STEM Majors, Art Thinkers (STEM + Arts) – Issues of Duality, Rigor and Inclusion

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Abstract

There is a growing interest in STEAM (STEM + Arts) education nationwide. To uncover why these interdisciplinary initiatives can play a significant role in the student educational experience, it is crucial to identify characteristics of university students, who are participating and enrolled in STEM and arts curricula. We are interested in students who would like to actively participate in dance curricula while pursing STEM degrees, and how those students perceive social inclusion given the dominant presence of STEM fields at a predominantly white institution (PWI). We conducted focus groups with undergraduate students from two NC State University dance companies. Focus groups transcripts were coded according to our research questions along with an additional taxonomy including academic emotional engagement, self-efficacy and level of activity. Sub-themes were analyzed using pattern matching and thematic analyses. Data themes included personal, academic and institutional issues, as well as career workforce preparation. Students indicated that rigor, stigma, enhanced problem-solving skills, interdisciplinary thinking, and increased diversity and inclusion opportunities characterize their dance experiences. These experiences highlight aspects of human diversity including ethnicity, race, gender identity and class, and how dance provides a safe zone that is significantly different than their STEM coursework. Current dance students expressed why the arts are an intentional part of their academic experiences. The students drew parallels to problem-solving approaches, team collaboration and data-driven application for the "think and do" ethos that is central to the university. Our findings offer STEM researchers and leaders, along with policy-makers and funding agencies, opportunities to reframe the current thinking and approaches central to broadening participation in STEM.

Introduction

According to a White House briefing by the President's Council of Advisors on Science and Technology (PCAST) report (2012), the U.S. Department of Commerce estimates that STEM jobs will grow 1.7 times faster than non-STEM occupations in the coming decade. In order to meet these workforce demands, the United States will need approximately 1 million more STEM professionals than the amount projected to graduate by 2018. North Carolina State University is a leader in data analytics, bio-manufacturing, computer engineering, and is at the forefront of national efforts on interdisciplinary collaboration related to innovation and design, data-driven science, environmental health science, and digital transformation of education, just to name a few. U.S. News and World Report (2013) cited the institution as a top STEM producer. With the interdisciplinary focus at North Carolina State University, the arts also provide an opportunity for curricula integration and collaboration – as students participating in the university dance programs are mainly matriculating in STEM majors.

Arizona State University (ASU) implemented the Center for Science and the Imagination in 2012 to bring together scientists and artists - in order to implement art-based inquiry into the scientific process. According to the ASU Magazine (2015), the institution's faculty members have offered their perspectives on the integration of STEM and the arts:

We know increasingly from the learning sciences that the kind of pedagogy that has high impact for student learning is exactly the kind of pedagogy that has been part of an arts curriculum for a long time. (Steven Tepper, dean of the Herberger Institute for Design and the Arts)

The reason that imagination is in the title of the center and is a core part of what we do is because it's not turf that anybody owns. Imagination is crucial to being successful, whether you're a physician, an engineer, or an artist. (Ed Finn, founding director of the Center for Science and the Imagination (CSI)

It's not just inserting the arts into STEM research; it's this idea of how one set of research questions can influence and impact the research and questions that are raised elsewhere. (Grisha Coleman, an assistant professor in the School of Arts, Media and Engineering)

Research by The Kennedy Center's ArtsEdge supports the STEAM trend as indicated on its website: *STEAM is complimentary with 21st century skills, particularly the "4 Cs" of creativity, collaboration, critical thinking, and communication, and is gaining traction across the country with support from a wide range of organizations, including the National Science Foundation, the National Endowment for the Arts, and the U.S. Department of Education.* In addition, the National Science Foundation is currently funding dance, as an art form, when combined with technology foci. For example, Clemson researchers (e.g., Mullen, 2016) find that blending movement and computer programming supports girls in building computational thinking skills. Professor Petrucci, an architect and a professor in the ASU Design School within the Herberger Institute, acknowledged the intersection of STEM and the arts and stated: *An artist will approach a problem in a completely different way than an engineer. They have certain sets of skills and knowledge that they bring and the designers or the artists will bring a human-centered approach. You're beginning in two different places and my argument is that you need as many points of departure as possible to be truly innovative. STEM is not enough. It's a start, but it's not enough. What's smart about contemporary curricula in STEM-based fields is a lot of educators are realizing they have to teach this in different ways. It's more like design thinking, based on problems and based on solutions, rather than abstract models* (ASU Magazine, 2015).

Others (National Society of Black Engineers - NSBE Bridge, 2016) have also indicated that dance can serve as a bridge to STEM inclusion. Spotlighting the STEM From Dance program, the NSBE report focuses on the problem-solving, teamwork and creativity skills-building and enhancement that emerges at the intersection of the two domains. Though STEM from Dance focuses on high school students and mathematics curricula, the program strengthens creativity, spatial awareness and collaboration. The program's director confirmed the criticality of cultural relevance and confidence building among those in the formative years of the STEM pipeline.

This notion of a pipeline has been long used to describe the supply of K-20 students as a pool of underrepresented students likely to matriculate and successfully complete a STEM curriculum at both the undergraduate and graduate levels (NCES Digest of Education Statistics; Science and Engineering Indicators, 2008). Various policymakers and funders, including the Educational Testing

Services (2015), American Association for the Advancement of Science (AAAS, 2014) and National Academies of Sciences, Engineering, and Medicine (2016), have examined the STEM + Arts dichotomy. For example, Educational Testing Services suggests that hands-on, project-based application learning can improve retention, augment design thinking and offer perspectives on STEM's impacts on society among college students. The Forum on Science and Technology Policy entitled, Synergy in STEM + Arts: Catalyzing U.S. Innovation and Competitiveness (AAAS, 2014), drew more than 400 attendees from academe, funding agencies, policymakers and industry. The forum explored interdisciplinary domains, such as process and product design, user experience, team collaboration and entrepreneurship achieved by combining the arts and STEM disciplines. Lastly, the National Academies of Sciences, Engineering and Medicine (2016) argues that the arts are not simply a tool to facilitate STEM education and that the arts can stand on their own merits.

Although we do agree with the articulated message from the AAAS Forum, we contend that understanding current programs that have similar reach in a higher education context is worthwhile. In addition, the STEAM discourse provides an opportunity to explore social inclusion issues (Payton, Suarez-Brown and Lamar, 2012) issues that shape how diverse groups potentially (dis)engage in STEM disciplines.

Study Context

The NC State Dance Program, as one of the six arts programs of ARTS NC STATE, gives students opportunities to study dance through direct experience in choreographic and performance processes. ARTS NC STATE is a collective arts organization that offers programs in theater, dance and music, as well as a center for crafts, a museum for visual arts, and an initiative for hosting professional touring artists.

At the center of the Dance Program are its two student companies: the NC State University Dance Company, a modern dance company nationally acclaimed by the American College Dance Association, and the Panoramic Dance Project, a company dedicated to exploring diverse dance styles, including jazz, modern, hip-hop, African and Latin. Through these student companies, the university dance instructors offer choreography, technique, performance, community engagement, professional projects and a variety of courses. The Dance Program participates in community-focused outreach projects throughout the year, most recently performing at the NC Museum of History, leading a workshop at a local middle school, and partnering with Burning Coal Theatre Company on The State of Dance.

The dance department offers the following courses for academic credit: *Problems in Dance Performance, Current Trends in Afrocentric and World Dance, Dance Composition and Independent Study in Dance.* Students can also participate in a master class series, an Arts Village, three formal concerts and the American College of Dance Association annual conference. These courses and offerings are open to all undergraduate and graduate students matriculating at the institution. The department, however, does not offer a dance major. Hence, we use STEM + arts rather than STEAM to characterize the context of the students who participated in this study.

Given the above background, we sought to explore the following questions:

- How do academic, personal, institutional and career factors shape the experiences of STEM + arts students?
- How and why do these experiences inform policy changes to current STEM education to broaden participation?

Our manuscript is structured as follows. We examined the literature to uncover findings in the STEM and arts literature in ***higher education*** contexts. This is followed by our summary of the literature and is divided into higher education and K-12 categories to determine relevant social and professional aspects of how it can inform our study. We discuss our research methodology for gathering data from current dance students. This is followed by our results and implications and conclusions for future research.

Literature Review

We began our literature review using peer reviewed journal articles from ERIC and ProQuest from 2000 to 2015. We selected the ERIC database given its emphasis on education-related content, which is often used as a source to identify improvements and the best practices in educational pedagogy. We choose ProQuest to identify scholarly publications in the arts, social science and science/technology collections. This enabled us to potentially capture results for the science, art and education foci of this research study.

From *ERIC*, we searched for the following keyword combinations: (arts education) AND STEM (65 results), (arts education) AND STEM AND (higher education) (25 results), (arts education) AND (STEM spelled out as science technology engineering math) AND (higher education) (0 results), (arts education) AND (the 4 words - science technology engineering and math) (5 results), STEM AND dance (0 results), STEM AND dance AND (higher education) (0 results), (arts education) AND STEM AND (higher education) (0 results). In addition, *ProQuest* searches returned the following results: Science Technology Engineering and Math AND Dance AND Higher Education NOT Physical Education NOT Music NOT Early Childhood (45 results), Arts Education + Science, Technology Engineering and Math + Dance (190 results) Arts Education + Science Technology Engineering and Math + Dance and Higher Education (181 results). Table 1 shows

Keyword Search	ProQuest	Eric
Arts Education + STEM	5751	65
Arts Education + STEM in Higher Ed	5312	25
Arts Education + (all terms - science technology engineering and math)	2159	5
Arts Education + (science technology engineering and math) in Higher Ed	2403	0
Arts Education + STEM + Dance	2343	0
Arts Education + (science technology engineering and math) + Dance	190	0
Arts Education + (science technology engineering and math) + Dance + **Higher Education**	135	0
Arts Education + STEM + Dance + **Higher Education**	523	0
(science technology engineering and math) + Dance + Higher Education NOT Physical Education NOT Music NOT Early Childhood	45	0

Table 1: ERIC and ProQuest Search Results by Keywords

these keyword results.

While these results are general from the literature perspective, our review, however, indicates a few observable patterns relative to the current state of STEAM research. That is,

1) An overwhelming number of research studies focus on K-12. This suggests that research on the intersection of STEM + arts has emphasized pre-college examples.
2) These studies typically focus on getting young children interested in STEM topics via interventions, such as summer camps, after school programs and workshops that complement and/or reinforce K-12 curricula. *We found few studies that focused on the intersection of STEM, arts and higher education.*

Given the lack of studies in the STEAM and higher education domain, there is an opportunity to generate new data that may inform future research.

Literature Review Results

STEM + Arts In K-12 Education

In general, K-12 students crave multi-sensory learning experiences, therefore engaging in these experiences promote improved student outcomes (Edwards, 2011). Introducing the arts into STEM classroom instruction increases student motivation and engages students in using interdisciplinary approaches to problem solving (Edwards, 2011). Multi-sensory methods in pedagogy have been used to improve computational thinking and informatics-based concepts, such as algorithms, programming languages, abstraction and data structures. One successful method is having students use dance to illustrate the details of several different sorting algorithms, by numbering each students and having them use real dance moves to swap places, as elements in an array might when being put through some sorting algorithm (Edwards, 2011). Kezar (2001) reported overwhelmingly positive feedback from students that participated in such dances and viewed videos of the dances online as evidence of the impact of their work.

Multi-sensory learning experiences provide opportunities for transformative learning experiences, (Pugh and Girod, 2007). Pugh and Girod (2007) sought to present a new paradigm in science education defining their approach in terms of transformative, aesthetic experiences. Arts participation was said to provide transformative experiences, because successfully participating in the arts requires deeper engagement with finite and complete events that allow one to understand (her)himself and the world in a new manner. Pugh and Girod (2007) argue that engagement with scientific ideas can have this same type of effect on an individual. They define a transformative experience outside the world of art, and then present pedagogical ideas to help create transformative student experiences in the classroom (particularly in STEM fields) that are similar to those in the arts.

Others (Ross, 2000) assert that dance (as an art form) enables the creation of these transformative experiences. Dance, however, is often overlooked as an integral part of the educational experience even when other arts are embraced. Ross challenges assertions that literature is the art form with the best paradigm for understanding human cognition. While narrative storytelling may be a fundamental feature of rational human thought, Ross (2000) contends that dance is just as capable of storytelling via kinesthetic avenues. Thus, if storytelling is at the crux of human cognition, dance can mostly certainly enhance human rationality.

Oftentimes, the arts are perceived as a means of building skills that benefit students in core subjects, like mathematics and language arts. Daugherty (2013), however, quoted prior research that claims that if we bring arts into the schools on the belief that it will cause increased test scores and improved outcomes in core subjects, the arts can easily be removed if these outcomes are not seen to quickly improve. The arts must be implemented and desired for their own intrinsic qualities. Ross (2000) also warns against mining dance and the arts for their byproducts that maybe viewed as useful in other areas of education, rather than recognizing the strengths of the art alone. As an advocate of arts education, Ross acknowledges the benefits that arts and dance specifically, can have in other areas, but urges educators not to sell the arts as instruction that only has more practical uses in other fields.

STEM + Arts in Higher Education

Through a collaborative autoenthnography experience, Sochacka, Guyotte & Walther (2016) found crucial links between the arts and STEM learning in higher education. Sochacka, et al (2016) created a studio course for university students that focused on design challenges for local and global waste as well as water problems. Afterwards, they recorded what they gained as educators from this experience. The authors found that a problem-based learning approach when informed by the arts can have a positive impact on outcomes in engineering education. Introducing the arts into the STEM classroom helped students to examine the relationship between themselves and the real world problems they sought to solve. Sochacka, et al (2016) found that introducing the arts through STEM could better prepare students for creative problem solving and design.

Though the Theory of Multiple Intelligences has been embraced in the K-12 educational community, Kezar (2001) urges that the same situation happened in higher education, as there are biological differences between students with different learning styles and these should be taken into consideration to improve student outcomes. Several other authors, however, claim that many of the competencies required for success in the arts and liberal arts are also required in STEM coursework. Enrollment in STEM and technical fields have been on the rise, while enrollment in the humanities has been shrinking over the past five years (Frenkle, 2013). Despite this finding, Harvard University (Simpson and Kelly, 2013) and Virginia Tech (Wagner, et al, 2014) are working to bring students back to the humanities, noting that both engineers and artists rely on their creativity and ingenuity to make strides in their fields.

Other studies (Matusovich, 2010; Thiry, 2011; Wilson, et al, 2014) provide results of student interviews related to participation in extra-curricular activities and student organizations. In a longitudinal study of eleven undergraduate (five male and six female) students at a US technical university, Matusovich (2010) explored the experiences of engineering students who were interested in and participated in dance. Students entered college as engineering majors, and were interviewed once a year to discuss their progress and their decision to study within the STEM field. After matriculating for one academic year, only one student decided not to pursue an engineering degree, and she indicated that pursuing a degree in education (teaching) would afford her more time to also pursue dance. In general, this study found that the women participants experienced a lack of connection to their engineering degree, but generally had higher GPAs than their male counterparts. From a pedagogical perspective, the researcher suggested that engineering schools should help students associate engineering careers with their own personal goals and interests, hence combining and aligning identities. We suggest that this may and can include some affiliation with the arts, peer groups, culture and other factors for both personal and professional career identities.

Thiry (2011) examines whether the benefits that undergraduate students gain by participating in co-curricular research experiences, can be offered by other activities such as internships, off-campus research, and what the authors call "general college experience." The general college experience may include participation in the arts. The possible gains included professional benefits, the ability to think like a scientist, becoming a professional, skills building, career preparation and career clarification. Sixty-two undergraduate seniors were interviewed. Thirty-two of which were women. In each gain category explored in this study, the "general college experience" generated more negative than positive comments from students in interviews.

Wilson, et al. (2014) used a framework consisting of academic emotional engagement, self-efficacy and level of activity to explore the links among co-curricular activities. Academic engagement has been linked to academic outcomes including student motivation, academic abilities and critical thinking. In STEM disciplines, academically engaged students are more likely to persist, and to have emotional and behavioral pathways critical for

desirable learning outcomes (Wilson, et al., 2014, p 627-628). Self-efficacy is the degree to which one perceives that (s)he can develop a plan of action to accomplish a given goal or desired outcome. Self-efficacy theory posits that individuals will readily engage when activities that they are confident that they will be successful in an activity and withdraw from endeavors that create discomfort (Wilson, et al., 2014, p 628). The level of activity captures co-curricular. Wilson, et al. (2014) defined co-curricular activities as those that take place during and outside of the normal school day. Co-curricular activities include student organizations, professional societies, sports, informal study groups, just to name a few. We adopt this co-curricular definition for our study.

The Wilson, et al (2014) study asked if greater involvement in co-curricular activities is associated with higher emotional engagement, and which types of activities have the strongest link to academic engagement. Over 1,000 undergraduate engineering students at four different universities were surveyed. Of the students surveyed, 69% were male, 52.6% were white, 22.9% were Asian, 13.9% were Black, and 10.6% reported other ethnicities. Using a Likert scale questionnaire, students reported on perceived academic efficacy and emotional academic engagement, as well as their levels of involvement in academic and nonacademic co-curricular activities. The study found that high participation in nonacademic activities correlated with a weak relationship between academic engagement and self-efficacy. Wilson, et al. (2014) found that participation in nonacademic activities was associated with stronger academic engagement than nonparticipants with the same efficacy level, particularly at the low efficacy level. This result is consistent with the view that engagement outside of the academic major is associated with strong academic emotional engagement. For students with higher self-efficacy, the effects of nonacademic co-curricular participation were not as significant on their academic emotional engagement. For students with higher self-efficacy, the difference in academic emotional engagement between students participating in nonacademic co-curricular activities and those non-participants was not statistically significant.

The STEAM Opportunity

President Obama's Committee on Arts and Humanities (PCAH, 2011) advocates for STEAM education and integration for the United States to promote innovation and economic development. The committee's report contends that sustaining the nation's leadership role requires that students need music, dance, poetry, painting and/or other arts experiences. This is not to suggest that arts are subservient to STEM, or merely exists to invoke atheistic appeal.

As Root-Berstein (2008, 2011) and AAAS (2014) suggest, the arts and STEM are compliments, and each of the studies goes further to provide examples where science and technology were enabled by the arts. A few such examples include:

- The creation of the modern MRI for children used by GE Healthcare
- 3-D printing technologies from ZPrinting at MIT
- An improved portable drinking package for TetraPak developed with the assistance of the branding and marketing consultant, Prophet
- Steve Jobs and the reinvention of the Apple experience, including the iPhone
- Bridge design and construction
- Pace makers design and control for abnormal heart rhythms

Likewise, Land (2013) notes the intersections of the arts, humanities, and STEM disciplines foster creativity and innovation via cross-curricular collaboration in media, design and data visualization.

Root-Berstein (2008) uses biographies, autobiographies, obituary notices among Nobel laureates, National Academy of Sciences, and the Royal Society scientists and a survey to Sigma Xi members to assess the number of arts avocation among these groups. One measure used was the average number of arts and crafts avocations among each group. *Sigma Xi respondents had an average of 0.33 arts or crafts avocations; the U.S. public, 0.35; Royal Society members, 0.59; National Academy of Sciences members, 0.56; and Nobel laureates, 0.94* (Root-Berstein, 2008, p 53). These measures point to a diversity of interests and talents among STEM experts. Reported avocations included visual arts, music, literature, dance, and poetry.

Our research explores students' STEM + arts educational experiences, how these experiences are perceived and if the arts enable persistence in the STEM disciplines. Co-curricular offerings that enable students to participate in STEM + arts balance the rigor associated with STEM disciplines with active and continuous involvement in activities that align with personal interests. Students that form the sample group for this study are participating in co-curricular dance programs and are not dance majors.

Research Methodology

As Kvasny and Richardson (2006) advocated, we used critical research theory and carefully attempted to identify frameworks to address our research questions. Higher education STEAM studies are underrepresented in the literature. To understand why STEM college students participate in dance programs, we conducted focus groups that resulted in identification of hidden assumptions, resistance to a dominant ethos associated with dance students by dance students, and challenges to what it means to be underrepresented in one discipline (STEM) while overrepresented in another (dance). Issues associated with gender and race identity were also revealed. For example, we contend women are likely to possess dual identities (strong, masculine personas to compete in STEM; weak/soft dancers). Neither fallacy is warranted or strengthens inclusion in either field.

There is a triple jeopardy associated with race, dance form and personal identity. This triple jeopardy results from the reality of few Blacks in STEM, even fewer in dance (with the exception of the hip-hop hypermasculinity and hypersexualization) and characterization by the broader culture. There are clearly intersectional opportunities for both the arts and STEM programs to support and embrace diversity and inclusion. We posit, however, that **intentional intersectionality** must recognize context particularly when a "critical mass" of individuals from any group is lacking. This is typically the case when members of underrepresented groups are few, and issues of power and influence can further limit social and professional inclusion. We exercised care to maintain anonymity of study participants, because the application of multiple identity markers result in small numbers of individuals being placed in any group.

To understand why students participate in a dance program, we conducted focus groups. According to Frith (2000), focus groups are an effective qualitative method for enabling collective discussion and interaction between research participants that facilitates the exploration of underresearched topics. In addition, focus groups are an effective means to investigate small and convenient groups, ascertain the experiences of participants on a given topic and provide guidance for survey and other research methods.

We conducted two focus groups: one with the *Dance Company* and another with the *Dance Project* students. The *Dance Company* group included 12 students with 8 freshman, 2 sophomores and 2 seniors. *Seven* of the 12 students majored in STEM fields, such as applied mathematics, animal science, biochemistry, statistics, or chemistry. The remaining students were studying in other areas, such as social work and marketing. In the *Dance Project* group, 13 students participated in the focus groups with 4 freshman and seniors, respectively, 3 sophomores, and 2 juniors. *Eight* of the students in the *Dance Project* group are STEM majors drawn from engineering or chemistry. We used the National Science Foundation STEM Classification of Instructional Programs Crosswalk list (2015) to cluster the students' majors as STEM or non-STEM. By having different majors in the focus groups, we were able to explore educational experiences across STEM disciplines and investigate the diversity in culture, ethnicity, course of study, regional origin, level of dance training prior to college matriculation and geographical backgrounds of participants while examining the central shared interest in dance.

The students ranged in age from 18 to 22. All of the students spend 8 to 12 hours weekly in the dance studio and/or engaged in some dance-related activity. Twenty-four of the 24 students were female.

Each focus group session lasted on average seventy-

Themes Among Dance Students	Sub-Themes Within Each Theme
Academic	Program Rigor Commitment to Academic Major(s) Problem Solving Skills Emotional Engagement Self-Efficacy
Personal	Stigma/Peer Perceptions Identity Safe Zone
Institutional Issues	Diversity & Inclusion STEM Public Relations Competition Storytelling
Career Workforce Preparation	21st Century Skills Creativity Helps STEM/STEM Helps

Table 2 . Themes in the Data from Focus Groups

five minutes. The sessions were audio recorded and later transcribed by a member of the research team. The authors reviewed the data transcripts to discuss and identify (sub) themes related to the research questions, as well as share perceptions regarding the focus group sessions.

Following this, three independent coders reviewed the transcripts and coded the data in accordance with the research questions and the Wilson, et al. (2014) taxonomy. This taxonomy included academic emotional engagement, self-efficacy and level of activity.

Themes and Subthemes

We used pattern matching and thematic analyses to assess sub-themes identified by the independent coders and the members of the research team. Table 2 shows the four themes (Academic, Personal, Institutional Issues and Career Workforce Preparation) along with the corresponding sub-themes. As noted earlier, the academic theme is adopted from Wilson, et al. (2014). Emotional engagement, program rigor, commitment to a major and self-efficacy were identified as sub-themes based on patterns observed.

The personal theme captures the individual identity associated with a professional or degree of study, and captures peer interactions along with perceived normalized behaviors associated with the degree of study (Sochacka, et al., 2016).

The institutional theme addresses the way students view the university's appreciation for the arts and to some extent how the arts fare on a campus with a heavy STEM focus. This theme includes diversity and inclusion, public relations and storytelling. These sub-themes capture broadening participation efforts in the disciplines, and can help with communicating promising practices and overcoming discipline chasms as articulated by joint efforts of the National Science Foundation and National Endowment of the Arts (2011).

Lastly, the *career workforce preparation* theme captures creativity and skills necessary for complex problem solving in interdisciplinary work environments (Thiry, 2011; Land, 2013).

The results of intercoder reliability after coding data from the two focus groups yielded kappas of 0.689, 0.720 and 0.472 for coders 1 and 2, coders 1 and 3, and coders 2 and 3, respectively. The average intercoder reliability was 0.627. According to Li (2015), intercoder reliability ranged from moderate to substantial.

Table 2 provides a list of themes and sub-themes identified based on the data collected during the focus group sessions.

Table 3 captures the students' comments on their dance engagement experiences. The table reflects how the comments align with the academic, personal, institutional issues and career workforce themes. Each subtheme is shown in parenthesis. We also crossed-checked these sub-themes with the coding completed by the independent raters.

Implications

Our findings show that dance is a fundamental part of the STEM matriculation experience for the undergraduate students in this research study. Though few have intentions of pursing professional dance careers, an *academic* theme was evidence to the discourse. The students consistently indicated that the arts and STEM serve as complements, and both are best served when there is flexibility in curricula to facilitate arts participation. Extreme rigor is a characteristic among dance and STEM curricula – given the research-driven choreography and studio time of the former, and the data-driven laboratory time of the later. Admittedly, the students indicated that dance provides spaces and places for self-expression where their creativity is valued *and* accepted. There is, however, a duality of rigor that exists. This duality is often met with a pivotal point for students when dance and STEM are coupled as dual majors for students, and in these instances, students are forced to choice one curriculum over the other. This duality of rigor is accounted for in this study and discussed in terms of the STEM rigor coupled with the dance rigor. While STEM is often based in a lab setting for practice and hypotheses testing, dance requires studio time for the same reasons. Both are data-driven and characterized by long hours, continuous improvement, and teamwork.

Students in our study, however, indicated that a dance minor option helped them to continue participating in the art form. They felt that a dance major would be too restrictive and limit the diversity, inclusion and the participation of students who could engage in the curriculum. This confirms that co-curricular participation and involvement impacts academic performance and satisfaction (Wilson, et al., 2014) – as eleven of the thirteen STEM majors indicated that they were satisfied with their academic performance (Table 3). Further, students seem to gauge their self-efficacy along ***both*** academic and co-curricular involvement for a summative effect (Wilson, et al., 2014).

In terms of the *personal* theme in the data, the students discussed how their peers perceived them as dancers. Their peers oftentimes questioned why are they dancing, and would follow with a "it is just dance" sentiment. This is to suggest that dance is not perceived as an academic discipline or is not as important as STEM – hence, implying some level of academic elitism and a restrictive discipline identity (Sochacka, et al., 2016). In addition, personal identity played into this notion of what is rigorous and what is not. Several participants indicated that there are assumptions and often dance-associated stigma from the broader student population. Women experienced a gender identity (Kvasny and Richardson, 2006) complex where dual personas between masculine hardness dominated STEM interactions and feminine "soft and fragile" was often coupled with perceptions of dancers. Black (and those of color) female students were often associated with hip-hop due to the broader society's perceived norms of who performs a particular dance form.

The students view the arts/dance as a critical mechanism to support *institutional* diversity and inclusion theme. While the students perceived that the institution did not provide equal or ample coverage on arts-related stories in comparison to STEM, they encouraged the arts unit to challenge itself by telling its own narratives and align these stories to the institution's mission. The students observed the diversity in dance based on the plurality of their race/ethnicities, college majors, demographics, dance forms, first-generation college, geographic backgrounds and prior experiences. They openly questioned if this inclusion existed in their STEM courses and suggested that this was not the case.

Interestingly, the participants mentioned that STEM is often depicted as a geek, hard, male-dominated cul-

Theme	Students' Comments
Academic	(Engineering and Dance) aren't mutually exclusive for me. I knew I needed something to help me be creative going into *Engineering which is a very rigorous major. It helps me in Engineering because I feel like I can combine my skills from art and dance and my skills in Engineering and find my own niche* (Rigor). I decided to *major in architecture, which also interested me. Dance helps me to balance*. (Rigor; Emotional Engagement) I agree that it's very *balancing. I enjoy coming to company class so much, it's a time to come and release the stress of my other classes. Dance is what sold NC State for me* (Emotional Engagement), I was choosing between NC State and Virginia Tech and decided on NC State because it was the one with a dance program. I'm majoring in biochemistry. (On a scale of 1 to 5 with 5 being highest), 13 of the total students noted that they were *satisfied with their grades and happy with their majors*. Eleven (11) of the 13 were STEM majors. (Self-Efficacy)
Personal	*I find dance just as important as chemistry, but I think STEM pushes the arts out and has created a stigma around what being an artist is vs what being a scientist is* (Stigma). I feel like I've been attacked for having these other interests, or constantly being questioned by my peers (Peer Perceptions) about why I need to dance. Again dance helps me grow as a person and gives me an outlet but *I've had moments where I questioned my path and asked if I should put dance on hold in order to be a "better" chemist.* (Identity) I think *dance helps my grades and my studying because having a more structured schedule is better for me, and dance gives me a place to release stress* (Safe Zone) and then I'm a lot more motivated when I return to my course work. *I can be "me" when I come to my dance classes and have a sense of community here*. (Safe Zone) I find it *easier to talk to female students about calculus problems than to approach a male student. Male students see me as inferior* (Peer Perceptions), because they understand the math but I don't. That's at least how I perceive it. I am in *STEM and female. Students, males especially, ask me why am I wasting my time in dance. They do not think I know calculus because I am female. Being a dancer makes this even harder*. (Identity; Peer Perceptions)
Institutional Issues	The *university does not showcase the arts (or needs to do a better job of promoting what we do here other than academics and engineering)* (STEM PR Competition). The arts help me as a STEM major. This would show that we are proud of the program. *Diversity and inclusion is rich in the dance department (differences in race, backgrounds, styles, majors…..). If diversity is important, then show it.* (Diversity and Inclusion) *Without these dance classes, I am not sure that I would see diversity in my chem, engineering or math classes. Having these dance experiences are what diversity is about or should be about. I mean that there is diversity of dance experiences, race, we are mostly women, from different parts of the country, majors*, etc… (Diversity and Inclusion) But…the *arts need to tell their stories* also (Storytelling). It is just as important as (engineering). *Sometimes the arts play down its own importance* (Storytelling). Both are important to us as students…after all, we are the next generation, right?
Career Workforce Preparation	Dance *helps with critical thinking and creativity in approach to course work* (Creativity). I've *used work from dance directly in a final project for a class and I got a 100 on that project because it was such a creative approach* (Creativity). Dance also has helped me with intentionality and having a point and focus in my approach to course work. Dance *helps with teamwork and connecting with different people in group work. Doing different styles of dance helps approach diversity in other situations*. Also *time management* (21st Century Skills; Helps STEM/STEM Helps). *I think both (STEM + Arts) help each other* (Helps STEM/STEM Helps). Dance helps make up who I am as a person and a student. It *provides a new perspective* (Creativity), being around students that think the same way I do *in statistics classes, it's nice to have an art form to come to and be around people that appreciate things other than numbers* (Helps STEM/STEM Helps). Its very balancing for me.

Table 3. STEM Students' Comments on Dance Engagement

ture that fails to embrace flexibility, creativity or diversity. Dance has similar images depicted by primarily females (few males) with thin body types, and for more classical dance forms, white females are the expected participants. Our focus groups debunked these images and pointed to the variety that exists within their groups, including diversity of thought. The participants viewed the STEM + art option for dance as a mechanism to facilitate having both STEM and arts on campus. Several expressed that a dance major would force them to select between two fields, and would not facilitate the time associated with a double major. They indicated that the studio time (Daugherty, 2013; Sochacka, et al., 2016) of both disciplines would mean matriculating more than the typical four years, and in fact, limits diversity of who participates in the art form. A shift from dance co-curricular to curricula for those interested in a dual major could also negatively impact academic emotional engagement, self-efficacy and level of activity (Wilson, et al., 2014).

Twenty-first century skills building and *workforce preparedness* were anticipated among the students. They pointed to STEM + art experiences to promote multiple approaches to problem-solving, creativity, innovation and collaboration (Land, 2013). These points were further validated by the first author's one-on-one interviews with six dance alumni. These alumni are now professional dancers, researchers, STEM doctoral students, lawyers, scientists, engineers and business professionals. The alumni consistently reflected on the problem-solving approaches in their majors in comparison to dance, and the rigor associated with both. The dance studio time was described as being akin to the STEM lab time among the alumni (Daugherty, 2013; Sochacka, et al., 2016), and alumni signaled that their current workplace practice involves:

- Hypotheses testing (STEM) that is likened to movement exploration (Dance)
- Data driven research/investigation to address and approach a concept or theme (Both disciplines)
- Theory to ground the problem-solving processes (Both disciplines)
- Application (think+do) for performance (Dance) which is similar to the presentation of results (STEM)

STEM + Arts Policy Challenges in Light of Current STEM Education

Traditional STEM education is said to be linear and overly masculine while espousing a culture that focuses on "weed-out", non-supportive and exclusivity (National Academies of Sciences, Engineering, and Medicine, 2016). The entry of STEAM or STEM+arts models, however, have been said to be the catalyst for U.S. innovation and competitiveness (Root-Bernstein, 2011; AAAS, 2014). While research (Root-Berstein, et al., 2008) demonstrated that the linkages between the arts and STEM is not new, current silos within higher education models do not best serve

the agility needed for current and future students to leverage and grow STEAM skills. Existing curricula and advising models will require flexibility in student support while providing opportunities for cross-discipline collaboration, as well as shared studio/lab time. These models also require a careful examination of who are the faculty engaged in the cross-discipline teaching and whether or not students persist (or not) in their intended majors and/or minor.

One challenge is to consider and restructure what it means to be a STEAM versus a STEM + arts student. Does the STEAM student require dual-enrollment in majors across two distinct curricula that often have few intersections among courses, content and professors? If the STEM + arts model is adapted, how can co-curricular and minor dances/arts options provide the education experiences desired by students and the rigor needed to support the creative process? In our study, the STEM+arts model is supported via university course offerings, but students are highly committed to the out of class time element (e.g., studio time to implement what has been discussed, hypothesized and investigated). For policy-makers, the challenge of dual majors and even co-curricular offerings poses questions of affordability of participation in STEAM – particularly when more than four years is the anticipated in a current climate of rising higher education costs. These rising educational costs are often most challenging for under-represented, first-generation and low-income students – This raises questions around participation and inclusion in fields that currently have minimal representation.

With the costs associated with dual major or other STEAM models, policy-makers will need to address the lack of diversity and its impact of the U.S. innovation and competitive imperative as offered by the AAAS (2014) forum. Higher education is continually challenged by and often rethinking institutional policies on diversity, or the lack thereof among STEM faculty and students (National Academies of Sciences, Engineering, and Medicine, 2016). When assessing gains in the field, data on under-represented populations in STEM can best be described as a long creep (National Academies of Sciences, Engineering, and Medicine, 2016) that is often met with barriers for students and faculty of color, alike. For the under-represented STEAM student, these barriers can be two-fold by coming from both disciplines and the associated matriculation experiences which can result in more challenge to academic emotional engagement, self-efficacy and level of activity as offered by Wilson, et al. (2014).

Conclusion

STEAM can be viewed as a structure to foster inclusion, broaden participation and nurture persistence. In this study, students **were not** dual majors (STEM and dance). Rather, students participate in one of two dance companies with options to partake in a master class series, an Arts Village, formal concerts and an annual national conference.

Students reported their experiences as the duality of rigor where two disciplines require a significant amount of time commitment. Whereas STEM fields are often crux in the lab pedagogy, art (dance) similarly focuses on a studio and rehearsal time. The participants in the study were frank about the challenges often associated with being female in male-dominated disciplines. Yet, the addition of dance heightened the stigma perceived by peers as a lack of commitment on the parts of the dancers to the STEM disciplines.

The students reported a perceived degree of problem-solving skills enhancement where STEM and the arts equally bolster one another (Edwards, 2011). This enhancement is the result of interdisciplinary, data-driven thinking where there is a Think+Do model in STEM paired with a Performance+Presentation in the arts. Lastly, the opportunity for diversity was largely supported and is inclusive of diversity of thought, disciplines, participants' backgrounds and even dance forms. The challenge of this work is for higher education to find a blend of where the arts and STEM (Edwards, 2011) can co-exist while enabling students with multiple interests to navigate curricula and engage in experiences (Simpson and Kelly, 2013; Wilson, et al, 2014; Webster 2016) to strengthen what STEAM has to offer and what does it mean in co-curricular environments. We are left to ask if there is any difference between a STEAM student and a STEM + arts student, and this requires a (de)restructuring of discipline identities (Sochacka, et al., 2016). We offer that the presence of major versus minor offerings and enrollment are simple, but not sufficient characterizations of either student.

We offer that the work can be used to examine "place and space" ethos (Matuscovich, 2010) – as both the physical locale and interpersonal culture can impact participation in the disciplines. These places and spaces foster engagement among students to seek interdisciplinary connections to societal and innovation problems that can prove to be more relevant to the learning process (AAAS, 2014). As several students concluded,

> *When I come to the (dance) studio, I can drop everything, be myself and become my creative self without the stuff out there.*
>
> *We are a family, and it is helpful having this space. Though the (teachers) push us, we can also come in and talk to them and each other. . . .because at the end of the semester, we have to produce as a unit, a group, a team.*
>
> *The studio is my refuge, my home away from my dorm room. I am more comfortable in the (dance) studio. No one judges yet everyone cares.*

Future research can provide more focused studies on this topic. Educational issues could investigate and consider how the ARTS supports STEM education, and vice versa. Studies on creativity, gender and race/ethnicity participation, broadening STEM participation, curriculum design and workforce preparation can offer the field additional knowledge in the development and implementation of STEAM policies. Longitudinal students are needed to understand how academic curricula are evolving to meet the needs of the STEAM and STEM+arts students, and how does either model help students persist in traditional STEM courses of study. Lastly, diverse methodologies across larger sample sizes would also improve our understanding of the duality, rigor and inclusion into STEAM and STEM + arts career participation.

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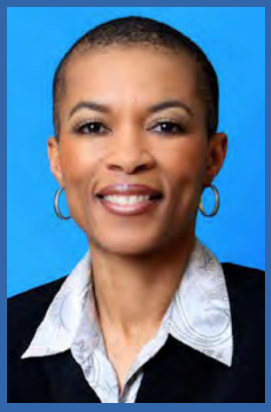

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