CG takes place before you ever sit down at the…	2.217
27	Anyone can succeed in this field given enough time and training.	1.919
18	The most important factor for success is a person's motivation.	1.864
9	Deadlines, salaries, and other "incentives" cripple creative expression.	1.662
42	There's a difference between mastering the software and using it creatively.	1.535
16	Success in the field mandates creative types who are both left-brained and…	1.392
14	Success requires a vivid imagination.	1.171
46	You can still do extremely well in CG even if you don't know how to draw.	1.118
3	Success requires the ability to manipulate objects in your head; mentally…	1.088
4	It's like turning a switch on and off. You go back and forth from logical…	0.901
12	The CG field is all about communicating ideas and opinions.	0.850
38	An understanding of art history is truly beneficial.	0.842
24	The technology complicates the aesthetic process.	0.544
15	The medium is the message.	0.431
11	The technology precludes a playful approach to work in the field.	0.330
39	A logical, orderly, and reasoned approach to work in the field is essential.	0.327
31	The technology imposes a structure on the creation of CG that makes it…	0.321
6	CG generated mathematically (e.g., computer-generated fractals) really…	0.292
32	Creative expression depends on mastery of the software.	0.278
47	Using pull-down menus, the "undo" feature, and similar "trial and error"…	0.170
25	Understanding the value of CG requires a new aestheticism.	0.099
10	The goal of CG production is to elicit an "affective reaction."	0.038

APPENDIX L - continued

Normalized Factor Scores – Factor 3 – Romantic Creatives

No.	Statement	z-score
23	The nature of the technology means that you really can't "feel" your way...	-0.027
41	A lot of what's showcased as CG isn't really creative at all but, instead,...	-0.115
20	CG are, by definition, pragmatic and useful.	-0.138
22	The need to understand math makes this an impossible career field for many.	-0.216
13	The aesthetic aspects of the field can't be taught.	-0.240
36	This field is defined to a large degree by what software and hardware...	-0.374
2	The computer software requires you to proceed step by step.	-0.389
19	CG can't be understood in terms of "truth" and "beauty" like paintings might.	-0.431
33	Those who succeed in the field aren't truly artists, but they aren't really...	-0.434
43	Success is determined by which tools (software applications and hardware)...	-0.472
48	Success depends more on a keen eye, an aesthetic sense, and an intuitive...	-0.473
28	The technology reduces color, light, and form to numerical representations...	-0.607
1	The technology compels you to be a problem solver.	-0.620
8	CG is more of a craft than an art.	-0.685
29	The fine arts have a moral foundation that is lacking in CG.	-0.752
30	Those who spend their time scripting or programming to produce CG...	-0.765
44	Creating with a computer lacks intimacy; the technology inhibits personal...	-0.894
35	The most creative workers in this field are also the most technologically...	-0.936
45	Success is defined in terms of commercial acceptance and marketability.	-0.936
21	The CG field requires substantial intelligence.	-0.943
7	CG output is best understood as things, not thoughts.	-1.113
5	Because they exist as transient images on a screen, most CG lacks the...	-1.363
17	Although most tasks in CG can be solved in a variety of ways, there is...	-1.381
37	This field attracts nerds.	-1.475
26	Images produced by computer will never be valued as much as paintings...	-1.641
40	Technology and creativity are like oil and water; they don't mix.	-1.971

APPENDIX M

Distinguishing Statements Array Positions – Factor 3 – Romantic Creatives

No.	Statement	Factors One	Factors Two	Factors Three
27	Anyone can succeed in this field given enough time…	-5	-1	+5
9	Deadlines, salaries, and other "incentives" cripple…	0	0	+4
24	The technology complicates the aesthetic process.	-2	-1	+2
31	The technology imposes a structure on the creation…	-2	-2	+1
6	CG generated mathematically (e.g., computer…	-2	-3	+1
10	The goal of CG production is to elicit an "affective…	+3	+3	0
41	A lot of what's showcased as CG isn't really creative…	-3	-3	0
20	CG are, by definition, pragmatic and useful.	+2	+1	0
22	The need to understand math makes this an…	-4	-3	0
43	Success is determined by which tools (software…	-4	0	-1
48	Success depends more on a keen eye, an aesthetic…	+3	0	-1
1	The technology compels you to be a problem solver.	+2	+5	-2
21	The CG field requires substantial intelligence.	+3	+3	-3
17	Although most tasks in CG can be solved in a…	0	-1	-4
37	This field attracts nerds.	0	0	-4
26	Images produced by computer will never be valued…	+1	-1	-5

APPENDIX N

Factor Q-Sort Values for Statements Sorted by Consensus vs. Disagreement

No.	Statement	Factors One	Factors Two	Factors Three
40	Technology and creativity are like oil and water; they...	-5	-5	-5
25	Understanding the value of CG requires a new...	+1	0	0
42	There's a difference between mastering the software and...	+3	+4	+4
47	Using pull-down menus, the "undo" feature, and similar...	0	+1	+1
8	CG is more of a craft than an art.	-1	-2	-2
7	CG output is best understood as things, not thoughts.	-2	-1	-3
14	Success requires a vivid imagination.	+4	+4	+3
18	The most important factor for success is a person's...	+5	+4	+4
4	It's like turning a switch on and off. You go back and...	+1	+2	+2
29	The fine arts have a moral foundation that is lacking in...	-1	-2	-2
11	The technology precludes a playful approach to work in...	0	+1	+1
44	Creating with a computer lacks intimacy; the technology...	-2	-4	-2
19	CG can't be understood in terms of "truth" and "beauty"...	-3	-2	-1
33	Those who succeed in the field aren't truly artists, but...	-1	-3	-1
35	The most creative workers in this field are also the most...	0	-1	-3
3	Success requires the ability to manipulate objects in...	+4	+2	+3
20	CG are, by definition, pragmatic and useful.	+2	+1	0
39	A logical, orderly, and reasoned approach to work in the...	+2	+3	+1
23	The nature of the technology means that you really can't...	+1	+2	0
16	Success in the field mandates creative types who are...	+2	+5	+3
38	An understanding of art history is truly beneficial.	+1	0	+2
13	The aesthetic aspects of the field can't be taught.	+2	0	0
28	The technology reduces color, light, and form to...	-3	-4	-1
30	Those who spend their time scripting or programming to...	-3	-5	-2

APPENDIX N - continued

Factor Q-Sort Values for Statements Sorted by Consensus vs. Disagreement

No.	Statement	Factors One	Factors Two	Factors Three
2	The computer software requires you to proceed step by...	0	+1	+1
31	The technology imposes a structure on the creation of...	-2	-2	+1
12	The CG field is all about communicating ideas and...	+5	+1	+2
41	A lot of what's showcased as CG isn't really creative at...	-3	-3	0
22	The need to understand math makes this an impossible...	-4	-3	0
43	Success is determined by which tools (software...	-4	0	-1
10	The goal of CG production is to elicit an "affective...	+3	+3	0
15	The medium is the message.	+1	-2	+2
5	Because they exist as transient images on a screen, most...	0	-4	-4
17	Although most tasks in CG can be solved in a variety of...	0	-1	-4
48	Success depends more on a keen eye, an aesthetic sense,...	+3	0	-1
37	This field attracts nerds.	0	0	-4
24	The technology complicates the aesthetic process.	-2	-1	+2
6	CG generated mathematically (e.g., computer-generated...	-2	-3	+1
36	This field is defined to a large degree by what software...	-1	+3	0
9	Deadlines, salaries, and other "incentives" cripple...	0	0	+4
45	Success is defined in terms of commercial acceptance...	-1	+2	-3
32	Creative expression depends on mastery of the software.	-4	+1	+1
26	Images produced by computer will never be valued as...	+1	-1	-5
46	You can still do extremely well in CG even if you don't...	-1	+2	+3
34	The truly creative work in CG takes place before you...	+4	0	+5
1	The technology compels you to be a problem solver.	+2	+5	-2
21	The CG field requires substantial intelligence.	+3	+3	-3
27	Anyone can succeed in this field given enough time and...	-5	-1	+5

Note: Consensus and disagreement based on variance across normalized factor scores; organized from greatest consensus at top of table to greatest disagreement at bottom.

APPENDIX O

Oklahoma State University
Institutional Review Board

Protocol Expires: 10/14/2003

Date: Tuesday, October 15, 2002 IRB Application No ED0331

Proposal Title: A Q-METHODOLOGY STUDY OF STUDENT BELIEFS ABOUT THE CHARACTER OF CREATIVITY IN THE EMERGING DISCIPLINE OF COMPUTER GRAPHICS

Principal
Investigator(s):

Anthony Alley
1309 Woodview Lane
Edmond, OK 73013

Bruce Petty
261 Willard
Stillwater, OK 74078

Reviewed and
Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Dear PI :

Your IRB application referenced above has been approved for one calendar year. Please make note of the expiration date indicated above. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

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

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

Please note that approved projects are subject to monitoring by the IRB. If you have questions about the IRB procedures or need any assistance from the Board, please contact Sharon Bacher, the Executive Secretary to the IRB, in 415 Whitehurst (phone: 405-744-5700, sbacher@okstate.edu).

Sincerely,

Carol Olson

Carol Olson, Chair
Institutional Review Board

VITA 2

Anthony D. Alley

Dissertation: A Q-METHODOLOGICAL STUDY OF STUDENT BELIEFS ABOUT THE CHARACTER OF CREATIVITY IN THE EMERGING DISCIPLINE OF COMPUTER GRAPHICS

Major Field: Curriculum and Instruction

Biographical:

Personal Data: Born in Parkersburg, West Virginia, on September 24, 1953.

Education: Graduated from Mentor High School, Mentor, Ohio in 1971. Received a Bachelor of Arts degree in Psychology from the University of Cincinnati, Ohio in 1975. Completed a Master of Education degree with a major in Educational Psychology in 1982 at the University of Oklahoma, Norman. Received an Education Specialist degree in Adult Education from Troy State University Montgomery, Alabama, in 2001. Completed the requirements for the Doctor of Education degree with a major in Curriculum and Instruction and a concentration in Information / Communication at Oklahoma State University in May 2003.

Experience: Retired from the United States Air Force in 1995 having served as a tactical reconnaissance pilot, instructor pilot for undergraduate pilot training and pilot instructor training programs, curriculum designer, exchange office with the Royal Air Force (Great Britain), and Associate Dean of Education and Faculty at the USAF Air Command and Staff College. Currently employed with Oklahoma Christian University as an Assistant Professor of Art and Design and an Assistant Professor of Mass Communication, teaching courses in the design and development of interactive multimedia and computer graphics.

Professional Memberships: Association for Computing Machinery Special Interest Group on Graphics and Interactive Techniques (ACM SIGGRAPH); International Society for the Scientific Study of Subjectivity; Kappa Delta Pi; Phi Kappa Phi.