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UNIVERSITY OF CALIFORNIA, SAN DIEGO
CALIFORNIA STATE UNIVERSITY, SAN MARCOS

Integration of the Arts in STEM:
A Collective Case Study of Two Interdisciplinary University Programs

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Education

in

Educational Leadership

by

Sheena Ghanbari

Committee in charge:

California State University, San Marcos
Professor Merryl Goldberg, Chair
Professor Jennifer Jeffries

University of California, San Diego
Professor Alan Daly
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2014

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Chair

University of California, San Diego
California State University, San Marcos

2014

Dedication

To my team, Mom, Dad, and Nay, you are my rocks, thank you for your unwavering love and support. As creative STEAM practitioners, you are each a living inspiration for this research. This dissertation is dedicated to my family.

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Chapter 3, *Pioneering University Programs at the Intersections of the Arts and STEM*, in part is being prepared for submission of publication. The dissertation author was the primary investigator of this material.

Chapter 4, *Learning in Interdisciplinary Environments: a Collective Case Study of Two University Programs that Integrate the Arts with STEM*, is in part being prepared for submission for publication. The dissertation author was the primary investigator of this material.

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Abstract Of The Dissertation

Integration of the Arts in STEM:
A Collective Case Study of Two Interdisciplinary University Programs

by

Sheena Ghanbari

Doctor of Education in Educational Leadership

University of California, San Diego, 2014
California State University, San Marcos, 2014

Professor Merryl Goldberg, Chair

The arts represent a range of visual and performance based fields that have shown to have profound intrinsic and cognitive benefits. Building on this premise, one of the emerging ways to integrate the arts with other academic disciplines is the inclusion of the arts with the Science, Technology, Engineering, and Math (STEM) learning, renaming it STEAM. This qualitative study aims to understand the experiences of individuals that have pioneered university programs that integrate the arts with STEM and to share student learning experiences within these interdisciplinary programs. Bolman and Deal's theories of organizational development, sociocultural theory, and experiential learning theory are the three guiding frameworks in the analysis of leadership and student learning in the selected university programs. Using a collective case study methodology, I compare and contrast extant and interview data to paint the picture of two distinct university programs.

Chapter One: Introduction

Art making reflects some of the landmarks of human accomplishment across the globe and, while few achieve such feats, countless individuals from all walks of life can appreciate them. Van Gogh's *Starry Night*, Maya Angelou's *I Know Why the Caged Bird Sings*, and Beethoven's *Fifth Symphony* are just a few examples of artwork that is recognized among an international audience. A general understanding of the evolution and importance of the arts in education helps set the stage for this study. In addition to background information about the arts in education, this chapter presents the purpose of this study, research questions, and general frameworks and methodology incorporated to address the research questions. This section also introduces the practice of integrating the arts with STEM learning to create STEAM.

Background

The question of what constitutes the arts can be subjective; traditionally the arts include both visual and performance based practices that use a variety of media. The congressional definition of the arts adopted in 1965 by the National Endowment for the Arts (NEA) and the National Endowment for the Humanities (NEH) states:

The term 'the arts' includes, but is not limited to, music (instrumental and vocal), dance, drama, folk art, creative writing, architecture and allied fields, painting, sculpture, photography, graphic and craft arts, industrial design, costume and fashion design, motion pictures, television, radio, film, video, tape and sound recording, the arts related to the presentation, performance, execution, and exhibition of such major art forms, all those traditional arts practiced by the diverse peoples of this country and the study and application of the arts to the human environment (20 U.S.C. 952 (b)).

The congressional definition of the arts is applied while being mindful that the arts in education are predominantly categorized as visual arts, music, theater, and dance.

Within the field there has been a fair amount of research on the relationship between the arts and cognitive development. More specifically, research demonstrates that art education has an impact in developing critical thinking skills (Burton, Horowitz, & Abeles, 2000; Catterall 2012; Lampert, 2006). Complementing the work of arts researchers and educators, cognitive psychologists and neuroscientists have also become supporters of embracing the arts to improve learning. Discoveries regarding mirror-neuron cells are providing a complementary scientific narrative that connects the arts with critical thinking in addition to a host of other cognitive and emotional competencies (Blatt-Gross, 2010; Jeffers 2009).

Despite the apparent benefits of integrating the arts, there has been resistance in establishing the arts as a viable and complex academic branch of learning that is essential to a well-rounded education (Dewey, 1934; Eisner 2002; Heilig, Cole, & Aguilar, 2010). The arts are generally the first programs to be cut during economically challenging times (Rabkin & Redmond, 2004; Winner & Cooper, 2000). In order to combat policies that deter or neglect the inclusion of the arts there is a continued push by arts advocacy groups to measure the impact of the arts in schools and communities.

Other disciplines, notably the sciences, have less of struggle in establishing their importance in the schema of the educational landscape. Ensuring that the United States is a leader in science, technology, engineering, and math (STEM) education has been a focus of the Obama administration. Additionally, the National Science Foundation (NSF) budget is overwhelmingly larger than the funding for the National Endowment for

the Arts (NEA). In fiscal year 2012 the NEA has allocated \$135,000,000, a 16 percent decrease from the previous year. In contrast, the NSF has allocated \$7,003,100,000,000 for fiscal year 2012, a 13 percent increase from the prior year (Mikulski, 2011). While there are other entities in both the sciences and the arts that contribute towards financial backing, the NEA and the NSF represent the primary federal funding agency in the respective fields. This disproportionate spending between the arts and the sciences is telling of the value placed on the arts from a federal policy perspective. This messaging that values the sciences over the arts is reflected in the United States education system as well.

Educational policies have created a questionable climate for the future of the arts. K-12 arts coursework is marginalized by legislation like No Child Left Behind (NCLB) that focuses on high stakes testing, as well as math and reading improvement. While the legislation includes arts standards, many schools do not have the means to enforce these standards (Beveridge, 2010; Efland, 2005). Required arts coursework is also not established at the middle and high school level, with over 40% of institutions having no arts requirement for graduation (Parsad & Spiegelman, 2012).

Similar challenges have also been cited in higher education. “Today, American students demands for postsecondary art instruction clashes with the economic realities of postsecondary education” (Warburton, 2006, p. 11). This misalignment between the student demand and diminishing faculty positions presents an unfair burden to full-time arts faculty in comparison to their counterparts in other subjects. Despite their mounting workload, arts faculty members are also earning less competitive wages than faculty in other departments (Warburton, 2006). Historically, “vital” academic subjects like the

sciences and mathematics have taken precedence over inclusion of the arts (Janson & Janson, 2004).

Despite some of the inconsistency surrounding funding and the integration of the arts, recent research and practice present a promising future for arts education. An international survey of Chief Executive Officers (CEOs) and university students have revealed that both students and CEOs agree that creativity is the most important emerging competency for future leaders. The CEO's interviewed identified different sources of creative energy and the arts reflected one of the four core categories of creativity that were identified (IBM, 2010). Arts education and creativity have been reiterated in popular literature as important issues for promoting innovation. The work of Sir Ken Robinson, Richard Florida, and Daniel Pink are all have shed a light on the timely importance of creativity. Their books respectively, *Out of our Minds: Learning to be Creative* (2011), *The Rise of the Creative Class* (2004), and *A Whole New Mind* (2005), have taken scholarly literature about the importance of the arts and creativity and positioned this ideal in mainstream dialogues.

This awareness about the importance of the arts and creativity support the shift from STEM to STEAM. This emerging strategy strives to heighten awareness around the benefits of the arts by establishing the relevance and integration of the arts with STEM based initiatives, thus creating the STEM to STEAM (STEM plus art) movement (Clark & Button, 2010; Tarnoff, 2010). The growing prevalence of STEAM in practice has prompted some academic attention on the subject and these studies will be summarized in the literature review. The integration of the arts with STEM efforts has the potential to

be a promising and mutually beneficial initiative that enhances learning in technical fields while bringing the contributions of the arts to the forefront.

Purpose of the Study

Despite the growing momentum behind this movement there is minimal research documenting successful STEAM programs. STEM to STEAM is more recognized as a K-12 term and there is less higher education research that addresses the direction of this movement (Sharapan, 2012). There have been several opinion pieces about the positive contributions of STEAM, but there are still limited empirical studies specifically focused on STEAM programming at the university level. This study aims to fill some of that void by assessing the contributions of the arts to the STEM movement at the university level by exploring the leadership exhibited by those involved in establishing STEAM programs in addition to examining student learning in these programs.

Research Questions

The current policies, practices, and the growing literature around the cognitive benefits of the arts have informed the general direction of this study. These factors, coupled with the growth of arts and STEM collaborations, have created the foundation to explore the following research questions:

1. What are the experiences of those involved in developing university programs that integrate the arts with STEM?
 - a. Who provided the leadership to develop the programs and what actions did they take?
2. What are student learning experiences in university programs that integrate the arts with STEM?

- a. If student learning outcomes been established, how do students perceive the degree to which the outcomes were achieved?

In order to answer these research questions a collective case study design was applied.

Theoretical Frameworks

This study will incorporate three theoretical lenses to frame the existing literature and data analysis.

Bolman and Deal. One facet of this study will be to examine the development of university programs that integrate the arts and STEM. Bolman and Deal's frames for organizational development will be applied as means of describing the actions of leaders as they developed programs that integrate the arts and STEM. The authors' pose four frames of organizational development: structural, human resource, political, and symbolic. Each frame presents a unique angle for leaders to approach their organization. The conceptual underpinnings of this theoretical framework will be further developed in the review of the literature and the application of this framework will be explained in Chapter 3.

Sociocultural theory. This study also analyzes the student learning experiences and outcomes within programs that integrate the arts with STEM. Sociocultural theory is a fitting lens to understanding the complexities of knowledge construction. Largely informed by Vygotsky, (1980) his seminal work in the field of psychology resulted in the development of theoretical framework that relied on a multifaceted interpretation of learning and development. In theory, this approach highlights the social elements of and semiotics in human development, while also taking into account genetic factors that

influence learning (Steiner & Mahn, 1996). The methodological foundation of a sociocultural approach to learning will be presented in the literature review and the application of this framework will be elaborated in Chapter 4.

Experiential learning. The third and final theoretical framework integrated in this study is experiential learning. This educational theory was established by Kolb (1984) and draws from the work of several seminal thinkers, most notably, Dewey, Lewin, and Piaget. At its crux, experiential learning embraces the fundamental role of experience in learning. With sociocultural theory, this lens is employed to examine student learning experiences and also presents a holistic approach to learning that acknowledges subjectivity in the learning process and combines “experience cognition, perception, and behavior” (Kolb, 1984). The specific learning cycles that inform experiential learning are elaborated in Chapter 2 and then applied with the findings presented in Chapter 4.

Methods Overview

This research is exploratory and employs qualitative methods. Qualitative research relies on the premise that the world is not a fixed or measurable place, and therefore multiple and shifting constructions and interpretations of reality are inherent in qualitative research (Merriam, 1998; Esterberg 2002). A qualitative approach is the ideal research method for this study because it will allow for a deep and narrow analysis of a few programs that integrate the arts with a STEM discipline.

A collective case study design will be utilized to organize and synthesize the extrapolated data. A collective case study allows for a comparison of multiple cases within a bound criteria. The two university programs included in this study integrate the

arts with a STEM discipline. Each program is also housed within a Research I University and has been in existence for at least five years. The use of these selection criteria forms the “bound criteria,” which is a hallmark of a collective case study methodology.

Within the collective case study, multiple sources of data were collected in an effort to create a comprehensive picture of both programs. Site visits took place at both programs and extant data was collected. This was followed by semi-structured interviews with program founder, students, and alumni.

Background of each program. The two selected programs are an ArtScience program and ArtTechnology program respectively. The ArtScience program was established in a science department within a large Research 1 university. The program founders are a full professor in the sciences and an established public artist. They began teaching courses in 1997 and received internal and external support to officially establish the program in 2006. The program courses are taught by five core faculty members in addition to four collaborating faculty at the program. There are 175 to 250 students who are taking ArtScience courses annually and the university itself is comprised of approximately 26,000 undergraduate students. The three most saturated demographics of the university are Asian, White, and Hispanic representing 41%, 32%, and 16% respectively.

The ArtTechnology program exists outside of an academic department and is a college within a large Research 1 university. Leadership for establishing this program was provided by a Founding Provost who was hired to establish the program with the assistance of a founding faculty committee. The ArtTechnology program houses 3,625 undergraduate students of the approximately 24,000 undergraduate students at the

university. Courses are taught by one of the six individuals at the program or by a faculty member from a different department. The program rotates faculty from different departments but the general structure of required coursework is fixed. There are three sequential courses, an upper-division writing requirement, and an applied practicum or internship for students. The ethnic makeup of the universities are similar. The predominant student demographics of the university, which houses the ArtTechnology program, is 45% Asian, followed by 23% White, then 16% Hispanic.

Dissertation organization. This dissertation is comprised of an introductory section, a section reviewing the literature, and is followed by two stand-alone articles that address the first research question and second research question, respectively. The first chapter provides the necessary context to understand the importance and relevance of the study. This general overview situates the reader, presents the research questions for the study, and sets the stage for the literature review. After establishing this backdrop, the relevant research on the benefits of the arts is synthesized in the second section. In addition to providing an overview of pertinent research, this section will also address the gaps in current research. In the third and fourth chapter the methodology is further explained and findings from data collection are presented and analyzed. Finally, in the fifth chapter the prior sections are reviewed and expanded upon in a discussion that includes the significance and future implications of this research.

Chapter Two: Literature Review

This chapter elaborates the relevant literature and the selected theoretical frames for this research. This study is inspired and informed by the existing literature on the learning benefits of the arts at the K-16 levels and will also provide context about the state of arts policies. Within the analyses of arts and learning issues, topics of interest include transfer of learning within the arts and the neurological links between learning and the arts. Beyond exploring the trends in arts education literature, Bolman and Deal's frames of organizational development, sociocultural theory, and experiential learning theory are elaborated. This section will also provide background information on the intersection of the arts with each STEM discipline prior to engaging in the literature around the STEM to STEAM movement.

Arts and Learning

The cognitive benefits of artistic endeavors were brought to the forefront with John Dewey's (1934) seminal work, *Art as Experience*. His pragmatic theory of aesthetics contributed towards the acceptance of the arts as a viable and complex academic branch of learning that is essential to a well-rounded education. Traditionally, arts coursework is *inquiry-based*, which means it revolves around questioning and understanding concepts versus finding the answer to a given problem. The arts are highly interdisciplinary and regularly require an individual to engage in multiple skills (Fiske, 1999). An inquiry-based model of learning, such as that provided by an arts curriculum, requires higher levels of thinking and promotes learning (Simon & Hicks, 2006). There are some empirical studies, in K-12 and higher education, which support the benefit of arts in curriculum. These studies provide evidence that learning in the arts improves

general engagement and enhances the ability to think critically (Deasy, 2002; Fiske, 1999; Gullatt, 2008).

The majority of research in arts education has been conducted in a K-12 setting. This is logical because there is a natural tendency to rely on the arts in the process of childhood cognitive development. Studies in K-12 have shown that a high level of exposure to the arts has positive impacts on learning and student achievement (Catterall, Chapleay, & Iwanaga 1999; Catterall 2012; Burton, Horowitz, & Abeles, 2000; Hetland, 2012). While there have been fewer studies that focus solely on the integration of the arts in higher education, all of the literature that highlights the benefits of the arts for student learning is relevant in making a case for continued arts integration.

There have been a few studies focusing on art and critical thinking at the university level that provide a foundation for further research. An assessment of the arts in public universities establishes that learning in the arts exerts its greatest effect on truth-seeking, critical thinking maturity, and open-mindedness (Lampert, 2006). Moreover, arts exposure to non-arts majors has also had positive effects. Students were able to capitalize on the inquiry-based nature of their arts coursework and apply this to their respective coursework, thus analyzing problems in a different light and arriving at multiple solutions. Without this perspective from arts coursework there may have only been one solution or no solutions (Barlow 2002; Costantino, Kellam, Cramond, & Crower 2010).

The arts have the ability to enrich individuals of different ages and of varying achievement levels because “the creative arts do not discriminate” (Simon & Hicks, 2006, p. 87). Economically disadvantaged, academically struggling, and minority

students have cited the supportive and inclusive nature of the arts to be a mechanism that overcomes obstacles in their personal and academic lives. By boosting the imagination and encouraging new ways of understanding, the arts broaden the constructs of a formal education (Simon & Hicks, 2006). Across all educational levels, the arts act as healthy outlets for expression as well as a means of improving cognitive development such as higher level thinking skills. While some recent arts outreach initiatives target underprivileged communities, exposure to appropriate and affordable arts education in these communities tends to be limited (Oreck, Baum, & McCartney, 2000).

The boundless challenges that the arts can provide are one of the characteristics that resonate with high achieving students. Academically gifted students have inclinations to participate in the arts; arts coursework can be limitless and provide these students with challenges (Smutny, 2011). This further supports the notion that the arts have distinct positive attributes that encourage learning for students with various backgrounds and functioning at a range of different achievement levels.

While distinct art forms have been linked to different capacities, heightened critical thinking is an emerging theme across involvement in the arts. There is more evidence supporting the cognitive benefits of music and theater than visual arts and dance (Catterall, 2012). High involvement in theater arts and music has been directly connected to above average academic performance. Specifically, music has been repeatedly correlated with improved mathematics scores and the theatre arts are persistently linked with improved language arts skills (Burton, Horowitz, & Abeles, 2000; Martinez et. al 2008; Walker, Tabone, & Weltsek, 2011). A recent study supported by the Department of Education shows significant findings by Developing Reading Education with Arts

Methods (DREAM). The DREAM Institute provided visual arts and theatre instruction to third and fourth grade teachers and found that DREAM students scored significantly higher on the standardized language arts tests than control group students (Saraniero & Goldberg, 2011).

Transfer of learning. Transfer, or the ability to have positive effects that extend beyond the exact conditions of learning, is at the core of the educational system (Bransford & Schwartz, 1999). Research continues to show that learning through the arts has the ability to transcend across different disciplines and enrich the curriculum even if the subject seems completely unrelated to the arts (Burton, Horowitz, & Abeles, 2000). The concept of the transfer of learning has been of interest to education and cognitive science researcher for over a century and in the 1990s there was a surge of interest in transfer research focusing on the effects of improved academic achievement through the arts (Catterall, 2002).

Rauscher's (1995) seminal study at the University of California, Irvine boldly asserted that students' cognitive and spatial abilities were enhanced after listening to Mozart's 1781 sonata for two pianos in D major. This research had a pronounced presence across national media outlets and encouraged further research regarding the secondary benefits of the arts. The *New York Times* subsequently published an article focused on how listening to Mozart gives college-bound students an edge on the SAT; the general consensus was that Mozart makes you smarter (Deasy, 2002). There have been criticisms regarding the validity of the findings associated with the "Mozart Effect." Later studies have not been able to replicate these results and have found that there is no statistically significant difference between the group of students that were exposed to

Mozart and those that were not (McElvie & Low, 2002; Waterhouse, 2006).

While some groups consider the increased attention on the resulting benefits of the arts to be advantageous to the arts, prominent scholars have taken a closer look at the past data and have determined that true transfer of learning is a difficult feat to achieve. It is nearly impossible to establish a causal relationship because positive traits associated with arts, such as creativity, imagination, and critical or divergent thinking, are not exclusive to the arts. Similarly, the assumption that studies citing the transfer of learning from arts are unidirectional, meaning that the benefits are moving from the arts to another discipline, and does not account for a potentially symbiotic relationship (Burton, Horowitz, & Abeles, 2000; Eisner 1998). For these reasons, scholars caution against the argument that the transfer of learning is the *most* valuable attribute of arts education.

Strengths based tests of students with high arts involvement has been linked to an array of dispositions including: risk-taking, task persistence, ownership of learning, self-confidence, critical thinking skills, and social tolerance (Catterall, 2012; Gullatt, 2008). Studies that highlight specific benefits from learning in the arts are more widely accepted and encouraged than studies that simply aim to show how the arts can strengthen another academic subject. It is dangerous to value any academic discipline over another; “to diminish one is to diminish the possibility and promise of them all” (Burton, Horowitz, & Abeles, 2000, p. 255).

The issue of transfer has come to dominate research on the arts and, according to some researchers, tarnish the arts education debate. The cognitive capacities that are associated with the arts are not negligible, but the overemphasis on these outcomes rather than others has resulted in a skewed framework for justifying the importance of non-

cognitive and intrinsic benefits of the arts (Gullatt, 2008). Prominent authorities in the field echo that the focus of arts educators should remain in showcasing contributions that are unique to the arts. Related and ancillary effects of the arts should not be the predominant voice in promoting arts education (Eisner, 2002). The concern is that justifying the arts by their power to affect learning in a different academic area actually increases vulnerability by expecting too much from the arts (Winner & Cooper, 2000). The danger in this type of reasoning is that the arts will lose their position if improved academic achievement is not seen as a result of arts coursework (Hetland & Winner, 2001; Hatfield, 1999).

Additionally, there is controversy regarding the transfer of learning from the arts because there have been conflicting findings in the research. The lack of clarity in establishing how ever-present or rare transfer effects are is one of the reasons why researchers are at odds with findings regarding transfer in the arts. There are also far more studies regarding the transfer of skills from the arts that establish correlation rather than causality. Some studies also cite political and social pressures to articulate the value of the arts as and showcase how studying this field can serve broader goals and broader audiences. Despite all of the disagreement regarding the validity and importance of the transfer of learning through the arts, much of this criticism could be remedied if future research does not continue to ignore the intrinsic benefits of the arts (McCarthy, Ondaatje, Zakaras, & Brooks, 2005).

Arts education and the neural functioning. Education researchers are not the only group that has produced literature that supports the benefits of the arts in education. In an effort to learn how to live enjoyably and productively an avenue has opened up for

cognitive psychologists and neuroscientists studying arts education and cognitive capacities. Research shows that there are specific brain networks, called neural networks, which have been associated with different art forms. These networks are outlined in the figure below. While this theory establishes that each distinct art form involves a separate neural network, there is less conclusive evidence describing if and how these networks overlap (Gazzaniga, 2008).

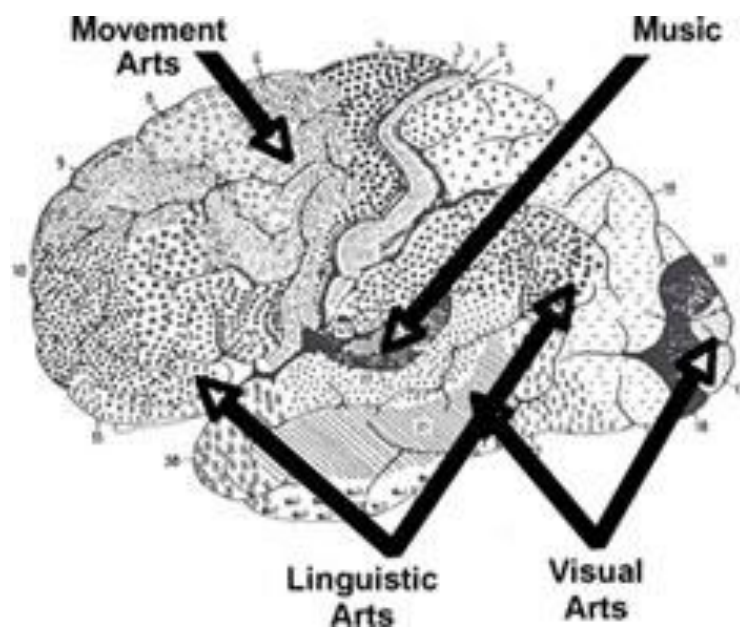


Figure 1. “How Arts training influences cognition” (Courtesy of Posner Lab and Vonda Evans) adapted from “Learning, Arts, and the Brain,” *The Dana Consortium Report on Arts and Cognition*, 2008.

A common theme among a collection of studies that focus on the neurological effects of arts training is that the arts can heighten other cognitive processes. This theoretical reasoning for these findings is that intrinsic motivation in the arts translates into high interest and sustained motivation, which ultimately improves cognition (Poser,

Rothbart, Sheese, & Kieras, 2008). Individual studies have also presented various specific findings stemming from arts involvement. Some key findings from this collection include that visual arts and experience is correlated with math skills (especially geometry), music involvement is correlated with reading skills, dance effects observational learning abilities, and the performing arts are linked with language and memory development (Wandell, Dougherty, Ben-Shachar, Deutsch, & Tang, 2007; Grafton & Cross 2008; Dunbar 2008). Studies on the arts and the brain have also illustrated that there are both environmental and genetic factors that are predictors of artistic motivation (Gazzaniga, 2008; Dunbar 2008). Researchers from both ends of the dialogue agree that the arts have positive influences on learning and these findings are the basis for encouraging arts integration.

STEM to STEAM. There are examples of arts integration with a range of academic subjects, but for the purposes of this study the following section will focus on the role that the arts have played in STEM education. In contrast to the wavering support for arts programs, there are clear monetary allocations focused on fostering STEM education. In addition to the previously mentioned disparities between the NSF and the NEA, President Obama has repeatedly recognized the importance of STEM education as a means of strengthening national security and ensuring global competitiveness. The consistent support for the STEM fields is also a reflection of the growing demand for STEM jobs; the NSF projects the science and engineering workforce to grow at a rate of 6.2% while the overall US workforce growth rate is 1.6%. This data is reinforced by the Government Accountability Office (GAO), which has been reporting the disproportional growth in STEM fields in comparison to other industries (Burke & McNeill, 2011).

Despite the uneven support between STEM and arts education, research suggests that there are more commonalities in learning in the arts and sciences than one might presume. Similar cognitive processes across the disciplines are one of the factors that promote collaborations across sectors (Costantino, Kellam, Cramond, & Crowser, 2010). Academic arts programs are beginning to articulate how the arts support and contribute to STEM education. This emerging strategy strives to heighten awareness around the benefits of the arts by establishing the relevance and integration of the arts with STEM based initiatives, naming it the STEM to STEAM movement. “The arts promote cultural change, trigger the imaginative conscience and community action and act as a bridge towards scientific understanding and application of sustainable efforts” (Clark & Button, 2010, p. 43). The integration of the arts with STEM efforts has the potential to be a promising and mutually beneficial initiative that enhances learning in technical fields while also bringing the contributions of the arts to the forefront.

The emerging STEM to STEAM movement is largely grounded by an effort to incorporate the arts with STEM as an equally important, and not simply a supplementary subject (Bequette & Bequette, 2011; Artworks, 2012). The promising collaborative efforts in K-12 curricula as well as higher education research conferences have set the stage for future inquiry into STEAM based learning. These efforts are reflected in the collaborations and joint funding efforts of the NSF and the NEA, the two predominant federal agencies responsible for the promotion of STEM and the arts respectively. The “Symbiotic Art & Science Conference” and “Bridging STEM to STEAM: Developing New Frameworks for Art-Science-Design Pedagogy Conference” are two early examples of significant initiatives supported by both federal agencies (Art Works, 2011; Rhode

Island School of Design, 2011). More recently, the STE[+A]M Connect conference is an example of a privately supported engagement effort to engage scholars and practitioners working at the intersections of the arts and STEM (Steamconnect.org, 2014). Following in these footsteps, there have been university programs, as well as K-12 programs, that have incorporated STEAM into the organizational mission or vision (Hollander, 2013; Mote, Strelecki, and Johnson, 2014).

The growing dialogue around the importance of creativity also plays a role in emphasizing STEAM-based learning (McCullen & Winkler 2012; Kleimen, 2008). As illustrated by Pink (2006), the 21st century environment is shifting towards right-brain thinking and arts education works towards fulfilling this need. Pink argues that while left-brained logical thinking is still necessary, it is actually right-brained skills like artistry, empathy, and collaboration that are integral for success in the modern economy. These skills are being taught by the arts, making arts education a fundamental part of the modern classroom (Pink, 2009). Most creative thinkers do not view their works as bounded within a discipline, but rather are inspired by the connections between disciplines (Lehrer, 2012). This type of trans-disciplinary thinking resonates with the new STEAM paradigm, which questions the rigidity within science and math and encourages the infusion of creativity (Mishra, Henrickson, & the Deep Play Research Group, 2012).

Intersections between the arts and STEM. “Without art and science, our world would be a dull place and creativity would see the light of day less often” (Brown, 2011, p. 7). As evidenced by the density of exhibitions, conferences, and faculty collaborations exploring the art of science and the science of art, the synergy and

distinctions between the artistic and scientific process is not a new topic of inquiry. Historical examples of science as motif in visual arts include Rembrandt's (1632) "Anatomy Lesson of Dr. Nicolaes Tulp" to Lichtenstein's (1970) "Peace through Chemistry" pictured in Appendix A (Welchman, 2004). With respect to integrating the arts in science education, the arts have been generally regarded as a catalyst to make scientists see things differently or consider alternate solutions to the problems they study (Barlow, 2002). Beyond using the arts as a tool to improving science learning, there are learning communities that have merged arts and science university coursework and have seen positive outcomes: students have realized new fields of blended study and cited stronger understanding of both the arts and sciences (Needle, Corbo, Wong, Greenfeder, Raths, & Fulop 2005; Kvietkauskas, 2011). Research suggests that arts and science collaborations have the potential to break new territory and use the respective audiences to inform the broader public (Brown, 2011).

"New technologies draw on both artistic and scientific knowledge, each contributing to the other's design" (Gouzouasis, 2006, p. 3). In transitioning to the specific intersections between art and technology it is important to note that the skilled use of technology is considered a critical 21st Century competency. Fittingly, there have been many strides to integrate technology with academic disciplines (Jenkins, 2006). Unlike collaborations with the arts and some of the other STEM fields, the marriage between the arts and technology is relatively widespread. For example, majors like graphic design, computer arts, have become relatively commonplace at universities. Similarly, technical programming tools are foundational skills for digital, new media, and video artists. There is a strong push for highlighting arts-based technology education

because it has been argued that artistic applications of technology are a critical facet of new learning (Gouzouasis, 2006; Watts 2008).

“During a series of workshops organized by the National Science Foundation with the National Endowment of the Arts, one of the discussions that emerged rapidly was the urgent need to find new ways to connect the arts and design with science and engineering” (Malina, 2012, para 5). Engineering is a particularly pragmatic discipline of study with the STEM field and is the only subject area of the grouping that is taught predominantly in postsecondary education (Catterall, 2013). There is a strong demand for engineering professionals in the United States. In 2012 the unemployment rate for engineers was only two percent, in comparison to the national average, which was just over eight percent (Geron, 2012). There are aesthetic decisions in the engineering process hence the natural crossover of the arts with and accordingly, one study documents the integration of arts coursework in an engineer major. Findings from the inquiry included student testimonials about strengthening creative problem solving skills, tolerating ambiguity, and improving visualization skills (Costantino, Kellam, Cramond, & Crower, 2010). There is a clear impetus for encouraging engineering students and improving engineering coursework at the university level; the integration of the arts is one strategy for boosting creativity in the profession.

“We're creating new abstractions and logical relationships all the time...that's why I see math as art” (Robinson, 2009, para 15). A common integration of art and math is seen in da Vinci's (1492) iconic mathematical illustration of human proportions in the “Vitruvian Man,” pictured in, Appendix A. This artwork reflects the relevance of mathematics in teaching visual arts. However, with respect to the research on arts and

learning, math aptitude is most commonly connected with music experience. Music appears to have the most logical relationship with mathematics, especially when considering the role of rhythm and ratios in music. Research has presented mixed reviews regarding the degree of influence that music on learning math. A meta-analysis of the breadth of quantitative studies examining the relationship between music and math does reveal modest support for a positive relationship (Vaughn, 2000). Much of this relationship is established through examining math sections in standardized tests taken at the middle and high school level. There is less research examining the effects of integration the arts in math education at the university level.

STEAM is a relatively new term, but collaborations across the intersections of the arts and STEM are not a novel idea. The synthesis of the interdisciplinary collaborations above shows fluidity between academic disciplines. In the past couple years there have been a few articles that focus specifically on the implementation of STEAM in schools. One case study of an exemplary middle school science teacher illustrates that excellence in STEM is fostered through arts-based instruction (Henrickson, 2014). Accordingly, STEAM-based programs in elementary schools are becoming more visible and the Stephen W. Hawking charter school is a unique example of a school that was developed completely around the notions of STEAM (Dipping, 2013). Another elementary school case study reflects the process of establishing a collaborative high-level partnership between an STEAM academy and local museum (Mote, 2014). In higher education one study presents a STEAM program that was created in part with support from Lockheed Martin, a prominent aerospace and technology corporation, and the State University of New York at Postdam. The university will be implementing a STEAM program as part

of their Student-Initiated Integrative Major, and this research outlines the reasoning and process for establishing this new undergraduate opportunity (Madden, Baxter, Beauchamp, Bouchard, Habermas, Huff...Plague, 2013). Programs like this exist within higher education, but there is still minimal research sharing the process of creating STEAM based curriculums and partnerships and even less insight into the impact of existing programs.

Policies Related to the Arts in Education

Some of the impetus for continuing the research on the contributions of the arts is to better inform arts education policies. There are current underlying policies and standards that impede the integration of the arts in schools. There is also a parallel lack of rigor in implementing standards for arts policies. At the state level, most individual states have adopted arts education standards for K-12, but there is no system of accountability that ensures that these standards are being met at the local level. Regulations have less influence when there are not accountable measures to ensure prioritization of instructional time. There is a lack of consistency in arts standards at the university level, as well (National Assembly of State Art Agencies, 2011). This undermines the value of the arts and this could be avoided by policies that are more conscientious as to the merit of art programs in schools.

While this study is grounded in higher education and informed by arts education research in universities, the narrative begins at the K-12 level. In California 89% of schools fail to offer a standards base course of study in all four art disciplines (music, visual arts, theatre, and dance) (Brown, 2007). Loose standards at the K-12 level affect the rigor in reinforcing arts standards in higher education. Similarly, high stakes testing

has marginalized arts in the classroom. Elective coursework, like the arts, are sacrificed in order to place at-risk students in remedial courses (Beveridge, 2010). Arts standards are present in the NCLB legislation, but since the arts are not included in the testing required by NCLB, these courses are gradually being squeezed out of the curriculum. This was by no means the intent of the legislation, but nonetheless there have been undesirable outcomes for the arts. Since the arts provide an alternative means of viewing reality there are broad and unobservable consequences resulting from this legislation (Heilig, Cole, & Aguilar, 2010).

One theme that emerged throughout arts education and public policy literature is the limited resources allocated towards arts programs within academic settings. The U.S. Department of Education's National Center for Education Statistics provides reports that less than eight percent of national university faculty are classified as performing or visual arts faculty. These arts faculty members spent an average of 67% of their time teaching, while faculty affiliated with other academic departments reported an average of 49-65% of their time teaching. Full time arts faculty have also voiced that there is an unfair workload in contrast to other disciplines, and despite the mounting workload, arts faculty members are also earning less competitive wages than faculty in other departments (Warburton, 2006). With the unstable budgetary state of educational institutions, the future of the arts in both K-12 schools and universities are threatened and in turn a "culture of scarcity" is created (Dimitriadis, Cole, & Costello, 2009, p. 361).

Funding the Arts. "Over the last several years we've seen a significant decrease for arts funding in our nation's public schools. This is an alarming trend given the well-documented and far-reaching benefits a quality education in the arts provides"

(Americans for the Arts News, 2011). This concern was expressed by the current President of the Americans for the Arts, the largest non-profit organization dedicated to advancing the arts. The lack of monetary support for arts education is commonly alluded to as a source of distress in arts education research and practice across all levels of learning. However, substantiation of this claim with tangible statistics is less frequently presented in the literature.

Painting an accurate picture of national monetary support or lack thereof towards the arts in education involves examining a range of funding sources that benefit both art programs in schools and cultural institutions in addition to taking into consideration allocated institutional monetary support. One way to get a general pulse of support dollars for the arts is to track the budget of the NEA. This independent federal agency was created by congress in 1965 and is a major source of funding for artists and art programs in schools as well as art institutions. The NEA strives to enrich the nation by “supporting works of artistic excellence, advancing learning in the arts, and strengthening the arts in communities through the country” (“NEA at a Glance,” 2011). It had an original budget of \$2,500,000; the organization grew rapidly and in the early 1990s funding reached its pinnacle at \$180,000,000. The NEA had a 13% cut this year, the deepest cut the agency has had in the last 16 years, making the 2012 budget only \$135,000,000 (Bauerlein & Grantham, 2008; Mikulski, 2011). There are clear disparities across the arts and sciences, but there is reason to believe that supporting the arts will become more of a national priority in the future. 2014 marks the first year since 2008 that NEA appropriations have gone up with the current appropriations at \$146,021,000 an increase from \$138,383,218 in 2013.

Due in part to the inconsistent funding from the NEA, there have been additional grant-making bodies that have stepped in to provide opportunities for art programs in schools. For example, specific arts grants from the Department of Education, the NSF as well as regional entities, are attempting to improve the state of the arts in schools with grants that support innovative arts programs (U.S. Department of Education, 2009). From a school or university vantage point, it is necessary to not only pursue grant opportunities, but also allow for ample curriculum planning as well as district or university wide funding that includes the arts. The state of arts funding is not ideal, but research on public opinion of the arts will continue to inform the debate regarding the arts in education. An overview of national funding for the arts and pressing policy issues presents a framework to understand the context of arts education research, as well as the impetus to examine the broader cognitive benefits of the arts.

Theoretical Frameworks

The three theoretical lenses that were integrated into this study are Bolman and Deal's frames of organizational development, sociocultural theory, and experiential learning theory. These distinct frameworks provide the conceptual foundation to explore leadership and student learning within both university programs.

Bolman and Deal. In addition to framing the relevant theoretical literature for student learning, it is also necessary to have a contextual understanding of the organizational management literature that has influenced this study. Leadership and organizational development experts, Bolman and Deal, have been collaborating on publications for the past 29 years and one of their most noted books is *Reframing Organizations: Artistry, Choice, and Leadership* (1997). They introduce four frames to

analyze organizational development: structural, human resource, political, and symbolic. Each frame provides a distinct perspective to explore organizational development.

An organization's structure is like a skeleton and it has the ability to impede or support efficiency, productivity, and effectiveness. There are several different types of structural configurations, ranging from rigid bureaucracies to organic environments; each configuration has the potential to be successful. Bolman and Deal (1997) show the need for structures to meet the desires and driving forces of the organization. They go on to say the structural frame is marked by strategy and implementation and generally receives a great deal of attention from leadership.

The human resource frame is focused on the impact of people in a given organization. Bolman and Deal (1997) state that this frame targets employee needs and is characterized by supporting and empowering individuals within an organization. This type of investment in the individual includes training, education in addition to creating opportunities for promotion or rewards and allowing for autonomy. Bolman and Deal (1997) conclude that shared information and heightened communication are examples of positive outcomes that can rise from emphasizing the human resource frame.

Political aspects of an organization include negotiation and relationship building. Bolman and Deal (1997) advise leaders to look at the distribution of power and interests at a given organization, or in this case, educational institution. They explain the political view as a continual process of negotiating and bargaining among interest groups, with the goal of creating constructive politics for equitable institutions (Bolman & Deal, 1997).

Finally, the symbolic frame is typified by inspiration, organizational vision, and culture. This frame is highly complex and ambiguous, but still provides significant value

towards organizational achievements. Bolman and Deal (1997) observe that in contrast to rules and regulations, symbols are nurtured by myths, stories, rituals, and metaphors. Since culture is a challenging factor to creating or changing an organization, it is not surprising that an analysis of the application of the four frames found that this frame was less commonly used by leaders in comparison to the three other frames of organizational development (Bolman & Deal, 1997).

Taken as a whole, the aforementioned frames provide a flexible and holistic approach to assess organizational development. More specifically the four frames proved one lens for analyzing leadership experiences at university program and complements the two additional theoretical frameworks: sociocultural theory and experiential learning.

Sociocultural theory. This study also integrates sociocultural theoretical framework. In some research this same theory is labeled a sociohistorical approach, but for the purposes of this study the term sociocultural will be utilized. At the macro-level, this theoretical framework underscores the social, cultural, and cognitive influences in self-construction as well as knowledge construction (Harter, 2012). Focusing on the latter, knowledge construction is a complex process that reflects much of the impetus for establishing institutions of education.

In educational research, sociocultural theory is characterized by the *situatedness* of learning. That is, thought processes are culturally embedded and context bound. This theory runs counter to the Central Processing Model that claims each individual has a central processing center that contains general skills and tendencies. (Wegerif, 2004) By emphasizing the external, or social, relevance of learning, sociocultural theory aligns with the ideals of collaboration in classroom settings. Sociocultural theory was predominantly

influenced by Vygotsky; a seminal thinker in psychology (Vygotsky, 1980).

Vygotsky. “What is the relation between aesthetic response and all other forms of human behavior? How do we explain the role and importance of art in the general behavioral system of man?” (Vygotsky, 1925, p.1). These questions, explored in Vygotsky’s dissertation, express the deep-seated interest that he had in understanding the unique contributions of the arts. His research interests transcended the arts and psychology and he continued to develop complex theories about cognitive development. His establishment of the genetic law of development directly related to the concept of co-construction of knowledge realized in sociocultural theory. The genetic law emphasizes the social interaction component of human development and acknowledges the interconnectedness of this process (Vygotsky, 1978).

His work on neural and cognitive processes resulted in the establishment of *functional systems*, which reveals the systems at play for an individual to complete a given task and in addition to how these individuals reorganize cognitive strategies in order to address new learning challenges. Three prominent elements of a Vygotskian framework are reflected the sociocultural theory: social sources of mediation, semiotic mediation, and genetic analysis (Steiner & Mahn, 1996). Essentially, there are social, linguistic, and biological elements that all feed into knowledge construction. The acknowledgement of a broader approach to learning, as exemplified by sociocultural theory is consistent with research regarding the integration of the arts to assist learning in different subjects.

Experiential learning. In addition to sociocultural theory, experiential learning is also integrated as a theoretical framework to address the student learning in programs

that integrate the arts with STEM. Experiential learning was introduced as a theory in 1984 by Kolb and is based on educational theories of several noted scholars. His intent was to present a comprehensive theory that places “experience” at center of learning. The three researchers that are most directly referenced in this framework are Lewin, Dewey, and Piaget. These scholars present learning models and each of them acknowledges that learning is a process.

Kolb (1984) notes Lewin’s model of learning places concrete experiences at the heart of the learning cycle. These tangible experiences are the basis for observations and analysis and the formation of abstract concepts. The created concepts are then tested in new situations and the cycle repeats. Lewin creates a problem-based model of learning that is reliant upon receiving adequate feedback. Kolb posits that this type of process highlights the goal oriented nature of learning and balances the importance of both observation and action.

Kolb (1984) observes that Dewey presents a similar model of learning to that of Lewin, but places additional emphasis on the developmental aspects of learning. He describes learning as a symbiotic process where impulse evolves into knowledge through interventions of judgment, observation, and purpose. Kolb notes that Lewin states the initial action is stalled and it is the push and pull of the above interventions that transforms impulse into meaningful purpose.

Kolb (1984) finds another comparable model for learning and cognitive development in Piaget’s four stages for cognitive growth. As determined by Piaget, these stages account for individuals from the time they are born into their teenage years. The first stage is called the sensory motor stage, the second is the representational stage, the

third is the concrete operations stage, and the fourth is formal operations. These stages show growth from infancy, where learning primarily occurs through stimulus and response, to adolescence, which is marked by hypothetical deductive reasoning. Piaget also connects experience, concept, reflection and action as the fundamental points for establishing adult thought.

The intersections of these three bodies of work led Kolb (1984) to develop the experiential learning theory is an educational framework that recognizes the overlaps in the theoretical frameworks discussed above and presents a new perspective based on common themes from seminal thinkers of the 20th century. Placing emphasis on the process and the role of experience in learning the framework presents a working definition of learning as “the process whereby knowledge is created through the transformation of experience” (Kolb, 1984, p. 38).

Bolman and Deal’s frames of organizational development provide a lens to understand the leadership dynamics of interdisciplinary university programs while the sociocultural theory and experiential learning are the lenses through which to understand student learning within those programs.

Access to the Arts as a Social Justice Issue

Social justice is grounded by the notion of equal rights and opportunities for all and is a fundamental value that is vital towards creating a 21st century educational agenda. This ideal has not yet been realized in the educational system, as there are gross inequalities with respect to funding that create an uneven playing field (Kozol, 2012).

Access to quality arts education is social justice issue, as research suggests that exposure

to the arts is important to the development of human beings and hindering such programs present inequitable environments for students (Garber, 2004).

The increasing emphasis on high stakes testing is one way in which arts coursework is made vulnerable and pushed to the periphery (Beveridge, 2010). All students will be adversely impacted if modifications are not made to create supportive academic environments that validate the arts, but more so, students that have no other avenue of arts exposure aside from public school will be particularly affected by the gradual diminishing of the arts in the public sector (Dmitriadis, Cole, & Costello, 2009). The research on the cognitive impact of the arts shows that arts coursework also has the ability to positively impact individuals that do not respond to other aspects of the curriculum. Many individuals who fall in this category are already underserved in the schools and experience significant educational failure rates. The arts instigate meaningful connections for non-traditional learners; these students that are not normally “successful” are able to feel a greater sense of accomplishment and self-worth. This already marginalized group of students will suffer more when arts programs are cut or downsized (Dmitriadis, Cole, & Costello, 2009). Institutions and individuals have made it a priority to locate and close the gaps in our educational system, but the cutting of arts programs and coursework has the potential to widen instead of close the achievement gap.

A national survey of elementary schools compares the recent state of arts education in classrooms to data from 10 years prior. The amount of visual arts and music teaching is largely the same, but there has been a decline in theatre and dance in schools. What is more concerning from this study is that impoverished schools have exceedingly

less access to arts programs than their more affluent counterparts (Parsad & Spiegelman, 2012). This means that economically underprivileged students have fewer opportunities to be involved in the arts, and are therefore less likely to experience the enriching and cognitive benefits of arts education.

The Economic and Civic Importance of the Arts and Creativity

Arts education also presents connections with national prosperity. With the increasingly competitive and global economy, the need for educational leadership is magnified. The United States educational system has been criticized for poor test scores, low retention rates, and high tuitions; for this reason, the need for effective educational reform is ever present (Brown, 2007; Kozol, 2012; Brown 2007). Research has shown that the cognitive benefits of the arts are one of the positive outcomes associated with arts education; therefore, an increased investment in arts education is timely for the United States to remain globally competitive (Livingston, 2010). More so, creativity is championed as a core competency that is intrinsically associated with arts. Valuing creativity in leadership further promotes the preservation of arts education (IBM, 2010).

Educational leaders at all levels can contribute towards informing the public and politicians about the growing body of research surrounding the benefits of the arts. Arts education research and advocacy efforts have been criticized for not spreading the knowledge to a broad enough audience. The emphasis is placed on informing individuals who already support the arts instead of reaching out and changing public opinion (McCarthy et. al, 2004). This approach is limiting the impact of arts advocacy. Therefore, leaders must engage with a broader audience of policy makers and those who

allocate public funds in order to influence the conversation toward greater and sustainable funding for the arts in school settings.

Establishing a strong federal support arm for the arts establishes a national commitment to the arts in our schools as well as the broader community. To elaborate, institutions like the NEA have a significant leadership role when viewing the arts from an international perspective. Artists are regularly exhibiting or performing for an international audience and in order to present a strong commitment to the arts, organizations like the NEA become instrumental in funding and representing the arts. By showing support for arts initiatives that have a global presence, the NEA becomes “a symbol of official American reciprocity and investment in the global citizenry of the arts” (Howard, 2001, p. 95). This investment reflects a broader commitment towards cultural awareness and interest in participating in artistic dialogue that crosses international borders.

Areas for Future Research

There are a multitude of areas and intersections between arts and education that would benefit from further inquiry. Within academia, the arts have a historically inconsistent reputation for quality of research and a continued commitment to empirically rigorous research is necessary to advance the field (Winner & Cooper, 2000). In comparison to studies in the K-12 arena, there is less research around the continuing benefits of the arts in higher education and added emphasis on such studies would strengthen and balance out the body of research in arts education.

One broad area for further discussion is the STEM to STEAM movement. There is a growing interest in the intersections between the arts and STEM, but there are

minimal theoretical frameworks that explore the convergence of the arts and STEM based learning (Clark & Button, 2010). With the growing attention on the STEM to STEAM programming, a solid theoretical understanding of this movement will be a valuable area for future research. This, in addition to the growing body of literature on the cognitive benefits of the arts and learning, has guided this research. In an effort to contribute towards an emerging facet of arts education and participate in the broader national dialogue surrounding STEM education, this study is deliberately situated in the intersections and collaborations of the arts and STEM.

Summary

Research suggests that cognitive improvements, like heightened critical and creative thinking skills, are benefits of arts education. Critical thinking is a versatile and desirable trait that is essential to learning; naturally, this is one facet of arts research that has received a fair amount of attention. Studies have linked various art forms to heightened thinking and problem solving skills. There is some variation on the types of skills associated with a given art form, but critical thinking is a commonality across art forms (Catterall, 2002). Similar to the way that creativity has been intrinsically associated with the arts, improved critical thinking skills is connected with the inquiry-based nature of the arts.

While some scholars are skeptical of producing a one-sided picture of the benefits of the arts, the general consensus is that secondary qualities that are transferred from arts learning to the learning in other core areas can complement the inherent benefits of the arts. Since it is nearly impossible to establish a causal relationship through the transfer of learning, the research reflects some variability in results. There is a need to employ

rigorous research methods in order to ensure that findings regarding the transfer of learning in the arts are sound and valid (Winner & Cooper, 2000). The attempt to quantify the contributions of the arts is timely, but the intangible emotions that are innate to art experiences also need to play a central role in shaping the body of research examining the benefits of the arts.

Despite the positive direction of arts education research there are disparities in the quality of arts programs and this has social justice implications. Underprivileged students and non-traditional learners are in a position to suffer the most from sub-par or non-existent art programs in schools and universities (Oreck et. al , 2000). Additionally, the highly competitive global economy requires a comprehensive agenda for education that includes improved critical thinking skills within this broader dialogue and requires the arts to remain in schools. Likewise, continued accessible research on the expansive contributions of the arts will assist in creating informed policies and programs integrating the arts in education.

Shifting to the literature that specially situates this study, discourse around integrating the arts with STEM initiatives serves as a means to practice the theories and findings of the cognitive effects of arts education. The STEM to STEAM movement highlights the contribution of the arts and places arts coursework at the same level of importance as STEM coursework (Hooper, 2012). This progressive view is spreading in K-12 and higher education settings, and in order to reinforce STEAM programming continued research is necessary to inform and track the inclusion of the arts. The STEM to STEAM movement is an emerging area of research that has gained momentum over the course of the past few years.

In order to create a strong theoretical foundation, a leadership, cognitive, and educational framework is integrated into this exploratory qualitative study. Beginning with the research inquiry into leadership at STEAM programs, Bolman and Deal's (1997) frames of organizational development guide the questioning and analysis of educational leaders that have pioneered university STEAM programs. The frames present a flexible platform for understanding the structural, human resource, political, and symbolic frames of establishing programs that integrate STEM and the arts. Shifting to the student learning facet of this research, the origins of sociocultural theory provide an appropriate framework for understanding the multifaceted possibilities of student learning through the arts. This theory is informed by the research of Vygotsky and takes into consideration the collaborative and innate influences in knowledge construction. The third and final theoretical framework employed is experiential learning. This accounts for the central role of experience and hands on application in STEAM based learning. The three frameworks provide a strong basis for leadership and learning within interdisciplinary university programs.

Finally, the spotty support for the arts does not parallel the above research outlining the benefits of the arts (Gullatt, 2008). Despite the fact that most Americans strongly support art integration in schools and communities, the trends in funding and legislation do not reflect this outlook. The overwhelming majority of American parents stated that they strongly believe their children should be exposed to the arts and that they believe the arts make positive contributions to the community (Dimaggio & Pettit, 1999). However, policies created as a result of high stakes testing requirements have marginalized the arts (Beveridge, 2010). Similarly, there are concerns about sustaining

quality arts programming in higher education; a lack of emphasis on art requirements in the admission process and the minimal funding for art programs and faculty questions about the value of the arts (Hatfield, 1999; Warburton, 2006) produce barriers to systemic support for the arts. This state of affairs runs contrary to what existing research has demonstrated regarding the positive contributions of the art and there are issues of aesthetic equity and economic prosperity that also come into play when arts education is not preserved and accessible to all students.

Chapter Three: Pioneering University Programs at the Intersections of the Arts and STEM

The challenges in today's global economy are exceedingly complex and it is not surprising that creativity has been deemed one of the most desirable qualities for emerging leaders (Florida, 2002; Florida, 2005; IBM, 2010; Pink, 2005; Robinson, 2011). One approach to foster creative problem-solving skills in students is arts integration. The arts and STEM disciplines, while seemingly disparate, can capitalize on the other's strengths through what is now called the STEM to STEAM movement. The premise of the STEM to STEAM movement is to integrate the arts with STEM learning because STEM alone is insufficient to tackle the issues of our time (Maeda, 2013). As former Rhode Island School of Design (RISD) President, John Maeda states, "Innovation happens when convergent thinkers, who march straight ahead towards their goal, combine forces with divergent thinkers – those who professionally wander, who are comfortable being uncomfortable, and who look for what is real" (Maeda, 2013, p. 1). These are the types of collaborations that the 21st century demands.

The focus on STEM education has been established via policy makers over the last decade and the robust spending to promote STEM fields only furthers the ongoing commitment to these disciplines. STEM jobs are growing approximately six times as fast as opportunities in other fields (Burke & McNeill, 2011). Correspondingly, there is a federal strategic planning process for improving STEM education and the Obama administration has proposed the goal of producing 1,000,000 additional STEM graduates by 2020 (Holdren, 2013).

Collaborations between the arts and STEM fields take place across the K-16 landscape, but, in practice, the STEAM acronym has been more prevalent in K-12 settings. A clear reason for this is not apparent, but some leaders in the arts note that the term “STEAM” comes with baggage, particularly the use of the arts as simply a support to STEM. Despite a slower embrace of the STEM to STEAM rhetoric in higher education, the ideology of bridging the arts with STEM is still evident at the university level. In order to better understand how the arts and STEM disciplines intersect in higher education settings, the following research questions are addressed in this article:

1. What are the experiences of those involved in developing university programs that integrate the arts with STEM?
 - a. Who provided the leadership to develop the programs and what actions did they take?

In this study I will share the journeys of the individuals who pioneered two distinct programs that incorporate the arts and STEM.

Literature Review

A review of relevant literature informs this inquiry of program leadership in interdisciplinary university programs. Beginning with an overview of studies that connect arts integration to student learning and STEM education, this body of work helps elucidate the motivating factors for arts inclusion. Following this synopsis is an overview of Bolman and Deal’s four frames of organizational development. These four frames act as the theoretical framework to contextualize this research.

Arts and Cognition. Arts integration is supported by neuro-educational findings. Research shows that there are specific brain networks, called neural networks, which

have been associated with different art forms. From a scientific vantage point arts training is correlated with heightened critical thinking skills and intrinsic motivation in the arts has been associated with sustained engagement and improved cognition (Asbury & Rich, 2008). Adding the arts to an academic discipline does not instantly makes a person smart, but an authentic drive to partake in the arts is connected with strengthening other brain functionalities.

It is worth noting that re-examination of prior research suggests that studies highlighting the value of the arts have produced inflated results. For example, the “Mozart Effect” derived from Rauscher’s (1995) assertion that student’s cognitive and special abilities were enhanced after listening to Mozart’s 1781 Sonata for two pianos in D major has not been replicated in later studies (Waterhouse, 2006). Similarly, Winner and Cooper (2000) conducted a meta-analysis of 31 previous studies that linked the arts to academic achievement and found limited causal links between arts involvement and academic achievement. The main takeaway being that overcompensating the effects of arts education actually puts the arts in a vulnerable position. Other fields are not expected to boost achievement in different disciplines and expecting too much improvement in other fields from arts integration takes attention away from the innate benefits of studying the arts (Eisner, 2002; Gullat 2008; Winner & Cooper, 2000).

Researchers working to articulate the value of the arts have had set backs, but there is a strong body of research that make valid claims about the connection between arts involvement and academic achievement (Catterall, 2002; Catterall, 2012; Hetland, 2012; Lampert, 2008; Saraniero & Goldberg, 2011). One interesting pattern linking the arts and achievement is exposed through Root-Bernstein’s (2008) study of international

Nobel Laureates from 1901 to 2005. This group of high-achieving individuals identified avocations in the arts significantly more than the general public. While this does not establish causation between arts involvement and heightened cognition it does provide a basis to challenge educational policies that marginalize the arts. The complicated funding and public policy debate in the arts calls for thoughtful research that highlights the contributions of the arts and disagreements within the field create an opportunity for more rigorous studies that showcase exemplary artworks and highlight the merits of the arts.

Connecting the arts with STEM. “Principles for the Development of a Complete Mind: study the science of art, study the art of science, develop your senses, especially learn how to see, realize that everything connects to everything else” Leonardo da Vinci’s notebooks (1452-1519) (Atalay & Wamsley, 2008, p. 96).

As evidenced by da Vinci, the inherent interconnectivity between the arts and STEM, and particularly art and science, is not a new area of inquiry. There is an entire field of artist scientists, and collaborations between the fields reveal a synergy between the seemingly contrasting artistic and scientific processes. This notion supports the creation of interdisciplinary university programs. For example, Costantino, Kellam, Cramond, & Crower (2010) explored one program introduced arts coursework for engineering majors and conducted an analysis of student learning with the new arts requirements. Students shared the impact of this experience and their testimonials described strengthening creative problem solving skills, tolerating ambiguity, and improving visualization skills.

The shift to STEAM is also garnering attention by U.S. policy makers.

Congresswomen Suzanne Bonamici and Congressman Aaron Schock created a Congressional STEAM caucus in January 2013 to establish the place of the arts in driving innovation in the economy while changing the language in education to acknowledge the importance of both the arts and STEM. Americans for the Arts President Robert Lynch welcomed this opportunity to represent the arts in a broader context, “the message of how the arts can help launch creativity and innovation among our nations students will have a proper place in the halls of Congress” (“The Congressional Steam Caucus,” February, 2013). The NEA and The NSF have also partnered to create new ways to connect the arts and design with science and engineering (Malina, 2012). These agencies promote collaborations by providing joint grant opportunities for interdisciplinary research and conferences in the STEAM field. The attention and energy surrounding the field impacts educational leaders that have created programs that put STEAM ideals to practice. University program development, much like organizational development, involves multiple frames of thinking and acting that shape the mold of a given program.

Bolman and Deal. Seminal leadership authors, Bolman and Deal (1997) present four frames for understanding organizational development: structural, human resource, political, and symbolic. Universities have many layers and the creation of a new university program requires a multifaceted approach from leadership, accordingly, I have applied Bolman and Deal’s frames of organizational development as the theoretical lens for this study.

Because organizations are complex, surprising, deceptive, and ambiguous, they are formidably difficult to understand and manage. Our theories and images determine what we see, what we do, and what we accomplish. Perspectives too simple or too

narrow become fallacies that cloud rather than illuminate managerial action (Bolman & Deal, p. 34, 1997).

Each frame accounts for a distinct perspective that helps leaders to find clarity amid the messy and sometimes confusing task of leadership. The figure below outlines the main themes of each frame:

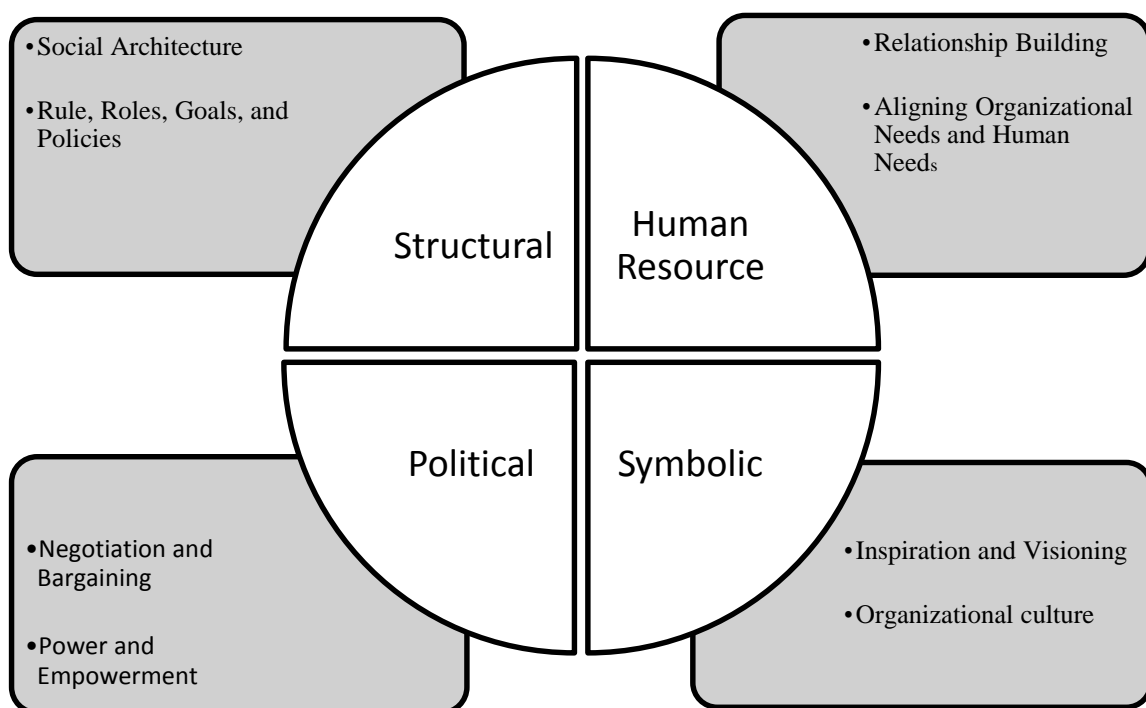


Figure 2. Bolman and Deal's Four Frames

Beginning with the structure or skeleton of an organization, this encompasses overarching elements like organization policies and subtler infrastructure like the social architecture of a program. In contrast, the human resources frame brings relationships and human needs are at the forefront. Shifting to the political frame, the focus in this lens is on the negotiations of power. Finally, the symbolic frame personifies organizational

culture, which is characterized by inspiration and storytelling. Organizations, and the individuals behind them, are multidimensional and this model acknowledges that reality (Bolman & Deal, 1997).

Applying this theory to university leadership allows for a comprehensive view of how each founder has pioneered a new space for learning. The two selected university programs in this study were created in a time when there were limited models for comparison. Creating these programs required founders to function across all four frames. In conversations with individuals who started the programs, I inquired about each of Bolman and Deal's (1997) four frames of organizational development using structural questions around program goals and policies, human resource questions involving staffing, political questions regarding advocacy and negotiation, and finally symbolic questions about visioning.

Methods

The research design acts as an umbrella for collecting and analyzing data from two programs that integrate at least one arts discipline with at least one STEM discipline. With Bolman and Deal as the overarching framework, I elected to utilize a collective case study to compare and contrast interviews with leaders from two programs that I have named the ArtScience program and the ArtTechnology program.

Collective Case Study. By definition a case study is an exploration of a bounded system (Creswell, 2008). For the purposes of this study a case represents one university program that integrates the arts with a STEM discipline. A collective case study requires two or more cases and this methodology lends itself for presenting a comparative account of two university programs (Noor, 2008). In this instance, a collective case study design

allows for a broader unit of analyses. Across the ArtScience and ArtTechnology programs, as a preliminary step, extant data was collected from both programs. This data includes strategic planning documents, course information, program evaluations, and images taken from each site. In addition to the preliminary data collection, I conducted semi-structured interviews with the individuals who founded each program. I provided these leaders with a general guideline of questions but allowed for some flexibility within the interviews.

Interviews accounted for the bulk of the data, but in addition to planned interviews I had casual conversations with the founders and physically toured the program premises. I then had the audio files from the interviews transcribed and began the process of coding the data. To reflect the exploratory intent of the research question and sub-question, there was no use of pre-established codes that could potentially constrain the parameters of the data. I used an *open coding* a method that is driven by data and not a preconceived notion of what the data would reveal (Esterberg, 2002). Twenty-seven codes were identified from program founder interviews and these codes were then categorized into like themes.

Existing STEAM Programs

The first step in this research was to analyze the current arena of university programs in the United States that intentionally integrate one or more arts disciplines with one or more STEM disciplines. There are several support programs and research labs within the STEAM domain, but for the purposes of this inquiry programs had to have a formal instruction component. I selected programs that taught courses to the undergraduate student population and the coursework is integrated into the broader

campus curriculum. Additionally, an inclusive definition of the arts was applied and programs could integrate visual and or performing arts fields. Starting with a list of seventeen programs, the goal was to select one to three programs and conduct a case study or collective case study of the leadership journey of the program(s) from the initial concept to the present day. The programs spanned public and private universities, rural to urban locales, and various disciplines across the arts and STEM. There are undoubtedly more university programs that could have been included, but emphasis was placed on identifying prominent established programs. The next step was to narrow this list into a feasible inquiry that I could conduct over the course of a year.

With the intent of sharing narratives from experienced leaders in the field, the preliminary selection criteria required programs to be in existence for at least five years and to be situated within a Research 1 university. The next layer of the criteria was more fluid. In order to observe program leadership with a similar university infrastructure, two programs were identified within the same public university system. Aside from longevity and existence within a large public research institution, the two programs are seemingly different from the exterior.

Overview of the ArtScience program. Located in a community with a small-town feel, the ArtScience program is in a university that is at the epicenter of the neighboring city. The city has a population of 64,500 people, while the university enrolled over 26,000 undergraduate students as of fall 2013. The campus community has a strong agricultural and environmentally progressive feel, and it is not surprising that the dominant industry in the city is education. The campus is sprawling and covers over 7309 acres of land, which is slightly larger than the area of the neighboring city.

The idea for this program grew out of a collaboration between two female educators, Co-Founder 1 and Co-Founder 2. Co-Founder 1 is a trained scientist and established researcher that has a flair for art making, while Co-Founder 2 has an undergraduate degree in genetics in addition to a Master of Fine Arts; both individuals have extensive teaching experience and consider being an educator central to their purpose. They were creating an anatomical animal sculpture and both noted how easy it was to remember this anatomy “because they had their hands on it” (Co-Founder 1 and Co-Founder 2, personal communication, June 1, 2013). The idea for teaching art and science in tandem stemmed from this experience.

At a faculty meeting Co-Founder 1 pitched the idea for teaching a joint course with Co-Founder 2 at a faculty retreat. “That’s how our first class was born. The stars aligned and the normally onerous process of course approval was relatively simple. It usually takes a year. I got the approval back in six weeks,” said Co-Founder 1 (Co-Founder 1, personal communication, June 1, 2013). Under the umbrella of a science department, the founder’s co-taught courses for 10 years before the officially established the ArtScience program in 2006.

The program was created with pilot funding from the Executive Vice Chancellor of the university. “When we became a program it was exciting to get a space on campus even though it’s a very old building, it’s one of the oldest buildings on campus. It was slated to be torn down but it’s actually been a perfect place for us” (Co-Founder 1, personal communication, June 1, 2013). The space she is referring to is able to function as a hybrid laboratory and studio for ArtScience classes. Since its inception there have

been private funds in addition to the university startup capital that have sustained the program.

ArtScience courses are taught by five core faculty members and are available to all undergraduate students on campus. Since the program is not a major, students have the option to take several courses in the program or just one course. One way that the ArtScience program is integrated in larger academic fabric of the campus is through the university-wide undergraduate honors program. The ArtScience course requirement exposes several students from varying majors to the program. The program is comprised of 175 to 250 students per year, offers three general education courses, and has several specialty seminar courses, from which they offer two or three annually. The three general education ArtScience courses are photography course, an entomology/art course, and a music/science course.

Overview of the ArtTechnology program. The ArtTechnology program is situated in a highly de-centralized public university in a major city that is home to multiple institutions of higher education. With a population of over 1.3 million the metropolis contains a booming biotechnology community, a robust manufacturing and military sector, in addition to plentiful tourist and cultural attractions. The university itself is relatively large, occupying over 2000 acres of land. While the cities surrounding each program vary in size and industry make-up, both universities are large research institutions that have a significant economic impact on their neighboring communities.

Characterized by a unique college system that groups students thematically versus by major, the ArtTechnology program is actually the core undergraduate curriculum of a college nested within the larger university. Institutionally there was a push to create a

new innovative college that reflected the current climate and revolutionary role of technology. The idea to integrate the arts as well as technology was voiced by some committee members and soon became embedded in the new college's strategic planning process. The group in charge was comprised of a steering committee of faculty across the academic spectrum, led by a Founding Provost. "I have a track record for applying or being available for things that are not known, that not set in concrete, where nobody says 'this is how you do it.' I think that is what attracted me to this position," she said, of her inclination to apply for the Founding Provost position. "I also really liked the theme and the idea of creating an educational environment that was quite different from what we have in other colleges" (Founding Provost, personal communication, July 29, 2013).

The university created a Founding Provost position to lead the planning effort for the new college and a female Professor in the Biological Sciences was named the Founding Provost. She took the position in 2000 and the program officially launched in 2001. Today the leadership and curricular aims of the ArtTechnology program are involved with conversations about the push for STEAM education, but when the program was created the STEM to STEAM language was not prevalent. The ArtTechnology program is centered on technology as well as arts and culture and coursework integrates various arts and STEM combinations. In addition to the theme of bridging technology, with arts and culture, collaboration and experiential learning were embedded as core values within program. The formalized and inclusive process from idea to fruition sets the stage for launching a program that is institutionally backed.

In contrast with the ArtScience program, it is unclear who had the initial concept for the theme, and from conversations it sounds like there were multiple parties involved

with initial ideas that guided the ultimate direction of the ArtTechnology program. The issues of space and funding are less central to this program, but there are hurdles with sustaining leadership that emerge through a deeper analysis.

The ArtTechnology program is comprised of a required series of three sequential courses, an upper division writing requirement, and an applied practicum for students. For students attending a particular college, within the larger university, it is a required that all of these courses are completed. There are 3,625 students in the college that requires this coursework and this accounts approximately 16% of the undergraduate student body. Faculty from other departments on campus are rotated in to teach the sequential trio of courses additionally there are six positions dedicated to managing and teaching in the ArtTechnology program.

Leadership Themes in the ArtScience Program

Resourcefulness in the structural frame. The ArtScience program would not exist today if it were not for the idea of the co-founders and the continued drive to realize their vision. In my interviews, there was a pattern of addressing limited resources to create the program. Neither of them fixated on this challenge as hindering the quality of the program. They both had positive attitudes and focused their efforts on solutions and improvements. For this reason it seemed appropriate to label this theme as *resourcefulness*.

Co-Founder 1 shared how general financial scarcity affects the growth of their program:

One of the things that happened through all of the budget cuts in the last few years is that teaching loads are heavier. One challenge is that there are people who would love to engage with us and do something new but

they really can't because they are teaching six classes a year. How would they do anything else? (Co-Founder 1, personal communication, June 1, 2013).

Co-Founder 2 drives the point further "it's like handing somebody a couple of sticks and saying, okay, start the fire" (Co-Founder 2, personal communication, June 2, 2013).

She also shared her challenges coming into this position of leadership as an established public artist, versus the more traditional route of joining as a tenure track faculty member.

My salary is something that we scratch in the dirt every quarter to get, and that's because we are a program. We have no legitimate money stream. It's a little hard on me, it's like perpetual dating...I want the marriage here (Co-Founder 2, personal communication, June 2, 2013).

She has been recognized and even rewarded for her exemplary contribution to the university, but providing steady compensation for her position has been an ongoing struggle. Co-Founder 1 has found loopholes to support her fellow program founder's teaching.

She is not a faculty member although this quarter for the first time I was able to get her lecturer status, which technically makes her an academic federation faculty member...That's actually been something of a challenge but also it's given us the level of freedom that we might not have had otherwise because she is not trying to deal with the department or climbing up through promotions or anything. She is doing this because she's interested in doing it and excited by it (Co-Founder 1, personal communication, June 1, 2013).

They have faced structural challenges in the process of developing the ArtScience program, but have adeptly found ways around these barriers. They have made creative use of space on campus and have also obtained private funds to support facilities for the

program. Co-Founder 2's salary, while being a source of stress, is something that they have been able to manage, as she is currently an active teacher of ArtScience courses.

Relationships of power in the political and human resource frame. Looking predominantly through a political and human resource frame, another theme from interviews with founders are the delicate nature of relationships within and outside of the organization. Co-Founder 1 reiterated the importance of diplomacy as a leadership quality.

I'm able to talk to a lot of different kinds of people and I'm able to have them understand that I really interested in them. I'm really capable of compromise when it's appropriate...it's really critical that you are able to be diplomatic in your communication (Co-Founder 1, personal communication, June 1, 2013).

Being diplomatic transcends simply being amicable—it effects course approval and acceptance or resistance from other programs.

It was such an easy time getting our courses approved because we were prepared for opposition from people who work in the humanities. I don't know. We just were lucky. Once we started teaching and we started getting a lot of attention, we did get some pushback from the art faculty. We were very much embraced by the design faculty (Co-Founder 1, personal communication, June 1, 2013).

Both founders discussed their intentionally inclusive approach towards building relationships with university faculty. For example, when the program was able to host a series of acclaimed visiting lectures, the program founders called on individuals with most opposition towards the program to have the honor of introducing these keynote talks. With upcoming retirements they both know that recruitment and expansion is the

next step for the program and diplomacy is critical to sustain the program beyond their tenure.

Another relationship that the founders referenced frequently in their individual interviews was their relationship to one another. They both spoke of each other in a glowing manner and cited their partnership in leadership as a distinguishing strength of the program. With Co-Founder 1 as a Scientist/Artist and Co-Founder 2 as an Artist/Scientist, they approach situations in a complementary manner.

I would say that I have a more linear thought process and I come at things from a certain direction and she comes from a different direction but where it comes together we end up with something that's very, very unique. She brings her experience in arts, in creativity, in building large-scale public art, sculpture, and ceramic mosaic to the table. As we think these projects up, we always know that they're going to be scientifically as accurate as possible because that's what I do. They're going to be aesthetic, creative, and successful as a professional design because that's her expertise that she brings to the mix (Co-Founder 1, personal communication, June 1, 2013).

A co-leadership situation could add a power struggle within an already complex university bureaucracy, but the mutual respect between the program founders supersedes personal motivations.

Hands on cross-disciplinary learning in the symbolic frame. Another theme from the ArtScience program is that a “hands on” and “cross-disciplinary” vision drives learning. This is evidenced by several courses that culminate in a public art project. I toured the different projects throughout campus and viewed one final project in action—a series of anatomical renderings of various types of bees. The impact of these projects is lasting and visible to the campus and broader community. In viewing the program founders in their element, guiding students through a final project, their passion was

evident. Co-Founder 2 shares that, “in my own life I’ve felt the power of connecting my head, heart, and hands,” and continues to explain that as a maker, she wants to share the positivity that comes with creating something (Co-Founder 2, personal communication, June 2, 2013).

I know crossing disciplines is the right thing to do. We’ve made some big mistakes, and it’s because everybody’s not at the table. And politically we’ve made mistakes because everybody’s not at the table. What we do is not beneficial to who’s seated next to us, in the next country. So I think cross-discipline is just to signal that, cross-world. Get out of your tribe and into humanity. And I know that making art and science are going to require us to have our humanity squarely in front of us to endure in a very thriving way...I can’t really say for sure why I have out my energy completely in this direction. It’s not cost-efficient, it’s not easy, but it’s meaningful, and it’s humane (Co-Founder 2, personal communication, June 2, 2013).

Her statement reflects the compassionate culture of the ArtScience program.

From the symbolic frame, the leadership in the program is able to inspire and motivate program participants and share their collaborative and applied vision of bridging arts and science.

Leadership Themes in the ArtTechnology Program

Newness and fluidity in the structural frame. Transitioning into the leadership of the ArtTechnology program, the interview with the Founding Provost revealed the intentionally evolving structure of the program.

This was just at the beginning of Information Technology, the idea of media and multimedia, just was really new and people didn’t quite know what this was but it felt really exciting, and people also felt that this was a new competency that students really needed to develop (Founding Provost, personal communication, July 29, 2013).

She spoke to a “newness” that motivated the creation of the ArtTechnology program. The founding committee also canvassed other university programs as a means of preliminary research.

We felt, of course, we were very unique, and I think we were. When you look nationwide, there were pockets of places where graduate programs were developed with a similar theme, but no undergraduate programs. People were really excited about this and I’m still excited about this (Founding Provost, personal communication, July 29, 2013).

There was and is a dialogue about the program being ahead of its time. The campus’s accreditation committee echoed these sentiments noting that this was the only campus with clear learning goals and outcomes for digital literacy skills.

“The theme excited many people who were on the bleeding edge of technology art and media. You recruit some interesting people” (Founding Provost, personal communication, July 29, 2013). The Founding Provost paints a lively picture of the energy bustling at the beginning of creating the ArtTechnology program. A Visual Arts Professor, who served on the program’s founding committee also spoke to the innovative beginnings of the ArtTechnology program.

I thought this program would describe the future. I thought it offered a lot of possibilities for students particularly because you could come from the sciences and take it, arts and take it, humanities and take it and you would be exposed to other kinds of students (Founding Committee Member, personal communication, August 21, 2013).

Concepts from the structural frame of organizational development are referenced frequently as this program is the product of years of planning. In this planning, visioning, and goal outlining process of the ArtTechnology program, the Founding Provost notes the importance of using “broad strokes” to keep the program fluid and adaptable.

Our vision was that this is never cut in concrete; that this will always evolve, how we interpret this vision has to evolve. We always wanted to

bridge academic barriers, we always wanted to challenge student's ability to think creatively and become an innovator by not just getting stuck in their comfortable academic major that they picked, but to really bring in other ways of thinking and other ways of doing inquiry. Coming back to the arts as really the broadest ways for human beings to make sense, to make sure that our students start to understand, appreciate, and apply. In other words, there is a lot of flexibility in how you do this and what courses you development, but there is also the need to never just stay the same (Founding Provost, personal communication, July 29, 2013).

Her realistic approach allows for the program to sustain and thrive in periods of transition. What she likely did not predict was the degree of changes with leadership in the ArtTechnology program. After her time as Provost from 2000 to 2007, there were several individuals who stepped into the position briefly between 2007 and 2012. The newest Provost has been in this position since January 2012. With all of the shifts in leadership the program's structure has been tested and in this process the program has maintained its form.

Establishing community in the political and human resource frame. Much like the ArtScience program, alliances with individuals within and outside of the university were taken into consideration when constructing the program. The Founding Provost commented on the ability to empower others as a one of the critical leadership qualities in developing a new program.

You have to be a visionary. You have to be a good listener. You have to be able to bring people together. You have to be able to excite people, and you have to be always able to communicate this vision so that other people understand what this can be (Founding Provost, personal communication, July 29, 2013).

She explains that this program can only sustain itself through internal and external partnerships and that the program needs to attract individuals who know how to create these partnerships and are comfortable working in an environment without clearly

defined boundaries. The Provost observed that the ArtTechnology program has become a resource for new cutting edge research initiatives that are being developed on campus.

“It was really interesting and amazing how often people approached me, you work with one and then it just snowballs” (Founding Provost, personal communication, July 29, 2013). For example, when the university was vying for a large research entity centered on human imagination, the ArtTechnology program was one of the first entities approached for feedback about positioning the university for this opportunity. Politically, providing guidance for emerging campus initiatives helped bolster the ArtTechnology to be a central figure on campus and a benchmark for emerging programs. One factor that contributed towards establishing this reputation is the unique practicum requirement. This involves an academic internship and written reflection of a student’s experience in the ArtTechnology program. The Founding Provost explained that the program theme attracts individuals interested in facilitating social change through the involvement of art and “the vehicle for participation was the practicum that allowed students to engage in these community projects through a course and for academic credit” (Founding Provost, personal communication, July 29, 2013).

The physical location of the ArtTechnology program, next to visual arts graduate and faculty studios, was also a way that helped fortify collaborations with visual arts. A Visual Arts Professor and former founding committee member expresses,

Some of their classes are courses for us, we teach courses for them, so there is a symbiotic relationship between the two, which I think a lot has to do with the curriculum but also has to do with the proximity, being next to each other (Founding Committee Member, personal communication, August 21, 2013).

People generally drive partnerships, but in this case the facility location also acted as an important catalyst for collaboration between the Department of Visual Art and the ArtTechnology program.

Building on the human resource challenges that were presented with leadership, there were also challenges with staffing. “We had a hard time finding people. That was the biggest challenge. It was really the people” (Founding Provost, personal communication, July 29, 2013). Recruiting individuals who are aligned with program goals was harder than anticipated. The Founding Provost continued to speak highly of the current team in place at the ArtTechnology program, but these individuals were not easy to find. Many of the faculty in the program have research and experience that lies outside the realm of a “typical” academic path. Whether it be outreach to individuals in the community or recruiting people to the program leadership has had to take actions from the political and human resource perspective.

Experiential interdisciplinary learning in the symbolic frame. At the heart of the ArtTechnology program, the Founding Provost describes the importance of experiential learning, or learning through doing, while bridging across disciplines. This concept is symbolic of the program values but was sometimes met with fear.

We wanted students to communicate in more than one medium, one is writing, but then the other one should be some other medium. It could be dance. It could be multimedia. It could be music. It could be traditional art. There was a fear that this requirement would lead to a product, if you want to call it that, that would be at the level of a kindergartner, when we all had to do art projects and they were cute because you were young but it wasn't really art or artistic. I think that fear was more because people were looking at the product and not the process, and they didn't appreciate the importance of the process of having a requirement where communication happens in a way that is uncomfortable for most people in

academe because how we communicate is through words (Founding Provost, personal communication, July 29, 2013).

The program was deliberately created with diverse voices and this is apparent through the makeup of the founding committee, which included undergraduate representatives and a faculty representative from each of the following departments: Anthropology, Communication, Computer Science & Engineering, Mechanical & Aerospace Engineering, History, Literature Music, Physics, Theatre & Dance, and Visual Arts. The broad array of disciplines in the committee prepares the program for diverse opinions and involvement from a multitude of disciplines. Another core philosophy that is apparent today at the ArtTechnology program is experiential learning. The Founding Provost confirms that this was at the foundation of developing the program, and continues to be a central theme. Experiential learning is fully integrated in the program's learning goals and academic plan and is a part of the culture in the ArtTechnology program.

The current leadership in the program have sustained the founding committee and Founding Provost's vision of an experiential approach and actions like the establishment of a biannual Experiential Learning Conference show that applied learning has remained a central theme in the program. The strength of documentation and planning by the Founding Provost and founding committee has enabled current leaders to preserve the symbolic elements of the ArtTechnology program.

Discussion

Narratives of both programs present reflections from all four of Bolman and Deal's frames. The below table outlines the major themes identified in both programs.

Table 1. Leadership themes in the ArtScience and ArtTechnology programs

Key Leadership Themes By Program	
ArtScience	ArtTechnology
Resourcefulness in the Structural Frame	Newness and Fluidity in the Structural Frame
Relationships of Power in the Political and Human Resource Frame	Establishing Community in the Political and Human Resource Frame
Hands On Cross-Disciplinary Learning in the Symbolic Frame	Experiential Interdisciplinary Learning in the Symbolic Frame

Contrasting journeys in the structural frame. All three program founders are pioneering new paths in educational leadership, but their structural experience is varied. The ArtScience program grew from an organic collaboration that was not engrained in the university planning efforts. The co-founders ambitiously pursued their idea and were co-teaching courses for several years before they established themselves as an official program. In contrast, the ArtTechnology program stemmed from an institutional endeavor to create a new college. The university created the founding position and a female Biological Sciences Professor on campus applied and received the position.

The distinct beginnings of each program play into their current structures as well. The leadership of the ArtScience program has been steadfast. The founders are still very much a part of the program and working to expand the program to become larger and more central on campus. Without this type of dedication from the ArtScience co-founders it is unlikely that the program would exist in the way that it does today. At the

ArtTechnology program the Founding Provost still works on campus, but in a different position. Since her tenure, there have been several individuals that have been in the Provost position. Despite the stable way the ArtTechnology program was established, throughout the course of the years the program has experienced much turmoil with respect to leadership and staffing. Had the strong initial structures not been in place it is likely that the ArtTechnology program would have endured additional challenges in times of unclear leadership.

Balancing power and partnerships in the human resource and political frames. All three leaders were well aware of the complex human and political relationships at play in the development of their programs on campus. The issues they faced were different, but there were more commonalities than differences across these frames. The ArtScience co-founders employed inclusion and diplomacy to best position their program. The ArtTechnology program was focused on developing relationships in a similar manner for positioning purposes. With their respective collaborations the leaders kept the organizational purpose of their program in the forefront and welcomed conversations from entities on and off campus. This openness to ideas and partnerships was a common trait that helped program leaders build relationships and increase program visibility.

Visioning in the symbolic frame. The environment and feel of the two programs were different but there was a great deal of overlap in their visions. At the heart of both programs is an experiential model. The idea of learning by using one's hands propelled the ArtScience program into fruition. At the ArtTechnology program an applied practicum requirement was a fundamental piece of the curriculum. Leaders frequently used the term "cross-disciplinary" to describe the ArtScience program, and this was

reflected in my observations as well. By definition cross-disciplinary studies involve learning a subject through another discipline (Morillo, Bordons, & Gómez, 2003). For example, teaching biology through visual arts is an example of cross-disciplinary instruction. Each course in the ArtScience program clearly integrates an arts and STEM discipline and has a tangible project based curriculum. The ArtTechnology program is characterized as “interdisciplinary.” This involves an integration of two or more academic disciplines to create something new or address an issue that requires multiple perspectives (Morillo, Bordons, & Gómez, 2003). The program is also more theoretical in its integration of arts and STEM disciplines. All of the classes do not integrate a specific arts and STEM discipline, instead, the coursework is covers a range of topics that vacillate depending on who is teaching. Both programs are early examples of integrating the arts with STEM. The challenges with being an innovator include resistance, fear, and confusion and the clarity in vision is the way that these leaders have been able to combat this type of noise.

Implications for future research and programs. This study presents an inquiry into two rich cases of established Research 1 institutions that integrate one or more arts and STEM discipline. Honing in on the leadership journeys through Bolman and Deal’s (1997) frames of organizational development, this study reflects the importance of each frame. Interview findings suggest that strong visioning is particularly central to creating these multifaceted programs. Continued inquiry on leadership and the visioning process would add to the body of research of program development in higher education.

With the national attention on STEAM, I expect a growth of programming efforts in the field. The programs in this study preceded the STEM to STEAM dialogue,

but are active in STEAM circles today. STEAM is becoming a part of an academic dialogue and as this language continues to build momentum it is necessary for research and program evaluation to share the best practices and impacts of such programs. Areas for future research include a larger national and international survey of such programs and the leadership journeys of creating these programs. Does developing STEAM programs require different competencies than developing other university programs? And more so, are these programs enhancing the creativity of our workforce? There is a great deal of room for further investigation of the blossoming STEAM paradigm.

Chapter Four: Learning Across Disciplines: A Collective Case Study of Two University Programs that Integrate the Arts with STEM

“Art is not the possession of the few who are recognized writers, painters, musicians; it is the authentic expression of any and all individuality”—John Dewey, *Time and Individuality* (1940)

The arts have the potential to be transformative for individuals from different walks of life and consumption of the arts should be accessible to all. Art can embody healing qualities for someone who is physically suffering, challenge the scientific approach to inquiry, or act as a vessel for commenting on political atrocities. The effects of the arts touch lives beyond that of the artist. It is an enduring discipline that captures cultural histories and documents civilizations. Dewey’s progressive views on art and learning are still relevant today. In higher education, there are programs that blurring discipline boundaries and purposefully integrate arts in the classroom and community.

One area that has received particular attention in education and policy debates is the STEM to STEAM movement, the impetus to include the arts in science, technology, engineering, and math learning (Maeda, 2013; Robellen, 2011). There are voices in academia and industry that suggest a shift toward STEAM situates the United States to be globally competitive. In 2013 a Congressional STEAM Caucus was created to integrate the arts into STEM curricula. “There were digital music devices before the iPod, but it took creative design and interface development from Apple to transform the way the world listens to music,” states Congresswoman Bonamici, caucus co-founder. Former RISD President, Maeda, echoes “I believe art and design are poised to transform our economy in the 21st century like science and technology did in the last century” (Group

Aims to Integrate Arts and Design with Arts Education Efforts, 2013). Other universities are beginning to acknowledge the potential of STEAM and while focusing on the intersections of the arts and STEM. This study examines student learning at two programs that integrate the arts with STEM. In a collective case study approach this inquiry aims to share the how student learning experiences and perceptions of how well learning goals were achieved.

Literature Review and Conceptual Frameworks

Bound by two established and symbiotic theoretical frameworks, a review of relevant literature contextualizes this study. The research supporting arts integration informs the curriculum choices of both selected programs and sociocultural and experiential learning theories are used in tandem as a lens for understanding knowledge creation within university programs.

Arts Integration. While it is not the primary role of the arts in academia, visual and performing arts have the ability to enhance learning in other subjects. Arts coursework is *inquiry-based*, which means it revolves around questioning and understanding concepts versus finding the answer to a given problem. There are multiple right answers. An inquiry-based model of learning is analogous with principles of critical thinking that are typically highly sought after aims of university coursework (Heilig, Cole, & Aguilar, 2010; Goldblatt, 2006).

Studies have also revealed that learning through the arts has the ability to transcend across different disciplines and enrich learning in disciplines beyond the arts. (Burton, Horowitz, & Abeles, 2000; Hetland 2013; Saraniero & Goldberg 2011). An assessment of the arts in public universities establishes that learning in the arts exerts its

greatest effect on truth-seeking, critical thinking maturity, and open-mindedness (Lampert, 2006). Similar findings were replicated when arts coursework was integrated in a university engineering program. Students were able to capitalize on the inquiry-based nature of their arts coursework and apply this to their engineering coursework, thus analyzing the problem in a different light and arriving at multiple solutions. Without this perspective from arts coursework there may have only been one solution or no solutions (Costantino, Kellam, Cramond, & Crower 2010). Similarly medicine has benefited from arts integration. Specifically theatre arts have been used as a catalyst for improving bedside manner and increasing clinical empathy (Dow, Leong, Anderson, &Wenzel, 2007).

Why STEM. Some educators question why the arts would be a likely addition to STEM education, but I would like to frame why STEM education is in need of arts integration. STEM jobs are growing approximately three times as fast as non-STEM occupations (McDougall, 2012). This booming industry growth calls for strong STEM programs at the university level, but poor retention figures shows that many students are not successful in their attempts to pursue a STEM degree. Only 43% of students that enter a four-year institution with a declared STEM majors actually graduate with a STEM degree (Holdren, 2013).

Students have different learning styles and neuroscience shows that human beings have the ability to learn through visual, auditory, and kinesthetic cues. Arts integration enables teaching content in multiple ways, which in turn creates more neural pathways and a higher probability of retaining knowledge (Land, 2013). In addition to improving learning, the core content, arts integration can be engaging and bring joy to learning.

“Whether drawing with free-form gestures or playing improvisational theater games, artists jump start creative work through activity that is fun, unrestrained, subversive, whimsical and free of a specific goal” (Brown & Tepper, p. 13, 2012). This type of process-oriented thinking is common and is conducive to creativity. Art and artists are able to create and contemplate serious pieces while maintaining a level of playfulness (Brown & Tepper, 2012).

Sociocultural theory. Learning is a complex process. The theoretical underpinnings that drive this inquiry of student learning in STEAM programs are sociocultural theory and experiential learning theory respectively. Largely informed by Vygotsky, his seminal work in the field of psychology resulted in the development of sociocultural theory. In educational research, sociocultural theory is characterized by the notion that thought processes are culturally embedded and context bound and there are social, linguistic, and biological elements that all feed into knowledge construction (Vygotsky, 1980; Wegerif, 2004). By emphasizing the social relevance of learning, sociocultural theory aligns with the ideals of collaboration in learning environments and furthermore is consistent with principles supporting arts integration (Efland, 2002).

Experiential learning. With sociocultural theory as the primary cognitive framework, experiential learning acts as an educational theory to specifically frame the central role of experience in learning. Experiential learning theory defines learning as, “The process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience” (Kolb, 1984, p. 41). Kolb’s theory draws upon foundational ideologies from Lewin, Dewey, Piaget among other influential 20th century scholars with overlapping educational

ideals (Kolb & Kolb, 2005). Experiential learning theory pulls from these theories and constructs a new framework based on six commonalities among seminal researchers.

The guiding principles of experiential learning theory according to Kolb and Kolb (2005) are the following:

1. Learning is best conceived as a process, not in terms of outcomes. As Dewey establishes, the process and goal of learning are the same thing.
2. All learning is relearning. Using a student's beliefs as a base, learning happens when topics and ideas are examined and presented in new contexts.
3. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Conflicts drive learning and require an individual to shift between various modes of thinking and acting.
4. Learning is a holistic process of adaptation to the world. It is an integrated function of that requires feeling, perceiving, and behaving in addition to thinking.
5. Learning results from synergetic transactions between the person and the environment. According to Piaget, there is a learning equilibrium that is established with taking in new experiences with existing concepts and applying existing concepts to new experiences.
6. Learning is the process of creating knowledge. Experiential learning theory employs a constructivist belief where knowledge is created and recreated versus being transmitted as fixed ideas (Kolb & Kolb, p. 3, 2005).

The combination of these traits is the crux of experiential learning theory.

Methods

Building upon the sociocultural ideals of cognition and an experiential framework of learning, this qualitative study utilizes a collective case study methodology to analyze data from two university programs. A collective case study is sometimes called a multiple case study and is characterized by one or more cases that allows for comparisons within and across cases (Baxter & Jack, 2008). I selected this design in order to compare and contrast findings around student learning in two university programs.

The selected university programs are bound by the following criteria: integrate at least one arts discipline with at least one STEM discipline; reside within a Research 1 institution; and be in existence for at least five years. I initially identified seventeen programs across the nation and proceeded to narrow the list to feasibly collect data over the course of one year. The two selected university programs abide by the aforementioned criteria and are undergraduate programs within the same public university system. I have named these programs the ArtScience and ArtTechnology program respectively.

The ArtScience program was officially established in 2006 and aims to bridge arts and science learning. It is open to students of all majors at the university and is comprised of five primary faculty members in addition to four collaborating faculty members. Students can take one or several courses in the program. The ArtTechnology program is focused on technology in conjunction with art and culture and was created in 2001. This program is structured a little differently than the first research site in that the program is the mandatory general education course series within a college on campus. Undergraduate students rank their college selections when applying for admission and if

selected into the ArtTechnology college they are required to take three sequential courses, complete an independent internship or practicum that applies course knowledge, and complete an upper division writing course. There are six management and teaching positions dedicated within the program in addition to a pool of rotating faculty from other departments. Despite these structural differences experiential learning is a focal point for both programs. The ArtScience program uses the phrase “experiential learning” in the program tagline and the courses are intentionally project based. The ArtTechnology program also embodies an experiential learning model through their required practicum course and hosts a biannual “experiential learning conference.”

After gathering background information regarding both programs through extant data and preliminary questionnaires, I conducted semi-structured interviews with students and alumni in both programs. I had general guidelines for interview questions but the interviews were largely conversational and fluid. The transcriptions from student and alumni interviews accounted for the bulk of the data within this collective case study. My intent was to provide insight for the following research question:

1. What are student learning experiences in university programs that integrate the arts with STEM?

a. If student learning outcomes been established, how do students perceive the degree to which the outcomes were achieved?

To address the question and frameworks I asked students and alumni about their academic and professional goals, the student experience in each program, and collaborative projects. Additionally in the ArtScience program I asked about how the program was doing in respect to general program goals and in the ArtTechnology

program interviews I asked about the effective or ineffectiveness of achieving specific student learning outcomes identified by the program.

With this data, I used *open coding* to establish like themes within each program. This method avoids predetermined codes and uses language from the interviews to drive the different codes (Esterberg, 2002). 54 codes were derived from student and alumni interviews in both programs. I then categorized the recurring codes into themes for each program and analyzed the similarities and differences of student learning findings and their connective threads to sociocultural and experiential learning theory.

Data Analysis

Learning themes in the ArtScience program. For the ArtScience program I conducted 13 student interviews, three alumni interviews, and two impromptu interviews with community members who also partook in program projects.

Sociocultural: collaborative learning. I visited the site during finals week and conducted interviews with students at an outdoor setting, where they were working on an art-based final project. Students were coming in shifts throughout the day to work on a mural project for a science course about various types of bees. Each student was assigned a particular type of bee, for example a nurse bee or a queen bee, and were responsible for learning about their bee and sharing that knowledge with peers. The project also had to function as a collaborative permanent sculpture. They were conversing and comparing their work to make sure their pieces were anatomically correct and fit within the broader mural that they were creating. They knew that there was a larger purpose to the art piece that they were creating and in order for the group to have a successful outcome there needed to be dialogue between the classmates. “The entire

thing is basically a collaboration. You're trying to figure out where does this go? Where does that go? Can I borrow your mold?" said a student in describing the collaborative work the course (ArtScience student, Sociology student, personal communication, June 1, 2013).

Students also commented on the amount of collaboration in the ArtScience program as being atypical.

It's a different way of approaching a problem by getting the solution as a team. Oftentimes I don't think I really have to do that in my other classes, getting all together to work on a project in a creative environment. It's a really nice way of looking at things and I think that it will help me in the future when I have other projects, even if it's not an artistic project (ArtScience student, Biological Science major 1, personal communication, June 1, 2013).

Another student also commented that the experience of adding a clay replica of the habitat and anatomy of a nurse bee helped her engage with her peers and learn about the other species of bees as well, "It helped me realize that I shouldn't always focus on one thing but also take into consideration other people that are around me" (ArtScience alumnus, Sociology major, personal communication, June 1, 2013).

An alumnus with a science background also echoed the benefits of learning from her peers. She felt like the level of collaboration in the ArtScience courses helped her learning in both subjects. "It's highly collaborative in both aspects. Being collaborative in the arts trains you to be collaborative in the sciences and I think it is slightly easier in the arts because it is less intimidating" (ArtScience alumnus, Entomology major, June 1, 2013). Course instructors made an effort to make arts accessible and students from all backgrounds commented on their ability to create and accomplish the creative expectations of program classes.

The social context of learning is fundamental to sociocultural theory and runs counter to the notion that learning is a one-way street where abstract concepts are digested by the student in a solitary fashion. Interviews revealed 18 different instances where students cited that they were learning concepts through collaboration.

Experiential learning: retention through doing. Another prominent pattern around student learning was the impact of learning through doing and the retention of this information. A few students with a science background were particularly vocal about their appreciation for this type of applied coursework. A premedical student talked about the monotony of some science courses.

Why can't all of our classes be like this? ...In your average class you are in this mentality like, all right, I've just got to get this information down, memorize it, take a test and move on...the information that I've learned in this class I am going to retain so much better...I think this what I am going to take from this program in the long term, aside from what I learned, it is rethinking the way that I learn information and retain information (ArtScience student, Premedical Biology major, personal communication, June 1, 2013).

Without being prompted, students suggested that they would like to see their other coursework incorporate a more experiential or artistic approach. "Honestly this information that I've learned through my work with my classmates, I'm pretty sure I'm going to remember it. It helps me retain information instead of just memorizing it for a test" (ArtScience student, Animal Biology major, personal communication, June 1, 2013). Another student commented, "I wish I could take organic chemistry in a way where I could learn it in an artistic way" (ArtScience alumnus, Human Development major, personal communication, June 1, 2013). A third student repeated,

I would like this style of teaching to be incorporated into other classes...I take math and physics and computer classes, where we basically learn

about theorems but then never apply it to anything. It feels like a memorization more than learning. It would be harder for classes like math, but I wish they could bring in examples and mix things up (ArtScience student, Computer Engineering major, personal communication, June 1, 2013).

A recent alumnus of the program also talked about her experience using her hands and learning through experience in the ArtScience program.

Just being so hands on from day one, it clicked. I learned so quickly and I cared more because I was involved in it. It's definitely something that makes you learn content so much deeper and with so much more meaning in a shorter period of time...I'm a really visual person, and I think with science, a lot of times it's not visual enough for me. And then being able to create that with your in hands, it just it really stuck in new ways (ArtScience alumnus, Human Development major, personal communication, June 1, 2013).

Experiential learning theory emphasizes the overlap of experiencing, thinking, reflecting, and acting. The quotes above show how cognizant students are of their own learning and retention and what's more is that by going through this cycle of learning students will be, as Kolb and Kolb describe, (2005) empowered to take control of their own learning.

Enjoying learning. Another significant theme throughout interviews was the seemingly simple notion that learning can be fun, or engaging. Interviewees used the words “stress-free environment,” “relaxed,” “casual,” and “fun” to describe the ArtScience program (S. Ghanbari, personal communication, June 1, 2013). While having fun may not be a defined principle of sociocultural theory or experiential learning theory, it is one of the reasons that the arts are integrated into STEM learning. There is no denying the power of enjoying learning, or the power of an engaged learner.

I really like this course, especially compared to my other science classes, it offers a different way of learning. You go to lectures, and they're great because you learn so much, but it's really easy to forget why this stuff is important in real life. Coming out to [location of the ArtScience program] and seeing the research facility, I feel like it made it that much more real.

It just makes me excited about science again (S. Ghanbari, Biological Science major 2, June 1, 2013).

Excitement and engagement run hand in hand in creative transformative learning experiences.

I think that this program changed my entire university experience. I never would have gotten into art...I'm really grateful that this has opened my mind...ArtScience program founders are absolutely incredible people who work so hard on this program, so I think it's inspiring when you see how much they care and how hard they work (ArtScience Alumnus, Entomology major, personal communication, June 1, 2013).

The students I conversed with talked about the encouraging nature of the program.

“They definitely want to bridge the gap between artists and scientists, and they focus on being creative, and that's a scientific thing as well...it just culminates in this really positive feeling that art and science are both valuable” (ArtScience Alumnus, Anthropology major, personal communication, June 1, 2013).

Learning Themes in the ArtTechnology Program

At the ArtTechnology program I conducted three student interviews and six alumni interviews. These interviews were generally longer because the program had established specific student learning outcomes for the writing requirement and practicum requirement of the program. I was able to ask the students how they felt the program was doing overall and specifically how the program was doing on each learning outcome.

One of the goals of introducing the practicum or an internship component to the program is interdisciplinary inquiry—it strives to “Establish and explore connections from more than one discipline or perspective.” All nine participants felt that this goal was realized in their experience at Program 2. When asked about this learning outcome, an Environmental Sciences major responded,

The program does a really great job of this, especially the variety of instructors you have, and the variety of media that you are exposed to. You're asked to incorporate music, films, a lot of literature, and scholarly papers into your work, and they encompass a variety of backgrounds (ArtTechnology Student, Environmental Systems major, personal communication, August 26, 2013).

The program pulls from disciplines beyond the STEAM paradigm, but still has a focus of incorporating technology and art as a connective thread throughout the program.

Overall the interviewed students and alumni felt like ArtTechnology program was successful in reaching its learning outcomes, but one area for improvement is the following goal: "Apply theories or concepts from their disciplines to experiences external to formal lecture instruction." Of the nine interviews five of the participants felt like the practicum and overall program did not fully realize the aforementioned goal. Some students did site volunteer, travel, work, or research opportunities that highlighted this learning outcome, but it was not as universally successful as the other program goals.

Sociocultural: collaborative learning. Like the ArtScience program, learning through collaborative projects was a theme that emerged from student and alumni interviews in the ArtTechnology program. "The practicum really sticks out for me. The whole practicum experience was basically a group project. It was a dialog among 16 students" (ArtTechnology alumnus, Cognitive Science major, personal communication, December 5, 2013). In addition to the practicum experience, which many students described as a distinguishing and central facet of the ArtTechnology program, there was also project-based learning and arts integration in general program courses.

In one class we made created a mini-comicon to display comic books that we had made. It was definitely a group effort where each group created a booth that was supposed to center around the comic we picked and also draw an audience (ArtTechnology alumnus, Environmental Systems

major, August 26, 2013).

This type of collaborative coursework fosters collaboration across majors.

It was interesting to see how an art major or communication major would attack the problem...I was very rigid with the way I thought, it was almost kind of computational, and it was good to see outside perspectives, someone who was more creative or right brain oriented as opposed to my rigid structure. The meshing of those different types of personalities was pretty interesting and it was nice to see how that all combined when we solved a problem (ArtTechnology Alumnus, Mechanical Engineering major, November 20, 2013).

The quote above is from an alumnus who is currently a working engineer. He explained how the collaborative projects in the ArtTechnology program has helped his own thinking and his ability to work with all different types of people in his current position. As in the ArtScience program, sociocultural theory is highlighted through artful collaborations.

Experiential learning: influencing careers. Interviews at the ArtTechnology program also revealed examples of hands on learning, but this was not as prevalent as in the ArtScience program. Instead, interviews showed more of a focus on professional development and the importance of experiential learning in that context. Seeing that the ArtTechnology program requires a series of mandatory undergraduate coursework it is logical that this program emphasizes preparing graduates for that next step. “They did a really good job of connecting your interests and future goals with the practicum requirement” (ArtTechnology alumnus, Biochemistry major, personal communication, September 5, 2013). The practicum opportunity is flexible enough that students can cater the requirement into an internship that of their interest. This requirement brings experience to the forefront. The practicum is paired with a writing requirement so

experiencing, thinking, and reflecting is happening symbiotically. The next step would be for students to act on what they have learned.

“I plan to apply to med school so practicing interviewing skills and writing personal statements were really helpful for me,” said recent graduate of Program 2 (ArtTechnology alumnus, Biochemistry major, personal communication, September 5, 2013). The practicum and writing requirement helped students focus and clarify their post graduation goals. “It’s like writing a paper on your college experience...it’s not something I thought of until I had that course and was able to reflect on how classes and your major has an effect on you. The practicum was one of the things that had a really big impact on me here” (ArtTechnology alumnus, Biochemistry major, personal communication, September 5, 2013).

Students also talked about the breadth of ArtTechnology classes and how it helped guide the major selection process. The program requires coursework in a student’s freshman year and this integration of classes at the beginning of the university experience might have an influence on major choice. The program requires a sequential three quarter series taken freshman year in addition to an upper-division writing course and practicum requirement that is must be completed prior to graduation. Participants described the upper division requirements as “applied,” “pragmatic,” and “focused on career goals” while the freshman sequential series was described as “theoretical,” “diverse,” and eye opening.

Broadening student perspectives. Interview participants seemed surprised by some of the big picture impact they felt from the ArtTechnology program. A psychology alumnus who is currently employed by the army explained how the program influenced

him post-graduation. “I didn’t really appreciate the program until a year or two after I graduated...I can’t say I was very appreciative of the arts until after college”

(ArtTechnology alumnus, Psychology major, personal communication, December 4, 2013). He spoke to a specific course medical ethics course that was part of the freshman series.

It was the first class I took that really made me look at a lot of things that I believe from a different angle...Realizing that not everyone views the world the same way I did. Looking at it from their side and realizing that they’re coming from a completely different viewpoint...You realize how hard it is to come to those compromises that our country and our government and culture has to balance (ArtTechnology alumnus, Psychology major, personal communication, December 4, 2013).

His eyes were opened to complex issues being analyzed through a range of perspectives and through a variety of mediums.

Students also talked about growing through challenges.

I think when we were able to make our own art, we were also given a chance to use different technology that we wouldn’t normally use...it just asked us to step out of our comfort zone and use computer programs that we weren’t used to (ArtTechnology student, Environmental Systems major, personal communication, August 26, 2013).

Since courses were made up of people from all majors many of the ArtTechnology requirements were things that they had not explored in previous coursework.

Through broadening perspectives and pushing new modes of learning the program has left a lasting impression on many of its participants.

The Practicum shaped who I am and what I do now. It helped me decide to get my masters in social work and go into non-profit management...the program has helped me do many things better. I think the skills I have gained from this experience are self-reflective skills. Listening, really truly listening, to someone’s story, listening to where they come from, their culture, and being able to see their biases and my own biases (ArtTechnology alumnus, Sociology major, personal communication,

December 23, 2013).

These types of eye opening experiences help build strength of character and guide students on their respective paths after graduation.

I was one of the people selected to do a speech in front of the class at the end of the quarter, which for me is kind of amazing because I used to have a really bad speech impediment, and it gave me so much confidence, and it's one of the experiences I look back on with so much pride (ArtTechnology alumnus, Cognitive Science major, personal communication, December 5, 2013).

She was able to face her fear and grow through the experience.

Discussion

While the programs content and structure are completely different they both conveyed powerful student learning experiences with largely similar themes. An overview of the discussed themes is presented in the table below.

Table 2. Student learning themes in the ArtScience and ArtTechnology programs.

Student Learning Themes by Program	
ArtScience	ArtTechnology
Sociocultural: Collaborative Learning	Sociocultural: Collaborative Learning
Experiential Learning: Retention Through Doing	Experiential Learning: Influencing Careers
Enjoying Learning	Broadening Student Perspectives

The role of learning outcomes. One of the aims of this research is to present student perceptions of learning outcomes and how well these goals were realized. In respect to specific learning outcomes, the ArtScience program did not have published

outcomes, but interviews still showed that students had a clear understanding of their class and program goals. Students and alumni were well aware that the program aims to bridge arts and science learning with a hands-on approach. This might be a reflection of the fact that classes are taught consistently by the same faculty members. I would recommend publishing specific learning outcomes as the ArtScience program expands in order to measure program effectiveness and document student success stories. This is one area where the ArtScience program can look to the ArtTechnology program as an example.

The ArtTechnology program promotes is focuses on preparing undergraduate students with the necessary skill-set entering the work force or continuing education and their goals are broader than strictly promoting STEAM. For this reason, learning outcomes encompass more than the integration of art or technology and focus on things like critical thinking, civic engagement, and information literacy. The programs broader focus on writing and scholarly aptitude fits clearly within the university mission and vision. While the scope of this study does not include a comprehensive program evaluation, interviews with students and alumni showed that the majority of these participants felt like goals were being met.

The program has gone through many evolutions of leadership but the learning outcomes have remained as a consistent pillar of maintaining program quality throughout the years. Having formalized writing and practicum goals allows program leaders to track student learning and modify their coursework accordingly. By having a solid structure and position on campus, I expect that the ArtTechnology program will remain a central part of the larger university.

A collaborative experiential learning model in practice. The student and alumni perspectives from the ArtScience program and the ArtTechnology program generally presented a common narrative. Students of all majors are able to converge and exchange ideas, and accordingly, this high level of collaboration was one of the most repeated themes from both programs. Similarly, both programs are committed to implementing an experiential learning model. It is not surprising that this model is central to the purpose of the university programs since integrating the arts often brings a hands-on element to learning. Beyond simply learning through doing, to be fully realized, experiential learning requires thoughtful planning and reflection. Both programs incorporated a complete experiential model, but they had different strengths. The hands-on element was central to the experiences of students and alumni from the ArtScience program. Participants talked about applying their knowledge into creating tangible objects. This process was not only enjoyable and new for many of the students, but also helped them retain the subject matter. At the ArtTechnology program students talked less about the act of creating and more about the thinking facet of experiential learning. Participants talked about how coursework influenced their college major and career choices. There were clear opportunities, like the practicum, where students could explore and reflect on their own interests. A balanced convergence of opportunities for making and thinking is ideal.

The A in STEAM. The ArtScience program and the ArtTechnology program are both innovators in the STEAM community and were both created in a time when it was novel to have a formalized university program with an art and STEM focus. The ArtScience program in particular has integrated the arts comprehensively into their

courses. The program has received local and national recognition for the art produced from their classes. One example is the collective mural project that was exhibited in the Washington D.C. U.S. Botanical Garden. The mural is now housed permanently on their campus and is a part of a large and growing presence of art and science collaborations. The high level of arts integration and student engagement in the ArtScience program is a successful benchmark not only for the ArtTechnology program, but also for any emerging STEAM program.

In both programs the arts are championed as an academic discipline and a tool to improve learning in other disciplines. Students and alumni from all academic backgrounds were interviewed and testimonials showed that STEM students had particularly transformative experiences with arts integration. Many of these students cited their experience in both programs as an eye-opening interaction with the arts that they would not have been inclined to explore otherwise. Echoing the initial notion that these disciplines are stronger together than apart and that STEM needs the arts, interview participants presented a strong case for art integration. Increased creativity, broadened perspectives, and discovering unknown strengths are some of the comments STEM students shared about their learning through art-making.

Areas for future research. There is ample room for further investigation on learning experiences in programs that embody the STEAM model. More specifically, future research on programs with established learning outcomes should be conducted to see if there are differences in programs that integrate arts and STEM versus programs that keep the disciplines separate. Further research evaluating current STEAM programs is necessary to understand the impact of these university programs and continue to paint the

narrative of these interdisciplinary academic programs. The field is new and growing but there is a wealth of unique partnerships and programs integrating arts and STEM fields. Research at innovative sites will help share various models and document the influence of STEAM-based learning. Beyond universities, non-profit and corporate entities have also initiated STEAM programming and a closer look at the outcomes of these programs will also benefit the field and enrich learning in various walks of life.

Chapter Five: Discussion and Conclusions

This chapter provides a summary of findings, presents a broader discussion about the implications of this research, explores areas for future research, and shares my personal motivation for embarking on this research. It includes a reiteration of the purpose of this study, a review of the theoretical frameworks and methodology, and a discussion about research conclusions, project limitations, in addition to the significance and policy implications of this research.

Purpose of the Research

Research on arts and cognition suggests that there should be more value placed in fostering the arts within universities. Creativity and innovation are pillars of economic success and are correlated with the arts (IBM, 2010; Root-Bernstein, 2008). Furthermore, arts involvement has been linked to a host of positive traits and there are innate benefits to partaking in the arts (Gates, 2007; Hetland, 2012; Lampert, 2006). One facet of arts integration that has received a fair amount of national attention is the STEM to STEAM movement (Catterall, 2013). To put this in perspective, over the course of data collection for this study an academic STEAM journal was launched from Claremont Graduate University and a Congressional STEAM Caucus was established on Capitol Hill (*The STEAM Journal*, 2013; Reps Bonamici and Schock Announce Bipartisan Congressional STEAM Caucus, 2013). Similarly, there are a growing number of university programs that reflect STEAM ideals of bridging the arts and STEM disciplines. Research still does not reflect the robust programming efforts and this study aims to contribute to STEAM research and provide insight into leadership and student learning at university program that integrate the arts with STEM.

Research Questions

This study explores leadership and student learning within and across two university programs. The research questions are as follows:

1. What are the experiences of those involved in developing university programs that integrate the arts with STEM?
 - a. Who provided the leadership to develop the programs and what actions did they take?
2. What are student learning experiences in university programs that integrate the arts with STEM?
 - a. If student learning outcomes been established, how do students perceive the degree to which the outcomes were achieved?

The questions are intentionally broad to account for unanticipated experiences of program founders, students, and alumni.

Review of Methodology

Three theoretical lenses and a collective case study methodology are applied to address the above research questions.

Bolman and Deal. The first research question examines the leadership efforts from the perspective of individuals that have founded a university program. Seminal leadership authors Bolman and Deal (1997) present four frames of organizational development and this is the overarching theoretical lens that addresses the educational leadership facet of this study. The four frameworks consist of a structural, human resource, political, and symbolic point of view and interviews with educational leaders

incorporated questions addressing each of these frames. The full guidelines for interview questions are provided in Appendix D, E, and F.

Bolman and Deal's approach leadership is both soulful and methodical.

We want this volume to help lay the groundwork for a new generation of leaders who recognize the importance of poetry and philosophy as well as analysis and technique, who embrace the fundamental values of human life and the human spirit (Bolman and Deal, p. 380, 1997).

The authors establish the complexities of organizational development and the multifaceted role of leaders. In this study, the selected educational leaders have pioneered the creation of a new interdisciplinary university program within a large public university system, a particularly complicated and challenging order. Leaders had to navigate across all four frames to establish their program.

Sociocultural theory. The second research question is focused on learning experiences from a program student or alumnus view and to examine these findings I apply a lens of sociocultural theory and experiential learning. Founded by Russian Psychologist Vygotsky, this framework emphasizes that learning and development are interconnected with social and cultural contexts (Vygotsky, 1980). Like Bolman and Deal, sociocultural theory embraces complexity and veers away from simplistic explanations for leadership or learning (John-Steiner & Mahn, 1996).

The research connecting cognition to arts involvement is at the foundation of this study. Building on that body of research, sociocultural theory embodies some of the rationales for arts integration and acts as a cognitive lens for understanding knowledge construction. Through this framework learning through the arts is socially bound and the instructor becomes a cultural mediator (Efland, 2002). Learning becomes a collective

and collaborative process.

Experiential learning theory. Related to the cognitive sociocultural framework, experiential learning is a pragmatic lens that acknowledges the central role of experience in learning. This framework directly integrates ideas from Dewey, Lewin, and Piaget to create a new comprehensive educational theory for learning. The overlap across these seminal thinkers provides a rich theoretical foundation. At its core, experiential learning theory is most closely related to Dewey's (1938) "theory of experience," where *fruitful* experiences guide learning in a progressive classroom.

In respect to student learning in interdisciplinary university programs, this theory also supports the integration of the arts because of the experiential qualities of the discipline. The project-based approach to art making lends itself to be analyzed from an experiential learning frame. Bolman and Deal, sociocultural theory, and experiential learning stem from disparate fields but come together to present a comprehensive theoretical foundation for this study. From a leadership, psychological, and educational lens respectively, these theories work in tandem to support an exploration of leadership and student learning experiences within interdisciplinary university programs.

Collective Case Study

This research incorporated a collective case study methodology to compare the two selected university programs that integrate at least one arts discipline with at least one STEM discipline. The two selected university programs are part of the same large public university system and are relatively established programs. A collective case study allowed for two distinct accounts of leadership and student learning experiences in addition to comparisons across the both programs. I visited both programs, collected

extant data, and conducted interviews with founders of both programs in addition to students and alumni from each site.

Summary of Findings

Prior to my experience interviewing individuals at both site I reviewed public data about each program. Semi-structured interviews with pertinent individuals were the key tool in developing a stronger understanding of how each program was created and the experiences of students from both programs.

Program Demographics. The ArtScience program is comprised of three general courses in addition to several special seminars. The program offers two or three of these seminars annually. The courses are taught by five core faculty members and have 175 to 250 students participate in the program each year. The program is situated in a large Research 1 public university where 73% of the students are White or Asian and 16% of the student population is classified as Hispanic. The predominant industry in the region is education, but the community also has a strong agricultural component.

The ArtTechnology program is the required coursework for separate college within a large Research 1 public university system. Program coursework consists of three sequential courses, an upper-division writing requirement, and an applied practicum for students. There are 3,625 students currently in the college that incorporates the ArtTechnology program. All of these students are required to take the three sequential courses in their first year and then complete the writing requirement and practicum by their final year. There are six people dedicated to the program in addition to several faculty from various departments that also rotate teaching courses. Demographics of the university show that almost 45% of the undergraduate student population classify

themselves as Asian and the next largest ethnicity is White with 23% followed by Mexican-American at 12.5%. Both programs have a less than 5% population of African American students.

Program Interviews

Semi-structured interviews were the primary method of data collection within this collective case study comparison. The below table outlines the interviews I conducted at both sites.

Table 3. Completed interviews at the ArtScience and ArtTechnology programs

ArtScience	ArtTechnology
2 program founder interviews	1 program founder interview, 1 founding committee member interview
13 student interviews	3 student interviews
3 alumni interviews	6 alumni interviews
2 community member interviews	

Program founder interviews. The interviews with founders revealed two distinct journeys of program development. In the ArtScience program, the concept for fusing the arts with science learning stemmed from the collaboration of the program's co-founders, a professor in the sciences and a noted public artist. Their vision of co-teaching arts and science was supported with pilot funding from a university provost.

Leadership themes in the ArtScience program. Major themes from interviews with the founder at Program 1 were resourcefulness, relationships of power, and a hands on cross-disciplinary approach. Both founders shared the challenges of supporting the program and the continuous need to be resourceful. Using Bolman and Deal's structural frame as a unit for analysis, the program founders explained the structural challenges with program development, but also shared ways that they navigated such obstacles.

From finding physical facilities on campus, to obtaining private funds, knowledge of university policies and the ability to adapt to different situations has been instrumental in developing the ArtScience program.

The next theme explored in the first program is the relationships of power, through a human resource and political frame. The founders spoke to their complimentary and respectful relationship with one-another in addition to their inclusive and diplomatic approach to collaborating with entities within and beyond their university. In respect to human resources, they spoke to the value of establishing a relationship not only with one another, but with other departments on campus. The politics within a large university are intricate, and accordingly, leadership has had to make strategic decisions to best position their program.

The third theme that resonated strongly in both program founder interviews was a hands on and cross-disciplinary approach to bridging arts and science. Using Bolman and Deal's symbolic frame, the leadership's commitment to this vision resonated in interviews and was apparent during my site visit. The impact of learning through doing is at the heart of the program and founders were both passionate advocates for teaching science and art in a harmonious collaborative environment. The terminology of "cross-disciplinary" and "hands on" is utilized because it reflects the language of the co-founders in their interviews.

Leadership themes in the ArtTechnology program. Shifting to the ArtTechnology program, the leadership journey overall was a much more institutional and collective process in comparison to the ArtScience program. The university had established the need for creating the new college and the concept for the college was

established through a committee of faculty members from various departments on campus. It was agreed that this new college would integrate arts and culture with technology, for ease of recognition in this study I had named the program ArtTechnology. Once the focus of the college was established the university created a provost position to lead the academic planning process and make this idea a reality. A female Biological Sciences faculty member was selected to lead this process. I interviewed the Founding Provost in addition to a member of the founding faculty committee.

These interviews revealed the theme of newness and fluidity as a structural ideal for the ArtTechnology program. A thorough academic planning process was underway and program goals and student learning outcomes were published with the onset of instruction at the ArtTechnology program. The Founding Provost spoke to the process of establishing the parameters of the program using broad strokes. This way the program concept and curriculum would remain current and be able to adapt accordingly.

Another theme from interviews with leadership of the ArtTechnology program is establishing community. Using the human resource and political frames, the Founding Provost explained the importance of relationships within the program and with the greater campus. She is no longer the provost of the ArtTechnology program and there have been several people in that role since the program's inception. Challenges with staffing were prevalent. The solid program structure helped manage the magnitude of transition with leadership. The interdisciplinary and sometimes ambiguous nature of the program requires strong partnerships to perpetuate the program. The Founding Provost explained

that it took a unique type of individual to thrive in this setting and finding these individuals was the greatest obstacle.

Repositioning to a symbolic lens, the vision of the ArtTechnology program is largely interdisciplinary and experiential. This vision has been the driving force of the program from its creation to present day. Both programs show similarities in visioning and purpose despite differences in the structure and development of the programs. Again the terms “interdisciplinary” and “experiential” are utilized because these reflect the language of the Founding Provost and founding committee member’s interviews. This vision is parallel to the ArtScience vision theme of being a “cross-disciplinary” and “hands-on” program.

Student and alumni interviews. Learning themes emerged from students and alumni interviews in each program.

Learning themes in the ArtScience program. The main learning findings within the ArtScience program were collaborative learning, retention through doing, and enjoying learning. Looking at collaborative learning through a sociocultural theory framework, where the social context of learning is key, students and alumni shared their experiences of group work and sharing ideas with their peers. They cited this high level of interaction as being atypical and something they experienced more from the ArtScience program than from their other coursework. Students work together on collaborative art pieces in the program and in this process they listened and learned from one another to create works that are not only scientifically accurate, but also aesthetically pleasing.

Retention of course concepts was also a benefit of the hands on approach to

learning in the ArtScience program. In line with the experiential learning theoretical framework, participants noticed that the experience, or the “making,” process helped the course content “stick.” They also commented that other classes, particularly STEM coursework, would benefit if it employed this type of experiential model. Interviewees explain that this approach to learning is more efficient and effective than rote memorization.

Another theme worth noting is the level of enjoyment of program participants. From interviews and my own experience on site, it was clear that the ArtScience program promoted a welcoming, relaxed, and fun environment. The positivity provides a learning environment that is prime for camaraderie and transformational experiences. There were not published student learning outcomes, but it was clear that students had meaningful learning experiences and were aware that the larger purpose of the coursework was to bridge arts and STEM learning. The strong leadership and vision for the program was also apparent in student and alumni interviews.

Learning themes in the ArtTechnology program. Interviews with alumni and students at the ArtTechnology program included questions about their general experience in addition to questions about specific learning outcomes. The program has published outcomes that are largely focused on general academic preparation like critical thinking, writing, in addition to skills that are unique to the program like information literacy, civic engagement, and global awareness. The program learning aims are broader than specific learning in technology or arts and culture and participants largely felt that established learning outcomes were realized. Major themes were collaborative learning, influencing careers, and broadening student perspectives.

Much like the ArtScience program, learning through collaboration was repeated throughout the interviews. Students spoke about the level of group work and the unique collaborations that came from students in different disciplines. Both programs are open to students of all majors and as a result many collaborations took place with individuals that would not have normally been paired in classes together. Sociocultural ideals were at play and learning took place and creative collaborations helped generate new ways of thinking.

The next theme that emerged was the ArtTechnology program's influence on guiding students in their career path. One requirement of the program asks students to complete an internship or practical application and reflect on this experience. Interviews revealed that the opportunity to apply coursework to their own interests helped focus their professional goals. The ArtTechnology program intentionally incorporates an experiential model of learning and coursework, which includes arts integration.

Seeing that global awareness was a program learning outcome it was not surprising that students and alumni spoke to how the ArtTechnology program broadened their perspectives. Students were able to identify their own biases and see the biases in others. Though the program focused on integrating arts and technologies, the takeaways that students and alumni spoke to were larger than simply acquiring new skills. Their experience in the program shaped the way they processed information and viewed learning.

Unlike the leadership narratives, student learning in both programs revealed a great deal of the same principles, grounded in interdisciplinary, collaborative, and experiential learning. Students and alumni were connecting STEM and the arts and

noticing commonalities across the disciplines. Students and alumni from various majors were interviewed at both programs. There was a reoccurrence of individuals in STEM fields speaking to the benefits of learning through doing and the creative advantages of approaching problems collaboratively with individuals from different backgrounds.

Both university programs integrated an arts and STEM discipline before the STEAM dialogue materialized in educational circles. The ideology of integrating the arts with STEM precedes the STEM to STEAM dialogue and the two selected programs are examples of an academic model for improving STEM and arts learning by utilizing strengths of the seemingly disparate fields. As the demand for innovative STEM practitioners' increases, and more programs emerge, the leadership and student learning journeys from these programs show the benefits of challenging traditional models of learning. The programs do not set out to teach creativity but the learning environments promote the construction of knowledge through creativity thinking strategies. Students are welcomed to question and shape their own learning (Madden et al., 2013).

Preserving discipline integrity. When bringing together different disciplines in a learning environment there is the concern of losing the depth or content of one the subject areas. The STEM to STEAM movement faces the same challenge and sometimes criticism. Program founders at both sites expressed that there are mutual gains when the arts and STEM are taught together. In order to avoid diluting the course content it was imperative to have area experts teaching the courses. For example in the ArtScience program an artist and scientist co-teach a course integrated learning about insects from both perspectives. All classes in the ArtScience program are not co-taught, but the faculty in the program are established in the specialties they are teaching. The

ArtTechnology program pulls from all subject areas to teach coursework. While this approach does not provide the same level of consistency throughout the years the program is structured enough that instructors from different departments can teach a course and have it connect within the larger program goals.

Limitations

There were limitations within this study that largely had to do with the duration and scope of the study. My research questions were intentionally broad and exploratory and a qualitative approach was best suited for this inquiry. The aim was not to acquire generalizable findings, but to present narratives of two established programs that could guide future programs and inform educational policies.

In gathering extant data, I was limited to what the programs could provide in terms of background knowledge, evaluations, and planning documents. The amount of extant data collected from the two selected programs was not parallel and limited new findings could be established from this documentation. These records and background knowledge served more as a means of triangulating my observations and findings from interviews. While the programs are both in the same large public university system, the programs are not evenly stacked. The ArtScience program is smaller and is not its own college, like the ArtTechnology program; this was a limitation when attempting to make general structural assessments across both programs.

Within each program I elected to interview the *founding* leadership, in order to understand the process of creating a new interdisciplinary program. In the ArtScience program the founding faculty were still teaching within the program and at the ArtTechnology program the Founding Provost was no longer leading the program. A

program evaluation of leadership cannot be assessed because all leaders and faculty were not interviewed in this study. Similarly, a formal assessment of the effectiveness of student learning outcomes at the ArtTechnology program would require additional student interviews.

A potential area of bias is my own subjectivity and emersion in the STEM to STEAM community. I work in the department of visual arts at the University of California, San Diego and have seen several new research initiatives emerge, particularly with arts and engineering. My positionality is something that I was cognizant of and counteracted by refraining from asking leading interview questions. Also, in the data analysis process I intentionally elected to use an open coding technique so the words of interviewees would guide the actual codes and ultimately the interview themes at each site. This way I was not projecting my own sentiments into the analysis of findings.

The Future of STEAM in Practice and Policy

In a world where our future industry challenges are largely unknown and a global society has become increasingly connected, it is imperative that educational institutions prepare students to thrive within this climate of the unknown. Studies across the K-16 landscape have documented the negative effects of squandering creativity (Garber, 2004; Heilig et al., 2010; Warburton, 2006). As echoed by Sir Ken Robinson's famed TED talk "Many highly talented, brilliant, creative people think they're not — because the thing they were good at school wasn't valued, or was actually stigmatized" (Robinson, 2006). This type of discouragement is damaging to learning and is also misguided.

This research takes a different approach and examines two university settings where creativity is blossoming. Focusing on emphasis placed on preparing STEM

graduates, this study looks at the impetus for arts integration in university STEM programs. Careers in STEM are no longer rigid and confined by technical ability; creativity and social aptitude are equally important traits for STEM professionals (Maeda, 2013; Madden et al., 2013). Findings from this study suggest that employers who are looking to innovate should integrate individuals from a variety of backgrounds and create an environment poised for collaborative problem solving. Building alliances from industry to academia is also necessary for both universities and organizations to share accounts of optimal student experiences and desired traits.

From an academic viewpoint, educators and administrators have an opportunity to communicate best practices of university programs that show the impact of STEAM based curricula. Furthermore continued conferences or opportunities for program leaders to collaborate and share examples of arts and STEM integration are necessary for program improvement and knowledge creation. For universities that are embarking on interdisciplinary program within the intersection of the arts and STEM this research promotes the benefits of incorporating an experiential program model.

In order for a viable shift in promoting arts integration, increased allocations for the arts are necessary to provide the programming and educational demands of a creative workforce. Also, balancing arts spending with the investment in STEM learning would reflect the shift in values that this research recommends. Policy improvements like increased national funding for the arts, interdisciplinary grants across the NEA and NSF, and the Congressional STEAM Caucus, give a policy voice to this study and the greater body of research presenting the cognitive benefits of the arts.

Looking at specific higher education policy implications from this study, there is a strong case for requiring incoming undergraduate students to partake in coursework that blends various STEAM disciplines. Interpersonal skills are essential to learning, communicating effectively, and building relationships and through the ArtScience and ArtTechnology programs students and alumni developed these types of essential life skills (Spitzberg & Cupach, 2011). The high level of collaboration among individuals of different backgrounds is an ideal way to introduce university coursework to students, and furthermore, establishing an appreciation and understanding of the arts and sciences is productive and beneficial for any area of study. These programs could take various forms and integrate different combinations of arts and STEM fields. I recommend that university STEAM programs require students to participate in their Freshman year, are open to all majors, integrate at least one arts and one STEM discipline, and apply an experiential approach to learning.

It is important that these programs create a space that allows for interaction between student with different backgrounds and different strengths.

I think one thing that is really cool about this program is that it brings together a lot of people together from a diversity of majors. We've got everything from Computer Science, to me, an Animal Biology major, to Math, to Design. Even though it is about art and science, since those two categories are both so broad it brings a lot of different people together. I think that's really valuable because otherwise, especially in big schools, people sort of identify with their group...being able to work together I feel like it's kind of enriching. Not kind of, really enriching! (ArtScience student, Animal Biology major, personal communication, June 2, 2013).

Students and alumni at both sites commented on the unique and rewarding opportunity to collaborate with individuals from different majors.

The policy influences of this research are not restricted to higher education. K-12

institutions would also benefit from modifying the curriculum to strengthen interpersonal skills and enrich learning through multiple disciplines. Ways of offering these opportunities include the addition of a STEAM elective course and integration of the arts and STEM appropriately in respective classes. This type of collaborative coursework would help prepare students for college.

Implications for Future Research

Given the current attention and relevance of STEAM further research is timely. This research is a qualitative inquiry into two specific university programs there is a great deal of room for further investigation of STEAM programs in higher education. Continued research on innovative STEAM programming is necessary to document various models of STEAM-based learning, and evaluate programs that in the intersections of the arts and STEM.

Surveying STEAM learning. Stepping back, a national and international survey of university programs that bridge the arts with STEM would capture the various academic formations of STEAM. This type of ambitious report would reveal the concentration of these programs and present any relationships between academia and industry. I would recommend further inquiry into programs situated in art and STEM departments on a campus. I suspect that STEAM programming efforts have preceded research efforts due to the slower nature of publishing. There is not a body of scholarly work that measures the impact of STEAM programs and there is a need for quantitative literature in the field as well. STEAM programs take place in a variety of settings beyond schools ranging from cultural institutions to for-profit businesses, and an

assessment of program impact in these less traditional environments would also benefit the field.

Aesthetic social justice. In this study all program founders were women. There was no intent to seek out female leadership, but this research shares exemplary leadership qualities of female university program founders. This finding is an interesting starting point for further research that deliberately focuses on the experiences of female pioneers in higher education, and more specifically women in STEAM. Is there a disproportionate amount of women in STEAM leadership roles? Are there gender specific traits that make women more inclined to take on these types of programs?

In response to the research that documents the widening gap of access to arts education in underprivileged and wealthy communities, it is necessary to initiate arts programming in these already underserved neighborhoods (Parsad & Siegelman, 2012). Are K-16 STEAM programs equally distributed in areas of varying socio-economic status? Do minority students have equal access to STEAM programs? Do these types of interdisciplinary experiential programs help retain minority, or first generation students? These types of questions address aesthetic equity and are a matter of social justice. Every child and every adult learner is deserving of access to a comprehensive education that includes the arts and STEM. Continued research can create a clearer picture of the state of arts education and STEAM programming therefore informing advocacy and policymaking efforts.

A Blending of the Arts and STEM in Self and Study

My background, interests, and aspirations are at the heart of this research. From the beginning my world has been at the intersections of the arts and STEM. Both of my

parents, and the majority of my family, are engineers who have instilled a sense of discipline, logic, and linearity in my thinking. I developed an affinity for the arts at a young age and was particularly drawn to visual arts and design. Thankfully, I grew up in an environment where this creative flair was embraced and nurtured. In my undergraduate studies at the University of California, San Diego I double majored in Visual Arts and Communications. The program had an emphasis on the conceptual and experimentation and pushed me outside my comfort zone with my art-making and writing. I enjoyed the excitement of the creative process, but also wanted to employ my pragmatic, technical, and administrative strengths.

My next educational step was to pursue my Master's in Arts Management at Carnegie Mellon University. Located within a school of public policy, the program allowed for a comprehensive business management perspective of creative enterprises. Quantitative and qualitative coursework was valued alike and courses like financial and statistical analysis were paired with specific arts administration courses. By working in arts institutions during my schooling I was able to apply this knowledge and gain experience. The unique challenges of artists and arts institutions were palpable. I saw firsthand how limited resources were a part of the narrative of arts education and arts organizations. I found this struggle with resources frustrating and I wanted to be part of communicating the larger message about the value of the arts.

For the past five and a half years I have worked as the marketing manager for the Department of Visual Arts at UC San Diego. As the first person in this position, I have created a communications infrastructure from the ground up to support publicity efforts and act as a liaison between the department and greater public. Collaborations with

STEM are also prevalent in my work environment. The Department of Visual Arts has recently launched research initiatives in the new Structural and Materials Engineering building at UC San Diego in a larger effort to cross-pollinate the disciplines.

When embarking in my doctoral studies the STEAM movement was just beginning to gain momentum and there was a great deal of interest around this new paradigm. I was regularly attending innovative artscience exhibitions, interdisciplinary or co-taught courses, and inspiring talks that highlight the central role of creativity in arts and STEM collaborations. Programs poignantly showed why the Arts and STEM are better suited together and particularly complementary to the industry demands of the 21st century. I did not find a parallel narrative in academic literature and decided to focus my dissertation in this realm of STEAM.

In canvassing arts and STEM university collaborations I learned about several emerging and exciting programs across the nation. In an effort to maximize impact, I elected to examine established programs and share insights and best practices from these prominent sites to benefit and influence the creation of newer programs. Leaders at both sites welcomed an inquiry into their programs and allowed me to tour the program facilities, provided me with guidance on collecting extant data, and helped connect me with their student and alumni base. The willingness and collegiality of leaders at both programs was a key factor in successfully implementing this study.

At the time when the selected programs were created, in both cases, there was little to no precedence of a comparable academic program. Interviews with program founders were inspiring and revealed the strength of character and vision of the women that pioneered these programs. The creation of a new university program is a tremendous

undertaking and their passion and conviction came through clearly in this process. They were able to overcoming fear and resistance from the broader academic community. For future program leaders this research suggests establishing a clear and compelling vision and having an inclusive approach to program development that integrates strategic partnerships within and beyond the university.

Beyond the leadership journey, I was interested in presenting a student voice in this research. A random sampling of students and alumni from the program shared their experiences in each program. Alumni participants had a great retrospect into their experience and shared how the programs influence their path, while students had a fresh recollection of specific projects and collaborations in the programs. The combination of these participants was critical to establishing each case study under the collective umbrella. Findings from this research imply that emerging interdisciplinary programs should establish student learning outcomes at the onset of the program, encourage collaborations across different majors, and employ a comprehensive experiential model that emphasizes hands-on learning and reflection.

This study shows how leadership and learning blend together to create memorable student experiences. I witnessed first-hand the delicate balance of tenacity and savvy that leaders possessed and saw this play into appreciative and transformative student learning experiences. Undergraduate education is a time of self-discovery and these innovative university programs provided a safe context for students to test their own creativity and explore disciplines they would not have normally selected.

Beyond the direct impact of these programs within their respective universities and communities, this study has leadership, program development, student learning and

policy implications. The work of the founders and the experiences of students and alumni transcend into cases for preserving arts education and integrating arts with STEM disciplines. The arts can be a playground for experimentation and this pairs nicely with the methodological and linear characteristics of STEM learning. With this combination, begins the recipe for true innovation.

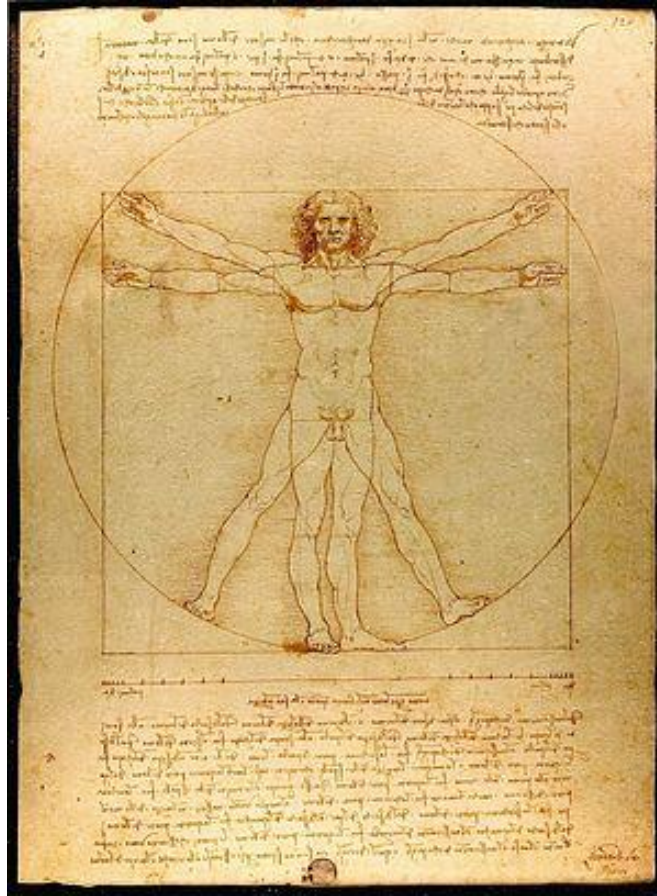
Appendix A: Referenced Artwork



Rembrandt, “Anatomy Lesson of Dr. Nicolaes Tulp,” 1632



Roy Lichtenstein, “Peace Through Chemistry” 1970



Leonardo da Vinci, "Vitruvian Man," 1490

Appendix B: Invitation to Participate

Sheena Ghanbari, a candidate in the doctoral educational leadership program at University of California, San Diego (UCSD) and California State University San Marcos (CSUSM), is conducting a study that explores program leadership and student learning. You are being contacted because you have been identified as a student in a university program that integrates an arts discipline with a STEM (Science, Technology, Engineering, and Math) discipline.

Principal objectives:

The purpose of this research is to explore the experiences of educational leaders that have launched academic programs with arts and STEM disciplines while examining the student learning outcomes in these respective programs.

You are being asked to participate in a 10-20 minute interview. The interview will be conversation and, with your permission, will be audio taped and transcribed. After the interview you will receive a transcript of the interview for checking and clarifying any information.

While your participation in this study is voluntary, it has the potential to positively affect the STEM to STEAM movement in higher education.

If you would like to participate in the study please contact Sheena Ghanbari, sghanbari@ucsd.edu to set up an in person or virtual interview.

**Appendix C: Sample Questionnaire (answered through conversations with
educational leaders)**

Human Resource Question:

1. How many students participate in your program each year?

Structural Questions

2. What are the student/program learning objectives of this program?
3. Why did you select to specifically integrate “inserts arts discipline” and “insert STEM discipline?”

Human Resource Questions:

4. Who were the key individuals in establishing this program, and how did they assist in starting this program?

Symbolic Question:

5. What is your personal motivation for pioneering this program?

Appendix D: Semi-structured Interview Protocol for Program Founders

Structural Questions:

1. Tell me about the first time you had the idea for _____ program?
2. Tell me about the factors or forces on your campus or community that aided in the creating, implementing, and supporting your program?

Human Resource Questions:

3. Tell me about the staffing structure of the program as it grew over time?

Political:

4. Tell me about the key advocates for this program in the campus and community?
-How are the relationships with these individuals/groups maintained?
5. In the process of implementing this program did you come across any policy challenges?
-If so, please describe the challenge and how you and your team responded to the challenge.
6. What key leadership attributes do you find assisted you in establishing this program?

Symbolic:

7. What is the vision for your program for the next five years?

**Appendix E: Semi-structured Interview Protocol with Students and Alumni of the
ArtScience Program**

1. In what ways would your experience in the _____ program advance your career goals?
2. Describe a project in the ___ program where you were required to work collaboratively?
3. The following program/learning outcomes have been identified by your program:
(list program/learning outcomes)
How do you think the program does on each of these points?
4. Is there anything else that you would like me to know about _____ program?

Appendix F: Semi-structured Interview Protocol with Students and Alumni of the ArtTechnology program

What was your major/year?

If you recall, what courses have you taken?

Do you think your experience in the program advanced your career goals? Tell me a little bit about your work today?

Do you recall a project in the program where you were required to work collaboratively? If so can you describe this experience?

The following program/learning outcomes have been identified:

- Synthesize connections from their Practicum experiences that illuminate and deepen their understanding of their discipline (integration of theory and practice)
- Establish and explore connections from more than one discipline or perspective (interdisciplinary inquiry)
- Apply theories or concepts from their disciplines to experiences external to formal lecture instruction, e.g., fieldwork, study abroad, work experiences (expansion of theoretical foundation developed in lower-division and major courses).

Civic Engagement

- Examine complex community issues from multiple perspectives (community-based learning and research, integration of theory and practice, professional and scholarly preparation, and global understanding)

Professional and scholarly preparation

- Demonstrate self-awareness of their skills, abilities, values, research or personal and professional interests

- Establish disciplinary connections between their Practicum and career choices
- Demonstrate skills and attributes needed to succeed in their post-graduate plans

Increased global awareness and understanding

- Understand the complexity of others' cultures - beliefs, communication styles, rules, values, rites, and practices
- Identify and articulate new perspectives about their own cultural biases

How do you think the program does on the above points?

Is there anything else that you would like me to know about the program?

Appendix G: Consent Forms, Program Founders, Students, and Alumni

Consent to Participate in Research: Program Founders Invitation to Participate

Sheena Ghanbari, a doctoral student in the joint doctoral program at California State University San Marcos (CSUSM) and University of California, San Diego (UCSD), is conducting a study that explores the program leadership and student learning. You are being contacted because you have been identified as a Program Leader of a university program that integrates an arts discipline with a STEM discipline.

Principal objectives:

The purpose of this research is to explore the experiences of educational leaders that have launched academic programs with arts and STEM disciplines while examining the student learning outcomes in these respective programs.

Description of Procedures

You will provide relevant program materials to the researcher.

You will complete a twenty-minute online survey via google forms.

You will be interviewed individually. The conversational style interview will take up to an hour and, with your permission, will be audio taped and transcribed. You will be provided the general framework of interview questions prior to the interview in addition to a transcript of the interview for checking and clarifying any information.

Risks and Inconveniences

There are minimal risks to participating in this study. These include:

1. Loss of personal time necessary to participate in the interview and review of the transcript.
2. Potential breach of confidentiality.
3. Fatigue from the interview process.

Safeguards

Safeguards put in place to minimize risk include:

1. Interview sessions will be restricted to 1 hour; if it persists longer than this duration, it can be stopped at your request.
2. Your interview data will be kept confidential, available only to the researcher and her committee for analysis purposes. The audiotapes will be destroyed following final analysis; no later than June 15, 2014. Pseudonyms for names, projects, and institutions will be used when the interview is transcribed to minimize the risk of identification. You will be given the opportunity to review the transcribed interview and to eliminate any comments or references you feel may be identifiable or have negative connotations with respect to the district or school leadership. Your responses will not be linked to your name or address, and there will be no follow-up sessions.
3. The researcher will allow for breaks during the interview process and will have water and snacks to minimize fatigue.

Voluntary Participation

Your participation is entirely voluntary, and may be withdrawn at any time. If the length of the interview becomes inconvenient, you may stop at any time. There are no consequences if you decide not to participate.

Benefits

Although your participation will yield minimal direct benefits to you, we believe that the study has the potential to positively affect the STEM to STEAM movement in higher education.

Questions/Contact Information

This study has been approved by the California State University San Marcos Institutional Review

Board (IRB). If you have questions about the study, you may direct those to the researcher, Sheena Ghanbari, sghanbari@ucsd.edu or the researcher's advisor/professor(s), Dr. Merryl Goldberg, goldberg@csusm.edu and Dr. Jennifer Jeffries, jjeffries@csusm.edu. Questions about your rights as a research participant should be directed to the IRB at (760) 750-4029. You will be given a copy of this form to keep for your records.

I agree to participate in this research study.

I agree to have the interview audiotaped.

Participant's Name

Date

Participant's Signature

Researcher's Signature

This document has been approved by
the Institutional Review Board at
California State University San Marcos
Expiration Date: April 15, 2014

Consent to Participate in Research: Students Invitation to Participate

Sheena Ghanbari, a doctoral student in the joint doctoral program at California State University San Marcos (CSUSM) and University of California, San Diego (UCSD), is conducting a study that explores program leadership and student learning. You are being contacted because you have been identified as a student in a university program that integrates an arts discipline with a STEM (Science, Technology, Engineering, and Math) discipline.

Principal objectives:

The purpose of this research is to explore the experiences of educational leaders that have launched academic programs with arts and STEM disciplines while examining the student learning outcomes in these respective programs.

Description of Procedures

You will participate in a 15-30 minute interview. The conversational style interview will take up to thirty minutes and, with your permission, will be audio taped and transcribed. You will be provided the general framework of interview questions prior to the interview. After the interview you will receive a transcript of the interview for checking and clarifying any information.

Risks and Inconveniences

There are minimal risks to participating in this study. These include:

1. Loss of personal time necessary to participate in the interview and review of the transcript.
2. Potential breach of confidentiality.
3. Fatigue from the interview process.

Safeguards

Safeguards put in place to minimize risk include:

1. Interview sessions will be restricted to 30 minutes; if it persists longer than this duration, it can be stopped at your request.
2. Your interview data will be kept confidential, available only to the researcher and her committee for analysis purposes. The audiotapes will be destroyed following final analysis; no later than June 15, 2014. Pseudonyms for names, projects, and institutions will be used when the interview is transcribed to minimize the risk of identification. You will be given the opportunity to review the transcribed interview and to eliminate any comments or references you feel may be identifiable or have negative connotations with respect to the district or school leadership. Your responses will not be linked to your name or address, and there will be no follow-up sessions.
3. The researcher will allow for breaks during the interview process and will have water and snacks to minimize fatigue.

Voluntary Participation

Your participation is entirely voluntary, and may be withdrawn at any time. If the length of the interview becomes inconvenient, you may stop at any time. There are no consequences if you decide not to participate.

Benefits

Although your participation will yield minimal direct benefits to you, we believe that the study has the potential to positively affect the STEM to STEAM movement in higher education.

Questions/Contact Information

This study has been approved by the California State University San Marcos Institutional Review Board (IRB). If you have questions about the study, you may direct those to the researcher, Sheena Ghanbari, sghanbari@ucsd.edu or the researcher's advisor/professor(s), Dr. Merryl Goldberg, goldberg@csusm.edu and Dr. Jennifer Jeffries, jjeffries@csusm.edu. Questions about your rights as a research participant should be directed to the IRB at (760) 750-4029. You will be given a copy of this form to keep for your records.

I agree to participate in this research study.

I agree to have the interview audiotaped.

Participant's Name

Date

Participant's Signature

Researcher's Signature

This document has been approved

by

the Institutional Review Board at

California State University San Marcos

Expiration Date: April 15, 2014

Consent to Participate in Research: Alumni Invitation to Participate

Sheena Ghanbari, a doctoral student in the joint doctoral program at California State University San Marcos (CSUSM) and University of California, San Diego (UCSD), is conducting a study that explores program leadership and student learning. You are being contacted because you have been identified as an alumnus a university program that integrates an arts discipline with a STEM discipline.

Principal objectives:

The purpose of this research is to explore the experiences of educational leaders that have launched academic programs with arts and STEM disciplines while examining the student learning outcomes in these respective programs.

Description of Procedures

You will participate in a 15-30 minute interview. The conversational style interview will take up to thirty minutes and, with your permission, will be audio taped and transcribed. You will be provided the general framework of interview questions prior to the interview. After the interview you will receive a transcript of the interview for checking and clarifying any information.

Risks and Inconveniences

There are minimal risks to participating in this study. These include:

1. Loss of personal time necessary to participate in the interview and review of the transcript.
2. Potential breach of confidentiality.
3. Fatigue from the interview process.

Safeguards

Safeguards put in place to minimize risk include:

1. Interview sessions will be restricted to 30 minutes; if it persists longer than this duration, it can be stopped at your request.
2. Your interview data will be kept confidential, available only to the researcher and her committee for analysis purposes. The audiotapes will be destroyed following final analysis; no later than June 15, 2014. Pseudonyms for names, projects, and institutions will be used when the interview is transcribed to minimize the risk of identification. You will be given the opportunity to review the transcribed interview and to eliminate any comments or references you feel may be identifiable or have negative connotations with respect to the district or school leadership. Your responses will not be linked to your name or address, and there will be no follow-up sessions.
3. The researcher will allow for breaks during the interview process and will have water and snacks to minimize fatigue.

Voluntary Participation

Your participation is entirely voluntary, and may be withdrawn at any time. If the length of the interview becomes inconvenient, you may stop at any time. There are no consequences if you decide not to participate.

Benefits

Although your participation will yield minimal direct benefits to you, we believe that the study has the potential to positively affect the STEM to STEAM movement in higher education.

Questions/Contact Information

This study has been approved by the California State University San Marcos Institutional Review Board (IRB). If you have questions about the study, you may direct those to the researcher, Sheena Ghanbari, sghanbari@ucsd.edu or the researcher's advisor/professor(s), Dr. Merryl Goldberg, goldberg@csusm.edu and Dr. Jennifer Jeffries, jjeffries@csusm.edu. Questions about your rights as a research participant should be directed to the IRB at (760) 750-4029. You will be given a copy of this form to keep for your records.

I agree to participate in this research study.

I agree to have the interview audiotaped.

Participant's Name

Date

Participant's Signature

Researcher's Signature

This document has been approved
by
the Institutional Review Board at
California State University San Marcos
Expiration Date: April 15, 2014

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