3-16-2018

Examining STEAM implementation through the lens of organizational learning

William Louis Grillo
Rowan University, wgrillo86@gmail.com

EXAMINING STEAM IMPLEMENTATION THROUGH THE LENS OF ORGANIZATIONAL LEARNING

By

William L. Grillo III

A Dissertation

Submitted to the
Department of Educational Services and Leadership
College of Education
In partial fulfillment of the requirements
For the degree of
Doctor of Education
at
Rowan University
February 25th, 2018

Dissertation Advisor: Monica Reid Kerrigan, Ed. D

Dedication

This dissertation is dedicated to my family. My accomplishments have always been products of your unconditional love and support. I have spent countless hours discussing the difficulties associated with completing this program and each of you were always willing to be a sounding board for my jubilance and frustration. There is no greater gift in life than a loving family and I am so thankful for all of you.

Acknowledgements

I would like to first acknowledge the arts educators and administrators whom have inspired me to continue teaching. Arts education grows through the collective efforts of artists who care about the future. Thank you to all my colleagues.

I would also like to acknowledge my professors at Rowan, my dissertation committee, and my chair Dr. Monica Reid Kerrigan. I am extremely grateful for your guidance and I feel you have profoundly impacted my development as an education professional. My process of discovery and creativity as a practitioner has come into focus due to your efforts and I will remain perpetually thankful for this gift. Thanks for being such great teachers.

Abstract

William Louis Grillo III
EXAMINING STEAM IMPLEMENTATION THROUGH THE LENS OF ORGANIZATIONAL LEARNING
2017-2018
Monica Reid Kerrigan, Ed. D
Doctor of Education

This study examined STEAM implementation from the qualitative perspective of New Jersey K-12 school leaders and through the quantitative lens of organizational learning. Using a convergent parallel mixed methods design, sixteen school leaders were interviewed regarding their process of implementing the integrated learning framework known as STEAM. Simultaneously, an Organizational Learning Mechanism Questionnaire was distributed to the teaching faculty of participating districts. This study found that current K-12 school leaders were implementing STEAM with top down administrative support, emergent processes, standards focused curricula, and innovative means of marketing their programs. Significant differences were also found between K-8 and high school districts. Support from organizational learning mechanisms was marginal, suggesting that the espoused processes of school leaders where not abundantly supported by pre-existing professional learning processes. Two separate manuscripts conclude this work, discussing STEAM implementation from the perspective of school leaders and the differences between K-8 and high school districts.

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

List of Figures

List of Tables

List of Table (continued)

Chapter 1

Introduction

The U.S. Department of Education has promoted many educational policy goals to ensure that science, technology, engineering, and math (STEM) curricula is improved and promoted within K-12 schools across the nation. With nearly three billion dollars spent since 2003 and over $600 million in the past two years, the Obama Administration and state governments have been able to spur momentous support for STEM education as a bottom-up means to catalyze numerous types of industrial, economic, and educational innovation (US DOE, 2015). One of the primary policy suggestions was to motivate educators to facilitate both preparation and inspiration inside the STEM classroom (President's Council of Advisors on Science and Technology, 2010). Citing the cumulative and sequential nature of K-12 math and science curricula, the council asserted that instilling inspiration is key to students envisioning how to connect with material and solve global issues (PCAST, 2010).

Based on these policy movements and suggestions, an alternative policy movement has surfaced which suggests there is a noteworthy gap in the education system's plan to spur STEM inspiration amongst America's youth. This model is titled STEAM and suggests that instilling principles of art and design can help bridge the systematic nature of STEM education with real world creative problem solving.

While at the onset, STEAM seems to have promising approach to curriculum integration and educational innovation, there is very little policy guidance driving its implementation in K-12 public schools. Furthermore, it is not understood how schools must adjust their organizational routines to integrate STEAM effectively. For these reasons, this dissertation will examine STEAM implementation through the lens of organizational learning.

STEAM Background

This section will explore STEAM's philosophical tenets as both a learning framework and model for transdisciplinary learning in the classroom.

STEM to STEAM. Science, technology, engineering, arts and mathematics (STEAM) represents a developing interdisciplinary movement focused on catalyzing educational innovation through the exploitation of art and design skills within traditional STEM classrooms (STEM to STEAM, 2015). From the beginning, STEAM has been a movement with three primary goals prescribed by the Rhode Island School of Design (RISD), 1) place art and design at the center of all future STEM policy research, (2) make art and design an integral piece of K-20 education systems, and (3) promote the hiring of artists as catalysts for innovation within the STEM industry (Stem to Steam, 2015). Districts across the United States are adopting and implementing STEAM ideas to meet the demands of federal STEM education policy.

The educational worldview associated with much of the STEAM knowledge base seems to represent social constructivist ideals as shown through written policies, teacher pedagogies and qualitative student perspectives (Martinez, 2011; Sade, 2014; Silverstein, 2011). It can be suggested that STEAM is a socially constructed policy developed by practitioners and local districts in the wake of a national STEM movement. Ingram, Schneider, and Deleon (2007) explain that as policy trickles down to local contexts, in this case STEM, individuals consider the social ramifications of change and adapt policy in ways that are more meaningful to them. So as STEM developed as a major US

Department of Education (USDOE) initiative throughout the 1990s, certain individuals noticed that innovation may not necessarily be a product of more STEM; rather, innovation might be the result of integrating the arts in STEM. The newly formed STEAM policy actors and champions overwhelmingly suggest that STEAM requires students to experiment and manipulate new knowledge, which Lincoln and Guba (2013) outline as core tenets of social constructivist thought processes.

Some grapple with the purpose of STEAM in our school systems, but integrating the arts within scientific inquiry has clear historical and philosophical precedence. Gardner (1984), as referenced by Murr and Williams (1988), discussed how technological innovation during the Renaissance Era seemed heavily dependent on the cognitive shift from the memorization of processes to the creation of visual models. Similarly, Geimer (2014) asserted that in the case of mathematics, the ability to visually model fundamental math principles provide a level of creativity within the discipline, as championed by individuals such as Leonardo di Vinci for feats of innovative engineering. In a 20th century context, Francis Crick, James Watson, and Maurice Wilkins used this same artistic modeling process to better understand mankind's genetic code and create the correct visual representation of the double helix (Gardner, 1984).

Physicist, philosopher, and science historian George Sarton believed that the goal of mankind was to achieve truth (science), justice (philanthropy), and beauty (art) (Millikan, 1938). While Millikan does suggest that artistic inquiry may still stand on an island by itself, the overarching point was that humans cannot exist in a singular dimension of truth, justice, or beauty. He stated this would be an incomplete method of contributing to the social well-being of mankind and therefore the combination of all three dimensions completes the whole man (Millikan, 1938). These historical examples of art and science integration, to which there are many more, are integral to understanding arts integrated practice used throughout the 20th century as well as STEAM's rebirth in 21st century learning contexts.

STEAM finds its way into the education sector as an outgrowth of integrated curriculum models of the early 20th century. An evolving curriculum model since the 1930s, the process of framing numerous disciplines around a central theme or problem has been a vital educational innovation that allows students to explore the transference from knowing in one discipline to understanding across many (Drake & Burns, 2004; Parsons, 1998; Root-Bernstein, 1991). STEAM accomplishes this transference by employing popular student-centered learning philosophies with an overarching goal of reinventing multiple societal constructs such as improving local economic value (Newton & Newton, 2014), instilling a sense of civic responsibility and justice through problem based learning environments (Krajcik & Shin, 2014; Lu, Bridges, & Hmelo-Silver, 2014), and fostering educational innovation through increased dialogue between teachers of contrasting disciplines (Goatley & Johnston, 2013).

The ways in which schools integrate these disciplines will not only be examined in the qualitative strand of this study, but also conveyed in the quantitative sense through the types of organizational learning mechanisms set up to allow teachers to share, retrieve, collaborate and communicate information related to their curricular objectives (Schechter & Atarchi, 2014).

Given what is understood about STEAM thus far in the 21st century, there seems to be a shortage of published or reliable resources regarding implementation in school contexts. Some research has begun to explore implementation, both as research entities and professional development for school districts looking to adopt STEAM within their school curricula (Cook, 2012; Ghanbari, 2014; Rabalais, 2014; Tomlinson-Clark, et al. 2014). While these districts ostensibly do so to innovate across the curriculum, limited research exists on implementing best practices and some districts continue to struggle against an educational system which continuously promotes less creative, more quantifiable standards of practice.

Arts integration push back. High stakes testing and rigorous standards based movements solidified their place in a society that demands excellence and transparency in exchange for public funding. As such, many school leaders and practitioners find adopting reform centered on arts integration unsettling, ambiguous, and possibly even counterintuitive to the accountability movement. D'Andrea (2012) argued that arts integrated pedagogies lack higher stakes assessments, which is of primary concern to policy makers and school leaders. Thus, "low stakes" assessment practices and curriculum reform may be viewed as inappropriate for the current climate. Furthermore, the hesitance to embrace arts integration, regardless of the research supporting its value, can sometimes be attributed to policy makers seeing the arts as merely a cultural building experience, rather than a viable approach to developing diverse student skill sets (D'Andrea, 2012).

Artistic pathways in STEM learning are seldom adopted by traditionalists in the educational spectrum, even though the act of innovating and creating something new is the sine qua non of artistic and scientific mastery (Vessey, et al., 2014). Masani (2001) asserted that constructivism is a modern enemy of science, stating that, “For if there is no objective reality, there is no one truth to a problem" (p. 294) and even goes as far as suggesting that constructivist inquiry is anti-scientific and baseless. Furthermore, Alan J. Friedman, formerly of the New York Hall of Science, stated that while certain aspects of the arts and sciences aid each other in achieving common goals, he does not promote widespread STEAM implementation because science and art are entirely different ways of looking at the world (Robeline, 2011).

To the contrary, Hope (2010) made a Sarton esque argument in a more contemporary education policy context. Hope argued that education policies should promote distinct modes of thought: a scientific mode for understanding how things work, a historical mode to discern when and why certain events took place, and an artistic mode for creating new ideas and products. Similarly, one of the most respected modern scientific minds, Dr. Neal Degrass Tyson, suggested (Tyson, 2015),

> Art and science call us to critically think, question our assumptions, and pursue our curiosities. As much as scientists (and) artists have been punished throughout history for challenging the status quo, they are some of the best-known catalysts of intellectual and cultural revolutions (p. 17).

Within Chapter 2, there is a great deal of literature supporting arts integration in STEM. As such, constructivist learning environments seem to be rapidly evolving in despite the rigid accountability driven systems currently in place. While competing worldviews will always endure, creative policy initiatives such as STEAM ensure opportunities for freedom, risk taking, and critical thinking to be applied to complex problems in modern educational systems. The caveat being, those in charge of championing said movements pay equal attention to implementation (Hope, 2010).

Understanding implementation approaches requires a parallel lens of examination; the first of which addresses the inner workings of a system in which programs are being implemented and manipulated. The second requires the study of STEAM programs and professional learning systems together as one entity. If Hope (2010) suggests that optimal results will be a product of detailing implementation for the integration of creativity and science, then a lens focused on organizational processes and mechanisms which support implementation seems necessary to the equation. Therefore, organizational learning enters the fold of this STEAM implementation inquiry.

Organizational Learning Background

STEAM inherently works against the way contemporary school districts function as system. Public schools have been structured such that their organizational footprint often includes discipline segregation, rather than integration. An organizational perspective is necessary for others to understand how STEAM is sustainable despite its lack of congruence with school structure. Drawing upon an important principle discussed by Hammond (2005) and purported by researchers in multiple fields, Shaked and Schechter (2013) stated that, "Every phenomenon must be viewed from the perspective of the whole system to which it belongs as well as its subsystems and the relationships between its various components" (p.14).

Initially explored by Argyris and Schon (1974), the early theories of organizational learning (OL) had to do with identifying theories in use, theories in action, and espoused belief systems that account for an organization's daily routines. Similarly, single and double loop learning influence an organization's ability to change and thus help delineate between those who prescribe "quick fix" solutions to complex problems and those who collectively adapt to sustain innovation (Argyris & Schon, 1974). Beyond theories and actions, Daft and Weick (1984) and Fiol and Lyles (1985) contributed to the early conceptualization of OL, suggesting that organizations can adopt specific worldviews and adapt by learning through information receptors.

Early OL theory allowed researchers to construct frameworks for established processes and mechanisms across different types of organizations. Many of these theories can be broken into what, where, and how organizations learn throughout their lifespan. For instance, Boone (2014) suggests there are operational and conceptual processes, while Popescu, Bunea, & Radu (2015) described these same processes as behavioral and cognitive. In exploring “what” organizations learn, the research delineates as to whether stakeholders are making simple procedural changes to action (operational and behavioral) or philosophical changes to the foundation of an organization’s belief system (conceptual and cognitive) (Popescu et al., 2015). Applied to schools, the research base blossoms even further and contextualizes the complexities of professional learning in school organizations.

How educational systems learn can be understood through Organizational Learning Mechanisms (OLMs). These mechanisms have been defined as disseminating, storing and retrieving information, sharing information with students and parents, analyzing and interpreting information, and accessing online information (Schechter & Atarchi, 2014). These mechanisms will be used as part of the quantitative strand of this study to examine systems that implement STEAM.

Research Problem

Research on STEAM implementation is continuing to grow, with foci ranging best practices, proven professional development strategies, and the structural components necessary for implementing interdisciplinary innovation across school structure. Unfortunately, the current educational climate in New Jersey leaves little room for school leaders to be involved in the more constructivist educational ventures. Over the past six years, New Jersey has implemented student growth objectives, new teacher evaluation models, school choice lotteries, and standardized test reform with PARCC (NJDOE, 2017). Between STEAM's lack of implementation frameworks and New Jersey's climate, it remains difficult for constructivist learning ventures to pass the muster of the accountability movement.

This problem has most recently been addressed by Ghanbari (2014), who suggested that the vague and unproven impact the arts have on STEM is as an issue of inequitable funding between the arts and STEM, marginalized arts policy within No Child Left Behind (NCLB), and economic dissonance between STEM and creative arts careers. NCLB mandates have forced creative arts programs to become marginalized and place disciplines that are not subject to high stakes testing within a second tier of importance (Cook, 2012).

Chowdhary, Liu, Yerrick, Smith, and Grant (2014) also contributed to the discussion of the problem, suggesting that a disconnect exists between new methods of interdisciplinary engagement that support student scientific inquiry and the skillsets included on local, state, and national assessments. Even with interdisciplinary professional development, Chowdhary et al. (2014) asserted that, "it is imperative and critical for teachers to increase their understanding and practice of interdisciplinary science inquiry (ISI)" (p. 880).

In the most local of contexts and directly related to the scope of this study, school leaders may struggle to properly build the constructivist school environment necessary for arts integrated learning in STEM. Teachers may struggle to incorporate problem and project based learning activities for students to discover the meaning of innovation. Finally, all school stakeholders may find themselves unable to pinpoint a means to change without a well-developed knowledge of how organizational learning mechanisms influence the implementation of new practices.

Research Purpose

The purpose of this study was to examine STEAM implementation by unveiling K-12 schools use of organizational learning mechanisms. STEAM is the subject under investigation and OLM's represent the many processes that may influence each participating district at large. I posed the following researching questions to effectively examine STEAM implementation through the lens of organizational learning:

1. What is the process by which STEAM is being implemented K-12 public schools of different socioeconomic groupings?
2. What does an organizational learning framework reveal about the pedagogy and collaborative processes of teachers engaged in STEAM?

Methodological Overview

I used a convergent, parallel mixed methods design to answer the research questions. In the convergent parallel design, qualitative and quantitative data were collected simultaneously and mixed with each other during the analysis phase to develop a series of inferences presented in Chapter 4 (Teddlie & Tashakkori, 2008). The Teddlie and Tashakkori (2008) was the primary methodological framework used throughout the study. There are three primary reasons I decided to employ a mixed methods design.

First, it has been suggested that interdisciplinary studies be paired with a mixed method design to understand social change through quantitative and qualitative lenses (Hesser-Biber & Nagy, 2010). Second, integrated learning frameworks require social and organizational change in schools due to its inherent demand for collaborative practice. Therefore, there is a need to explore the integrated framework itself (STEAM) and find a means to confirm desired processes (organizational learning mechanisms). Finally, Creswell and Plano Clark (2011) asserted that the convergent parallel design is appropriate when the researcher aims to confirm, validate, or corroborate research findings using separate data sets. Teddlie and Tashakkori (2013) agreed with Creswell and Plano Clark (2011), stating that, “A major advantage of mixed methods research is that it enables the researcher to simultaneously ask confirmatory and exploratory questions and therefore verify and generate theory in the same study” (p.37).

Teddlie and Tashakkori (2008) also suggested that mixed methods research can make stronger inferences and explore more divergent viewpoints. In a field where there is little cohesive understanding about how to implement STEAM programs, divergent viewpoints should be catalogued and inferences should account for both the program itself and the organizational learning mechanisms used to support the program’s goals.

I focused on collecting data from three sources to answer the research questions:

1. A semi structured interview protocol that addresses district implementation of STEAM from the perspective of school leaders and classroom teachers.

2. Supplementary documents such as lesson plans, syllabi, scope and sequence reflections, and policy guidance documents to reveal STEAM's prescribed curricula.
3. The Organizational Learning Mechanism Questionnaire developed by Schechter and Atarchi (2014) to reveal the processes that support implementation.

The semi structured interview protocol was created and designed using a framework suggested by Wengraf (2001). Wengraf suggested that for the protocol to be more reliable, the researcher should not lead participants to confirm any particular theory or concept from the literature review. For this to happen, a series of theory based questions were generated upon completion of the literature review, then reworded them inside of the protocol such that their presentation was general enough to promote responses unique to each participant. Study participants were provided with the option to provide supplementary documents at my request. Also, public curriculum documents were gathered and studied from the district's website.

The quantitative strand employed the OLM Questionnaire by Schechter and Atarchi (2014). This instrument contains 24 Likert scale items in four categories: disseminating, storing, and retrieving information, analyzing and interpreting information, access to online information, and communicating with students and parents. The questionnaire was presented as a Google Form and distributed to participants through participating school leaders.

Data analysis strategies were informed by Teddlie and Tashakkori (2009). A constant comparative method of qualitative analysis is used to compare incidents, integrate categories, delineate theory, and ultimately write theory based on narrative data.

Strategies such as analytic induction, identifying Units of Information (UOIs), analytic memos, and coding are used for interpreting qualitative data sets (Merriam, 2009; Saldana, 2013; Teddlie & Tashakkori, 2009). As discussed in Chapter 3 and revealed in Chapter 4, the constant comparative method was a prominent analysis tool for mixing data and comparing inferences across the QUAL and QUAN spectrums.

Quantitative analysis included the generation of descriptive statistics, frequencies, one way ANOVAs, and when necessary, Post HOC test pairs after a one-way ANOVA. Respondents (n=75) were grouped based on the socioeconomic status of their district and their teaching discipline.

Research Context

This study on STEAM and OL was situated in New Jersey K-12 districts of different socioeconomic groupings, specifically group CD, DE, and J. The choice of obtaining districts within different socioeconomic settings was inspired by the need to develop more research on urban creative policy making and address the creative policy gap in New Jersey communities (Boren & Young, 2012). The authors stated that:

> ...it is important to search for ways of overcoming the 'creative policy gap' and to explore how new conceptual spaces could be created in which policymakers can think differently, outside of their normal professional constraints, perhaps tapping into their mundane experiences and understandings of creativity, exploring their own creativity and engaging them in new forms of interaction with creative practitioners.

As previously discussed, the high stakes accountability movements in New Jersey leave a considerable gap in creative policy making in all New Jersey schools. Whereas Boren and Young (2012) address the gap in urban settings, I sought to apply this idea to a diversified set of socioeconomic districts as means to compare their approaches to STEAM.

The setting also contributes to understanding more about how diverse student populations are approaching innovation in school contexts. The US government has been committed to attracting and developing highly qualified minority populations into STEM fields. By situating this study within low and high socioeconomic districts, I was able to address observable issues of equity, access, and implementation barriers across the socioeconomic spectrum.

Research Significance

Schools are vigorously exploring the research landscape for 21st century ideas. STEM continues to be a part of that focus, as districts hope to mirror the innovative achievements from the Renaissance and early 20th century. This study explores a topic draws upon these very ideals, which will continue to play a significant role in shaping the future.

Understanding why and how the arts remain integral to educational goals is important in determining the value of the arts beyond human aesthetics. One may never be able to truly quantify the arts' influence on innovation, but research can continue show its influence from a qualitative perspective. To the contrary, one can quantify what supports creativity in high stakes educational planning. OLMs can help illuminate whether STEAM is being supported by the types of collaborative practice it requires.

As STEAM continues to grow and morph into new creative school curricula, schools in various contexts need guidance. Stakeholders need to evaluate the approaches of neighboring school districts so they can implement STEAM with a baseline set of principles. Also, school leaders must always consider how new programs and policies are being supported or hindered by their professional learning mechanisms, thus this study is significant in its multilevel strategy of inquiry- program and organizational levels.

Definition of Terms

STEAM - The integrated learning construct of science, technology, engineering, arts, and mathematics. The proper integration of these subjects includes the interpretation of science and technology through engineering and the arts, which can all be explained through mathematical principles (Hirashima et al. 2011).

Organizational Learning - The collective commitment of individuals to a common purpose within an organization, whom consistently reflect on the value of certain processes and procedures for the sake of developing more efficient and effective means of accomplishing goals (Leithwood, Jantzi, & Steinbach, 1995).

Organizational Learning Mechanisms - "Institutionalized structural and procedural arrangements that allow organizations to learn non-vicariously, that is, to collect, analyze, store, disseminate, and use systematically information that is relevant to their and their members' performance" (Popper & Lipshitz, 2000, p. 185)

Educational Innovation - The multi-contextual paradigm that is typically associated with policy, curriculum, assessment, leadership style, and pedagogy (Cohen & Ball, 2007; Towndrow, Silver, & Albright, 2012). Some of the associated processes include experimenting with new tools, resources, and/or conceptual frameworks to create new learning systems (Goatley & Johnston, 2013).

Social Constructivist Policy - The processes of decreasing traditional political power structures to allow the social ramifications of change to influence local policy interpretations (Ingram, Schneider, & DeLeon, 2007).

Integrated Learning - An educational construct which suggests learning is a nonlinear, multilayered process of translating information within interdisciplinary, multidisciplinary, and transdisciplinary environments (Drake & Burns, 2004; Parsons, 1998).

Chapter 2

Review of Literature

Theoretical Framework

STEAM represents an integrated arts curriculum in which students can use visual and design oriented modes of thinking to innovate across STEM subjects (Anonymous, 2011; Bequette & Bequette, 2012; Guyotte et al., 2014; Marcoux, 2015; Wynn & Harris, 2012). Integrating the arts in STEM seems to suggest a policy shift to which educators are looking to mimic the aesthetic driven innovation of the Renaissance (Geimer, 2014; Murr and Williams, 1988; Wynn & Harris, 2012). To do so, STEAM draws upon integrated learning constructs that require schools to break away from segregated learning models and adopt transdisciplinary curricula (Drake & Burns, 2004; Parsons (1998); Root-Bernstein, 1991; Strand 2006).

The progressive rhetoric surrounding STEAM suggests a need to examine the process by which STEAM is implemented at the K-12 level. While small and large-scale STEAM frameworks have been suggested in numerous studies (Park & Ko, 2012; Shaffer. 2013; Wynn & Harris, 2012) STEAM still lacks the vigorous policy guidance that has made STEM a priority throughout 21st century learning organizations. Integrated arts frameworks require highly collaborative, experiential, and reflective environments (Strand, 2006) that must be continuously supported by school leadership (Purnell, 2004; Wong, 2013). The application of an organizational learning (OL) lens may help irradiate the organization's role in implementing STEAM. An organization’s predisposition towards collective learning, radical change, and innovative practice may help inform an institution's process of implementation. (Senge, 1999; 2002).

The conceptual framework in Figure 1 is a rendering of how the national STEM agenda which was socially revised in a constructivist manner to include the arts. By understanding what, how, and where schools learn, implementation of STEAM may be better understood.

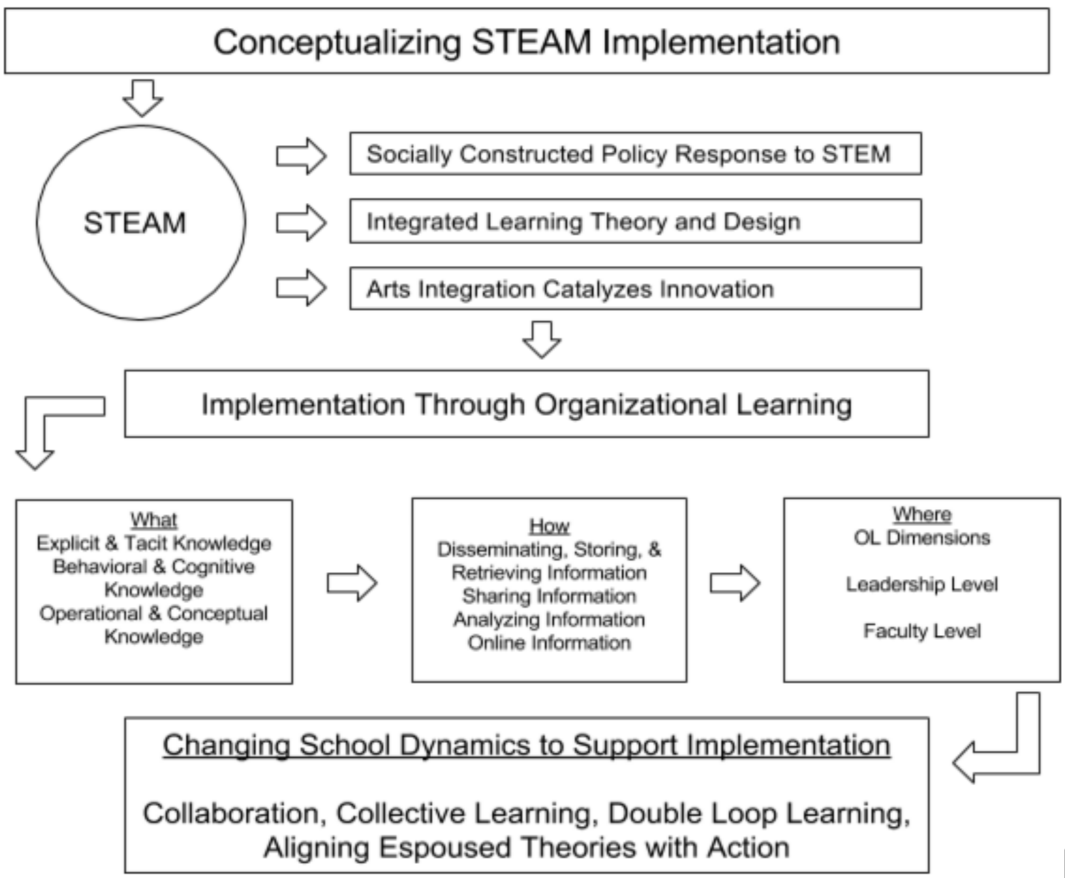

Figure 1. Conceptual Framework

Constructivist Policy Change

STEM education policy was initially created to further America's innovative footprint within school systems (USDOE, 2015). As a formal policy agenda in the 1990s, STEM was charged with integrating academic disciplines perceived as critical to the innovative process (Bybee, 2013). In 2013, the federal government formed a five-year strategic plan, outlining educational reforms for K-16 institutions (National Science and Technology Council, 2013). To better understand the narrative behind this reform, the United States Department of Education (2015) described the overarching purpose of increased STEM education in the following manner:

> In a world that's becoming increasingly complex, where success is driven not only by *what* you know, but by what you *can do* with what you know, it's more important than ever for our youth to be equipped with the knowledge and skills to solve tough problems, gather and evaluate evidence, and make sense of information (pg. 1).

Both politicians and educational leaders vigorously supported STEM for over twenty years. But, as Bybee (2013) suggested, the perception and implementation of STEM agendas commonly breaks down at the local level; meaning schools employ very divisive strategies for implementing STEM reforms within their normative operations and practices (Bybee, 2013). One reason for a breakdown in implementation is opposing worldviews and policy narratives regarding STEM in general.

Social constructivists subscribe to a worldview that asserts objective sciences, specifically the social sciences, which are sometimes impossible to separate from people's feelings and emotions (Lincoln & Guba, 2013). Similarly, experimenting and manipulating knowledge are more realistic methodologies even if the outcomes generate a less than objective truth (Lincoln & Guba, 2013). The idea of placing higher importance on experimentation and manipulation points directly to centering STEAM's worldview and policy focus on constructivist learning.

To better understand their philosophical undercurrent, Sade (2014) discussed the importance of critical design in STEAM through the words of Joseph Fry, "...we are designed by, and design within, the designed world, and that our designs continue to design long after leaving the drawing board, studio or laboratory" (p. 30). Thus, the shift from a pragmatic STEM movement to a constructivist STEAM agenda is revealed, but is better portrayed through an analysis of the STEM-STEAM policy process. This literature will depict STEAM policy as both an evolution from STEM and as its own developing socially constructed policy narrative.

Evolution through the policy process. The national focus on STEM suggests a need to establish a sense of how the policy progressed from the top down. The policy process itself can be described as a complex system which involves hundreds of actors working for any number of agencies, lobbying and debating issues that are deeply embedded in people's belief systems (Sabatier, 2007). As these actors participate in said process, it takes time for local systems to digest the tenets of the policy and ultimately act. It has been found that the policy process, from ideation to widespread adoption, can often take a decade or more (Sabatier, 2007).

As shown in Table 1, the STEM policy process veered course during the implementation phase. Person (2013) suggested that when policy is under the guise of a context separate from the target audience, implications for and consequences of the policy are never fully realized. Therefore, a divergence in STEM discourse emerges at the local level and change becomes eminent (Person, 2013). McLaughlin (1987) illuminated this type of change in stating, “change ultimately is a problem of the smallest unit. At each point in the policy process, a policy is transformed as individuals interpret and respond to it” (p. 174). The STEM agenda was ultimately interpreted and transformed by members of the creative class, resulting in a more constructivist minded policy that for some school districts, better suited their community’s desire to promote creativity and STEM innovation simultaneously.

Fowler’s (2012) policy process framework was used to depict the divergence between STEM and STEAM as they progressed from national initiatives to local action items. Table 1 suggests that in an era where state and federal government organizations maintain heavy influence on educational policy, STEM is largely a distributive policy that reallocated funding through capacity building and hortatory agendas to integrate largely pragmatic disciplines. Simultaneously, art and design practitioners felt marginalized and thereby mobilized a bias to redistribute power to creative disciplines. The dichotomy between non-arts and arts integrated STEM created a clear division in how innovation education should be approached in public school settings.

Table 1

STEM to STEAM Policy Process

Policy Steps	STEM to STEAM Policy
Issue Definition	A need for education systems to integrate learning in STEM disciplines for the purpose of innovation. Originally created in the early 1990s with various acronyms such as SMET and METS.
Agenda Setting	Early agendas discussed a need for technology and engineering to becomes equals with science and mathematics. A major initiative was to increase the K-12 focus on STEM in hopes more students, specifically minorities and women, would potentially enter STEM career paths. Place art and design at the forefront of research and influence the 21st century workforce to recognize the value in hiring creative individuals.
Policy Formulation	Goals in the formulation of STEM movements included a focus on 21st century workforce skills, environmental inquiry, economic inquiry, national security, women in STEM, and intellectual needs.
Policy Adoption	Federal STEM Strategic plan inclusive of education reforms, youth engagement in STEM programs, innovation funds, grants for STEM charters. Art and design supporters begin to suggest STEM is an incomplete method of promoting innovation. These supporters suggested creative design is the bridge to making innovative ideas functional, tangible, and meaningful to humans.
Implementation	Implementation roadmaps provided by the Committee on STEM Education (CoSTEM) and the National Science and Technology Council. Universities and K-12 programs implement the acronym STEAM to which they have access to all the same policy funding as STEM, but have access to far less policy guidance for integrating the arts. School districts and educational organizations seem to choose either STEM or STEAM during implementation.
Evaluation	Ongoing statistical analysis of STEM and STEAM's impact on the economy, workforce, and various innovations.

Note: This process summary is very abbreviated and is meant to depict a simplified policy process. Research is synthesized from USDOE (2015), Bybee (2013), Maeda & RISD (2015) & Fowler (2012) for the policy framework.

STEAM as socially constructed policy. If the result of STEM's policy processes was a divergent set of implementation strategies that contributed to the creation of STEAM, then STEAM itself should be analyzed through its own unique socially constructed policy process. In doing so, STEAM can be solidified as its own creative movement, not just an offshoot of STEM.

The social constructivist policy framework suggests that the policy process decreases traditional political power structures and considers the social ramifications of change (Ingram, Schneider, & DeLeon, 2007). In doing so, target groups become integral in the creation of a particular policy initiative. In the case of STEAM, the creative class is a target group who may feel the educational policy environment has largely ignored their position in the future of academia. Table 2 depicts STEAM a policy going through its own process, but in a socially constructed manner, which contrasts the more general process, presented by Fowler (2012).

There seems to be an underlying stigma surrounding constructivist policy in public schools. Schools are being driven towards a more data wise worldview, one that is pragmatic and places observable, quantitative growth at the center. For STEAM to be implemented properly, there must be simultaneous behavioral and worldview change. Sabatier and Mazmanian (1979) suggested that implementation is largely predicated on understanding the "extent of behavioral change required by target groups" (p. 543). It is surmised in this literature review, that change is championed by policy entrepreneurs willing to manage constructivist ventures.

Table 2

Socially Constructed STEAM Policy

Policy Steps	STEAM Objectives
Past and Current Policy Designs	Distributive STEM policies from the federal and state governments. Formation of a research problem suggesting the arts is dismissed as being integral to innovation and our economic future.
Institutions and Culture	K-12 institutions aiming to integrate arts and STEM Charter schools Higher Education Institutions Community promotion of student innovation
Target Populations	Creative minded stakeholders Business stakeholders who value creative job candidates School leaders charged with deconstructing the status quo Constructivist minded research in public education.
Future Policy Designs	Maximizing the difference between STEM and STEAM to change the discourse of innovative and integrated education. Arts and STEM integration ESEA (2015)

Note: Social Constructivist Policy Process taken from Ingram et al. (2007)

STEAM policy entrepreneurs. Policy entrepreneurs are then the individuals pushing and securing a constituent base around new emerging schools of thought. Mintrom and Norman (2009) suggested that these individuals must define problems in the current policy framework and exercise the social acuity necessary to provoke a public need for change. The provocation of a new social policy ideation results in a new narrative. McBeth, Shanahan, Arnell, and Hathaway (2007) contended that policy narratives are indicative of established public belief systems, yet also contain clear political agendas.

Initially, it was the Rhode Island School of Design (RISD) and their president John Maeda, who championed an emergent national STEAM agenda to support integrated artistic inquiry. As support grew amongst K-12 practitioners and institutions of higher education institutions, House Resolution 51 (2013-2014) was introduced to formally suggest the integration of art and design in STEM. (H.Res. 51, 113th US Congress). Soon after the work of RISD, the House and Senate Conference committee and Republican Suzanne Bonamici were able to pass arts and STEM integration into Elementary and Secondary Education Act (ESEA) in 2015, which will impact over 100,000 schools nationwide (Americans for the Arts Action Fund, 2015).

Thus, STEAM can be conceptualized as response to heavily funded STEM education reforms. The entrepreneurs in this instance may be artists, art educators, or constructivist minded school leaders across any discipline who believe design thinking is integral to innovation inside the classroom (STEM to STEAM 2015). Hirashima and colleagues (2011) formally defined STEAM as, “STEAM is Science & Technology interpreted through Engineering & the Arts, all understood with elements of Mathematics” (p. 2). Identifying the arts as a vehicle for interpretation suggests that scientific breakthroughs require aesthetic reasoning for further action (Maeda, 2013; STEM to STEAM, 2015). As with any emerging education policy, it seems necessary to clarify the perceived value of STEAM to justify its continuous presence in educational research and curricula.

The Perceived Value of STEAM

The value of STEAM has been discussed within three distinct categories: (1) integrating the arts and STEM will allow for future economic growth, (2) the arts allow students to identify and investigate issues of social justice, and (3) art and design are critical capacities for innovation of any kind. Bequette and Bequette (2012) called upon researchers to begin examining whether STEAM "serves the public good" (p. 47). This section addresses that very question and highlights research pointing to why STEAM implementation benefits issues of local economy, student civic responsibility, and student innovation inside the classroom.

Economic value. Suggesting arts integration in STEM will have an impact on something as complex as the economy is a difficult assumption to support. Lingo and Tepper (2013) asserted that, "While there is widespread agreement that both the nation's economic and health interests are advanced by studying and supporting the pipeline of scientists and engineers, nurses, doctors, and teachers, it is less obvious why artists deserve the same attention" (p. 339). Essentially, it is difficult to quantify the effect of the arts on our economic future.

Consequently, Newton and Newton (2014) argued that as our world population increases exponentially in the 21st century and natural resources continue to dwindle, creativity will emerge as the most abundant of human resources. The authors suggested that creative resources represent our only chance at solving emerging 21st century problems (Newton & Newton, 2014). Whether or not economic outcomes are a product of STEAM efforts in K-12 schools, educational institutions still tout this idea as a major platform during implementation.

Specific to STEAM, Wynn and Harris (2012) asserted that the STEAM movement will help improve America's innovation footprint through expanding on the quantitative bias commonly exploited through scientific inquiry. By unrestricting the single discipline bias and allowing unfettered creativity in the classroom, the tenets of STEAM have been shown to provide greater economic career projection, ethics and values, and prepare students to use principles of aesthetics to innovate through the use of technology (Strand, 2006; Spector, 2015; Tomlinson-Clarke; 2014). The economic argument was also promoted by John Maeda and RISD's strategic plan for STEAM implementation, which included three central initiatives: focus policy research on the integration of arts and STEM, advocate for the use of art and design principles throughout K-20 education, and show employers that creative artists will help catalyze economic innovation (STEAM to STEAM, 2015).

Influencing students to engage their civic responsibilities for the means of obtaining social justice is a value that emerges specifically from arts integrated learning. Clark and Button (2011) asserted that, "The arts promote cultural change, trigger the imaginative conscious and community action, and act as a bridge towards scientific understanding and the application of sustainable efforts" (p. 43). Marcoux (2013) invoked a more meta-analysis, suggesting that the arts applied to STEM provide a new set of who, what, where, when, and why questions for the world around us. Speaking to social justice, Sade (2014) focused more on process, claiming that to exploit social justice, there must be an urgency for interdisciplinary and transdisciplinary work by teams of researchers from all disciplines.

Civic duty is something that can be realized in the classroom using problem based learning- a frequent pedagogy and lesson strategy of STEAM. Problem based learning helps students understand how they fit into the society at large by developing metacognitive skills, procedural knowledge, relevant problem analysis skills, and collaborative learning skills (Krajcik & Shin, 2014; Lu, Bridges, & Hmelo-Silver, 2014). Researchers suggest that it is collaborative learning, specifically, that helps students mitigate competing perspectives using democratic principles and build strong relationships through respectful negotiation (Biswas, 2014; Ehrlich, 2000; Kezar & Lester, 2009). Hence, the research on civic responsibility in STEAM suggests that by placing students in problem based environments that require interdisciplinary inquiry, the students can address issues in their community and world around them. Different from STEM, the arts are situated as the imaginative tool necessary for solution driven innovations to occur.

Innovation. Innovation has continued to be one of the most commonly cited 21st century educational objectives and any policy promoting value in this area calls for investigation. Currently, initiatives such as the Investing in Innovation Fund (i3) provide money to schools for the development of learning innovations tied to raising student achievement (USDOE, 2015). The Obama Administration provided over a billion dollars in STEM funding for educational innovations and workforce readiness programs over the past five years and the President’s Committee on the Arts and Humanities (PCAH) successfully lobbied for grants supporting the implementation of the arts in math and science classrooms (PCAH, 2015). Yet, with the growing support comes increased confusion over what educational innovation actually means and looks like in schools.

Towndrow, Silver, and Albright (2012) and Cohen and Ball (2007) both defined educational innovation as a multi-contextual paradigm that is commonly associated with curriculum, assessment, leadership style, pedagogy, etc. Curriculum innovation, the focus of many STEAM models, is a process in which teachers experiment with new tools, resources, or conceptual frameworks to create new lesson strategies (Goatley & Johnston, 2013). This idea was expanded to suggest that curriculum innovation relies heavily on teacher-driven lesson innovations coupled with their positive agency towards the process (Bascia, Carr-Harris, Fine-Meyer, & Zurzolo, 2014). Research now suggests STEAM is often developed using collaborative, multimodal discourse that situates experience, reflection, and discovery in every lesson (Tomlinson-Clark, 2014). These depictions of educational innovations drive the investigation of specific strategies used in STEAM learning environments.

STEAM Curriculum Design

The integrated curriculum. STEAM's curriculum makeup is parallel to that of the integrated curriculum. Curriculum integration was initially a response to the over fragmentation of academic disciplines which ignored more complex, multidisciplinary patterns of inquiry (Parsons, 1998). The general concept of integrating subjects was suggested as early as 1935. The National Council of Teachers of English stated in 1935 that the integrated curriculum was the practice of combining all subjects and experiences inside one classroom (Drake & Burns, 2004). In theory, the model posits that the senses are not separate and linear, rather they are "imprecise, multilayered, volatile, always in process of translation, never precisely fixed meaning, and as always, a constituent of art" (Parsons, 1998, p. 103).

Integrated models are typically unpacked by educators within interdisciplinary, multidisciplinary, and transdisciplinary settings (Drake & Burns, 2004). Differentiating between the three is a matter of how the disciplines are used in conjunction with each other. Interdisciplinary is concerned with identifying common themes across the academic disciplines, transdisciplinary organizes subject matter around the direct inquiry of students, and multidisciplinary organizes standards around a singular theme (Drake & Burns, 2004). The literature does not definitively state whether STEAM exists solely as interdisciplinary, multidisciplinary, or transdisciplinary, meaning STEAM may possess qualities of all three depending on the method of implementation (Margaret et al., 2013; Sade, 2014; Spector 2015).

Root and Bernstein (1991) addressed the need for a multiple discipline theory, stating that the issue with teaching within a singular discipline model is that it stifles the student's ability to invent. Inventing, model making, and other constructivist activities act as abstraction processes, which help students transfer fundamental knowledge to the realm of understanding (Root & Bernstein, 1991). While inventing, students situate their integrated knowledge to complete a project, solve a problem, or create an artistic response during the learning process.

Problem & project based learning. Research seems to suggest problem and project-based learning are fundamental models for STEAM education. Bequette and Bequette (2012) posited that engineering and arts education are rooted in PBL pedagogy. Consequently, Tomlinson-Clarke et al. (2014) suggested STEAM is a more project based venture. Given both perspectives, it might be more appropriate to suggest that STEAM can be conceptualized as either or an integration of the two.

Problem Based Learning (PBL) is a constructivist-learning framework that requires students to solve complex, ill structured problems (Lu, Bridges, & Hmelo-Silver, 2014). PBL is commonly situated as a collaborative venture with students participating as cognitive apprentices to the teacher or learning environment itself (Lu et al., 2014). Classroom challenges posed to students can require tasks such as design, strategic performance, or procedural decision-making (Lu et al., 2014). Completion of problem-based projects is heavily dependent on the teacher's ability to scaffold a process that effectively models one or many of these skillsets.

Similarly, project based learning also refers to constructivist pedagogy, but it specifically addresses the idea that "students can't learn disciplinary content without engaging in disciplinary practices" (Krajcik & Shin, 2014, p. 447). The theory behind project-based learning suggests that students actively construct new learning and synthesize relevant concepts by applying prior knowledge to specific tasks, which is sometimes thought of as situated learning (Krajcik & Shin, 2014). So, to present both PBL and project based learning inside of STEAM, it may be apparent that STEAM situates design problems within project based ventures to develop higher order thinking and synthesis.

Higher order thinking. The development of higher order thinking skills as a result of learning within problem and project based environments occurs in two ways. As students attempt to find a single solution using a defined or target process prescribed by a teacher, they exercise convergent thinking. Conversely, a problem may require divergent thinking by allowing students to exercise fluency, originality, and flexibility (Margaret et al. 2013). Rabalais (2014) demonstrated that through the work of collaborative STEAM teaching teams, students were able to unlock multifaceted intelligence capabilities and holistic learning principles using both thinking strategies (Rabalais, 2014).

The cognitive benefits of solving complex problems with divergent thinking has led many authors to suggest that problem based learning is the primary catalyst for student innovation (Bequette & Bequette, 2012; Connor et al., 2015; Kim & Park, 2014**).** Kim and Park (2014) stated that problem based learning "gave participants the chance to discover and develop their aptitude and talent as an engineer through the course that included the presentation of interesting situations, the creative design resolve an issue alone, and the emotional experience of feeling cooperation and achievement during the creation process" (p. 230).

The synthesis of research on classroom strategies associated with STEAM fundamentally suggests that integrated curriculum requires students to project divergent thinking onto a series of problem based learning activities to create original, innovative solutions. Given all of the research on the evolution of STEAM through the policy process and its value to current educational leaders, it is prudent to begin the investigation on published frameworks for school implementation.

Implementation Frameworks

Classroom & practitioner. Initial research on STEAM implementation seems to focus on small, simple, and easily manageable solutions for school leaders and practitioners to put into practice. Table 3 depicts these small-scale efforts and reveals four emergent themes: collaboration, relevancy, spontaneity, and creativity (Wynn & Harris, 2012; Kuhn, 2015; Bequette & Bequette, 2012). Within these dimensions, Bequette and Bequette (2012) suggested that educators must, "Deploy pedagogy that encourages students to be curious, experiment, and take risks - key dispositions artist habits of mind engender" (p.46).

Shaffer (2013) outlined a series of guidelines for creating STEAM team teaching arrangements and how groups of practitioners could design problem based activities that specifically require artistic inquiry. Similarly, Wynn and Harris (2012) offered suggestions for effective collaboration of teachers of different disciplines. The authors also included model lessons which remained void of dense theory, to ensure practitioners could implement STEAM with relative ease.

As theory developed, researchers and practitioners sought deeper understanding of the conceptual frameworks used by students during integrated artistic inquiry. Bequette and Bequette (2012) implemented the pre-existing Studio Thinking Framework within Harvard's "Project Zero" to develop higher order thinking skills. This framework was deliberately loose in its defining language so students were free to approach the problems in their own way, thereby creating a multitude of divergent solutions (Bequette & Bequette, 2012).

Table 3

General Implementation Frameworks and Guidelines

Authors	**Frameworks and Guidelines**
Wynn & Harris (2012)	• art teachers must advocate to STEM teachers • real world learning • small projects first • be creative with the local environment • weekend meetings • checks and balances • be ready to do anything • think quick
Shaffer (2013)	• Start Slow • Use existing resources • Identify historical examples and models • Maintain a process oriented approach • Partner with arts educators • Use a variety of artistic outcomes • Ensure student relevancy • Plan a project • Allow a certain amount of failure • Chaos is good
Kuhn (2015) -- WAIT Framework	• With the arts • About and In the context of the arts • Through the arts
Bequette & Bequette (2012) - Studio Thinking	• pay attention to relationships • engage and persist • allow for flexibility • change directions • imagine new possibilities • express ideas, feelings, and personal meaning

In a more modern approach that directly ties STEAM to standards-based learning, Kuhn (2015) identified the “With About In and Through” (WAIT) Framework, which explored how to situate STEAM alongside the Next Generation Science Standards (NGSS) policy. By scaffolding the level of arts integration from very little to a lot, students were more able to call upon the creative processes and connect with NGSS definition of innovative thinking (Kuhn 2015).

District level frameworks. STEAM has been shown to be a larger agent of curriculum change at the district level, although research in this area is still developing. Park and Ko (2012) offered seven guiding principles for large-scale curriculum implementation:

1. How should the disciplines should be combined or fused in such a way that they do not disrupt the importance of current curriculum goals?
2. Instill the need for creative and diverse thought processes which apply basic theories to synthesized engineering or technology goals
3. Creative and diverse thought processes require the use of creative tools, pedagogies, and experiment designs
4. Focus on the need to realize the bigger social picture; "see the forest along with the trees" (p. 323)
5. Adapt to rapidly changing technologies
6. Predict future social, political, environmental, and economic needs through integrated and creative thought processes
7. Ensure that future scientists and engineers become a product of STEAM and manifest strong ethical, social, cooperative, leadership, and communicative values.

Park and Ko's (2012) guidelines represented a broad synthesis of many strategies and worldviews presented through the literature review. As such, this framework may be appropriate for implementation at the district level, due to the fact that considers larger network of stakeholders.

Continuing with district level research, Johnson (2012) used a change framework designed by Michael Fullan to frame how schools can better facilitate during STEAM implementation. Within this case study, the participating school obtained private sector partnerships that offered new learning opportunities for students (Johnson, 2012). The collective capacity between the school district and private partners lead to a more community centered curriculum design (Johnson, 2012). In doing so, their STEAM program provided students the "in-demand" skill sets sought by private sector leaders and employers (Johnson, 2012).

Professional Development

Professional development is a crucial aspect of sustainability in education reform. Referring to McLaughlin (1987) for a moment, "the quality of individual level responses [to a new policy or curriculum change] determines the quality of policy implementation" (p. 177). The organization plays a role in sustaining an implemented policy, but the individual practitioners are the ones who innovate within the framework (McLaughlin, 1987). In education, this process is commonly referred to as professional development.

Teaching artists is one method of providing professional development for STEAM programs. Tomlinson-Clarke and colleagues (2014) brought together a professional development consortium comprised of science, math, and technology teachers. These teachers subsequently collaborated with artist practitioners on creating STEAM lessons. The authors suggested the following due to these collaborations: (1) teachers believed that integrating subjects, as well as establishing smooth flow between topics, were the most important procedural factors (2) specific to lesson design, teachers were most concerned with inquiry based activity, collaboration, and learning through discovery (3) assessment should measure what is believed to be most important (Tomlinson-Clarke et al., 2014).

Professional development initiatives encompassing major curriculum change are sometimes met with practitioner resistance. Purnell (2004) studied this concept and explored whether teachers valued arts integration focused professional development. The findings showed 100% of respondents believed arts integration was important to teachers' accommodation of multiple learning styles, but the practice was utilized infrequently by their departments and district (Purnell, 2004). The study also indicated that even with 100% of respondents indicating arts integration was important, its infrequent application was primarily a product of low administrative support in developing effective pedagogy, a lack of meaningful assessment tools, and not enough interdisciplinary collaboration during the school day (Purnell, 2004). This study indicates the presence of observable barriers from the perspective of teachers which may drastically affect STEAM implementation.

In a similar study at the practitioner level, Strand (2006) inferred four predictors of success in integrated arts curricula: (1) the philosophical mission of each school as it related to integrated curricula was most important, (2) collaborative success was highly dependent on the personal characteristics of teachers, (3) administrative support of teacher partnerships allowed for the curricula to remain protected [sustained], and (4) the actual curriculum itself was developed from practitioner level critical thinking, improvisation, and reflection. These inferences point to both professional development and leadership concerns, therefore the need to develop a cohesive vision and provide administrative support are central to the role of educational leaders.

Finally, Wong (2013) studied how arts integrated curricula was designed, along with the factors associated with its success. During the longitudinal case study, Wong (2013) compared two approaches to STEAM implementation: one that had transparent support from district leadership and another in which illustrated hands off leadership. The findings showed that the sustainability varied most because of their levels of administrative support and feedback. Case A received little guidance from school leadership for planning, scheduling, and co-teaching strategies, which ultimately led to the demise of the initiative all together. Consequently, Case B developed a long-term integrated curriculum that became a part of whole school culture as a result of continuous school leadership involvement and support (Wong, 2013).

It seems that barriers associated with STEAM implementation can be diffused through the following professional development strategies: collaboration, supportive leadership for arts integration, making integrated learning part of the larger school mission, adapting to change across the whole organization, and remaining resolute to full system implementation (Johnson, 2012; Purnell 2004; Strand, 2006; Tomlinson-Clarke et al. 2014; Wong, 2013). STEAM implementation is reliant on a plethora of organizational attributes, including leadership level, practitioner level, and community level engagement and support.

STEAM Summary

Research on STEAM implementation has allowed schools to integrate the arts and STEM in a multitude of ways. As such, this study will examine research question one using the following factor groups:

1. Values and Purpose
2. Curriculum and Pedagogy
3. Implementation Structure
4. Teacher Development

If STEAM is to continue pushing innovation through integrated learning and collaborative problem solving, then it would be relevant to examine whether the school has a plan for developing these capacities amongst the teaching faculty. Related to policy implementation within social systems, Borass (2011) stated that, “The organizational capacity required in this case [social systems] is more diffused than the previous two, as it entails a certain degree of reflexive skills in a widely dispersed set of organizational actors, and their ability to communicate and create a sense of collective understanding” (p. 729). As STEM policy evolved to suggest art and design were integral to the educational innovation process, the reflexive skills necessary to implement an integrated curriculum effectively is largely predicated on an organization's collective learning capacity.

Drawing from literature rooted in corporate entrepreneurship, Nielson (2015) posited that organizational learning is an essential point of analysis when examining the implementation of new knowledge. The entrepreneurial nature of innovation and its long-term sustainability requires management support, the desire to learn across the organization, and the creation of new procedures (Nielson, 2015). The literature review will now address research association with organizational learning.

Organizational Learning

Organizational Learning (OL) is situated in this study to explore how schools learn to support new initiatives such as STEAM. Integrating five subjects at such a high level may suggest that schools need to provide professional learning systems to help teachers adapt to change. This section of the literature review will investigate OL in the following manner: describe and define OL, explore the evolving understanding of OL in various contexts, situate the practice of OL in education research, identify common frameworks for implementing OL, and finally, investigate instruments that have been used to measure the existence of OL in school settings.

There is a preliminary need to distinguish OL from a parallel body of knowledge, Learning Organizations (LO). Ortenblad (2015) suggested that the LO is inclusive of four distinct typologies: learning at work, organizational learning, climate for learning, and learning structure. Consequently, OL is defined as an institution's awareness of learning needs and the ability to store new information for change (Ortenblad, 2015). OL therefore is the actionable typology of learning, ultimately justifying its application in this study over the label "learning organization."

Early research. Early research in OL provided a theoretical infrastructure for how organizations evaluate professional learning. Argyris and Schon (1974) first explored an organization's "theories of action," which can be unpacked to reveal both espoused theories and theories in use. Their connection being that espoused theories account for underlying belief systems, which then vary in congruence with theories in use. The examination of theories in action represents a model for understanding an organization's internal consistency, congruence, effectiveness, and value (Argyris & Schon, 1974).

Theories in action are then evaluated next to single and double loop learning tendencies. Single loop learning represents the actions which perpetuate pre-existing system of governance; small change. To the contrary, double loop learning is more indicative of the change process in which actions contribute to a new, more effective system of governance; large change (Argyris & Schon, 1974). Both single and double loop behaviors are integral in the establishment of daily procedures and the balance between the two is ultimately evaluated when considering OL effectiveness.

Theories in action and learning tendencies, together, are distinguishing factors in recognizing Model I and Model II organizations (Argyris & Schon, 1974). Model I organizations continuously prescribe quick fixes, employ single loop procedures, are defensive towards change, and stray from experimentation or rapid innovation (Argyris & Schon, 1974). Model II organizations on the other hand are organizations that promote what is needed to change through both individual and collective means (Argyris & Schon, 1974).

As organizations attempt to align with Model II behaviors, they are met by defense mechanisms which work against the change process. Argyris (1990) examined common defensive routines including elaborate actions used to cover incompetence, institutional malaise, and the often-unmanageable nature of individual performance. Argyris & Schon focused much of their efforts writing and evaluating theory associated with evaluating action and defense mechanisms. Their ultimate goals being to help organizations, specifically leaders and to become more aware of their positive and negative learning dispositions.

Later, Daft and Weick (1984) asked similar questions regarding OL, but they started to evaluate organizations as interpretive systems that process learning through various “information receptors” (p. 285). These receptors accounted for; organizational scanning, interpretation, and learning. Scanning is the process of data collection; interpretation begins to attach meaning to data, and learning is the resulting actions of information processing (Daft & Weick, 1984). Both Daft and Weick (1984) as well as Argyris and Schon (1974) described OL as much more than a quest for knowledge acquisition, rather they suggested OL is actually the point in which individuals change based on newly acquired information.

After identifying the need for evaluating action, individual vs. collective learning was studied to further frame organizational learning. Fiol and Lyles (1985) examined whether OL is a culmination of individual learning efforts or a system capable of taking on learning habits of its own for consistent growth and long-term survival. Inside of a collective system, individuals must inevitably change practice to support change, but Fiol and Lyles contested that the conversation is more about how individual habits become organizational habits which promote continuous collective learning. Helberg (1981) is supported this claim, suggesting that organizations are dynamic systems that slowly develop worldviews, memories, beliefs, and habits. These attributes create the organization’s cognitive system which govern all action past, present, and future actions (Fiol & Lyles, 1985; Helberg, 1981).

Current research. Recent research addresses whether organizational learning is a more social construct, involving interpersonal relationships and knowledge sharing groups. Chive and Elgar (2005) suggested two perspectives: cognitive-possession and social process. The authors posited that cognitive possession occurs within and influences the habits of individuals. The authors stated, "organizations are able to learn, given they have identical or similar capacities to those of individuals (Chive & Elgar, 2005, p. 52).

The social process perspective on the other hand is a constructionist-centered philosophy of OL, which states that any interpersonal environment situates learning around relationship building (Chive & Elgar, 2005). Whereas cognitive possession suggests organizational habits mirror individual habits, the social perspective contests that habits develop through collective knowledge sharing.

Individual and social perspectives on OL can largely be a matter of worldview. Popova-Nowak and Cseh (2015) explored this idea in placing OL into four distinct worldview categories: functionalist, constructivist, postmodernist, and critical. The dominant OL worldviews, functionalist and constructivist, parallel the individual vs. social paradigms are presented by Chive and Elgar, (2005). Popova-Nowak and Cseh (2015) stated that, "the functionalist paradigm considers individuals as key agents in collecting, interpreting, disseminating, storing and retrieving information within organizations" (p. 306). To the contrary, the constructivist worldview embodies the social process of integrating knowledge through collective practice and shared culture.

Popova-Nowak and Cseh (2015) ultimately suggested a meta-paradigm framework in which the constructivist and functionalist perspectives are fused, leading contemporary research to identify the need for both individual and collective learning, but also place the social process at the forefront of organizational learning in the 21st century.

Defining organizational learning. Many authors have offered definitions of OL. Leithwood, Jantzi, and Steinbach (1995) considered research by Fiol and Lyles (1985) in their defining OL as “process of improving actions through better knowledge and understanding” (p. 8). Schwandt (1993) on the other hand, suggested that OL is a much larger organizational dynamic and is “a system of actions, actors, symbols and processes that enables an organization to transform information into valued knowledge which in turn increases its long-run adaptive capacity” (p. 8). Leithwood et al. seem to align with more of the functionalist worldview, whereas Schwandt’s approach is far more indicative of the social, constructivist process discussed by Popova-Nowak and Cseh (2015).

Building on their own social definition, Leithwood et al. (1995) continued to posit that OL can be defined as, “a group of people pursuing common purposes with a collective commitment to regularly weighing the value of those purposes, modifying them when that makes sense, and continuously developing more effective and efficient ways of accomplishing these purposes” (p. 9). It appears the authors aligned their definition even more with social capacities, highlighting the need for shared values and collective commitment during the OL process.

In summary, these definitions suggest that OL is a process. The process is one that requires groups of institutional stakeholders to identify problems and generate solutions to engender change. Change is then continuously perpetuated by the organizational learning process, but only if there is a collective capacity and willingness to evolve within individual and social levels.

Organizational Learning Theory

Just as STEAM must be evaluated based on its strategies in the classroom, OL requires inquiry into exactly what types of learning processes practitioners' experience during the implementation of new practice. Daft and Weick (1984) suggested early on that learning occurs within and through specific "receptors." These receptors can be framed in a discussion of what, where, and how organizations learn to better describe organizational actions.

What organizations learn. Boone (2014) stated there are two types of learning associated with OL: operational learning and conceptual learning. Operational learning refers to the technical know-how of a group while conceptual learning accounts for why things are done a certain way given a set of behaviors (Boone, 2014). Subsequently, Popescu, Bunea, and Radu (2015) expanding the concept by delineating between behavioral and cognitive knowledge. Behavioral learning is the process of turning new or explicit information into tacit knowledge by which organizational routines are created. Cognitive learning on the other hand begins by combining new knowledge into models of action. Both authors reveal a synthesized process of turning operational learning into behavioral knowledge and conceptual learning into cognitive knowledge.

Lam (2000) explored what organizations learn using a different lens, focusing on the differences between explicit and tacit knowledge. Explicit knowledge is codified and objective information that can be immediately used to improve efficiency, whereas tacit knowledge is acquired through practical experience and is often unarticulated by practitioners (Lam, 2000). Depending on the situation, practitioners use a combination of explicit and tacit knowledge to fulfil their professional responsibilities.

Thus, given the work of Lam and Boone as well as Popescu et al., four major archetypes of what organizations exist: embrained, embodied, encoded, and embedded. Lam (2000) synthesized each as follows:

- Embrained Knowledge = Individual Explicit Knowledge
- Embodied Knowledge = Individual Tacit Knowledge
- Encoded Knowledge = Collective Explicit Knowledge
- Embedded Knowledge = Collective Tacit Knowledge

How organizations learn. Mulford and colleagues (2003) contested that mutual adaptation largely accounts for how organizations learn. This idea suggests that individuals adapt their responsibilities to new challenges, from both reflective and unreflective viewpoints (Mulford et al., 2003). To adapt in an unreflective manner suggests individuals somewhat blindly adjust their responsibilities to meet new challenges and expect their colleagues to do the same in the hopes that new expectations will be met. Consequently, reflective adaptation is a team process. Mulford and colleagues (2003) described the latter as:

> In this way, the individual is contributing to the learning of the team. As other team members adapt their contributions not only in response to their sense of the team's new challenge but also in response to the responses of other members, each team member learns about the adequacy of her initial response and perhaps the need to adapt further (p.191).

Exploring how organizations learn also requires an understanding why some organizations do not learn, even when they espouse continuous innovation. Wang and Ellinger's (2011) idea of facade learning may best explain this occurrence. Some organizations promote the effort of learning, but new knowledge and processes often fail to result in innovation (Wang & Ellinger, 2011). Given the prior literature, facade learning may be the result of Model I behaviors, a lack of organizational habit forming, a disruptive social process, too much embrained and encoded knowledge, or a lack of vision that stifles individual change.

To that point, Senge (2002) asserted that organizations simply cannot learn, regardless of process, without personal change across all institutional levels. He argued that the many OL strategies are difficult to implement because they force powerful individuals to accept a certain degree of incompetence at the individual level. He stated that:

> The fantasy that somehow organizations can change without personal change, and especially without change on the part of people in leadership positions, underlies many change efforts doomed from the start-such as investing in new technologies to produce change, or "change programs" that get "rolled out" though the organization, or consulting that advises clients on "how to get their people to change," without ever inquiring about how they themselves may be a big part of the changes needed (p. 48).

Senge thus brings the OL discussion back full circle and suggests describing "how" organizations learn is still a matter of individual change, no matter how much the research advocates increased social processes. In schools, the onus is on leadership to remain accountable for establishing a vision for continuous learning while the practitioner is accountable acting on new knowledge that aligns with that vision.

Where organizations learn. Where organizational learn can be thought of in a series of physical and cognitive dimensions. Schwandt (1993), also referenced by Gorelick (2005), initially labeled the dimensions as environmental interface, meaning and memory, action and reflection, and dissemination and diffusion. Similarly, Senge (1999) thought of the dimensions as levels of personal mastery, mental modeling, sharing vision, team learning, and systems thinking. Finally, Gorelick (2005) applied a more literal approach in discussing information exchange, goal reference knowledge, organizational structuring, and sense making dimensions.

There are sparse commonalities regarding research on where organizations learn, most likely due to the number of variables that influence the many types of organizations one may study. As such, for the "where" to make more sense, OL must be contextualized into the setting at hand- public schools. School culture is an amalgamation of organizational learning, social, and cultural contexts (Higgins, Ishimaru, Holcombe, & Fowler, 2011). Though OL is commonly used to describe business culture, some research used OL as a lens to better understand educational systems.

Organizational Learning in School Settings

Organizational Learning in the school setting is an emerging field, as researchers are beginning to look at OL as a viable means to sustain faculty learning initiatives. Higgins, Ishimaru, Holcombe, & Fowler (2012) suggested that regardless of the numerous to attempts to improve professional development, many schools still lack the internal capacity to sustain new knowledge. The authors qualified this assertion as: "working together to restructure, re-culture, and otherwise reorient themselves in response to new challenges without the need of external intervention" (p. 271).

Certainly, schools have a vested ethical interest in building a culture for learning, but OL comes into the fold in examining whether district's specifically address the processes to which knowledge is disseminated, stored, and applied. Before unpacking these mechanisms at length, it is prudent to delineate between common profession development practices and organizational learning.

OL can be used as a lens to address whole system reform. Currently, Professional Learning Communities (PLCs) are widely adopted models for engaging teachers in practice-based inquiry and conceivably, practitioners could consider PLC's to be the model for OL in schools, but they are most often concerned with practitioner level data analysis. STEAM requires a whole system lens to see how the schools address a wide range of innovative change, at the student and teacher levels.

PLCs are a type of learning mechanism that investigates student achievement through collective inquiry, action, and reflection (DuFour & Eaker, 1998). Stoll and Louis (2007) described the PLC movement as one that is focused on situated group learning, builds a collective knowledge base, and "occurs within an ethic of interpersonal caring that permeates the lives of teachers, students, and school leaders" (p. 3). The PLC has become standard practice in many institutions, yet Boone (2014) states that some practitioners feel isolated in their PLCs, as administrators are sometimes unable to engage teachers in meaningful collective inquiry. Furthermore, McLaughlin and Talbert (2007) asserted that structural challenges (scheduling) and the persistence of teachers teaching "subjects rather than students" (p. 152) diminishes collaborative efforts, thereby undermining the objective of collaborative inquiry.

Research has shown that OL is a process which occurs at all times and is not a reform in and of itself. It is a system of mechanisms that can be called upon and leveraged at any moment, so long as there is an awareness of their presence. PLCs can address the dissemination and analysis of information (DuFour & Eaker, 1998) but they are still just small components of the organizational learning process. McCharen, Song, and Martens (2011) argue that "educational reform initiatives to improve schools and schooling have too little and too slow of an influence on practice. A supportive learning culture and continuous, collaborative organizational learning process are considered to be pivotal in driving long-term, innovative educational reform initiatives" (p. 296). OL can do so because of its connection to every part of the system.

School dynamics. OL requires a specific set of school dynamics to function effectively. Teachers have stated that some of these include the ability to make collaborative decisions, hold shared beliefs, and have regular access to resources (Leithwood et al., 1998). Others have suggested that OL is dependent on leadership that supports learning, psychological safety, and free experimentation (Garvin et al. 2008; Higgins et al., 2012). It is as such conceivable that STEAM may be very influenced by the latter.

A school must also contain a leader who is able to charge a faculty with the motivation to learn and innovate regularly. Hsiao and Chang (2011) asserted that transformational leadership and organizational leadership allow for organizational innovation. Thus, school leaders are thus charged with promoting consistent learning amongst the teachers and pushing for transformational change to drive educational innovation (Hsiao & Chang, 2011). However, leaders certainly do not have all the answers and require some freedom to develop programs through experimental means.

The ability for teachers to experiment is somewhat trapped in the dichotomy between accountability driven reform and social constructivist movements like STEAM. Research by Leithwood et al. (1998) found that teachers identified the need for school cultures to promote experimentation, risk taking, and collaborative freedom. Unfortunately, in today's context, Higgins and colleagues (2012) stated that, "the recent emphasis on standardizations and centralization of instruction in an era of high stakes accountability raises questions about what experimentation looks like in schools and who actually engages in experimentation and at what level" (p. 73). More so, experimentation requires teachers to step outside their comfort zones that have defined their professional approach.

Fear of the unknown is a product of doubt. Educational ventures in the classroom, with less than predictable outcomes, are ripe with doubt and dissent. Friedman et al. (2001) found doubt to be a major hindrance for OL in schools because of the general uncertainty of a new professional learning framework. Ironically, doubt can be the very thing that promotes inquiry and the need to learn (Friedman et al., 2001). This research suggested psychological safety is the great equalizer, as the freedom to explore without fear of consequence or accountability pressures will improve the practitioner's willingness to engage in new methods (Friedman et al., 2001).

Others have approached school dynamics through the identification of certain stimuli. The stimulus for OL is broadly defined by a school's initiatives, ability to remain current, and adapting to the changing student population, which is ultimately supported by an overarching schema inclusive of clear vision, positive culture, clear structures and strategies, and sufficient resources (Leithwood, Jantzi, & Steinbach, 1995). If these conditions exist, then the faculty must be responsible for consistent and open dialogue, reflective practice, the experimenting, and maintaining a commitment to reading and research (Leithwood, Jantzi, & Steinbach, 1995).

Finally, research has addressed the necessary components for consistent professional learning which include access to professional development and subsequent funding, collaborative planning time, least restrictive faculty contracts, and the opportunity to attend outside workshops (Leithwood et al. 1995). Also, regularly relying on faculty for PD resources, access to trade literature and its frequent dissemination to the faculty, curriculum and technology resources, assistance for implementing new practice, and access to common facilities were also identified as specific school dynamics crucial to organizational learning (Leithwood et al. 1995).

Organizational Learning Mechanisms

Researchers have offered up organizational learning mechanisms (OLM's) as the observable components of OL. As defined by Popper and Lipchitz (1998), OLM's are, "institutionalized structural and procedural arrangements that allow organizations to learn non-vicariously, that is, to collect, analyze, store, disseminate, and use systematically information that is relevant to their and their members' performance" (Popper & Lipchitz, 2000, p. 185). These processes are further categorized as integrated or nonintegrated OLMS, as well as dual-purpose or designated OLMS (Popper & Lipchitz, 2000).

The difference between integrated and nonintegrated OLMs depends on whether operators and clients are both actively apart of the learning process (Popper & Lipshitz, 2000). For instance, a teacher (the client) who reflects on the quality of pedagogy with a supervisor (operator) after a formal observation is working within an integrated, dual purpose OLM process, as both the client and operator are mutually taking part in the learning process and actively improving performance. To the contrary, if the supervisor were to simply create an action plan for the teacher to improve performance, the OLMs would then be non-integrated and designated. The conversation on integrated and non-integrated OLM's will return during the data analysis portion of this work.

This study will examine five OLM factor groups as identified and previously tested by Schecter & Atarchi (2014):

1. Disseminating Storing & Retrieving Information
2. Sharing Information with Parents and Students
3. Analyzing and Interpreting Information
4. Using Online Information

These mechanisms are appropriate for this study because the authors sought to create factor groups that were directly relevant to modern school contexts and exploit processes that promote the sharing of knowledge and collaboration amongst a teaching faculty (Schecter & Atarchi, 2014). Furthermore, an OLM assessment within a school setting will reveal the teachers' collective efficacy regarding school processes, as Schecter and Atarchi (2014) found that efficacy was positively related to the perception of effective OLMs within their secondary and elementary institutions. This is instrument will be discussed in the next section and throughout Chapter 3.

OLMs are also an effective means of addressing the other previously discussed components of organizational learning. Practitioner's actions and observations inside of each OLM factor group can possibly reveal some of the following:

1. Single Loop vs. Double Loop Learning
2. Theories in Use vs. Theories in Action
3. Individual vs. Collective Learning
4. Integrated vs. Non-Integrated OLM's

Measuring OLM's. The measurement of organizational learning is essentially dependent upon how the paradigm is framed. The Higgins and colleagues (2011) study developed a three-dimensional quantitative survey drawing upon research from Garvin et al. (2008). Similarly, Watkins & Marsick developed the Dimension of a Learning Organization Questionnaire (DLOQ) which measured seven categories of a learning organization and has been possibly the most replicated quantitative instrument. While this study will address some of these factors in the meta-analysis, STEAM needs to be analyzed through an instrument that addresses learning mechanisms.

Schechter and Atarchi (2014) developed the Organizational Learning Mechanisms (OLMs) Questionnaire for use in K-12 school settings. The OLMs include the following: disseminating, storing and retrieving information, sharing information with students and parents, analyzing and interpreting information, and accessing online information (Schechter & Atarchi, 2014). The authors call upon the replication of this instrument, suggesting the instrument provides schools with a tool for assessing the state of implementation for adopted processes. Furthermore, the authors suggest that understanding the perceived effectiveness of each OLM can help strengthen the school's professional learning community in times of turbulent change (Schechter & Atarchi, 2014).

Empirical studies using OLM's are tied to both schools and private organizations studying innovative practice. Smilonich (1999) used an organizational learning lens to address the implementation of large-scale change interventions at the Minnesota Department of Transportation. The author used an action research design to examine how organizational learning contributed to innovative leadership and engineering practices throughout the MnDOT organization (Smilonich, 1999). This study points to the value of using an OL lens in whole systems striving to achieve innovative practice.

Similarly, Cirella, Cantorino, Guerci, and Shani (2016) apply OLM's to a study on how OLM's influence the creative culture at an Italian fashion design firm. The authors contended that well defined cognitive, procedural, and structural mechanisms all positively impact creative culture and that there is a need to continuously understand the relationship between OLMs and creative fields (Cirella et al. 2016). Given that Cirella at al.'s research was also completed in 2016, there is a clear relevance to timing of this study, showing that OLM's may have a significant role in determining the quality and effectiveness of creative solutions in present day settings.

In the education realm, the previously mentioned Schecter and Atarchi (2014) study examined the meaning and measure of OLM's in secondary school is largely the model for the quantitative strand of this study. Schecter also completed work in understanding the influence of OLM's on special education and the school principal's sense of uncertainty. As a case study, Schecter and Feldman (2010) explored cultural, structural, and information processing perspectives of teachers and educational leaders in a special education school. From a quantitative vantage point, Schecter and Asher's (2016) examine how school principals' uncertainty was influenced by information acquisition, distribution, interpretation, memory, and retrieving information. Each having their own significant impacts in a present day educational leadership context further outlines the need to attach OLM research to contemporary educational issues.

Also in the education sector, Herndon (2006) used an OL lens to examine the use of peer review procedures within Virginia higher education institutions. Fifteen four-year universities were charged with creating an assessment protocol for student critical thinking. Each school then shared their plans with two other universities for peer review (Herndon, 2006). The author asserted that university peer review process created a clear pathway towards double loop learning (Argyris & Schon, 1974), but only if institutional conditions have balanced approaches to innovation and regulation (Herndon, 2006). This balance is indicative of organizational learning attributes including the anticipation of change, willingness to questions normative practice, and "fostering an emergent organization" (Herndon, 2006, p. 11). This study also used the OLM lens to confirm other aspects of OL such as double loop learning.

Finally, an OL lens was also applied to a study of U.S. public schools under sanction, to which the author aimed to understand whether there were environmental factors conducive to organizational learning (Finnigan, Daly, & Stewart, 2012). The study dissected whether schools implementing STEAM have an environment that promotes collaboration, leadership for learning, reflective practice, and other factors associated with OL. Based on all the studies above, there is clear precedence for attaching an OL lens to a study of educational innovation and policy implementation.

The aforementioned studies above inform this study from the perspective that they all address the importance looking at mechanisms that support a policy implementation or change of practice. Research on STEAM and OL may be integrated to help answer the central research question: How is STEAM being implemented within K-12 public schools? Research surrounding organizational learning provides a lens to which we can examine STEAM implementation from the following perspectives:

1. A qualitative inquiry into the process by which current K-12 school leaders have implemented STEAM throughout their organizations.
2. A quantitative inquiry into which dimensions of organizational learning are most pronounced throughout the process of STEAM implementation.

Chapter 3

Methodology

The methodological approach to this study was a convergent parallel mixed methods design. The corresponding procedures sought to answer the following research questions:

1. What was the process by which STEAM is being implemented within K-12 public schools of different socioeconomic factor groups?
2. What did the Organizational Learning Mechanism Questionnaire reveal about the pedagogy and collaborative processes from the perspective of teachers engaged in STEAM?

In choosing the MM design, there needed to be an alliance between QUAL and QUAN inquiry to fulfill a study's purpose. Teddlie and Tashakkori (2009) describe mixed methods analysis as dialectical, which suggests their compatibility and ability to build on each other's strengths provides the opportunity for contemporary analysis strategies (Teddlie & Tashakkori, 2009). Hesser-Biber and Nagey (2014), referenced Green et al. (1989) to outline the five primary reasons for choosing a MM design: (1) the ability to triangulate multiple data sources to answer the same questions, (2) complementarity as a means to use QUAN and QUAL to more thoroughly understand a social phenomenon, (3) developing a research design from the onset that considers narrative and numerical phenomena, (4) new studies or questions may emerge from the findings, in either the QUAL or QUAN strands, which initiate a great deal of future research, and (5) expand the range of inquiry in the current study and future studies.

The methodological framework shown in Figure 2 outlines data collection and analysis procedures for this study.

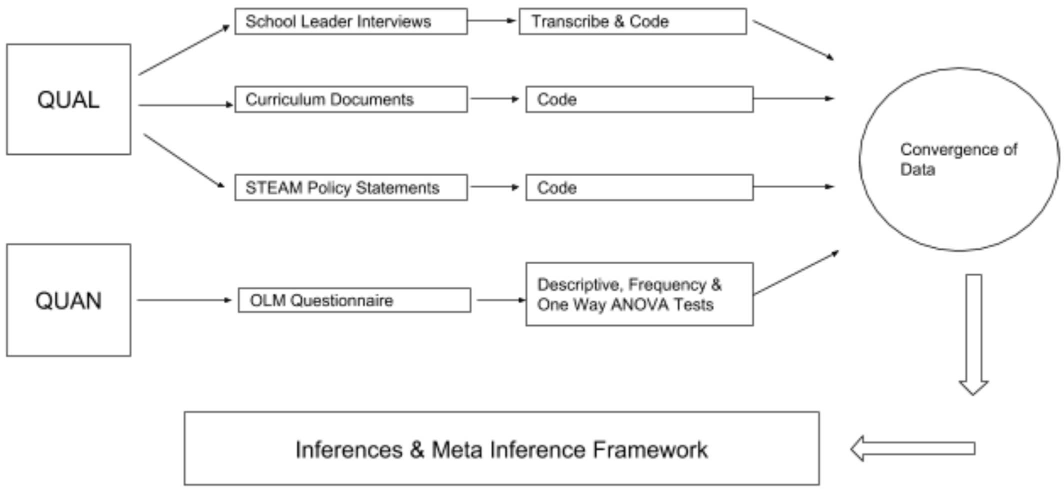

Figure 2. Methodological Framework

Strategy of Inquiry

The purpose of this study was to examine STEAM implementation from the perspective of school leaders and understanding the OLMs that provided support. With two separate knowledge bases in play, it seemed appropriate to study each paradigm separately and merge the findings later to understand their influence on each other. Creswell and Plano Clark (2011) suggested that the convergent design is appropriate when the researcher aims to "compare results or to validate, confirm, or corroborate quantitative results with qualitative findings" (p. 65). Furthermore, Creswell and Plano Clark (2011) confirmed that the convergent parallel design is most appropriate in educational policy studies.

A convergent parallel design involves collecting two separate data sets simultaneously, one qualitative and one quantitative (Teddlie & Tashakkori, 2008). In this study, the qualitative strand consisted of a semi structured interview protocol used to explore perspectives of school leaders in charge of STEAM implementation. The quantitative strand employed the Organizational Learning Mechanisms Questionnaire developed by Schechter and Atarchi (2014). Once data was collected, analysis and inference methods were approached using Teddlie and Tashakkori (2008) integrative framework for inference quality.

Setting

Six public schools in New Jersey of varying socioeconomic status and size were used as the research sites. Access to each district was secured after introductory emails were sent to superintendents. Superintendents either gave explicit directions for BOE approval or approved the study upon receiving more information. All research materials, including instruments and a prospectus, were provided to school leaders to ensure a transparent relationship between myself and each research setting.

Table 4 summarizes the characteristics of each participating district. Districts A and B were in urban leaning K-8 settings at the lower end of the socioeconomic spectrum. District C is also a K-8 district, but is in an affluent suburban community. District D sits in the middle of the socioeconomic spectrum and serves all students K-12. Districts E and F serve mostly high school students, with District E serving both middle and high school. District E serves a suburban population directly outside a major city. District F serves a rural student population and is comprised of three high school.

The range of districts included in the study helped build the foundation for a multilevel sampling strategy, which Teddlie and Yu (2007) suggested requires multiple units of analysis be nested within each other. Thus, within the setting frame lies units of analysis associated with socioeconomics, size, and grade levels.

Table 4

Setting Characteristics

District	**Factor Group**	**Grades Serviced**	**Total # of Schools**
District A	CD	K-8	2
District B	CD	K-8	2
District C	J	K-8	2
District D	FG	K-12	6
District E	FG	7-12	1
District F	DE	9-12	3

Sampling

Sampling in this study was designed using a multilevel framework. Teddlie & Yu (2007) suggested this method is appropriate for educational research studies because they often involve multiple units of analysis from any combination of state, district, teacher, or student levels. While the authors noted that multilevel sampling strategies often involve different types of sampling (purposive, stratified, random, etc.), both strands in this study used a criterion purposive sampling strategy.

Qualitative sampling. Two school leaders were chosen to participate in the interview protocol. Criteria for these leaders were that they had to be directly involved in the implementation of STEAM. A school leader in this study was defined as either district, building, or teacher leaders. Table 5 provides participant characteristics. The cross section of leaders included in the study continues to build on the multilevel sampling strategy. Participants (n=15) identified three relevant snowball samples who were used to clarify or expand upon specific aspects of their district's STEAM program.

Table 5

Qualitative Participant Characteristics

District	Participant	Position
District A	A1	Teacher Leader
	A2	Curriculum Supervisor
District B	B1	Curriculum Supervisor
	B2	Building Principal
District C	C1	Building Principal
	C2	Teacher Leader
District D	D1	Teacher Leader
	D2	Supervisor of Fine and Performing Arts
District E	E1	Teacher Leader
	E2	Curriculum Supervisor
District F	F1	Teacher Leader
	F2	Teacher Leader

Quantitative sampling. The OLM questionnaire purposely sampled teacher practitioners who meet both of the following criteria: participants must work in a school that actively engages in integrated STEAM education and be a member of the current teaching faculty. Participant responses (n=75) met the estimated response rate from this study's initial proposal.

Instruments & Data Collection

Qualitative data. The semi-structured interview (Appendix A) was developed through a process presented by Wengraf (2001). The process included identifying a series of related theory based questions that stem from the literature review and creating interview questions that do not force any specific theoretical language into the conversation (Wengraf, 2001). This process helped validate the instrument as an adequately reliable method of obtaining pertinent information to the process of STEAM implementation. Wengraf (2001) suggested that IQs should rarely be exact mirrors of TQs because the participants have their own patterns of speech and unique relationships to the underlying theory. Table 6 shows this process and is explained below.

Four factors were created upon synthesizing STEAM research from the literature review. Factor one was determined based on research by Newton and Newton (2014), Wynn and Harris (2012), Clark and Button, (2011), and Bascia et al. (2014), which, addressed value and purpose of arts integration. Factor two was determined based on research by Drake and Burns (2004), Root and Bernstein (1991), Bequette and Bequette (2012), Krajcik and Shin (2014), and Rabalais (2014), and explored the curriculum and pedagogical strategies. Factor three was determined based on research by Wynn and Harris (2012), Shaffer (2013), Kuhn (2015), Bequette and Bequette (2012), and Park and

Ko (2012) and addressed structural changes made to normative practice. Finally, factor four, was determined based on research by Tomlinson-Clark (2014), Purnell (2004), Strand (2006), and Wong (2013), and probed how teachers develop the skills necessary for arts integration across STEM subjects.

School leaders were asked to complete informed consent forms prior to recording their responses. Interviews were completed in person and over the phone. All transcripts and participant identifiers were kept confidential in a secure Google Drive account.

A curriculum lens was also needed to understand whether STEAM components addressed in the literature review were making their way into the prescribed curriculum. Curriculum documents were examined on participating district websites or requested if web access was unavailable. These documents provided insight into some of the unique STEAM units created by the school leaders and teaching faculty.

Table 6

Interview Protocol Framework

STEAM Factor	Theory Based Question	Interview Question
Value and Purpose	In what ways did the potential for economic, civic, or innovative value play the decision to implement a STEAM program?	How would you define STEAM education
		What do you believe motivated the district to implement STEAM?
		How do you feel the arts support STEM learning and the students' future?
Curriculum and Pedagogy	How do districts adapt pedagogy to fit traditional models of the integrated curriculum?	Please describe two major curricula modifications that helped support implementation?
	What do activities such as problem based learning and project based learning reveal about STEAM's curricular footprint?	How were these modifications decided upon?
		What types of pedagogy do you observe in the STEAM classroom? How is the teaching different from before?
Implementation Structure	In what ways did the district plan for change during the processes of implementing STEAM?	Who was responsible for leading STEAM in this district and why?
		Was there a planning process for implementation? If so, describe how it began to where you are now.
		What do you feel are the two or three biggest impediments to the process?
		Who have been the most important actors in circumventing these barriers?
		What are the next steps to continue implementation?
Teacher Development	In what ways is STEAM built into the professional development program? Are they supported with new knowledge and how is this knowledge integrated into practice?	What types of professional development are offered to support the teachers?
		In what ways does the district support collaborative teaching efforts?

Quantitative data. The OLM Questionnaire created by Schechter & Atarchi (2014) (Appendix B) was the quantitative instrument used in this study. The instrument contains 24 Likert response prompts in four factor groups: disseminating, storing, and retrieving information; sharing information with parents and students; analyzing and interpreting information; using online information (Schechter & Atarchi, 2014). Questions in each factor group will be responded to within a five point Likert scale: 1=does not exist, 2=rarely exists, 3=sometimes exists, 4=exists, 5=exists extensively.

School leaders were sent copies of the survey instrument prior to distribution. Upon approval, school leaders who participated in the study emailed the OLM Questionnaire out to faculty members using a Google Form. All participant identifiers were kept confidential and the school leaders themselves did not have access to responses.

Data Analysis

This convergent, parallel MM study was accompanied by a constant comparative analysis strategy. Referencing both Glaser and Strauss (1967) and Lincoln and Guba (1985), Teddlie and Tashakkori (2009) described the constant comparative analysis process as one with four steps: comparing incidents, integrating categories, delineating theory, and finally writing the theory.

The timing of analysis was also considered, as Merriam (2009) suggested that data collection and analysis are not linear processes; rather they should occur simultaneously to avoid the production of unfocused analytics. Thus, data analysis in this study was ceaseless to ensure inferences were focused and were allow significant time to develop. Each strand yielded its own set of findings which were then mixed to develop the seven inferences within Chapter 4. Those inferences were then used to create a final meta-analysis within Chapter 5.

Qualitative analysis. The beginning stages of QUAL analysis was a process of analytic induction, which, can be defined as an initial scan of data sets to determine preliminary categories, typologies, and hypotheses which will later be modified to represent themes (Teddlie & Tashakkori, 2009). This process took place during the transcription, memo, and initial coding phase. Each memo represented a brief, journal like analysis of each response, as well as comparative thoughts for between case analysis.

After analytic induction, Teddlie and Tashakkori (2009) suggested data should be unitized and categorized. Unitizing is the process of identifying Units of Information (UOIs) that can represent words, phrases, or even paragraphs related to potential themes. UOIs then, in turn, were placed into more rigorously defined categories during analytic coding. UOIs were generated mostly from the analytic memos and open codes, as this was where participant responses were synthesized and compared.

The coding processes in its entirety entailed generating open, axial, and selective codes. Adapted from a grounded theory context, Merriam (2009) suggested this can involve using narrative data to build meaningful labels (open codes), relationships and themes (axial), and finally a set of rich and robust inferences (selective). All coding was completed on the Dedoose to create an analytic audit trail and comprehensive set of research records (Bringer, Johnston, & Brackenridge, 2006).

Supporting documents were also analyzed throughout this period. These mostly consisted of STEAM information taken from district websites. Many of the documents included information pertaining to specific learning modules, mission statements, and standards. Documents were copied into Google Drive and paired with their own analytic memos. Table 7 summarizes qualitative analysis in its entirety.

Table 7

Qualitative Analysis Overview

Comparative Analysis Framework	**Analysis Procedure**
Comparing Incidents	Analytic Memos Analytic Induction of Transcripts & Memos Open Coding of All Documents UOIs
Integrating Categories	Axial Coding Categorizing DeDoose Output Readings
Delineating Theory	Selective Coding
Writing Theory	Qualitative Findings & Inferences

Quantitative analysis. The OLM Questionnaire (Schechter & Atarchi, 2014) contained 24 learning mechanisms within four categories: disseminating, storing and retrieving information, sharing information amongst students and parents, analyzing and interpreting information, and using online information. Respondents (n=75) reflected on their perception of each mechanism and answered within a Likert scale range of "does not exist" to "exists extensively." The original Schechter and Atarchi study pertained to validating each factor group, so replicating each statistical test used by the authors was not the most appropriate method for an implementation study.

Statistical analysis in this study begun by studying descriptive and frequency statistics for each factor group and each item within the factor groups. These tests were first explored for the entire participant group (n=75). Output tables were generated using

SPSS software and saved in Google Drive. Each table was then given a short narrative analysis to summarize its meaning in context to the study.

Following a whole group analysis, participants were separated by their profession. These groups included STEAM teachers (n=24), elementary classroom teachers involved in STEAM (n=26), and other faculty (n=25). Elementary teachers were separated because they are responsible for teaching many disciplines whereas middle and high school teachers are mostly teaching single disciplines. It was hypothesized this would make their perception of organizational learning and STEAM different than single discipline faculty. Descriptive and frequencies were run for these groups and finally, One Way ANOVA's were used to analyze mean responses between each group. The same process was used in analyzing participant responses based on their socioeconomic grouping.

Convergent analysis. Detailed thoroughly in the beginning of Chapter 4, data was mixed to create the final set of inferences, which, were ultimately used to answer this study's research questions. The set of selective codes generated from qualitative analysis were paired with factor groups and survey items from the quantitative. When placed alongside each other, specific practices suggested by the school leaders could be supported or contradicted by survey results. For example, a response such as "we implemented STEAM by first creating a vision for what it would look like in our school," was paired with the organizational learning mechanism "communicating vision to staff." These mixed pairings created this study's inferences and showed STEAM specific processes and possible organizational learning mechanisms that supported their implementation.

Integrative Framework for Inference Quality

The following discussion on validity and reliability is framed through the mixed methods authorship of Teddlie and Tashakkori (2009) and their integrative framework for inference quality. These authors suggested that mixed methods validity is best explained through new labels that consider the complex research variables associated with MM designs. In the beginning of Chapter 4, issues of interpretive rigor will be discussed to complete the integrative framework for inference quality.

Suitability. A mixed method design was suitable for this study based on the initial desire to compare two separate school processes: OLMs and STEAM implementation. It is hypothesized that OLMs associated with analyzing, storing, retrieving, and disseminating information may influence the STEAM process or help school leaders frame implementation for the teaching faculty, thus requiring two separate inquiries to study both STEAM and the system as a whole. Furthermore, in choosing a convergent parallel design, it is not necessary to wait for a single set of findings before designing or collecting the next set of data, allowing data to be collecting concurrently.

Within-design consistency. This factor addresses how well the chosen instruments coincide with the sample population (Teddlie & Tashakkori, 2009). Consistency between the two ensures that the data collected from the participants will appropriately inform the research questions. The QUAN strand is inclusive of a 24 item, five factor questionnaire that was shown to have very high internal consistency through both Schecter and Atarchi's (2014) exploratory and confirmatory factor analysis. This data can be viewed in Table 8.

The QUAL strand also looks to build a high degree of within-design consistency by using a protocol that follows creation procedures outlined by Wengraf (2001). As discussed earlier in the methodology, each interview question was generated based on a series of theory based questions. This process remained very important to the data collection and analysis in that interview participants were not influenced to speak about STEAM implementation using unfamiliar theory, philosophy, or vocabulary (refer to Table 2, p. 66).

Table 8

Internal Consistency and Reliability of Questionnaire

Factor Group	**Questions**	**Internal Consistency**
Disseminating, Storing, & Retrieving Information	10	.93
Sharing Information with Parents and Students	6	.86
Analyzing and Interpreting Information	6	.75
Using Online Information	2	.80
Overall Reliability Coefficient	24 Total Items	.95

Analytic adequacy. The constant comparative method (Teddlie & Tashakkori, 2009) of analysis involved consistently comparing incidents and integrating categories revealed through coding. Quantitative analysis also mirrored the constant comparative framework in that it compared groups of participants nested within the participating organizations. All inferences within Chapter 4 are direct products of mixing both data sets, which, ties in the importance of choosing a MM design. All analysis procedures were vetted by the entire dissertation committee.

Ethical Considerations

There were two overarching ethical considerations in this study. First, interview participants presented unique perspectives on STEAM policy implementation, which must be reflected accurately in the findings report. As previously stated, member checking in this instance is a paramount concern so that the unique processes are not misinterpreted or misrepresented in the data. Second, the survey was administered via a Google survey, which required me to ensure online data is stored securely and participant's responses remain "nonpublic" in Google preferences.

Limitations

The first limitation of this study was with transferring implementation frameworks from context to context. Schools are organized and multitude of ways, which means the implementation of any initiative, is unique to school's organizational structure. While the findings of this study may reveal common implementation trends, these trends ultimately must be adapted to fit the unique circumstances of a school.

Second, this study did not intend to generalize student outcomes associated with STEAM or OLMs. For many, the choice of implementing STEAM in a particular manner may be dependent on their expectation of improving student achievement. Student achievement in STEAM or STEAM effect on achievement in other disciplines was not within the scope of this study. School leaders discussed expected outcomes, but the methodology did not specifically test for them.

Finally, organizational learning can be perceived as both a conscious or unconscious process. Districts may actively alter learning mechanisms to support policy initiatives, but they also may change organically. School leaders may reveal certain changes to organizational learning throughout the course of this study, which would thus represent a conscious action on the part of leadership. To the contrary, as teachers implement policy, they may alter practice and advocate for certain organizational learning mechanisms that may not have been part of the original implementation "plan." Ultimately, there is a limitation in discerning what was "mandated" during implementation and what "happened" through organic change processes. Without a pretest of OLMs prior to implementing STEAM, it may not be possible to make certain distinctions.

Conclusion

Examining STEAM through the lens of organizational learning was done so through a parallel, convergent mixed methods design. Six research sites with varying sizes and socioeconomic placements were chosen as settings for the study's methodology to take place. The research instruments did favor a QUAL or QUAN perspective, thus requiring the outcomes of each parallel data to be analyzed separately and merged to effectively answer each research question. Site selection and participant sampling was part of a multilevel sampling design, which allowed for the blending of multiple sampling strategies (Teddlie & Tashakkori, 2009). In this research instance, purposive, criterion, and snowball samples were used to reveal findings associated with reputable and comparable K-12 public school contexts.

Data analysis and transformation was guided by valid and reliable parallel analysis procedures defined by Teddlie and Tashakkori (2009). Qualitative data analysis followed a constant comparative approach, with multiple rounds of coding categorizing used to define STEAM implementation theory from the perspective of school leaders and teacher leaders. Quantitative data was analyzed through descriptive, multivariate, and inference statistics associated with STEAM teacher responses to the OLM Questionnaire. The data was then mixed as a final layer of analysis.

Chapter 4

Results & Inferences

Chapter four presents data from both the qualitative and quantitative strands of this study. After a brief review of data analysis methods, data is organized into two sections: (1) K-12 school leader approaches to STEAM implementation and (2) comparing K-8 vs. high school STEAM implementation. The organization of data in this manner was the result of converging data associated with STEAM, school leadership, and organizational learning. Chapter four briefly addresses these convergent inferences, to which they are expanded upon within the ensuing manuscripts.

Data Analysis Overview

Qualitative. The collection and analysis of qualitative data occurred simultaneously, as Patton (2002) suggested that researchers must pivot back and forth between the two tasks. Teddlie and Tashakkori (2014) reaffirmed this methodology in stating that the building of themes and theories from the data is a gradual and continuous process of which evolves as the researcher interprets each new data set.

Twelve participants were chosen and interviewed based on predetermined criterion of school administrators and STEAM program coordinators. Snowball samples were also collected if the initial participant felt a faculty member could better elaborate on the district's STEAM initiatives. Consistent with the constant comparative analysis framework, Coyne (1997) suggested that additional samples may emerge during the collection of criterion or purposeful samples based on their theoretical purpose and relevance to the study. Four snowball samples were interviewed within this study.

After transcribing and coding the sixteen interviews, the themes drove the emergence of two distinct data categories: school leader approaches to STEAM implementation and differing strategies between K-12 and high school districts. Figure 3 displays this analytical process.

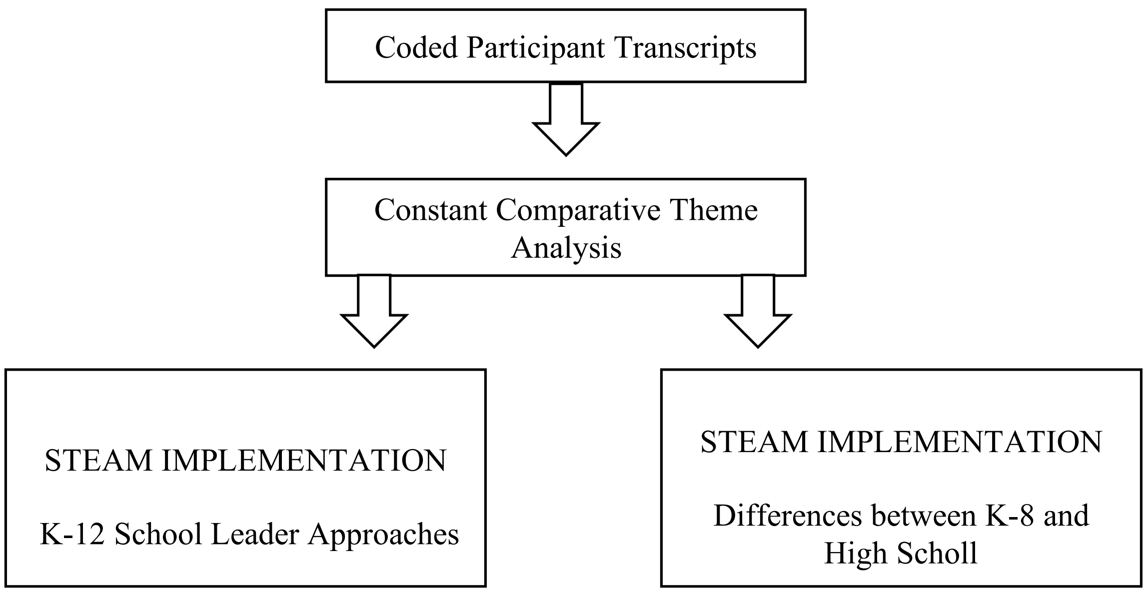

Figure 3. Qualitative Analysis Process

Quantitative. The OLM Questionnaire (Schechter & Atarchi, 2014) helped reveal important organizational attributes contributing to the STEAM implementation process. Survey participants (n=75) were grouped based on teaching discipline and the socioeconomic status of their district. Three categories of teaching disciplines were used during analysis: STEAM content specialists (n=25), elementary classroom teachers (n=26), and other faculty (n=24). Similarly, three socioeconomic groupings were used:

CD, DE, and FG-I. The sample distribution of these groups includes: CD (n=30), DE (n=39), and FG-I (n=6).

Descriptive and frequency statistics were analyzed through SPSS for the whole respondent population and the comparable groups. Next, one way ANOVAs were run to investigate whether significant differences existed between respondent groups. In some instances, a Tukey Post HOC was used to further compare respondent pairs. Analytical memos were continuously written to begin comparing quantitative findings to the qualitative themes on STEAM implementation.

Data Convergence

Data on STEAM implementation was converged with OLM Questionnaire responses to reveal whether participating districts were supporting their espoused implementation strategies with various means of professional learning. This step was vital, as Teddlie and Tashakkori (2007) suggested that mixed methods findings can only explore the enhanced understanding of a question if there is a means to make sense of both data sets in an integrated manner. Therefore, themes revealed through qualitative analysis had to be further explored through items on the OLM questionnaire.

To do so, responses within each factor group of the interview protocol was compared to factor groups on the OLM Questionnaire. This allowed the school leader approaches to be paired with organizational learning mechanisms that helped render a more complete picture of STEAM implementation in practice. Table 9 shows the factor groups for the QUAL and QUAN strands that were initially converged.

Table 9

Convergence of QUAL & QUAN Factors

QUAL Factor Groups (STEAM)	**QUAN Factor Groups (OLMs)**
Values and Goals	Disseminating, Storing, and Retrieving Information
Curriculum and Pedagogy	Analyzing and Interpreting Information
Implementation Structure	Sharing Information with Students and Parents
Professional Development	Using Online Information

Note: All categories are integrated with each other regardless of the above arrangement.

Upon analyzing the initial factor groups across the QUAL – QUAN spectrum, new Units of Analysis (UOIs) were generated that ultimately lead to the inferences within chapter four. Table 10 displays these UOIs. The QUAL themes pointed to many specific items within the OLM questionnaire, which showed a clear relationship between STEAM implementation strategies and the tenets of organizational learning in school settings. When mixed in an integrated manner, the espoused approaches of school leaders can thus be compared with the realities of said tasks within participating districts.

Table 10

Converging QUAL & QUAN Units of Analysis

QUAL Units of Analysis	**QUAN Units of Analysis**
Innovating Standards Based Practices	Reporting innovation and change
Emergent Implementation Plans	Curriculum reporting Reporting school projects
Engaging Community in Curriculum	Communicating with parents and students
Student Centered Philosophies	Meetings about the needs of students
Professional Development Outreach	Access to Professional Reference Material Distribution of Research Materials
Top-Down Support	Using Superintendent's Webpage
Socioeconomic Barriers	OLM Items 2,3,4,6,8,9,10,14,15,18,20,22,23

School Leader Processes

The ensuing results reveal the ways in which school leaders implemented STEAM within their respective districts and schools. These processes include initial motivations, prescribed actions, and curriculum approaches.

Top down support. Many participants spoke to the top-down strategies employed by their districts. Superintendents and principals, by way of wanting to engage a larger network of community members, spearheaded STEAM implementation through vision, budgeting, and the hiring of staff. When speaking to the importance of superintendent and principal support, one STEAM practitioner suggested:

Participant A2: The difference is that in a school where the leadership sets the tone in terms of what they are looking for in innovation and creativity...would then drive more of that activity.

Another school leader spoke to the passion behind their superintendent's desire to bring more design based thinking to the school district:

Participant A2: ...the leadership sat at the table and would figuratively smash their hand down on the desk saying, 'We need this. Design is what matters'.

While many spoke to the positive experience of top down strategies, some felt in the dark. In a follow up interview, a participant described:

Participant F3: A few colleagues and myself years ago went to an edCAMP called STEAM. We took it on ourselves to go over the summer, collected so much information, and made so many contacts. I went to my science supervisor (at the time) and said we have these great ideas and want to do this STEAM thing. She said, 'Oh that's great because central administration wants to do one.' I said well we have all kinds of things and plenty of stuff to talk about. They [the leadership] never once contacted me.

So as top down strategies were used across every participating district in this study, other participants struggled with top-down management, as they felt school leadership placed too much emphasis on the STEAM initiative which created resentment:

Participant E2: The former principal said to the STEAM teacher…'you are my golden boy...anything you want, anything you want' and just started giving him money out the wazoo...teachers became resentful.

In both instances, teachers spoke about school leaders, including superintendents taking a hand in program development, assessment, the creation of vision, and networking. Revealing clear school leader involvement in STEAM implementation is crucial to showing its impact on whole school culture. Since participants specifically reported STEAM be an outgrowth of school leader vision, it is then important to compare vision mechanisms within the OLM questionnaire.

One such mechanism, using staff meetings for discussing the implementation of school decisions, 87.9% of faculty reported these meetings “sometimes” to “always” exist. 46.6% of those respondents felt that the meetings “exist often” to “always exist.” Speaking to vision, 77.3% of faculty felt that school meetings focused on vision “sometimes” to “always” exist and the remaining individuals felt the practice either does not exist or rarely exists. The questionnaire accounts for some disparity between teachers being included in implementation planning and vision creating, but does show more than three quarter of respondents noticing top down strategies of planning and development.

Questions 18 and 19 pertaining to the development of vision and the implementation of school decisions both showed statistically significant results. Socioeconomic group CD had a mean of 2.5667 (sometimes exists to exists often) for Q18 and 2.1667 (sometimes exists to exists often) for Q19. The one-way ANOVA results, using an alpha of .05, showed a significance of $p=.000$ and $p=.05$, which continues the trend of socio economic group CD reporting lower OLM scores than the two higher groups.

Much of the motivation to implement STEAM comes from the highest rungs of school leadership which may be subsequently supported by learning mechanisms focused on vision and implementation strategies.

Emergent implementation. Speaking to the structure and plan for change, participating districts revealed the occurrence of emergent implementation plans, meaning they did not report the existence overly prescriptive implementation plans. Five out of six public schools did not have a clear plan for changing curriculum, pedagogy, structure, or professional development at the onset of their STEAM program. Participant A2 described the emergent processes in stating, “They basically knew that we were creating ship while flying it and hey [the school leadership] said take it a week at a time.” Participant B2 also discussed emergent plans, stating, “In the first few years, it (the STEAM program) was in vain only, but over the last few years, we have done a better job of embedding it into our system.”

An emergent process of curriculum implementation must in some way be supported by a mechanism for reporting, evaluating, or analyzing said implementation. When qualitative data on emergent implementation plans were compared to survey data on item four, the dissemination of periodic curriculum reports, results showed that such reports are available and may be used help STEAM’s prescriptive curriculum take shape. The frequency analysis of item four revealed that 63% of faculty members felt that curriculum reporting “sometimes” to “always” exists within their districts, suggesting the periodic alteration of the STEAM curriculum may be a part of this process. Furthermore, 72% of faculty members felt that published reports of school projects “sometimes” to “always exists.” The existence of learning mechanisms associated with the reporting of curriculum and major projects suggests that an emergent implementation process could evolve into a more prescriptive process if these mechanisms are consistently used by stakeholders.

Item one, published reports of school projects, was statistically significant within the content area grouping, with STEAM teachers reporting the highest mean and a between group ANOVA of 0.019. This ANOVA is a noteworthy statistic, as it may suggest that STEAM teachers are the primary receivers of this learning mechanism and may show that participating districts are attempting to bring greater community awareness to their STEAM initiatives.

This idea was confirmed numerous times throughout the interviews, as Participant B1 described, "We have a STEAM fair so the teachers could try to look at their curriculum less as a discrete subject and more about how there are those cross connections between the disciplines and of course still teaching to the standards." Treating classrooms less like discrete subjects and more like fluid, interdisciplinary environments was an important aspect of District B's STEAM philosophy.

Socioeconomic group CD revealed in question four, the periodic reporting of school curriculum, a mean response of 1.00 or "rarely exists." The one-way ANOVA, using an alpha level of .05, revealed a significance of $p=.000$, suggesting that the reporting of curriculum was less prevalent in lower socioeconomic districts and statistically significant compared to the other groups. Less reporting of curriculum and curriculum change would make new details within an emergent system difficult to sustain or effectively prevail.

STEAM programs are being implemented with emergent processes which allow for consistent curricular alteration, but the reporting of curriculum is less prevalent in participating districts serving lower socioeconomic areas. Due to the prevalence of advertising and STEAM to the public, the reporting of school projects may be a significant mechanism for STEAM practitioners as confirmed by the analysis of means.

Innovating standards. Participants C3, B1, A1, and A2 suggested that their STEAM programs were either created for bolstering current standards practices or becoming more aligned to state standards in the future. While it was mostly curriculum supervisors and building principals, who spoke to the value of integrating STEAM with existing standards, teacher leaders also expressed similar values, as they suggested being mindful of standards within the STEAM environment helped build a sense of trust with the administration. Participant A2 discussed this point, "The curriculum department has been very supportive and trusting that I would be hitting standards and do what I have to do. I feel I have done that."

Trust, although, was not a product of blind faith. Many curriculum supervisors had clear processes for developing the integration of STEAM and standards. Speaking to process that was evident in many of the participating districts, one curriculum supervisor stated that:

> Participant C1: We look at the standards that we have to teach across the different content areas, and based on the interests of the students, teachers and new opportunities that present themselves, we create modules, go out exploring, teachers self-direct, so it's really about opportunity and what is available to us at any given time.

Participant C1 summarized the approach of many school leaders in that the existing standards were a means to both identify learning modules and enhance the teaching of a specific standard through STEAM activities.

While many of the participating districts aligned STEAM with standards, it seemed that there were different visions for which standards STEAM would support. The Next Generation Science Standards, College and Career Readiness Standards, and Technology Literacy Standards were all cited as core components of K-12 STEAM program implementation by C3, B1, A1, and A2. Furthermore, districts also suggested the integration of STEAM with prepared STEM curricula such as Project Lead the Way and Code.org.

Based on the qualitative evidence above, the joining of STEAM programs with existing standards based practices shows a willingness to innovate within otherwise prescriptive frameworks. When mixing qualitative reports with survey data, the OLM questionnaire does inquire as to whether innovations and program changes are reported to the faculty at large. This item in the questionnaire was included within the "disseminating, storing, and retrieving information" category which ultimately accounts for how new information and processes are coded into the school's memory and accessed for the purpose of guiding decisions.

A frequency analysis of item nine within the OLM Questionnaire revealed that 38% of faculty felt innovation and change reports "exist often" and 26% feel said reports "sometimes exist." With a total of 64% of participants recognizing the use of innovation reporting within their district, it can be suggested that policy efforts, be it standards or STEAM, are supported by the reporting of innovation and change.

An ANOVA test revealed no significant differences between content specialization groups for the OLM on reporting innovation and change while socioeconomic differences did reveal some significance. Using an alpha of .05, the one-way ANOVA revealed that socioeconomic group CD was significant at p=.000. Pairwise comparisons using the Tukey Post Hoc revealed a significance of p=.000 when paired with socio economic group DE. It would seem based on these results that the lowest socioeconomic group was less likely to use the reporting of innovation and change as a learning mechanism, which may negatively influence the implementation of STEAM within existing standards frameworks. Also, the Post Hoc helped show that while group DE is close in socioeconomic rating, there are still enough significant differences in the reporting of innovation and change.

Furthermore, the process of innovation, regardless of the ability to report change and disseminate information to faculty, may also be hindered by other pre-existing barriers. Participant B2 discussed one such barrier: “We also have the struggle with our English languages learners and sixty percent are Hispanic, so the language and vocabulary is something they are missing...on top of being economically disadvantaged.”

STEAM programs are being implemented within the confines of current standards based movement. The OLM questionnaire revealed that a learning mechanism responsible for disseminating, storing, and retrieving innovative change may be supporting the continuous connection between STEAM and standards. Lower socioeconomic districts may struggle with innovative initiative given pre-existing language and economic barriers.

Marketing & partnerships. School leaders across all participating districts discussed unique marketing strategies for their STEAM programs and established attractive partnerships for professional development. Labels such as “Sickles Studio,” “Spark!,” and “Innovation Lab” were all heavily promoted throughout participant websites.

The OLM questionnaire confirmed that the communication of special programs was prevalent. Frequency analysis revealed that 98.7% of faculty members reported the district website is “sometimes” to “always” communicating academic achievement information and activities to parents. 66.7% of these faculty members reported that this practice “always exists.” It was clear through both the qualitative and quantitative data that participating school leaders wanted their communities to feel excited about the educational opportunities students had. District C1 promoted the following philosophy on their makerspace webpage:

> District C1: The Innovation Lab is where 4th and 5th graders learn the skills they’ll need to be successful in the world of tomorrow. Students are introduced to design thinking, engineering, computer science, and the digital arts as they learn to reframe failure as iteration and become the architects of their future.

Creating a clear mission statement for District C1’s innovation lab helped in the acquisition of partners and identification new learning modules, as participant C2 frequently talked about the importance of allowing learning opportunities to “come to us.”

This mission statement is also essential to the analysis of implementation procedures, as it clearly shows the value of arts integration within the innovation process. Specific curriculum modules communicated to the community include: problem based "gizmo" creations, environmental innovation focused on organic growing methods, and business innovation for 7th and 8th graders. These modules helped the district obtain "Innovate NJ" statues from the New Jersey Department of Education as well as secure partnerships with Real World Scholars, Rutgers University, and Gaylor CNC Solutions.

Other districts were more focused on engaging community for curriculum development and faculty professional development. For example, two districts developed partnerships with local and national theater organizations:

> Participant B1... we have an incredible partnership with the Count Basie Theater and the Kennedy Center for the Arts...teaching artists from these organizations come and model arts integration lessons to which the teachers then make their own extensions of the lessons.

Participant B1 showed how District B relied for outside support to aid in the implementation of arts integration activities. The teaching artists modeled the practiced and subsequently allowed teachers to take ownership of the process in their respective classrooms.

Other schools used partnerships to enhance curriculum modules in engineering and architecture:

> Participant E1: We have been talking to this building that has been going up in the city so we could check out their engineering and architectural process and approach. They talked a lot about models, showed us their blueprints...it was a really great experience for our engineering team.

Participant B2...my friend works for NASA and was around. She did a week of lessons on aeronautics, planes, and flight. If that's something we can pull in at the time, regardless of whether it happens to be mapped out at that particular time, let's do it. We aren't afraid of doing that.

Both B2 and E1 discussed the importance of using community partners to help establish new STEAM learning modules and ensuring the curriculum allowed for timely interventions of unique concepts such as architecture and aeronautics.

Community engagement in curriculum development and implementation was prominent throughout all districts and their purpose for casting a wider net of stakeholders included curriculum module development, professional development, and fundraising.

K-8 and High School STEAM

Program structure. The data revealed program structure to be distinctly different between K-8 and high school STEAM. K-8 districts integrated STEAM into their "specials" rotation, which included STEAM, music, and visual arts. Whereas the districts used to offer exploratory, basic skills technology courses in middle school, there is a new expectation of demonstrating said tasks in elementary school. Participant C3 described their district's process:

Participant C2: The first thing I did was push the basic stuff down to K-2. Learning how to type, keyboard, turn on the computer, that kind of stuff is integrated into our media literacy program. In third grade, we start expecting students to show what they know through technology. Now, because we didn't have a traditional computer class, it opened the opportunities to do some innovative stuff. So, when I got there two years, fifth and sixth grade is where we needed the hole filled immediately. It is basically a blended learning, project based makerspace.

Participant C2 seemed to suggest that basic technology skills, or in this case media literacy skills, are now expected to be developed at the lower grade levels, which then create the necessary curricular space for STEAM.

STEAM in high school districts D and E was not a single course students could register for or rotate into. Rather, it was a set of courses contributing to the overarching STEAM curricula. District F advertised to their community a bolstered series of courses within each STEAM discipline. Table 11 displays the basic frameworks for each participating high school:

Table 11 also shows that the course offerings have dual credit status with local community colleges as well as AP courses which could potentially earn the students credit. District D was concerned creating a program that met the needs of their local community. Similarly, District D explored dual credit options but in a more vocational manner:

Participant D1: We wrote a half a million-dollar grant and started these CTE programs. One is a construction program which is a re-imagining of the woodshop. The kids were primarily making Adirondack chairs and jewelry boxes...I had a big problem with that because I didn’t think that was really serving kids. So now, it's a construction program where they are getting concurrent credits with Temple University.

Participant D1 not only stressed the importance of vocational skills in District D's STEAM program, but continued with the idea of re-designing pre-existing learning environments such as woodshops to meet the needs of 21st century learners.

Table 11

High School STEAM Course Credit Overview

District	Course Credits Offered
District D	Dual credit vocational partnership across STEAM disciplines with the local community college
District E	AP Computer Science, Competitive Robotics, Music Technology, CAD and Engineering
District F	53 college now and dual credit STEAM courses in both AP and vocational settings

Curriculum design. As discussed in the program structure, K-8 programs pushed basic technology skills down to elementary grades, allowing middle school students to use technology in more creative ways. Data from curriculum analysis showed that K-8 districts focused their STEAM approaches on 21st century technology skills including coding, robotics, digital design, 3D printing, and multimedia. Table 12 provides examples from all three districts.

Table 12

K-8 STEAM Curriculum Overview

District	Units of Study
District A	Creation through Empathy, 3D Printing, Robotics, Coding
District B	Design & Modeling; Engineering (Project Lead the Way)
District C	Coding, Digital Arts, Engineering & Robotics

The most significant difference between K-8 and high school STEAM curricula was that K-8 programs were far more prescriptive in their approaches. The high school programs housed STEAM within an "academy" program, which as previously mentioned, included course sequences. Districts D, E, and F all discussed course sequences and providing students the opportunity to choose courses in each discipline. Table 13 shows the program of study for District F.

Table 13

District F Program of Study

District	Units of Study
Science	Anatomy, AP Biology, AP Chemistry, AP Physics, Forensic Science, AP Environmental Science
Technology	Printing, Internet Tools & Techniques, Digital Photography, Digital Video Production, Multimedia Applications
Engineering	Technical Drawing, Pre-Engineering, Engineering, CADD, Architectural Design, Robotics
Art	Photography 1, Voice and Diction, Art & Design, Art II, AP 2D Art, Computer Graphics, Digital Photography
Math	AP Statistics, Algebraic Concepts, Pre Calculus, AP Calculus

The K-12 population largely reported that curriculum development through OLMs was infrequent. Table 14 displays the quantitative results for OLMs pertaining to curriculum:

Table 14

Curriculum OLM's

OLM	Mean	Mode	Std. Deviation
Q2: Each curriculum/project has an updated instructional file	1.84	2.00	1.13
Q3: Summaries of teacher work/school projects are stored in a location accessible and known to everyone	2.173	2.00	1.26
Q4: Periodic reports on school curriculum evaluation are circulated	1.78	2.00	1.39
Q6: Our school website contains study materials for students (lesson and article summaries?	1.41	2.00	1.07

Table 14 reveals that four separate mechanisms for the development curriculum rarely to sometimes occur. So, while the curriculum was previously described as emergent from the perspective of school leaders, it is unclear how components of the curricula are coming together without strong support from these OLMs.

Student centered philosophy. There was an overwhelming sense in both the literature and in the words of interview participants is that STEAM allowed districts to explore student centered learning environments. Both K-8 and High School participants shared this sentiment, revealing that some of the core tenets of STEAM from the early literature ring true across grade levels.

Speaking to the value of maintaining STEAM as student centered initiative, Participant A1 stated: “We wanted them [the students] to be masters of their own thinking and leaders of their learning and that is done really effectively in a STEAM type atmosphere.”

In a participating high school, District F made the student-centered approach about authentic inquiry and allowing students to research topics that mattered most to them:

> Participant F1: The students are pretty in charge of 100% of the whole process. The students develop a capstone research proposal that involves all the STEAM disciplines and they take it as far as they can. Some develop prototypes, some its more just research based, some it comes totally to fruition.

The capstone projects discussed by participants in District F show how their approach to STEAM requires authentic student inquiry and an expectation to actually take action on the research completed by the student (developing prototypes, designing new products, etc.)

The student-centered nature of these STEAM programs very much confirms the relationship between STEAM and project based learning. Participant A1 stated: “…it creates a school culture built around problem and project based learning where we are using design thinking, innovating, researching, and inquiry."

Regardless of age or grade level, the need to make STEAM as authentic as possible was evident throughout the data. Purported, the participants suggest for students to master their own thinking and guide their own learning, they must build a toolbox of 21st century skills that can be developed through specific activities such as problem and project based learning. Participant B1 stated, "we think of a problem, we think of something relative to our students' world and then we design and try to build something that could help."

The OLM questionnaire showed that 92% of faculty members reported that regular meetings about the needs of students from the students themselves either "does not exist" (37.3%), "rarely exists" (22.7%), or "sometimes exists" (32%). While the espoused beliefs of the participants suggest that maintaining a student-centered philosophy is important, there may not be many mechanisms for students to reach out and express their educational interests.

Inference Quality

In chapter three, I discussed rigorous design quality within Teddlie and Tashakkori (2008) Integrative Framework for Inference Quality. These elements of rigor allowed me to collect data that directly addressed the identified problem and corresponding research questions. The following inference criteria was used to guide inference quality: interpretive consistency, theoretical consistency, interpretive agreement, and interpretive distinctiveness.

I posit that the inferences within this chapter meet said criteria in the following manner:

1. Inferences are a result of qualitative or statistical intensity; meaning each inference has an abundance of data, both qualitative and quantitative, to support the claim.
2. Each inference can be directly tied to theories presented throughout the literature review and offer supporting, null, or competing perspectives.
3. Peer reflection on each inference for considering alternative viewpoints, contradictions, and data interpretation.
4. Rigorous consideration of multiple inferences and using the data to identify the most distinct conclusions.
5. Ensuring that included inferences are products of the data mixing process and are sufficiently explained through both qualitative and quantitative data sets.

Meta Inference

Chapter four presented an analysis process rooted in constant comparative strategies. The objective of this chapter was to display this process and present data relevant to this study's research questions. Upon conclusion of the process, the final stage was to compose a series of analytical memos reflecting on all the inference statements within Chapter Four and begin the meta-inference process. Teddlie and Tashakkori (2008) suggest that this is the final stage of mixing in which the researcher considers the distinct inferences presented throughout chapter four and "addresses the degree to which a MM researcher adequately integrates findings, conclusions, and policy recommendations gleaned from each of the study's strands" (Teddlie & Tashakkori, 2008, p. 312). Figure four depicts this study's meta inference.

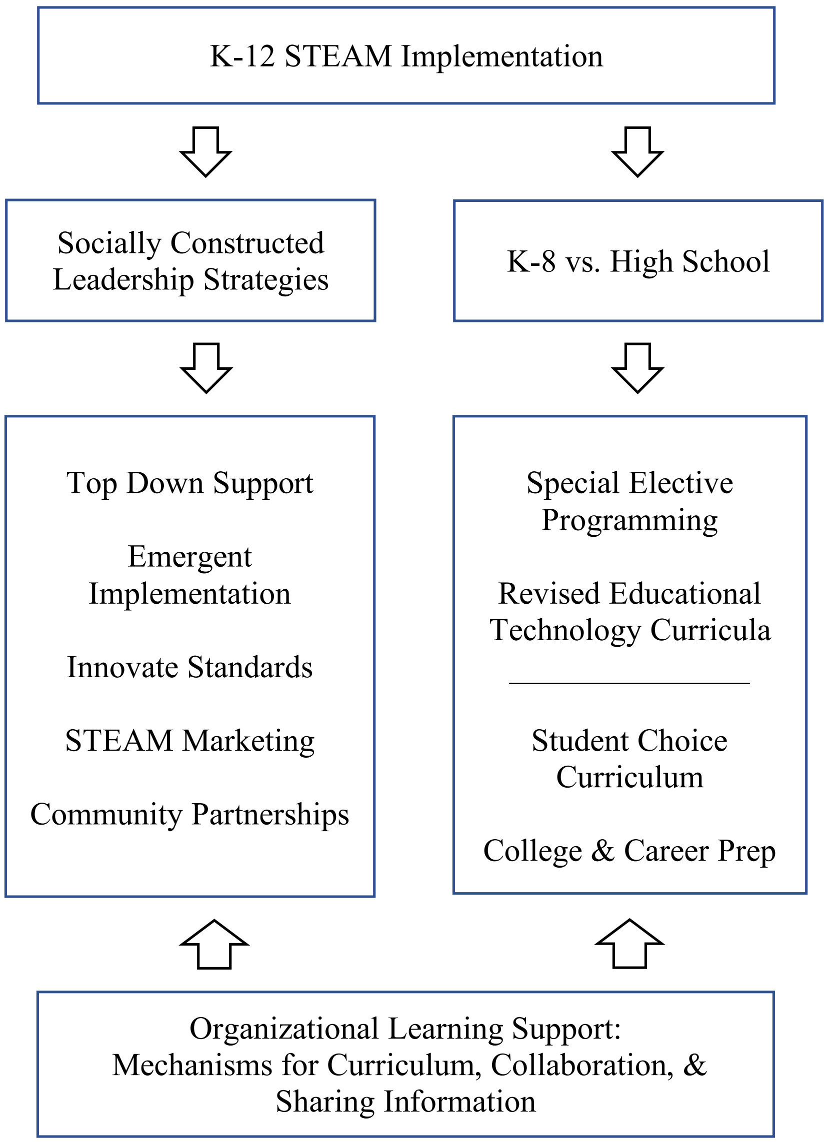

Figure 4. K-12 STEAM Implementation Meta Inference

Figure 4 addresses the central research problem discussed in Chapter 1. STEAM implementation has struggled due to a lack of policy guidance for practitioners. Figure four provides guidance as a result of the data presented in chapter four and it can be understood that many of these processes employed by school leaders were socially constructed. Providing top down support for the development of a STEAM curriculum over time set the stage for collaboration and risk taking. The marketing of STEAM to the community and the presentation of STEAM fairs as a celebration of learning showed that school leaders wanted community members to participate in the process of educational innovation. Furthermore, providing professional development through a series of partnerships with arts organizations showed that parts of the curriculum itself was socially constructed.

The data also provides guidance for STEAM implementation in different grade level contexts. K-8 programs transformed their educational technology curricula into STEAM makerspaces and innovation labs, to which the students were given a chance to explore a variety of coding, robotics, engineering, and empathy driven project and problem based tasks. In high school contexts, school leaders organized course sequences from across STEAM disciplines to frame their programs. The course sequences were geared towards college and career preparation, as well as independent study aimed at promoting authentic student inquiry.

Finally, the influence of organizational learning mechanisms was primarily centered in sharing information with parents, the analysis of curriculum, and collaboration. The overall impact of OLM’s was moderate, suggesting that school leaders may consider paying more attention to how innovative initiatives filter throughout their respective organizations thereby potentially impacting more stakeholders in a positive manner.

Chapter 5

K-12 School Leader Approaches to STEAM Implementation

Policy implementation in schools requires leadership to consider the vision, strategy, and structure of reform. In the creative disciplines, principals and district level administrators may delegate these tasks to teachers, as they trust their content expertise. Conversely, non-arts policy such as Science, Technology, Engineering, and Math (STEM) and new standards movements like the Next Generation Science Standards (NGSS) may come with more stringent leadership oversight when they are directly tied to grant funding and standardized testing. Thus, a leader's role in any arts driven policy that is built on constructivist principles may be ambiguous, unfamiliar, and challenging.

One issue school leaders face when implementing STEAM are the competing theories as to whether the arts belong in STEM. STEAM advocates have argued that the arts are a vehicle for interpretation, which allow STEM practitioners to incorporate aesthetic reasoning into the innovation process (Maeda, 2013; STEM to STEAM, 2015). Ghanbari (2014) suggested that the arts impact on STEM is vague and unproven, thereby hindering STEAM's presence as a formidable practice in educational innovation. Furthermore, the economic dissonance between STEM and creative arts careers continues to negatively affect the distribution of resources to constructivist school ventures (Ghanbari, 2014). Regardless, countless districts across New Jersey are implementing STEAM as an institutional policy for curriculum innovation and do so without experience or a roadmap to success.

With little guidance for STEAM implementation and competing perspectives on its place in education, research has started to explore the many school implementation approaches. Schools have transformed traditional libraries into constructivist makerspaces (Dottie & Walker, 2015; Lamb, 2016), reformed curriculum to include integrated STEAM (Ge, Ifanthaler, & Spector, 2015; Herro & Quigley, 2016; Kong, 2014), developed arts driven problem based lessons (Tomlinson-Clarke et al., 2014), and used STEAM as a platform for higher level technology integration (Herro, Quigley, & Jamile, 2017). These studies provide plenty of context for STEAM in the classroom, but little research has been done at the leadership level.

While the role of a school leader in STEAM may yet to be defined, it remains their job to support policy across the organization through vision, buy in, and professional learning (Fullan, 2012; Hsaio & Chang, 2011). One lens for understanding professional learning is organizational learning mechanisms, which are be associated with the search, acquisition, integration, and assimilation of knowledge (Higgins et al., 2012; Popper & Liptshitz, 1998). Different from learning constructs such as professional learning communities (DuFour & Eaker, 1998), OLM's address learning across multiple organizational levels and systems relevant to school teachers and administrators. Thus, implementation studies from the perspective of school leaders should address both whole system influences (OLMs) and the underlying sub-systems (individual implementation strategies) (Shaked & Schecter, 2013).

The purpose of this article is to present school leader approaches to K-12 STEAM implementation. Specifically, this work addresses how STEAM programs are structured and the nature of curriculum development. As part of a larger mixed methods study, the initial purpose was to examine how districts that had implemented STEAM were supporting their efforts through organizational learning mechanisms.

Review of Literature

Social constructivist policy shift. STEM was and continues to be a major public policy movement in education. In 2015, the U.S. Department of Education adopted a platform that posited higher level thinking and problem solving through STEM learning:

> In a world that's becoming increasingly complex, where success is driven not only by *what* you know, but by what you *can do* with what you know, it's more important than ever for our youth to be equipped with the knowledge and skills to solve tough problems, gather and evaluate evidence, and make sense of information (pp. 1)

As the USDOE and other stakeholders developed public policy initiatives and garnered billions in federal funding for STEM support, some practitioners and researchers felt the principles of art and design were notably omitted (Maeda, 2013). From their perspective, the act of innovating and creating something new is the sine qua non of artistic and scientific mastery (Vessey et al., 2014). So as STEM gained momentum through widespread implementation in K-12 schools, a constructive policy movement emerged exploring the fusion of arts and STEM education.

Ingram, Schneider, and DeLeon (2007) suggested that social constructivist policy occurs when a target group of constituents decrease traditional power structures and adjust policy to consider larger social ramifications. Local school leaders who implement STEAM believe their constitutions, in their institutions, believe the social ramifications of STEM without the arts is an incomplete formula for innovation.

Many educational policies change during the implementation phase, as its difficult for reform with roots too far from local contexts to consider the many associated variables (Person, 2013). Related to STEM and STEAM, the many public policies surrounding STEM left arts educators and creative students feeling left out of a major educational overhaul. As such, policy champions like John Maeda of the Rhode Island School of Design and Republican Senator Suzanne Bonamici passed arts and STEM integration into the Elementary and Secondary Education Act (ESEA) in 2015, which continues to impact over 100,000 schools nationwide (Americans for the Arts Action Fund, 2015). STEAM is now an institutional policy built into the pedagogy and curriculum of districts who feel the arts positively affect STEM learning.

The role of school leadership. A function of all school leadership is to establish vision and buy in among relevant stakeholders during periods of policy reform (Fullan, 2012). Harding (2013) asserted that people organize around a central vision during creative policy change, which thus requires school leaders to have, "mitigated the risk that comes with imagining a solution to an extraordinary dilemma and then have determined that action is better than inaction" (p. 52). STEAM can certainly be considered an extraordinary policy dilemma that requires said risk mitigation, as the outcomes of STEAM are largely untested (Ghanbari, 2014). Furthermore, vision is even more necessary in the case of STEAM because many practitioners hold opposing beliefs as to whether artistic inquiry belongs in STEM (Masani, 2001; Robeline, 2011) and arts level reforms commonly decrease leadership attention due to their low stakes assessments (D'Andrea, 2012).

Wong (2013) addressed the dilemma of risk taking in arts policy and investigated whether leadership interaction affected the sustainability of a new arts integration initiative. Designed as a comparative longitudinal case study, the author found that when school leadership was actively involved in threading arts integration throughout the fabric of a school's mission, the policy was successful and continued in the long run. Comparatively, the district that received little support for planning, scheduling, and co-teaching professional development stopped their arts integration practice shortly after implementation (Wong, 2013).

The acquisition of resources for arts policy is also a central leadership concern. STEM education received more than a billion dollars in funding during the Obama Administration and while some of that money was allocated for arts integration initiatives, STEAM has not had access to an equitable pool of resources (PCAH, 2015; USDOE, 2015). Johnson (2012) suggested that resources can come in the form of securing private sector partnerships. These partners, either local community or larger corporate entities, acted as curriculum partners and helped identify employable creative skills (Johnson, 2012). In the case of Tomlinson-Clarke (2014), school leaders partnered with teaching artists to develop and provide professional development. The leader's role, thus, may include identifying effective fiscal and non-fiscal resources to support and sustain implementation.

Miksza (2013) found that principals may be more inclined to secure resources for programs as a result of attending more school arts functions. Miksza found a positive correlation between administrative support (defined as the number of arts events attended) and leadership adequacy assessments. The authors found that the more arts events participating leaders attended, the more they reported arts practitioners were operating with inadequate resources (Miksza, 2013). While this is not a causal relationship, leadership support and direct interaction is of central importance to this study.

Finally, professional development is a responsibility of the school leader during a change in institutional policy. Purnell (2004) examined arts integration implementation and found that while most of the respondents felt arts integration was important, its infrequent application was primarily a product of low administrative support, inability to develop effective pedagogy, a lack of meaningful assessment tools, and insufficient interdisciplinary collaboration during the school day (Purnell, 2004). Lackey and Huxhold (2016) confirmed this finding, stating that teachers experience significant difficulties infusing the arts across the curriculum, aligning state standards, and applying cohesive pedagogies, all of which could be addressed with relevant professional development.

Based on the aforementioned research, school leaders who adopt arts integrated policy must mitigate the risk involved with low stakes policy (Harding, 2013), ensure that the arts are central to the school's mission (Wong, 2013), secure resources and partnerships to support the policy (Johnson, 2012; Tomlinson-Clarke et al., 2014), and have a plan for professional development along the way (Purnell, 2004).

Implementation. Changing the philosophical underpinnings of a group requires buy-in and connecting people with purposeful action. Clark and Button (2011) asserted that, "The arts promote cultural change, trigger the imaginative conscious and community action, and act as a bridge towards scientific understanding and the application of sustainable efforts" (p. 43). Newton and Newton (2014) argued that as our world population increases exponentially in the 21st century and natural resources continue to dwindle, creativity will emerge as the most abundant of human resources, thus making it one of the most employable skill sets in the 21st century. Implementation requires people to understand why something is important to their professional endeavors, thus organizing stakeholders around a central philosophy or vision is crucial.

While the philosophical foundations of STEAM are well developed to this point, implementing them in a school context without guidance is a demanding task. Park and Ko (2012) provided seven guidelines for large scale STEAM implementation. As a brief summary, the authors suggested districts must consider how to integrate subjects without disrupting the current environment, use creative and diverse thought processes when considering pedagogy, adapt to changing technology, implement the basic theories of engineering and technology, attempt to predict the future needs of society, and ensure future scientists and engineers become a product of STEAM and manifest strong ethical, social, cooperative, leadership, and communicative values (Park & Ko, 2012).

Curriculum implementation. STEAM inherently requires interdisciplinary and integrated learning. Constantino (2017) framed STEAM as a transdisciplinary method of inquiry, which means the curriculum organizes subject matter around unique student inquiries (Drake & Burns, 2004). Prior literature has also suggested that STEAM pedagogies can be viewed as interdisciplinary, multidisciplinary, as well as transdisciplinary (Margaret et al. 2013; Sade, 2014; Spector 2015). The difference between the three approaches depends on how students, the disciplines, and a problem are situated throughout the learning experience (Drake & Burns, 2013).

Schools often facilitate an integrated curriculum that breaks down traditional learning silos. Root and Bernstein (1991) stated that the issue with teaching within a singular discipline model is that it stifles the student's ability to invent. By unrestricting the single discipline bias and instilling unfettered creativity, STEAM's collaborative qualities have been shown to provide greater economic career projection, ethics and values, and student preparedness to use principles of aesthetics and technology to innovate (Spector, 2015; Strand, 2006).

Strand (2006) identified four predictors of success in integrated arts curricula: (1) the philosophical mission of each school as it related to integrated curricula was most important, (2) collaborative success was highly dependent on the personal characteristics of teachers, (3) administrative support of teacher partnerships allowed for the curricula to remain protected [sustained], and (4) the actual curriculum itself was developed from practitioner level critical thinking, improvisation, and reflection. These predictors may be necessary points of oversight for principals, curriculum supervisors, and departmental supervisors when implementing STEAM.

Specific to current curriculum trends in the 21st century, Kuhn (2015) identified the With About In and Through (WAIT) framework that explored how to situate STEAM alongside the Next Generation Science Standards (NGSS) policy. By scaffolding the level of arts integration from very little to a lot, students were more able to call upon the creative processes and connect with NGSS definition of innovative thinking (Kuhn 2015). Using STEAM to aid in standards based reform may be a point of compromise in districts that value arts integration, but are hesitant to dedicate resources to policy that doesn't directly impact quantifiable student achievement.

Classroom implementation. Classroom implementation includes both physical and pedagogical implications for school leaders to consider. Many STEAM learning environments are redesigns of traditional spaces such as libraries or computer labs. Often, these spaces are used as makerspaces for students to experience constructivist learning. Kurti, Kurti, & Flemming (2014) explained that makerspaces focus on the constructionist branch of constructivist learning, in which students initiate much of the learning process. Contemporary makerspaces allow teachers to use active learning approaches to which has been a pedagogy tied to the reform of engineering and technology education in the 21st century (Connor, Karmokar, & Whittington, 2015). Furthermore, these are socially constructed classrooms in which tiny communities of practice form as students collectively develop knowledge through their making (Green & Gredler, 2002).

Pedagogy and lesson design then must be extensions of the innovative learning environment. Bequette and Bequette (2012) stated that educators must, "Deploy pedagogy that encourages students to be curious, experiment, and take risks - key dispositions artist habits of mind engender" (p.46). As such, STEAM is often tied to problem and project based learning. Problem based activities are designed around an ill structured problem that requires students to apply multidisciplinary skill sets including design thinking, strategic performance, or procedural decision-making (Lu, Bridges, & Hmelo-Silver, 2014). Krajcik and Shin (2014) claimed that, "students can't learn During these tasks, students learn to leverage a series of thinking tools (Constantino, 2017) and develop collaborative skills relevant to the working world (Laoi, Motter, & Patton, 2016).

Organizational learning mechanisms. As the design of STEAM works against most organizational attributes that govern school structure, examining organizational learning mechanisms can illuminate how the system supports or hinders elements of STEAM implementation. The purpose of including an organizational lens in this article was to address the need to study the whole system alongside policy within the system. Shaked and Schechter (2013), in Hammond (2005), stated that: “Every phenomenon must be viewed from the perspective of the whole system to which it belongs as well as its subsystems and the relationships between its various components.”

As defined by Popper and Lipshitz (1998), Organizational Learning Mechanisms (OLMs) are, “institutionalized, structural, and procedural arrangements that allow organizations to learn non-vicariously, that is, to collect, analyze, store, disseminate, and use systematically information that is relevant to their and their members' performance” (Popper & Lipshitz, 2000, p. 185). These processes are further categorized as integrated or nonintegrated OLMs (Popper & Lipshitz, 2000). Schecter and Atarchi (2014) applied these concepts to the creation of the School Organizational Learning Mechanism Questionnaire that addresses the following: disseminating, storing, and retrieving information; sharing information with students and parents; analyzing and interpreting information; and using online information. Using these factor groups, the authors stated: “OLM assessment could provide schools with a means to monitor their implementation of widely adopted processes” (p. 601).

OLMs can be observed or perceived in multiple levels of a school system. Law, Yuen, & Fox (2011) stated that they can generally be observed through the classroom, school, and community lenses. The OLMs within each location thereby heavily influence collaborative decision making, shared belief systems, and mutual access to resources (Leithwood et al., 1998). As previously stated, STEAM requires collaboration, a mutual understanding of the arts value to STEM, and a leader’s ability to obtain resources.

This article draws upon research that outlines the known components of STEAM implementation and the types of organizational learning that could support STEAM's innovative tenets. As such, it is understood to this point that school leaders in charge of implementing policy must also understand the mechanisms which support policy acceptance, understanding, and evolution. Hsiao and Chang (2011) asserted that school principals and other leader are charged with promoting consistent learning to drive innovation. In the case of STEAM, this article is therefore concerned with whether the espoused implementation strategies of school leaders are supported by organizational learning mechanisms to reveal the extent to which implementation was fluid across the school system.

Methodology

This study used a convergent, parallel mixed methods design to answer the following research questions:

1. What is the process by which leaders of K-12 public schools of different socioeconomic groupings implement STEAM?

What does the examination of organizational learning mechanisms reveal about STEAM support systems from the perspective of teachers?

Setting. Six New Jersey K-12 public school districts participated in this study. Table 15 displays participant characteristics based on size, grade levels served, and socioeconomic status. Socioeconomic groupings in NJ are a ranked based on median household income from A (lowest) and J (highest). In obtaining socioeconomic information, inferences could be made regarding access to resources and the ability to innovate in more challenging educational climates. The districts also varied in size for exploring how STEAM is implemented in different scheduling constructs.

Table 15

School Setting Characteristics

District	Factor Group	Grades Serviced	# of Schools
District A	CD	K-8	2
District B	CD	K-8	2
District C	J	K-8	2
District D	FG	K-12	6
District E	FG	7-12	1
District F	DE	9-12	3

Sampling & participants. A criterion based sampling strategy (Patton, 2001) was used throughout the study. The criterion also required that participating school leaders have had at least two years of STEAM implementation underway. This allowed participants to discuss elements of change and time. Interview participants (n=16) were required to be school leaders directly involved with the STEAM process. As the person in charge of STEAM in each district varied, school leaders were defined as district level administration, building level administration, and teacher leaders heading STEAM implementation in an autonomous fashion. Table 16 provides an overview of qualitative participant characteristics.

Table 16

School Leader Characteristics

District	**Label**	**Role**
District A	A1	Teacher Leader
	A2	Curriculum Supervisor
District B	B1	Curriculum Supervisor
	B2	Building Principal
	B3	Teacher Leader
District C	C1	Building Principal
	C2	Teacher Leader
	C3	Building Principal
District D	D1	Teacher Leader
	D2	Departmental Supervisor
District E	E1	Teacher Leader
	E2	Curriculum Supervisor
District F	F1	Teacher Leader
	F2	Teacher Leader
	F3	Teacher

Survey respondents (n=75) included STEAM teachers (n=25), elementary classroom teachers from all schools responsible for incorporating STEAM (n=26), and non-STEAM faculty (n=24). School leaders did not participate in the survey as the purpose of the OLM survey was to understand whether espoused implementation strategies were supported by OLMs, which may be best understood through lens of district faculty.

Instruments & data collection. The qualitative strand included a semi-structured interview protocol that was designed using a framework by Wengraf (2001). Wengraf suggested that for the protocol to be more reliable, the researcher should not lead participants to confirm any theory or concept from the literature review. For this to happen, I created a series of theory based questions upon completion of the literature review, then reworded them inside of the protocol such that their presentation was general enough to promote responses unique to each participant. The protocol was organized into four factor groups: values and beliefs, curriculum and pedagogy, process and barriers, and professional development.

The quantitative strand used Schechter and Atarchi's (2014) School Organizational Learning Mechanism Questionnaire. The OLM Questionnaire measured 24 items in four factor groups using a Likert scale: disseminating storing and retrieving Information; sharing information with parents and students; analyzing and interpreting information; using online information.

Finally, curriculum documents were collected for exploring the implementation of the prescribed curricula. The final set of documents I collected included actual curriculum provided by school leaders or public curriculum documents stored on the district's webpage. Also, any other STEAM related documentation was requested (flyers to parents, STEAM fair brochures, etc.) so implementation outside the local school could be assessed.

Data analysis. This article is part of a larger mixed methods inquiry in which data analysis was guided by Teddlie and Tashakkori (2008). Analysis consisted of a four-step constant comparative process outlined by Teddlie and Tashakkori (2008): comparing incidents, integrating categories, delineating theory, and writing theory. Within these steps, codes were narrowed down during a process of analytic induction and a series of inferences were extracted. The discussion is a meta-analysis that synthesizes said inferences.

Survey results were analyzed in SPSS. Baseline descriptive and frequency statistics were run for the entire set of respondents (n=75). Then, descriptive and frequencies were run for comparable groups (socioeconomics and teaching discipline) to continue with the constant comparative method. One way ANOVA's were also used to understand any significant differences between comparable respondent groups.

Both quantitative and qualitative data sets were analyzed concurrently to maintain alignment with the convergent parallel design. The final step was to mix the data and converge findings to develop a series of inferences that revealed the processes used to implement STEAM and their supporting learning mechanisms.

Results

The five inferences below is supported with OLM data that show how strategies employed by school leaders are supported by mechanisms for continuous learning. In doing so, school leader approaches to STEAM implementation are viewed through both STEAM and organizational learning such that implementation is understood at multiple institutional levels.

Emergent implementation. Speaking to the structure and plan for change, participating districts revealed the occurrence of emergent implementation plans, meaning they did not report the existence overly prescriptive strategies. Five out of six public schools did not have a clear plan for changing curriculum, pedagogy, structure, or professional development at the onset of their STEAM implementation process. This was evident during discussions of many districts first year of implementation. Participant A1 stated, “They basically knew that we were creating ship while flying it and they [the school leadership] said take it a week at a time.” Participant B1 agreed in stating, “In the first few years, it [the STEAM program] was in vain only, but over the last few years, we have done a better job of embedding it into our system.”

While the programs were young and components were developing, participants still held planning meetings to discuss overarching objectives:

> Participant F1: In the infancy, we were trying to figure out the whole thing from the ground up. We had to figure out the components of the program. And then we also had two or three meetings with our central administration who were overseeing the whole program and determine what their expectations are for us. What are we going to do? How will we go about it? We tried to standardize it so our students all had the same expectations.

While Participant F1 suggested there were meetings between STEAM teachers and administrators to ensure a cohesive program approach, Participant F3 was adamant that many students still remained in the dark about certain elements of the STEAM program.

School leaders suggested new programmatic elements were emerging over time and the OLM data was used to show whether the district was reporting said change. Specifically, I examined whether curriculum change and major school projects were being published and reported to the faculty. This was important because I needed to understand whether emergent processes came with consistent information exchange.

Questionnaire item four, the reporting of curriculum and school projects, revealed that 63% of faculty members felt that curriculum reporting sometimes to always exists within their districts, suggesting the periodic alteration of the STEAM curriculum may be a part of this process. Furthermore, 72% of faculty members felt that published reports of school projects sometimes to always exists, meaning there is a mechanism available for communicating important projects across the organization, such as STEAM innovations. A rapidly evolving curriculum requires the consistent reporting of curriculum change to ensure practitioners have access to new content.

One Way ANOVAs revealed significant differences in both content area and socioeconomic respondent groupings. Questionnaire item one, published reports of school projects, showed STEAM teachers reported the highest mean response (3.00) which was significant at $p=0.019$ (alpha at 0.05). It can be understood that participating STEAM practitioners felt that their programs were supported by the consistent reporting of special projects.

Within the socioeconomic groupings Item four, curriculum reporting, revealed the lowest socioeconomic group CD only reported a mean response of 1.0 or “rarely exists.” The ANOVA found this statistic to be significant at $p=.00$ as compared to the higher socioeconomic groups. These results suggest the possibility that participating STEAM teachers may use the reporting of school projects mechanism more so than other departments, at least during implementation. The ANOVA suggests that curriculum reporting is scarce in the low socioeconomic group, which may hinder their ability to evolve their STEAM program.

The emergent implementation plans resulted in the four programmatic constructs shown in Table 17. The innovation labs and makerspaces were indicative of middle school models of implementation. Electives in many K-8 or 4-8 districts had students explore different elective areas on a rotation. STEAM became a part of that existing rotation. District B took a district wide arts integration approach by providing all teachers with relevant PD and influenced everyone to participate in STEAM. This plan culminated in a district wide STEAM fair in the spring. District F, a high school, created an after school academic activity in which students received credits for presenting capstone STEAM research projects at a local community college. Finally, high schools' D and E re-framed existing engineering and technology courses around STEAM principals and created a specific course sequence for interested students.

Table 17

Approaches to STEAM Programming

District	**Program Description**	**Grade Levels**
District A & C	Innovation labs and makerspaces. Some district wide arts integration.	K-8
District B	Whole curriculum arts integration and a common room for arts and STEM activity.	K-8
District D & E	STEAM course sequences inclusive of arts electives and traditional STEM	9-12
District F	Credit based, after school enrichment activity. Also includes a STEAM course sequence largely comprised of district AP offerings.	9-12

The innovation labs and makerspaces were indicative of middle school models of implementation. Electives in many K-8 or 4-8 districts had students explore different elective areas on a rotation. STEAM became a part of that existing rotation. District B took a district wide arts integration approach by providing all teachers with relevant PD and influenced everyone to participate in STEAM. This plan culminated in a district wide STEAM fair in the spring. District F, a high school, created an after school academic activity in which students received credits for presenting capstone STEAM research projects at a local community college. Finally, high schools' D and E re-framed existing engineering and technology courses around STEAM principals and created a specific course sequence for interested students.

Innovating standards. Interview participants suggested that their STEAM programs were either created for bolstering current standards practices or becoming more aligned to state standards in the future. It was mostly curriculum supervisors and building principals, who spoke to the value of integrating STEAM with existing standards.

> Participant B1: We look at the standards that we should teach across the different content areas, and based on the interests of the students, teachers and new opportunities that present themselves, we create modules, go out exploring, teachers' self-direct, so it's really about opportunity and what is available to us at any given time.
>
> Participant C3: We have to have something more concrete and comprehensive. That is why next year we are streamlining it to six, seven, and eight with a curriculum for each grade based around college and career readiness. Now we

have this document that can create more community buy in because we can say we are doing something mandated by the state.

Participant B1 and C3 drive home the importance of STEAM and standards alignment, as it is an important process for justifying STEAM and the time spent in STEAM learning environments to relevant stakeholders such as parents and BOE members.

While school leaders were involved in the standards alignment process, they were not necessarily involved in the planning of specific curriculum activities. One curriculum supervisor suggested:

> Participant E2: They [teachers] have a lot of autonomy, a lot of freedom, we call upon them to use their training and expertise...because I am not an expert in everything. I oversee the curriculum, but I can't tell a physics teacher when to teach what the physics teacher knows. I don't like to micromanage. So that is how the curriculum was developed.

A STEAM teacher leader suggested this type of autonomous curriculum approach is based on trust:

> Participant A1: The curriculum department has been very supportive and trusting that I would be hitting standards and do what I have to do. I feel I have done that.

A1 showed that while their administrators are concerned with accountability in the STEAM environment, they allow for A1 to have degrees of pedagogical freedom so long as standards remain at the core of STEAM activities.

The survey data below suggests that while more than half of teachers are experiencing the reporting of innovations, blending STEAM with standards adds another layer of complexity which would need to be effectively communicated across the organization. Furthermore, the ANOVA reveals that lower socioeconomic districts may be struggling to innovate based on lack of communication to teachers regarding change.

Item nine in the questionnaire, "the presence of innovation reporting," was used as the organizational lens for this inference. Item nine probes whether participants are regularly aware that reports of new innovations are disseminated. Frequency analysis revealed 64% of respondents felt that innovation reporting did exist, within a range of sometimes to often. A one-way ANOVA was used to compare responses based on socioeconomics. The lowest group, socioeconomic CD, reported a lower prevalence of innovation reporting and was significant at $p=.00$ (alpha at .05).

Marketing & partnerships. Secondary document analysis revealed clear attempts to brand each district's STEAM program through the school website and local print and web publications. The most developed example of this approach was District C's "Innovation Lab" web portal which expresses the following mission statement:

> Participant C3: The Innovation Lab is where 4th and 5th graders learn the skills they'll need to be successful in the world of tomorrow. Students are introduced to design thinking, engineering, computer science, and the digital arts as they learn to reframe failure as iteration and become the architects of their future.

This mission statement is essential to the analysis of implementation procedures, as it clearly shows the value of arts integration within the innovation process. Specific curriculum modules communicated to the community include: problem based "gizmo" creations, environmental innovation focused on organic growing methods, and business innovation for 7th and 8th graders. These modules helped the district obtain "Innovate

NJ" statues from the New Jersey Department of Education as well as secure partnerships with Real World Scholars, Rutgers University, and Gaylor CNC Solutions.

Other districts were more focused on engaging community for curriculum development and faculty professional development. For example, two districts developed partnerships with local and national theater organizations:

> Participant C1: We have an incredible partnership with the Count Basie Theater and the Kennedy Center for the Arts...teaching artists from these organizations come and model arts integration lessons to which the teachers then make their own extensions of the lessons for our school.

High schools used partnerships to enhance curriculum modules in engineering and architecture:

> Participant E1: We have been talking to this building that has been going up in Weehawken so we could check out their engineering and architectural process and approach. They talked a lot about models, showed us their blueprints...it was a really great experience for our engineering team.

Also speaking to high school partnerships, Participant E2 stated, "my friend works for NASA and was around. She did a week of lessons on aeronautics, planes, and flight. If that's something we can pull in at the time, regardless of whether it happens to be mapped out at that particular time." Both E1 and E2 sought out relevant learning modules that could be enhanced by local community partners.

The extent of community outreach, through branding and partnership building, was far reaching. From the organizational earning perspective, it was equally strong. Beginning with the mechanism for communicating information to community members, the OLM questionnaire revealed through frequencies analysis that 98.7% of faculty members reported that the district website is “sometimes” to “always” communicating academic achievement information and activities to parents. 66.7% of these faculty members reported that this practice “always exists.” There were no significant ANOVA findings, showing that community engagement was heavily regarded across the board.

Top down support. Many participants spoke to the top-down strategies employed by their districts. Top down support in these instances meant that superintendents and other school leaders were directly involved in the choice to implement STEAM in the district. Superintendents and principals, by way of wanting to engage a larger network of community members, spearheaded STEAM implementation through vision, budgeting, and the hiring of staff. When speaking to the importance of superintendent and principal support, Participant C3 suggested, “the difference is that in a school where the leadership sets the tone in terms of what they are looking for in innovation and creativity...would then drive more of that activity.” Similarly, Participant A1 spoke to the passion behind their superintendent’s desire to bring more design based thinking to the school district, “the leadership sat at the table and would figuratively smash their hand down on the desk saying, ‘We need this. Design is what matters.’”

Participants referenced school leaders taking a hand in program development, assessment, the creation of vision, and networking. Revealing clear school leader involvement in STEAM implementation is crucial to showing its impact on whole school culture. One curriculum supervisor was directly involved with looking for ways to help teachers and students innovate using technology:

> Participant E2: I try to find innovative ways to hire people, give PD to the staff, I try to find innovative ways to have teachers revise curriculum and curriculum related things. Currently I am researching ways to bring virtual reality to the district next year and have the teachers be comfortable fusing it into all curriculum, departments and disciplines within grades 5-8.

E2 was one of the only participants to discuss the need for innovative professional development as a logical accompaniment to the implementation of innovative STEAM learning environments. Other districts did seek out teaching artists, but they did not specifically cite the importance of innovation.

The most prominent organizational mechanism used to "check in" on implementation is the staff meeting. 87.9% of respondents reported implementation of school decisions within a range of "sometimes exists" to "exists often." Speaking to the communication of vision, 77.3% in a range of "sometimes" to "often" felt that vision was addressed in school meetings. One way ANOVA results, using an alpha of .05, showed a significance at p=.000 and p=.04, which continued the trend of group CD reporting a lower prevalence of OLM's.

Moderate organizational learning presence. Schecter and Atarchi (2014) identified four categories for organizational learning in schools. Using grand means, a "score" was generated for each category. Using a Likert scale, 0=never exists, 1=rarely exists, 2=sometimes exists, 3=exists often, and 4=always exists. The results are as follows:

- Disseminating, Storing, and Retrieving information = 1.90
- Analyzing and Interpreting Information = 2.54

- Communicating Information to Students and Parents = 1.97
- Using Online Information = 1.79

The purpose here is to show the full organizational influence on STEAM implementation. With three out of the four mechanisms operating in a range of rarely to sometimes exists, the state of organizational learning in the participating districts certainly has room to improve. The highest mechanism, analyzing and interpreting information, may be the result of increased accountability measures in the state of New Jersey. But, given the amount of policy focus on accountability, one would expect that number to be much higher.

While the overall prevalence of organizational learning was low, it does not suggest the districts were completely void of using mechanisms to directly influence their STEAM initiative. The participating supervisor, participant D1, suggested that when the administration looked at data on their graduates, 40% were going to four year colleges, 40% were going to two year colleges, and 20% were immediately entering the workforce. STEAM was a means to respond to this data in meaningful way:

> Participant D2: We wanted to become a more comprehensive high school...for a long time we were serving our students who focused on taking AP courses and focused our efforts on raising SAT scores...when we looked at that 60% who wasn't immediately entering a four-year college, we decided we wanted to do something drastically different.

Participant D2 applied a clear organizational learning approach to developing a STEAM program using post-secondary data analysis.

Similarly, District B threaded STEAM curriculum development throughout their

PLCs, allowing teachers to take charge in the creation of new STEAM activities, while also giving administrators the chance to observe the process. Based on these data, school leaders did employ OLMs through post-secondary data analysis and PLC integration. Furthermore, three of the districts held STEAM fairs and created STEAM sections on their school websites, which is a clear line of communicating with students and parents. It is possible the quantitative data in this instance does not completely explain the implementation efforts taken by participating school leaders.

Meta-Inference

Figure 5 shows the resulting meta-analysis framework of this study. Teddlie and Tashakkori (2008) suggested that this is the final stage of mixing in which the researcher considers the distinct inferences and "addresses the degree to which a MM researcher adequately integrates findings, conclusions, and policy recommendations gleaned from each of the study's strands" (Teddlie & Tashakkori, 2008, p. 312). As such, this meta inference is focused providing clear policy implementation advice for school leaders interested in STEAM.

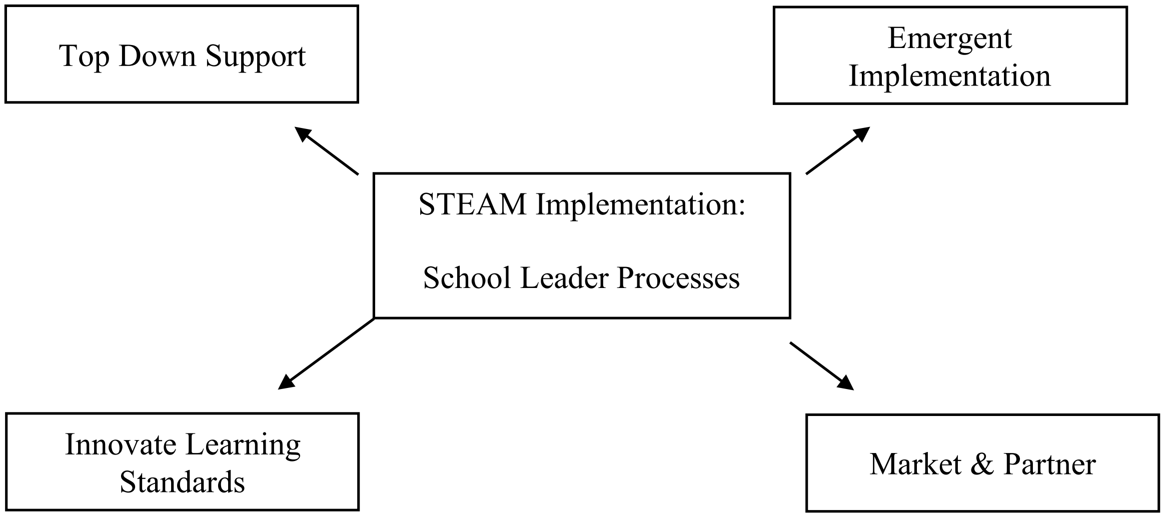

Figure 5. Leadership Processes for Socially Constructed STEAM Implementation

Based on the data, school leaders in this study showed that STEAM implementation was an emergent process that developed over time. The participating districts understood that STEAM was a relatively new learning construct, but showed a willingness to jump in without a predefined approach. Curriculum designers tied STEAM learning to state standards to legitimize the process. The programs were marketed in innovative ways which lead to fruitful learning partnerships with private organizations.

This study showed that STEAM was socially constructed, as very few of the program components were the result of meticulous prior planning or research. From the top down, the participants in this study wanted to take risks, create an autonomous system for innovation, and do so while stressing important learning standards. These decisions were developed in a whole system manner and at times supported using organizational learning mechanisms.

Discussion

In this article, STEAM was framed as a socially constructed response to STEM. STEM implementation comes with prescribed standards and an abundance of formal policy guidance. To the contrary, STEAM has very little prescriptive language guiding school leaders and this study showed their processes of innovative implementation. School leaders considered the implications of STEM learning and decided their local contexts would be unsuccessful without the presence of the arts. They also did so in lieu of limited data supporting its effectiveness in STEM (Ghanbari, 2014).

Research question one explored the process by which leaders of K-12 public schools of different socioeconomic groups implemented STEAM. The converged data showed that the participants' processes were emergent, marketed to the public, relied on partnerships for learning, and remained rooted in standards based education. Furthermore, the participating STEAM programs received a great deal of top-down leadership support. Socioeconomic status was not a major factor when considering leadership process.

The research addressed the importance of school leader support in arts integration policy (Wong, 2013; Miksza, 2013; Lackey & Huxhold, 2016; Purnell, 2004). If one asks teachers to continuously think outside the box and, in turn, expect students to develop the capacity to think outside the box in STEAM scenarios, school leaders must support those endeavors by eliminating pressures, allowing the process to unfold gradually, and being present throughout the process. The data showed this to be relevant through the presence of the emergent implementation plans, emergent curriculum design, and top-down support of STEAM. Harding (2013) suggested that it requires creative school leaders to mitigate the risk of the unknown and ultimately decide if action is necessary. While being less prescriptive and more improvisational may be unfamiliar to school leaders, these participants seemed to invite uncertainty.

To the contrary, allowing for emergent implementation and uncertainty without systems for continuous learning is dangerous. Hsiao & Chang (2011) argued school leaders are responsible for providing resources for professional learning to drive organizational innovation. If leaders promote an emergent plan, but do not provide mechanisms for rendering a successful path, then the organization is not contributing to the social construction of new policy. Certainly, the people are most important to social construction, but the organization itself continues to play a role.

Research question two examined OLM support systems from the perspective of teachers in the participating districts. This question revealed an impact based on socioeconomic status, as the lowest socioeconomic districts reported the least amount of interaction with OLMs. While organizational learning was not abundant overall, it was still more prevalent in the higher socioeconomic settings. Research showed the importance of organizational learning to the sustainability of new policy, suggesting STEAM in the participating districts could be at risk. It is also noteworthy that a process as emergent as the ones revealed throughout the study was not accompanied by stronger organizational learning.

It is possible sustainability was addressed through the connection of prescribed standards and STEAM. Many participants ensured that STEAM was a method of fulfilling standards based practices. Much like Kuhn (2015) tied STEAM to NGSS, this study showed STEAM being tied to technology, career, and science standards reforms.

Furthermore, engaging the community in the process and securing educational partnerships may have supplanted more traditional sustainability strategies, as involving the surrounding community in the innovation process can build a larger coalition of support for STEAM. Miksza (2013) asserted that obtaining resources was directly correlated to the school leader's involvement in arts integrated programs, thus sustainability is directly tied to the school leader remaining involved in the emergent STEAM process.

Finally, school leaders affirmed many of the curriculum strategies commonly associated with STEAM. The participants addressed the desire to have students master their own thinking through ill structured, problem based learning designs (Lu, Bridges, & Hmelo-Silver, 2014). They also expressed the need for more conceptual thinking across the disciplines such that the students could begin to make relevant life connections (Krajcik & Shin, 2014). Professional development was one of the important components a posited by Purnell (2004) and was satisfied in this study through both PLC inquiry and partnerships with arts organizations. More research would need to be done regarding the quality of these experiences from the perspective of STEAM teachers.

Conclusion

The five inferences in this study contain implications for school leaders because the data showed the participating administrators were involved in all aspects of the STEAM implementation process. The school leaders helped monitor and evolve the curricula, ensure the focus remained standards based, provided direct support by espousing top down support, and implementing practices across the district that promoted professional learning. In a purely quantitative sense, the presence of OLMs was not abundant, but as the data showed, school leaders addressed learning by partnering with outside organizations, promoting their efforts online and in person, and using data to drive STEAM's focus in the community. Future research should continue build a more focused framework for STEAM implementation, continue to develop evaluation methods, and study the STEAM learning environment to begin understanding the student innovation process.

Chapter 6

K-8 vs. High School STEAM Implementation

STEAM exists at the intersection of increased STEM education policy and the constructivist outcry for more art and design in public school curricula. As such, schools grapple with how to implement integrated STEAM and determine best practices. Since 2015, numerous authors have explored STEAM across K-12 contexts rendering a more refined image of STEAM in practice (Magerko et al., 2016; Connor, Karmokar, & Whittington, 2015; Cook, Bush, & Cox, 2017; Herro & Quigley, 2016; Xi at al. 2015). While the knowledge base is growing, opportunities exist for comparative perspectives on how STEAM serves students of different ages. Thus, this article compares the STEAM curriculum implementation strategies of high school vs. K-8 school leaders.

The ways in which curriculum designers apply STEAM in context has been of special interest to researchers as of late. Xu, Dirk, & Spector (2015) created one of the most comprehensive treatises on STEAM education, exploring the integrated framework through the lens of each discipline. In their chapter on moving STEAM research forward, the authors suggested:

> Our research needs to continue to examine the impact of these various mindtools on STEAM education, for example, the cognitive and metacognitive functions of each type of tools, and in what ways, under what conditions, and during which learning processes each tool provides support for knowledge representation, argumentation, problem solving, and metacognitive processes.

Xu et al.'s (2015) call for research seemed to suggest that the knowledge based must become more specific regarding the methods, learning modules, and conditions applied to practice. Exploring curriculum approaches can be an effective means of doing so and thus continue to expand the understanding of STEAM's impact on 21st century students. But, STEAM often exists as a less prescriptive, living curriculum venture, that emerges and develops over time. For these reasons, this analysis of STEAM curriculum will explore both the prescribed and emergent design qualities of K-8 and high school contexts.

Dongryeul and Bolger (2017) suggested in their most recent work on STEAM and pre-service teachers, "one of the most important factors in successful implementation of curricular reform is teachers' confidence in their ability to enact change" (p. 601). Confidence is a product of being comfortable and experienced with a series of actions. In schools, the curriculum prescribes concepts and actions, thus allowing the teacher to implement learning standards with greater self-efficacy. An emergent or living curriculum is inherently less prescriptive, meaning STEAM practitioners must leverage other learning mechanisms to develop structure and confidence. Thus, this study will also examine organizational learning mechanism's that address the ongoing distribution, storing, interpretation, and analysis of new information (Popper & Lipchitz, 1998; Schechter & Atarchi, 2014).

As part of a larger convergent parallel mixed methods study on the systematic implementation of STEAM through the lens of organizational learning, 16 school leaders were interviewed and 75 teachers were surveyed across three K-8 and three high school districts. The following data was extracted from that study to

- Goals and learning modules within prescribed or living curriculum documents
- Structural elements pertaining to scheduling and learning environments

- Differences between grade level contexts
- Organizational support for innovating curriculum and pedagogy

This study applied the following research questions:

1. What is the process by which STEAM is being implemented within K-12 public schools?
2. What does the Organizational Learning Mechanism Questionnaire reveal about the curriculum and collaborative processes from the perspective of teachers engaged in STEAM?

Review of Literature

Theoretical framework. The understanding of curriculum implementation requires an understanding of both the theory and practice of the curriculum under investigation. In theory, STEAM is a constructivist education movement in which research has espoused its ability to instill greater economic potential for creative students (Xi et a., 2015), focus learning on making and innovating (Park & Ko, 2012; Patton & Knochel, 2017), and ensure students learn to solve problems with a sense of civic duty, ethics, and empathy (Clark & Button, 2011; Xi et al., 2015).

In practice, the STEAM curriculum has been paired with problem based learning strategies, which, require students to meta-cognate and synthesize their understanding of many disciplines when addressing an ill structured problem (Quigley et al., 2017; Krajcik & Shin, 2014; Lu, Bridges, & Hmelo-Silver, 2014). While practitioners can combine the STEAM disciplines in any number of ways, many of the current empirical examples of STEAM in practice show that districts are using STEAM to bolster technology integration (Herro & Quigley, 2016), provide avenues for student choice (Herro &

Quigley, 2016), and provide more engineering experiences (Karmokar, & Whittington, 2015).

With so many prospective changes in play, both individual and organizational in nature, the STEAM curriculum may require Organizational Learning Mechanisms (OLMs) to help with the access, distribution, and analysis of new curriculum information. Schechter & Atarchi (2014) adapted original OLM theory from Popper & Lipchitz (1998) and created a questionnaire aimed at understanding whether practitioners experience support mechanisms for various school initiatives. Schechter & Quodach (2012) had previously suggested that OLMs are important considerations when studying curriculum implementation, as there is always a need to study the larger system at work.

STEAM in theory. STEAM, in theory, is rooted in the idea the synthesis of STEM subjects and the arts will catalyze innovation in teaching, learning, and the future of society. Sade (2014) quoted Joseph Fry in their discussion of STEAM, stating that, "...we are designed by, and design within, the designed world, and that our designs continue to design long after leaving the drawing board, studio or laboratory" (p. 30). Thus, the inclusion of the arts and design thinking act as fulcrums to which all STEM subjects may be applied to the outside world.

Curriculum classification. Many discuss STEAM in the context of being an arts integrated curriculum. Parsons (1998) suggested the integrated curriculum has historically been a response to segregated discipline models which sometimes ignore more complex, multidisciplinary patterns of inquiry. Arguing that learning is not a linear process, Parson's stated that arts integrated models are "imprecise, multilayered, volatile, always in process of translation, never precisely fixed meaning, and as always a constituent of art" (Parsons, 1998, p. 103).

This idea that an arts integrated curriculum model is volatile and never a fixed version of itself suggests that STEAM may be more of a living curriculum. Learning objectives that are written down and directed represent the prescribed curriculum model. Consequently, the living curriculum is not a fixed model. Magrini (2015) suggested that the living curriculum attempts to "engender experiences that will assist students in becoming self-directed learners" (p. 290). Thus, the curriculum is concerned more with the ontology of possibility over actuality (Margrini, 2015). Wolff (2013) argued that the contemporary living curriculum should be perceived as an "event in the making" in which one person (teacher-student) or thing (prescribed curriculum) is in control of the event. Instead, it is a cause and effect relationship between all parties whom must constantly consider not what is, rather what could be (2013). Therefore, STEAM may situate teachers and students to experiment with new interdisciplinary tools with great autonomy; making an overly prescriptive curriculum difficult to create.

Economic potential. Innovations, in education or business, often drive economic visions for the future. Yet, many times creative skillsets are left out the discussion of what is most important to the innovation process. Wynn & Harris (2012) asserted that the scientific community has continuously promoted a quantitative bias, which, has suffocated the career projections of many creative thinkers. STEM is frequently concerned with the creation of products and in many instances, it is the aesthetic intangibles that dictate success in the world of innovation (Xi et al., 2015). Similarly, Newton & Newton (2014) argued that creativity is emerging as our greatest natural resource for solving local and global problems, thus increasing their economic footprint in 21st century society.

***Innovation*.** For economic projections to come to fruition, the practice of innovation and the use of creativity must occur prior to individuals entering the workforce; meaning the education must require students to innovate in the classroom. Educational innovation occurs in many levels including curriculum, pedagogy, and student creativity. Curriculum innovation, the focus of many STEAM models, is a process in which teachers experiment with new tools, resources, or conceptual frameworks to create new lesson strategies (Goatley & Johnston, 2013). At the student level, STEAM is often realized using collaborative, multimodal discourse that situates experience, reflection, and discovery in every student experience (Tomlinson-Clark, 2014).

***Civic responsibility & ethics*.** Finally, some suggest STEAM may improve students' sense of civic responsibility, ethics, and values (Xi, et al., 2015). Clark and Button (2011) asserted that, "The arts promote cultural change, trigger the imaginative conscious and community action, and act as a bridge towards scientific understanding and the application of sustainable efforts" (p. 43). Students experience these tenants within problem based learning activities, which, allows students to understand their place in the society at large by developing metacognitive skills, procedural knowledge, relevant problem analysis skills, and collaborative learning skills (Krajcik & Shin, 2014; Lu, Bridges, & Hmelo-Silver, 2014).

STEAM in practice. The theory surrounding STEAM's purpose and function in contemporary schooling must be compared to empirical accounts of STEAM in practice. Addressing theory to practice is essential to understanding whether theories of STEAM's place in education is filtering into prescribed curricula. The following research studies address some of the most contemporary accounts of STEAM in K-12 practice including design elements and examples of STEAM teaching and learning from empirical sources.

Curriculum design. The design of STEAM at the curriculum level often involves a series of considerations that stem from prior research on best practices in STEAM. Quigley, Hero, & Faiza (2017) studied the domains, dimensions, and criteria of STEAM teaching and concluded that problem based deliveries, discipline integration, and a focus on acquiring problem solving skills should largely account for prescribed instructional content. Within these domains, the authors suggested the development of cognitive skills, interactional skills, creative skills, and discipline synthesis, among other criteria, should also guide the design of STEAM instructional content (Quigley et al. 2017). In context, the instructional content should in turn promote rich student inquiry, reflection, consistent feedback, student choice and relevancy, and among others, an appreciation for diversity (Quigley et al., 2017).

Much of the discussion of STEAM pedagogy and curriculum implementation comes from studies done within the Korean school system, who have been leaders in integrated STEAM learning since 2009 (Dongryeul & Bolger, 2017). Most relevant to this study, Park & Ko (2012) suggested a series of guiding principles for STEAM curricula to develop (the types of guiding principles suggested earlier by Margrini, 2015):

1. How should the disciplines should be combined or fused in such a way that they do not disrupt the importance of current curriculum goals?
2. Instill the need for creative and diverse thought processes which apply basic theories to synthesized engineering or technology goals
3. Creative and diverse thought processes require the use of creative tools, pedagogies, and experiment designs
4. Focus on the need to realize the bigger social picture; "see the forest along with the trees" (p. 323)
5. Adapt to rapidly changing technologies
6. Predict future social, political, environmental, and economic needs through integrated and creative thought processes
7. Ensure that future scientists and engineers become a product of STEAM and manifest strong ethical, social, cooperative, leadership, and communicative values.

Park and Ko (2012) seemed to carry heavy weight in consistent technology integration and adaptation, promoting diverse thought processes and creativity, and developing some of the social and ethical principles previously discussed in the literature review. Other authors also discussed frameworks for implementing STEAM (Bequette & Bequette, 2012; Kuhn, 2015; Shaffer, 2013; Wynn & Harris, 2012), but in more recent literature has focused on the specific lessons or curriculum models applied in context which has been integral in understanding how practitioners are applying the tenets of STEAM.

Some research has taken a more simplified approach to designing a STEAM curriculum. Patton and Knochel (2017) for instance described the STEAM curriculum as being part of the current maker movement in education. The authors suggested that the DIY movement in STEAM can be understood through the following: (1) stuff - "the knowledge ability to create conceptual or material objects" (p. 38), (2) sharing - allowing students to access communal hubs of information or tools, and (3) connection - collaborative making or the sharing of ideas to develop a community of practice (Patton & Knochel, 2017). These concepts are most commonly seen in STEAM models such as makerspaces or innovation labs, which, in many districts, have taken over traditional libraries.

K-8 STEAM. Herro and Quigley (2016) compared science driven approaches of three different practitioners in various grade level contexts. In one elementary setting, teachers were using problem based learning modules to explore concepts such as earthquakes, organic food distribution, and creating new animal ecosystems at the local zoo. Students in each of these scenarios employed art and design to create topographic models of their local community, construct vegetable gardens on the school campus, and Skype with local zookeepers about designing habitats for new animal species (Herro & Quigley, 2016).

In a separate study by Herro and Quigley (2016), the authors interviewed 21 STEAM teachers about their use of technology integration, student choice, and arts integration. Some of these activities included allowing students to invent their own 3D models of energy efficient buildings, exposing students to 21st century technology platforms such as Edmodo and GIZMO's, and allowing students to innovate new ways to play their favorite games (for example on student designed glow in the dark NERF ammo so him and his friends could play “NERF Wars” at night (Herro & Quigley, 2016). While the authors found that student choice and technology integration were major components of their STEAM learning designs, the use of artistic expression only occurred in 10 out of the 21 lessons (Herro & Quigley, 2016).

Engineering is a seemingly natural intersection of all STEAM disciplines. Connor, Karmokar, & Whittington (2015) argued that while engineering pedagogy at face value promotes the synthesis of these disciplines, many classroom strategies suffer from the same discipline egocentrism felt in other areas of study. These authors suggest that in practice, engineering education works best when it employs more of a studio arts and design thinking approach to organically call upon integrated STEAM. In one example of this strategy, Cook, Bush, & Cox (2017) described a STEAM approach with elementary school students in which they were tasked with designing roller coasters. The teachers used Walt Disney as a model STEAM practitioner and guided the students through the initial process of designing a roller coaster, discussing their design with a safety and park planning expert, and going through a revision and reflection phase.

High school STEAM. To this point, the above STEAM approaches were presented in the context of elementary and middle school contexts. Less research exists describing STEAM’s footprint at the high school level. Magerko et al. (2016) described the use of EarSketch software to improve access to computer science education amongst underrepresented populations. The software used digital music composition and arranging protocols, often found in platforms such as Garageband and Protools, to explain concepts such as coding and the design of digital environments. In using a relevant intermediary such as music, the student population increased their motivation and enjoyment of computer science, as well as their sense of belonging to digital communities (Magerko, et al., 2016).

Organizational learning. The implementation of new curriculum, especially one that is highly interdisciplinary and innovative, must have an extension of practice associated with teaching practitioners to work within the new framework. One lens to study this extension of practice is that of organizational learning (OL). Both Daft and Weick (1984) and Argyris and Schon (1974) described OL as much more than a quest for knowledge acquisition, rather they suggested OL is the point in which individuals act based on newly acquired information. Silins, Mulford, & Zarins (2015) argued that in schools, acting on new information commonly occurs as a social process, in which all school personnel share information to influence changes in practice.

One means of studying OL in schools is to address the concept of organizational learning mechanisms (OLM's). Originally discussed by Popper and Lipshitz (1998), OLM's are a means of collecting, analyzing, storing, and disseminating information relevant to improving or changing job performance. Schechter and Atarchi studied OLM's in multiple school contexts and argued that, "to keep pace with dynamic and uncertain environments, schools should develop collective learning activities and processes (i.e., OLMs) that can foster faculty's new and diverse knowledge bases and nurture faculty's shared belief in its capabilities" (p.578).

OLM's have also been used to study elements of the creative climate in workplace. Given that STEAM remains a young field of study and many districts lack formal guidance, practitioners must circumvent those barriers with creativity. Cirella, Canterino, Guerci, and Shani (2016) argued that, “creativity is not (only) about ‘creative individuals’, but is an organizational competence that can be improved upon or hindered by organizational learning mechanisms” (p. 221). The authors also argued that structural mechanisms are equally important in understanding creative climates, as they specifically show how creativity is supported through the sharing and integration of knowledge across an organization (Cirella et al., 2016). Thus, studying the mechanisms which support the implementation and integration of the arts and STEM can aid in promoting the type of creative climate necessary for teachers to use the arts in innovative ways.

The school curriculum is one place where many OLM’s have an effect. Using the organizational learning cycle described by Schechter and Qudach (2012), curriculum reform and implementation requires school leaders and teachers to:

- Acquire new information to reform and revise curriculum
- Distribute and share curriculum change with relevant stakeholders
- Interpret and articulate curriculum change to improve collective understanding
- Commit the new curriculum to organizational memory

Incorporating OLM’s into a study of STEAM curriculum implementation is important because STEAM requires teachers to share a great deal of knowledge about their disciplines to effectively design new learning modules that in turn require new types of interdisciplinary, multidisciplinary, and/or transdisciplinary pedagogy. It is thus important to understand the ways in which the school district supports these actions through the study of relevant OLM’s.

Methodology

This study featured a convergent parallel mixed methods design, meaning both the qualitative and quantitative data sets were collected and analyzed concurrently. Teddlie and Tashakkori (2009) described mixed methods as dialectical, meaning the compatibility and ability of the qualitative and quantitative strands to build on each other's strengths provides the opportunity for contemporary analysis strategies. As such, a constant comparative framework was used to analyze data from the Organizational Learning Mechanism Questionnaire (Schechter & Atarchi, 2014) and a semi structured interview protocol. The mixing of data from these two sources generated this study's inferences, which, focus on curriculum and classroom level implementation of STEAM. Each inference is coupled with an analysis of relevant OLM's that support said implementation efforts. The entire design of the study was vetted using Teddlie and Tashakkori (2009) Integration Framework for Design Quality which included considerations of: design quality, fidelity, within-design consistency, and analytic adequacy.

Public K-12 institutions in New Jersey were chosen as the setting for this study. Using a criterion sampling method, institutions were chosen based on the merits of their current STEAM efforts. To participate, the school had to be at least two years into their STEAM efforts so interview participants could appropriately discuss elements of change. The setting included three K-8 districts, two K-12 districts, and one 7-12 district. Participating districts were also chosen based on their socioeconomic status. Socioeconomic groupings in NJ are rated from A to J; A being the lowest and J the highest median family income. Two districts fell into factor group CD, two in DE, one in group FG, and one in group J. Setting characteristics allowed for comparisons in grade levels served, district size, and socioeconomic status.

Sampling & participants. Interview participants included school leaders within the participating districts who had direct knowledge of STEAM implementation. This included a cross section of principals, curriculum supervisors, and teacher leaders who were given the autonomy to implement STEAM without direct administrative involvement. Two participants were interviewed within each of the districts and snowball samples were also collected in the event an interview participant felt a third party had relevant knowledge. Total participants in the qualitative strand was n=16. Table 18 provides an overview of qualitative participants.

Table 18

School Leader Characteristics

District	Label	Role
District A	A1	Teacher Leader
	A2	Curriculum Supervisor
District B	B1	Curriculum Supervisor
	B2	Building Principal
	B3	Teacher Leader
District C	C1	Building Principal
	C2	Teacher Leader
	C3	Building Principal
District D	D1	Teacher Leader
	D2	Departmental Supervisor
District E	E1	Teacher Leader
	E2	Curriculum Supervisor
District F	F1	Teacher Leader
	F2	Teacher Leader
	F3	Teacher

Survey participants were given the OLM Questionnaire (Schecter & Atarchi, 2014) through a Google Form. Participating school leaders sent official emails to their faculty requesting they participate in the optional study. Survey respondents fell into three categories: STEAM teachers (those in charge of innovation labs, makerspaces, or others whose sole role was STEAM), elementary classroom teachers involved in STEAM (those who have alternate responsibilities along with STEAM teaching), and non-STEAM faculty. Total participants in the quantitative strand was n=75.

Instruments & data collection. A semi structured interview protocol (Appendix A) was created using a development framework by Wengraf (2001). Through topics discussed in the original literature review, theory based questions were developed relative to the research questions. Wengraf (2001) explained that, “the theory-questions ‘govern’ the production of the interviewer-questions, but the TQs are formulated in the theory-language of the research community, and the IQs are formulated in the language of the interviewee” (p.4). Questions were organized in four factor groups related to STEAM implementation: (1) beliefs and values, (2), curriculum and pedagogy, (3) process and structure, and (4) barriers. Participants sat for each interview either in person or over SKYPE. Informed consent forms were distributed prior to the interview and all interviews were recorded.

The Organizational Learning Mechanism Questionnaire (Schecter & Atarchi, 2014) was transferred to a Google Form and distributed through participating school leaders (Appendix B). The instrument contained 24 items within four factor groups: (1) disseminating, storing, and retrieving information, (2) sharing information with students and parents, (3) analyzing and interpreting information, and (4) accessing online information. These factor groups were originally discussed by Popper & Lipshitz (1998) and adapted for use in public schools by Schechter & Atarchi (2014). The factors were subject to both exploratory and confirmatory factor analysis, each showing a reliability alpha of .75 or higher (Schecter & Atarchi, 2014). An informed consent was included at the top of the Google Form and participants were asked to “agree” or “not agree” to the terms of the study.

Curriculum and lesson documents were also collected. Participants were asked to submit any implementations documents relevant to the study’s research questions. These documents were either distributed as hard copies, emailed, or listed on the district websites. Due to the amount of promotion surrounding the STEAM efforts of participating districts, much of the information, including curriculum, was published on the district websites.

Data analysis & inference quality. It is suggested that data analysis in a convergent parallel MM design be concurrent (Teddlie & Tashakkori, 2008). In conjunction with a constant comparative method of analysis, survey results and interview responses were constantly coded, memoed, and compared across the QUAL-QUAN spectrum to ensure resulting inferences were products of mixed analysis strategies. The inferences were also vetted using Teddlie & Tashakkori (2008) inference quality framework which included the following considerations: interpretive consistency, theoretical consistency, interpretive agreement, and interpretive distinctiveness.

Qualitative data, including interview transcripts and secondary documents, were analyzed using analytical memos and document coding. Consistent with constant comparative methods and the process of analytic induction, Merriam (2009) suggested a three-step coding procedure: (1) open coding - a meaningful set of initial labels, (2), axial coding - identifying relationships and themes, and (3) selective coding - determining a group of rich and robust inferences about STEAM curriculum implementation and organizational learning mechanisms. Codes and memos were compared across cases to show differences based on context and participant characteristics.

Quantitative data was analyzed in SPSS software. Descriptive and frequency statistics were run to understand baseline information regarding the respondent group. Then, One Way ANOVAs were used to compare respondents based on their relationship to STEAM (singular STEAM teacher, STEAM elementary teacher, or non-STEAM teacher). Each statistical output was then compared to incidents within the interview and document data to show how OLM's were supporting the espoused beliefs or prescribed actions of the qualitative participants.

The data in this article was extracted from a larger set of inferences on STEAM implementation. Related to the interviews, data was extracted largely from the questions pertaining to curriculum and pedagogy. Similarly, many of the OLM data discussed was extracted from the disseminating, storing, and retrieving factor group and analysis factor group.

Results

The ensuing results compare data between participating K-8 and high school districts. The curricula for each district, both prescribed and verbal accounts, were converged with elements of the OLM questionnaire to reveal the curricular scope and sequence from K-8 to high school settings.

K-8 contexts. K-8 districts were similar in their positioning of STEAM as a special elective. These electives were often defined as makerspaces or innovation labs in which STEAM was the primary learning construct. The districts also used problem based pedagogies and made a priority out of exposing students to 21st century technology, all while maintaining a focus on standards learning.

STEAM special electives. Districts A and C treated STEAM as a "special" elective. Each of the three schools rotated different students on a weekly basis into the STEAM labs, much like they would with art and music. In this way, the STEAM curriculum was delivered as an enrichment program students specifically focused on the constructivist side of learning. Both districts developed traditional "makerspaces" and tailored learning modules to expose students to different digital and technological skill sets.

> Participant A2: The motivation was to do things differently and the principal had enough confidence in me to do it from scratch, so we created a program that was very unique in regard to what it teaches and how. We turned the computer lab into a full on makerspace, which is easily the coolest room in the school....we have four 3D printers, laser cutter, fabric cutter, technology that most people wouldn't even go near or integrate in a meaningful way. So, we have turned the classroom on its ear so to speak.

A2 stressed the importance of the room being "cool" due to its ability to expose students to new types of technology. This may suggest that STEAM learning environments are being tasked with teaching technology beyond that of a computer.

While STEAM did occur mostly in learning siloes, District C's elementary school worked hard make arts integration and STEAM more of a school wide initiative.

> Participant C1: We worked out to really integrate it across all different special areas….so it (STEAM) wasn't just a stand-alone thing. We did a big unit on Di

> Vinci with everyone in the school and everyone had a piece of it. One group had sculpture, one had everything with visual arts, etc.

The school wide projects discussed by participant C1 showed that while STEAM was positioned as a special elective, there were still opportunities for teachers to integrate STEAM in their respective classrooms.

District B made more of an attempt to integrate STEAM across the curriculum. The curriculum director spoke about the creation of interdisciplinary PLC's and reforming their PLC model to develop a series of arts integration lessons for each class. In letting teachers create their own interpretations of STEAM through the PLC's, the curriculum was a teacher driven process:

> Participant B1: We have changed out PLC schedule. It used to be grade level based and now we have a combination of grade level and content area. So maybe on Monday's, 6-8 math teachers will meet, but then on Tuesdays the 6th grade interdisciplinary teams will meet. They have an opportunity to discuss what they are doing in their classrooms, but also discuss how they are reaching across the content areas so that students understanding learning is "across" and not just in one subject.
>
> Participant B1: It's all teacher choice and teacher driven. They have to be approved by administration, but it's "what do you feel will hook your kids, support your curriculum, addresses STEAM, and is something that you can create a tangible product for presentation at the fair.

Participant B ultimately revealed that their STEAM approach was a special in that the art and science teacher worked in a collaborative space and would on occasion collaborate on projects. But, as shown above, District B used PLC's as a means to also integrate STEAM across the curriculum, as did District C.

Technology & empathy curriculum. Every school leader involved in the design of STEAM curriculum expressed a desire for it to have a lens directed at the community and global society that surrounds them. In doing so, they acted on another one of their espoused values, which, was to make STEAM learning relevant to the students.

> Participant A2: Make something that makes the world a better place. That's what gets me excited. That's what we challenge kids to do. To do that, we have to teach them empathy and design and set up an entire curriculum that walks them through that process and challenges them to invent things that matter.

As an example of some of the empathy driven STEAM projects, District C discussed a global initiative while District A focused on the most local of contexts:

> Participant C1: We are partnering with another NJ district and a school in Harlem. The school in Harlem is then partnering with another NYC school and we are all working with the same agencies and the U.S. Embassy. We are making a picture book for younger children in Rwanda. The first books my children wrote were for 8th graders. Now we are trying to publish for little kids. So the project became so successful that between working with the agencies, UNICEF, the schools, and getting the U.S. Embassy involved, the children's book are going to be published all over the world. How cool is that?
>
> Participant A1: We have our occupational therapist who is in a wheelchair. So, the students designed something to help her. And then they also noticed that we didn't have any handicapped door openers, so they went to the board to try and

get this door installed so the lady could actually get across the building without actually having people hold the door for her.

Applying a mindful and empathetic lens to STEAM curricula made the K-8 contexts unique. Participants C1 and A1 both intended to help students identify problems and take action to help solve the issue. District also did this, as they would identify community problems such as “eating healthy on a budget.” Students would research healthy foods available at low costs, to help community members discover strategies for leading healthier lives. Students designed “meal maps” to also help non English speaking parents absorb the information.

The pacing of each district’s curriculum involved cycling grade levels through units or “experiences.” In analyzing the curriculum documents provided by each district, the curricula seemed to push technology integration and design. Below are curriculum examples from each of the three districts.

In all the experiences listed in Table 19, students are required to synthesize learning, prototype, design, and critique different types of products and innovations. Furthermore, it was expressed in the curriculum that the students would frequently work in engineering teams to accomplish the tasks within each experience.

District B was also focused on the use of technology, design, and modeling for their K-8 STEAM curriculum, which was implemented in conjunction with Project Lead the Way. Within the modules below, the district partnered with Count Basie Theater and Kennedy Center for the arts to integrate the arts across these learning modules and effectively make the STEM to STEAM transference.

It should be noted once again that District B had a very fluid interpretation of STEM, STEAM, and arts integration. In the eyes of Participant B2, the elementary principal, innovation was the overarching purpose and any means of accomplishing this was valid.

> Participant B2: My own personal thought is I take the term STEM and STEAM and feel it is all really innovation. This just happens to be how we are branding it right now. Just like makerspaces and what not. It is really all innovation and what's current.

Table 19

District A K-4 STEAM Curriculum

Grade Level	Curriculum Units
Kindergarten	**Fall** - computers, symbaloo, robotics, programming, Google app **Winter** - STEAM skills (cutting, folding, using tape, etc.)
First Grade	**Winter -** "Hour of Coding" - Covers basic coding language, debugging, and algorithms. **Spring -** "The Sounds of Music" - Covers acoustic engineering, sound waves, volume and pitch.
Second Grade	**Fall & Winter - "**Simple Machines" - Covers pulleys, wheels and axles, levers, inclined planes, wedges, and screws.
Third Grade	**Fall -** Magnetism, green energy, and weather. **Winter -** TV studio exploration including, writing, performing, and producing original content
Fourth Grade	**Winter -** Explorations in energy, circuit building, and aeronautical engineering. **Spring -** Design thinking "capstone" project

Note: Learning modules were taken from the District A curriculum website

Table 20

District B K-8 Project Lead the Way and STEAM Curriculum

Grade Level	**Curriculum Units**
K-6	Design and Modeling • Students will use solid modeling software (a sophisticated technique for representing solid objects) to affect the design process. • Students understand how design influences their lives, using this design process. • Students learn sketching techniques and use descriptive geometry as a component of design, measurement, and computer modeling. • Students, in teams, brainstorm, research, develop ideas, create models, evaluate design ideas, and communicate solutions. • Students trace the history, development, and influence of automation and robotics.
7-8	Automation and Robotics • Students trace the history, development, and influence of automation and robotics. • Students learn about mechanical systems, energy transfer, machine automation, and computer control systems. • Students acquire knowledge and skills through team problem solving, collaboration, and innovation.

Note: Learning modules were taken from the District B curriculum website

Finally, District C shared unit designs and learning modules for grades 4 and 5. The curriculum was broken into three developed modules (others were still being written at the time of the interviews): computer science, digital arts, and engineering. Table 21 shows the pacing of these modules and just like District A and B, technology integration and design thinking was central to the curriculum's overarching goals.

Table 21

District C Grades 4-5 Innovation Lab Curriculum

Grade Level	Curriculum Units
Computer Science	Module 1: Learn to Code with Scratch
	Module 2: Build a Website
	Module 3: Learning Programming Language
	Module 4: Music Programming
	Module 5: Building Mods w/Minecraft
	Module 6-8: Other Minecraft Challenges
Digital Arts	Module 1: Podcaster
	Module 2: Video Maker
	Module 3: Music Major
	Module 4: Video Game Maker
	Module 5: Other Makers
	Module 6: "From Parts to Arts"
Engineering	Module 1: 3D Designer
	Module 2: Cities and Skylines
	Module 3: Storybook World
	Module 4: "When in Rome"
	Module 5: Deconstructor
	Module 6: Recycling Challenge
	Module 7: Rube Goldberg Inventions

Note: Learning modules were taken from the District C Innovation Lab website.

District C, much like district A, used a systematic design thinking pedagogy in the classroom. The curriculum stated that design thinking is inclusive of sketching, designing, testing, and developing. The curriculum for grades 6-8 was still being developed at the time of the interview, but students in these contexts are to experience three contrasting entrepreneurial units in which the school creates a small business for the students run. The principal of the middle school in District C stated that their curriculum development for innovation was a work in progress:

> Participant C3: I think that everything that has been established is really fantastic and the kids are working and doing phenomenal projects. They are really taking their ability levels and going above and beyond, but I the one thing I felt we were missing was a very specific curriculum...How does this correlate to the standards? Do we have curriculum and how is it being supported? Is it necessary to have these programs or course offered to all of the students?

All three K-8 districts approached the creation of their prescribed curriculum differently, but all had the motivation to make their program empathetic, technology driven, experiential, and standards driven. All the districts used a special elective model to disseminate the curriculum and each revise their focus through constant reform; either amongst the teachers as in the case of District A and B or as directed by the administration as in District C.

High school contexts. The high school programs in this study were far less prescriptive in their STEAM approach. Both student choice and problem based learning were the most fluent of approaches to the design of STEAM in participating high school districts.

Student choice curriculum. Districts E and F used student choice as a mechanism to promote authentic STEAM inquiry. Students within district F apply to be in the school's STEAM program and choose their own capstone project. District E used elements of student choice in allowing students interested in STEAM to develop their own personalized course sequence in high school; an extension of their current high school academy program.

> Participant F1: So it's [STEAM] basically set up as an independent study where they get selected and apply their sophomore year...The students develop a capstone research proposal that involves all of the STEAM disciplines and they take it as far as they can. Some develop prototypes, some it's more just research based, some it comes totally to fruition.
>
> Participant E2: Well we will have our art academy and engineering academy, but we will also have a personalized academy so if we have someone who wants to do something a little more unique, with the help of teachers and counselors, they will be able to create their own interdisciplinary academy...If someone wants to do something very specific in STEAM like robotics for example, we can make that happen so long as they take a certain number of classes. We can create personalized trips or internships, etc.

Both F1 and E2 discussed student choice, but employed different approached. District F focused on the individual student and their authentic research interests, while District E allowed students to register for a STEAM driven course sequence.

Student choice in District D was present in their re-design of the traditional library space. Participant D1 stated:

> Participant D1: The makerspace, in most of the buildings, is a re-imaging of the library. As you know, in the traditional library our needs have shifted. It was always used for research and to supplement and enhance classroom instruction, so we said, 'let's make it a makerspace.' The students are tinkering with computers, modeling, Photoshop and we have a green screen. The students can really explore in way they hadn't before.

Participant D1 also suggested that student choice was a product of listening to what the kids were inherently interested in. In this instance, District D created a music engineering course for those interested in music technology. Music engineering is a common means of combining music, electrical engineering, physics, and technology, making it one of the most integrated STEAM avenues in the 21st century high school curriculum.

> Participant D1: What we really want to do is serve you [the students] so you tell us what you want...We were able to tap into the fact that there is a huge population that loves music and some even wanted to go to college for music, but we realized we didn't have a course for them. We found out it was music engineering and music production that they were interested in.

All three high school districts made sure that students were given a strong say in defining their STEAM experiences. Whether it be choosing a topic for authentic inquiry or creating a personalized course sequence, these high school districts allowed students to explore interdisciplinary topics carte blanche and curate their own STEAM experiences.

College and career preparation. Districts D, E, and F articulated many of their STEAM objectives with local community colleges and private businesses to increase post-secondary participation in STEAM majors and careers. While this was accomplished in a variety of ways, all the districts made sure students were shown ways of continuing their STEAM learning outside of the classroom after they graduate.

Articulating with local businesses was a means for District E to involve the community in the curriculum and show students how classroom concepts were applied in a career context. Participant E1 stated:

> Participant E1: We have been talking to the architects of this building that has been going up in our town so we could check out their engineering and architectural process and approach. They talked a lot about models, showed us their blueprints...it was a really great experience for our engineering team. We are actually going to have the head architect come in and talk to us.

Districts D and F articulated their STEAM initiatives with local community colleges. In the case of District F, students completed their capstone projects and presented their innovations or research to panel of professors from the local community college. District F also ensured that students in their STEAM academy had the opportunity to gain college credits in each of the STEAM disciplines. These credits were gained either through AP enrollment, a College Now program, or dual credit articulation agreements with the local community college. Table 22 summarizes these credit offerings.

Beyond community college credits, District F also partnered with local Universities and college professors to enhance their STEAM curriculum:

Participant F1: We have speakers come in, we go to Rowan's Virtual Reality center, we've gone to Philadelphia University, I have had speakers come in... I had a professor who came in and did 3D modeling and medical illustration.

Table 22

District F STEAM Academy College Credits

Disciplines	**Credits Offered**
Science	20 dual credit options
Technology	9 College Now credit options
Engineering	8 College Now and dual credit options
Arts	9 College Now and dual credit options
Mathematics	7 College Now and dual credit options

District D stated that the core tenets of their STEAM initiative were integrated into their Career and Technical Education (CTE) program. Much like district F, the goal was to show students how STEAM subjects were applied in the post-secondary world. Their CTE program includes construction, digital arts, engineering, and health care; all multidisciplinary examples of STEAM.

Participant D1: We wrote a half a million-dollar grant and started these CTE programs. One is a construction program which is a re-imagining of the woodshop. The kids were primarily making Adirondack chairs and jewelry boxes...I had a big problem with that because I didn't think that was really serving kids. So now, it's a construction program where they are getting concurrent credits with Temple University. There is also a partnership with Sussex County Community College where they will have a two-year path, and we have a tie in with the Local 68 Union out of Fairfield New Jersey.

All three districts had a clear desire to ensure their STEAM curriculum was increasing college access and focusing on career readiness. The final thread in this data set was that all the high schools were less concerned than their K-8 counterparts about making STEAM too prescribed or defined. The high schools made student choice so critical that there was no single STEAM curriculum. Rather, it was a series of choices within each district that allowed students to explore unique topics of inquiry, innovate based on what was relevant to them, curate their own STEAM course load, and use STEAM as a mechanism to gain access to post-secondary skill sets.

Convergent results. Consistent with the convergent parallel MM design, there is a need to understand what the OLM lens suggests about the implementation of STEAM. Teddlie and Tashakkori (2009) suggested that the mixing of data within a meta-analysis phase is what ultimately separates MM from single strand designs. As such, the following meta-analysis considers the implementation of the K-12 STEAM curriculum through the lens of organizational learning.

Communication barriers. K-8 and high school districts struggled with communicating the importance of their STEAM curriculum efforts. Table 23 shows the grand means for each OLM factor group and shows OLMs are perceived as infrequent methods of communication. Table 5 shows the grand means for each of the OLM factor groups. Each mean represents whether the OLM factor groups never exists (0), rarely exists (1), sometimes exist (2), exist often (3), or always exist (4). Participants (n=75) reported that overall, OLM's only sometimes exist in their school districts.

Table 23

OLM Grand Means

OLM Factor Group	Grand Mean
Disseminating, Storing, and Retrieving Information	2.01
Sharing Information with Students and Parents	2.07
Analyzing and Interpreting Information	2.55
Using Online Information	1.90
Overall	2.13

Note: 0=never exists, 1=rarely exists, 2=sometimes exists, 3=exists often, 4=always exists

One negative associated with these results was the lack of information disseminated to faculty members regarding the overarching purpose of each districts STEAM imitative. This lack of communication in turn may have led to inter faculty resentment. It also hid the individual STEAM achievements of those innovating inside the classroom.

Participant C2: I would say a lot of the teachers have 0 clue what I do. I would say most of them don't like me, don't want anything to do with me and most of the middle school teachers won't even talk to me.

Participant F3: It's been weird because nobody really knows that there are plenty of teachers trying to do STEAM like things.

The lack of disseminating, storing, and retrieving information expressed by C2 and F3 placed both middle and high school's districts in an ambiguous state of understanding, which lead to faculty resentment. As resources are diverted from other programs and little explanation is given as to why, resentment seems natural.

Participant A1: The former principal said to the STEAM teacher "you are my golden boy...anything you want, anything you want" and just started giving him money out the wazoo and teachers became resentful. The administration just focused on him and forgot about everyone else.

Participant showed that while STEAM can be an exciting venture, it is important to ensure its purpose and reasons for securing fiscal resources are expressed to the faculty at large.

Collaboration. The collaborative efforts of the participants were evident throughout survey and narrative results. Participants found STEAM collaboration to be teacher-student, teacher-teacher, and school-community driven. For instance, district B used PLC reform to bolster collaborative efforts.

Participant B1: We have changed out PLC schedule. It used to be grade level based and now we have a combination of grade level and content area. So maybe on Monday’s, 6-8 math teachers will meet, but then on Tuesdays the 6th grade interdisciplinary teams will meet

Table 24 shows the prevalence of school staff listening to the needs of students and the use of staff meetings to discuss implementation efforts. Consequently, the results also show that teachers were not planning together frequently and while the curriculum in this study was shown to be very student centered, question 12 shows that the students may not have had a forum for discussing what was meaningful to them. For these reasons, the nature of collaboration amongst the participants was contradictory.

There were also issues facing the collaborative efforts of building principals. Mainly in the K-8 districts, curriculum articulation was not very prominent between elementary and middle schools.

Participant A1: You have two different principals with two different styles, so (the programs) look different. They have different styles and I think that has hindered some of the development. It is an interesting dynamic to watch.

When asked about STEAM articulation between elementary and middle school schools within district C, participant C3 suggested there was a major disconnect in approach:

Participant C2: Not tight at all. I think at the upper school they only do one innovation for grades five and six and it's not the whole school.

It is evident through this convergent data on collaboration that STEAM’s interdisciplinary roots are apparent, but not as fluid across the participating districts. The organizational potential for collaboration amongst the participating districts was far from realized and certainly slowed the development of strong prescriptive action.

Table 24

Collaborative Learning Mechanisms

OLM	**Mean**	**Mode**	**Std. Deviation**
Q11: There are meetings where students present their needs to staff.	2.61	3.00	0.95
Q12: There are learning meetings between school staff and students to plan activities.	1.13	0.00	1.06
Q17: Teachers work together to plan educational activities.	2.60	2.00	1.03
Q18: Staff meetings evaluate ways to implement school decisions.	3.09	4.00	0.97

Sporadic curriculum reporting. While some participants discussed using PLC time for designing lessons or administrative initiatives to tie STEAM to state standards, teachers did not feel their districts were consistently reporting curriculum innovations through formal means.

Table 25 shows respondent data regarding curriculum focused OLM's. The means for each category fell below the "sometimes exists" mark in every instance except Q3.

This would suggest that the emergent and living STEAM curricula discussed by the participants may not have been developed through consistent organizational channels.

Table 25

Curriculum OLM's

OLM	Mean	Mode	Std. Deviation
Q2: Each curriculum/project has an updated instructional file	1.84	2.00	1.13
Q3: Summaries of teacher work/school projects are stored in a location accessible and known to everyone	2.17	2.00	1.26
Q4: Periodic reports on school curriculum evaluation are circulated	1.78	2.00	1.39
Q6: Our school website contains study materials for students (lesson and article summaries?)	1.41	2.00	1.07

Responses to questions 2-6 reveal that if STEAM curricula are not perceived to be evolving through documented means. Every participating district discussed their loose approaches to program implementation, which included the emergent development of a prescribed curriculum. Describing this sentiment thoroughly when asked about the development of a prescribed curriculum, participant B2 stated:

> Participant B2: I think it can't be defined as one thing...it needs to be defined on what is appropriate for that project in that specific time. We have five year olds and ten year olds have different developmental skill sets. It might mean getting dirty or exploring something first with technology and breaking out into small groups. It might mean something that just came up as a current event as component of STEAM that they are now going to insert because it's appropriate and timely…The projects might not match up perfectly with what STEAM is or what our curriculum says, but it's about exposure and getting them to understand what's possible.

Employing an approach that has teachers and curriculum supervisors create new curriculum components on the fly is possibly what makes these programs exciting to some. Given the goal of inspiring student creation and innovation, the curriculum may have to be very malleable. But, the OLM's suggest certain curriculum components may fail to become a part of the organizational memory and thus turn into new changes in practice.

> Participant F3: Like I am doing this stuff all the time and I am not looking for accolades, but there is no transformation. There is no change of the district or other people's practices.

This perception seems to call into question the sustainability and value of STEAM.

Discussion

This study showed drastically different interpretations of STEAM when comparing K-8 and high school contexts. Consistent with the arguments made by Newton and Newton (2014) and Wynn and Harris (2009), the participating school districts recognized that creativity and innovation were valuable economic ventures. This was apparent in the K-8 districts who started small student business and partnered with local businesses to improve upon curriculum relevancy. Similarly, high school districts made it a priority to show students college and career pathways congruent with the study of STEAM disciplines. STEAM still draws upon this primary tenet of STEM reform.

The curriculum design proved to parallel to many of the components of a living curriculum. Margini (2015) and Wolff (2013) both argued that the living curriculum is an approach that values the unknown. While the integrated nature of STEAM is somewhat obvious, the lack of prescriptive approaches suggests that classifying STEAM as a living curriculum approach could be validated through future research.

All the participating districts expressed a desire to make student experiences constructivist driven. They wanted their students to become makers and innovators. In striving for this through their curriculum designs, Patton and Knochel's (2017) "stuff, connection, and sharing" was fluid throughout. Districts re-designed traditional learning spaces like wood shops and libraries to house new technologies that students could collaborate on and design products with. Patton and Knochel's somewhat humorous suggestion regarding the importance of "stuff" is far more legitimate, as the participating districts were not afraid to throw teachers and students into an abyss of new variables. Furthermore, the amount of student choice shown in the data confirms Quigley et al.'s

(2017) assertions. These STEAM curriculum examples were constructivist for teachers and students; providing more reason to believe that the prescribed STEAM curriculum was never an overarching concern for school leaders.

The K-8 districts were in many ways mirrors of the empirical examples of contextualized STEAM (Connor, Karmokar, & Whittington, 2015; Cook, Bush, & Cox, 2017; Herro & Quigley, 2016; Magerko et al., 2016). While merely identifying the relationship between documented lessons and prescribed activities of the participants is nominal, it is still interesting to note that many STEAM initiatives favor technology integration. All but one district discussed the importance of technology experience and exposure. The “T” in STEAM certainly carried the most weight in this study.

Finally, the state of organizational learning and the use of mechanisms to support learning is largely unclear. The data on OLM’s as a whole, along with those specifically supporting curriculum and collaboration specifically, only revealed low to moderate use of OLM’s. Schechter and Qudach (2012) showed all the ways in which disseminating, storing, analyzing, and interpreting information influences this curriculum development processes, meaning the participating districts may innovate faster and more efficiently if they show a stronger awareness of OLM’s. Furthermore, Cirella et al., (2016) addressed the need for OLM’s when strengthening the creative climate of a workplace. It is reasonable to assume that for STEAM to meet all the innovative standards used to define its function in schooling, school districts must begin to address creativity as an organizational skill that can be assessed, developed, and improved upon over time (Cirella et al., 2016). Teachers cannot design a STEAM curriculum without an acute sense of how to innovate and create themselves.

Conclusion and Limitations

The influx of research on STEAM between 2015 and 2017 would suggest that it is a policy and curricular approach with considerable staying power. The participating STEAM programs implemented their curriculum to satisfy a larger need for innovation in the 21st century. As was the case during the industrial revolution or Renaissance, some educators have proven willing to challenge how learning is situated. It may be valuable for future research to focus on the assessing both the STEAM learning environment and student experiences. Through design based research, future inquiries can explore the impact of unique interventions within the learning environment.

The limitations of this study are that it could never account for the wide variance of approaches to STEAM curriculum implementation and Organizational Learning is still a developing lens for understanding professional learning in schools. Many practitioners see PLC's or in house professional development as the state of OL in school districts, but the perpetual state of learning in a district may be better understood through the mechanisms which support learning daily. If innovation is to continue in the education sector, tending to the continuous interdisciplinary development of teacher practice should be paramount.

References

Argyris, C.& Schon, D.A. (1974). *Theory in practice: Increasing professional effectiveness*. San Francisco, CA: Jossey-Bass

Argyris, C. (1990). *Overcoming organizational defenses: Facilitating organizational learning*. Boston, MA: Allyn& Bacon

Bennett, C J and M Howlett 1992. The lessons of learning: reconciling theories of policy learning and policy change. *Policy Sciences*, 25(3), 275–294.

Bequette, J. W., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. *Art education, 65*(2), 40-47

Biswas, A. E. (2014). Lessons in citizenship: Using collaboration in the classroom to build community, foster academic integrity, and model civic responsibility. *Journal on Excellence in College Teaching, 25*(1), 9-25.

Boone, S. (2014). Using organizational learning to increase operational and conceptual mental models within professional learning communities. *Journal of psychology and organizational culture 5*:(1) 85–99

Borrás, S. (2011). Policy learning and organizational capacities in innovation policies. *Science & Public Policy (SPP)*, *38*(9), 725-734

Bringer, J.D., Johnston, L.H., & Brackenridge, C.H. (2006). Using computer-assisted qualitative data analysis software to develop a grounded theory project. *Field methods, 18*(3), 245-266

Bybee, R.W. (2013). *The case for STEM education: Challenges and opportunities.* National Science Teachers Association Press

Clark, B. & Button, C. (2011). Sustainability transdisciplinary education model: interface of arts, science and community (STEM). *International journal of sustainability in higher education, 12*(1), 41-54

Chiva, R. &Alegre, J. (2005). Organizational learning and organizational knowledge: Towards the integration of two approaches. *Management learning, 36*(1), 1350-5076

Cirella, S., Canterino, F., Guerci, M., & Shani, A. (2016). Organizational learning mechanisms and creative climate: Insights from an Italian fashion design company. *Creativity and innovation management*. 25(2), 211-222

Connor, A.M., Karmokar, S. & Whittington, C. (2015). From STEM to STEAM: Strategies to enhance engineering and technology education. *International journal of engineering pedagogy, 5*(2), 37-47

Costantino, T. (2017): STEAM by another name: Transdisciplinary practice in art and design education. *Arts education policy review 0*(0), 1-7

Creswell, J.W. & Plano Clark (2011). *Designing and conducting mixed methods research* (2nd ed). Thousand Oaks, CA: SAGE Publications, Inc.

Dongryeul, K. & Bolger, M. (2017). Analysis of elementary pre-service teachers changing attitudes about integrated STEAM pedagogy through developing lesson plans. *International journal of science and math education, 15*(4), 587-605

Drake, S., & Burns, R. (2004). *Meeting standards through integrated curriculum*. Alexandria, VA, USA: Association for Supervision & Curriculum Development (ASCD)

Ehrlich, T. (2000). *Civic responsibility and higher education* (T. Ehrlich, Ed.). Phoenix, AZ: American Council on Education and Oryx Press.

Emmel, N. (2013). *Sampling and choosing cases in qualitative research: A realist approach*. London, UK: SAGE Publications, INC.

Fielder, N. (2008). Analytic density, postmodernism, and mixed methods research. In Bergmann, M.M. (ed). *Advances in mixed methods research* (pp. 37-53). London: SAGE Publications Ltd

Finnigan, K.S., Daly, A.j., & Stewart, T.J. (2012). Organizational learning in schools under sanction. *Education research international*, Vol. 2012, ID 270404

Fiol, M.C. & Lyles, M.A. (1985). Organizational learning. *The academy of management review, 10*(4), 803-813

Garvin, D. A., Edmondson, A. C., & Gino, F. (2008). Is yours a learning organization? *Harvard Business Review, 86*(3), 109–116.

Ge, X., Ifenthaler, D. & Speactor, M.J. (2015). Emerging technologies for STEAM education: Full STEAM ahead.

Gorelick, C. (2005). Organizational learning vs. the learning organization: a conversation with a practitioner. *The learning organization, 12*(4), 383-438

Green, S. K., & Gredler, M. E. (2002). A review and analysis of constructivism for school-based practice. *School Psychology Review, 31*(1), 53

Gunn, C. (2014). Innovators and institutions working as partners on sustainable change. In Gosper & Ifenthaler (ED.) *Curriculum models for the 21st century: Using learning technologies in higher education.* New York, NY: Springer

Gurteen, D. (1998). Knowledge, creativity, and innovation. *Journal of knowledge management, 2*(1), 5-13

Hancock, G., & Mueller, R. (2010). The Reviewer's Guide to Quantitative Methods in the Social Sciences. Florence, US: Routledge. Retrieved from http://www.ebrary.com.ezproxy.rowan.edu

Harding, T. (2010). Fostering creativity for leadership and leading change. *Arts education policy review, 111,* 51-53

Herndon, C. (2006). Peer review and organizational learning: Improving the assessment of student learning. *Research & Practice in Assessment, 1*

Herro, D., & Quigley, C. (2016). Innovating with STEAM in middle school classrooms: Remixing education. *On the Horizon, 24*(3), 190-204.

Herro, D. & Quigley, C. (2016). Finding the joy in the unknown: Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of science education and technology, 25*(3), 410-426

Hesse-Biber & Nagy, S. (2010). *Mixed methods research*. Gulford Press.

Higgins, Ishimaru, Holcombe, & Fowler. (2011). Examining organizational learning in schools: The role of psychological safety, experimentation, and leadership that reinforces learning. *Journal of Educational Change, 13*(1), 67-94.

Hirashima, T. (2011). *Proceedings of the 19th International Conference on Computers in Education*. Chiang Mai, Thailand: Asia-Pacific Society for Computers in Education

House Resolution 51, 113th United States Congress: H.Res.51 - Expressing the sense of the House of Representatives that adding art and design into Federal programs that target the Science, Technology, Engineering, and Mathematics (STEM) fields encourages innovation and economic growth in the United States.

Hsiao, H-C. & Chang, J-C. (2011). The role of organizational learning in transformational leadership and educational innovation. *Asia pacific education review, 12*(4), 621-631

Jang, E.E., McDougall, D.E., Pollon, D., Herber, M. & Russell, P. (2008). Integrative mixed methods data analytic strategies in research on school success in challenging circumstances. *Journal of mixed methods research, 2*(3), 221-247

Kezar, A., & Lester, J. (2009). *Organizing higher education for collaboration: A guide for campus leaders*. San Francisco, CA: Jossey-Bass

Kim, J., Egan, T. &Tolson, H. (2015). Examining the dimension of the learning organization questionnaire: A review and critique of researching utilizing the DLOQ. *Human resource development review, 14*(1), 91-112

Kim, Y. & Park, N. (2014). The effect of STEAM education on elementary school student's creativity improvement. *Communications in computer and information science, 115-121*

Kong, Y.T (2014). The implementation of STEAM program about air pollution in senior high school. *International information institute, 17*(10)

Kuhn, M. (2015). Encouraging teachers to W.A.I.T before engaging students in Next Generation Science Standards STEAM activities. *The STEAM Journal, 2*(1), 10.5642/steam.20150201.15

Kurti, R. S., Kurti, D. L., & Fleming, L. (2014). The philosophy of educational makerspaces part 1 of making an educational makerspace. *Teacher Librarian, 41*(5), 8-11

Lam, A. (2000). Tacit knowledge, organizational learning and societal institutions: An integrated framework. Organization studies, *21*(3), 487-513

Law, N., Yuen, A., & Fox, R. (2011). *Educational innovations beyond technology: Nurturing leadership and establishing learning organizations*. Springer, US.

Leithwood, K. (1995). An organisational learning perspective on school response to central policy initiatives. *School organization, 15*(3), 229

Leithwood, K., Leonard, L. &Sharratt, L. (1998). Conditions fostering organizational learning in schools. *Educational administration quarterly, 34*(2), 243-276

Liao, C., Motter, J. L., & Patton, R. M. (2016). Tech-savvy girls: Learning 21st-century skills through STEAM digital artmaking

Lingo, E.L. &Tepper S. J. (2013). Looking back looking forward: Arts based careers and creative work. *Work and occupations, 40*(4), 337-363

Magerko, B., Freeman, J., Mcklin, T., Reilly, M., Livingston, E., Mccoid, S., & Crews-Brown, (2016). EarSketch: A STEAM-based approach for underrepresented populations in high school computer science education. *ACM transactions on computing education, 16(*4), 14

Margrini, J.M. (2015) Phenomenology and curriculum implementation: discerning a living curriculum through the analysis of Ted Aoki's situational praxis, Journal of Curriculum Studies, 47:2, 274-299

Marsick. (2013). The dimensions of a learning organization questionnaire (DLOQ): Introduction to the special issue examining DLOQ use over a decade. *Advances in Developing Human Resources, 15*(2), 127-132

Masani, P. R. (2001). Three modern enemies of science: Materialism, existentialism, constructivism. *Kybernetes, 30*(3), 278-294

McBeth, M. K., Shanahan, E. A., Arnell, R. J., & Hathaway, P. L. (2007). The intersection of narrative policy analysis and policy change theory. *Policy Studies Journal, 35*(1), 87-108.

McCharen, B., Song, B. & Martens, J. (2011). School innovation: The mutual impacts of organizational learning and creativity. *Educational management administration & leadership, 39*(6), 676

Merriam, S.B. (2009). Qualitative research: A guide to design and implementation. San Francisco, CA: Jossey Bass

Miksza, P. (2013). Arts education advocacy: The relative effects of school-level influences on resources for arts education. *Arts education policy review, 114,* 25-32

Mintrom, M., & Norman, P. (2009). Policy entrepreneurship and policy change. *Policy Studies Journal, 37*(4), 649-667

Mulford, W., Sillins, C.A. &Leithwood (2003). *Educational leadership for organizational learning*. Hingham, MA, USA: Kluwer Academic Publishers

Nielsen, J. E. (2015). Corporate entrepreneurship, organizational learning, and knowledge implementation. *EkonomskiHorizonti, 17*(3), 199-214

Newton, L.D. & Newton, D.P. (2014). Creativity in 21st century education. *Prospectus, 44*(4), 575-589

Ortenblad, A. (2015). Towards increased relevance: Context adapted models of learning organization. *The learning organization, 22*(3), 163-181

Park, N. &Ko, Y. (2012). Computer education's teaching-learning methods using educational programming language based on STEAM education. *Network and parallel computing, 7513,* 320-327

Patton, R. M., & Knochel, A. D. (2017). Meaningful makers: Stuff, sharing, and connection in STEAM curriculum. *Art Education, 70*(1), 36-43

Persson, M. (2013). A theoretical inquiry of the use of knowledge in the policy process. In Lindberg, H. (ed). *Knowledge and policy change.* Newcastle, UK: Cambridge Scholars Publishing

Popescu, D.M., Bunea, A., &Radu, M. (2014). The duality of the concept of organizational learning. *Economic studies, 5*(3), 63-68

Popova-Nowak, I.V. &Cseh, M. (2015). The meaning of organizational learning: A meta-paradigm perspective. *Human resource development review, 14*(3), 299-331

Popper, M., & Lipshitz, R. (2000). Organizational learning: Mechanisms, culture, and feasibility. *Management Learning, 31*(2), 181-196

Prioleau, D. (2001). Arts education and the American campus: The leadership factor. *Arts education policy review, 102*(4), 35-38.

Purnell, P. (2004). A place for the arts: The past, the present, and teacher perceptions. *Teaching artist journal, 2*(3), 153-161

Quigley, C.F. & Herro, D. (2016). Finding the joy in the uknown: Implementation of STEAM teaching practices. *Journal of science education and technology, 25*(3)

Rabalais, M.E. (2014). STEAM: A national study of the integration of the arts into STEM instruction and its impact on student achievement

Rashman, L., Withers, E., & Hartley, J. (2009). Organizational learning and knowledge in public service organizations: A systematic review of the literature. *International journal of management reviews, 11*(4), 463-494

Root-Bernstein, R.S. (1991). Teaching abstracting in an integrated art and science curriculum. *Roeper review, 13*(2), 85

Sade, G. (2014). *Digital Da Vinci.* Springer; New York, NY.

Schecter, C. & Atarchi, L. (2014). The meaning and measure of organizational learning mechanisms in secondary schools. *Educational administration quarterly, 50*(4), 577-609

Schecter, C. & Asher, N. (2016). Principals' sense of uncertainty and organizational learning mechanisms. *International journal of education management, 26*(2), 138-153

Schecter, C. & Feldman, N. (2010). Exploring organizational learning mechanisms in special education. *Journal of educational administration, 48*(4), 490-516

Schecter, C. & Qudach, M. (2012). Toward an organizational model or change in elementary schools: The contribution of organizational learning mechanisms. *Educational administration quarterly, 48*(1), 116-153

Senge, P. (2003). Taking personal change seriously: The impact of organizational learning on management practice. *The academy of management executive, 17*(2), 47-50

Shaffer, L. (1999). Full STEAM ahead. *Instructor, 123*(5), 32-33, 35

Shaked, H. & Schecter, C. (2013). Seeing Wholes: The concept of systems thinking and its implementation in school leadership. *International review of education, 59*(6), 771-791.

Silins, H.C., Mulford, W.R., & Zarins, S. (2002). Organizational learning and school change. *Educational administration quarterly, 38*(5), 613-642

Smay, D., & Walker, C. (2015). Makerspaces: A creative approach to education. *Teacher Librarian, 42*(4), 39-43

Smilonich, D. G. (1999).*A case study of a large-scale intervention viewed through the lens of organizational learning and chaos/complexity.* The Union Institute

Strand. (2006). The heart and the journey: Case studies of collaboration for arts integrated curricula. *Arts Education Policy Review, 108*(1), 29-40.

Teddlie, C. & Tashakkori, C. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences.* Los Angeles, CA: SAGE Publications, INC.

Tomlinson-Clarke (2014). *Integrating the arts into STEM and common core curricula*. New Brunswick, NJ: Rutgers Graduate School of Education

United States Department of Education (2015). S*cience, technology, engineering, and math: Education for global leadership*. Retrieved from: http://www.ed.gov/stem

Wengraf, T. (2001). *Qualitative research interviewing*. London, UK: SAGE Publications, INC.

Williams, & McGuire. (2008). Economic creativity and innovation implementation: The entrepreneurial drivers of growth? evidence from 63 countries. *Small Business Economics, 34*(4), 391-412.

Wolff, M.R. (2013). To Event: Toward a Post-Constructivist of Theorizing and Researching the living curriculum as event-in-the-making. *Curriculum inquiry, 43*(3), 388-417

Wong, M. (2013). Developing integrated arts curriculum in hongkong: Chaos theory at work? *Curriculum Inquiry, 43*(2), 210–232

Wynn, T., & Harris, J. (2012). Toward a STEM + arts curriculum: Creating the teacher team. *Art Education, 65*(5), 42-47

Zohrabi, M. (2013). Mixed method research: Instruments, validity, reliability and reporting findings. *Theory and practice in language studies, 3*(2), 254-262.

Appendix A

Qualitative Instrument

Factor One: Values and Purpose

How would you define STEAM education?

What do you believe motivated the district to implement STEAM?

How do you feel the arts support STEM learning and the students' future?

ctor Two: Curriculum and Pedagogy

Please describe two major curricula modifications that helped support implementation?

How were these modifications decided upon?

What types of pedagogy do you most often observe in the STEAM classroom? How is the teaching practice different from before?

actor Three: Implementation Structure

Who was responsible for leading STEAM in this district and why?

Was there a planning process for implementation? If so, describe how it began to where you are now.

What do you feel are the two or three biggest impediments to the process?

Who have been the most important actors in circumventing these barriers?

What are the next steps to continue implementation?

How do you monitor and support STEAM moving forward? Discuss in the context of personal leadership approach.

Factor Four: Teacher Development

What types of professional development are offered to support the teachers?

Appendix B

Quantitative Instrument

Schechter and Atarchi (2014) OLM Questionnaire

1=does not exist, 2=rarely exists, 3=sometimes exists, 4=exists, 5=exists extensively.

Disseminating, Storing, and Retrieving Information

Summary reports of school activities/projects are prepared
Each curriculum/project has an updated instructional file
Summaries of teacher work/school projects are stored in a location accessible and known to everyone
Periodic reports on school curriculum evaluation are circulated
Evaluation reports on school projects are published
We receive professional literature (articles, books) about educational-pedagogical research
Staff meetings make use of protocols of previous meetings
Teachers go over summaries of the various staff meetings (protocols)
Reports about professional changes and innovations are circulated to the staff
There is a supply of professional reference materials

Sharing Information Among Students and Parents

There are meetings where students (student council) present their needs to the staff.
There are learning meetings between school staff and students (student council) to plan school activities.
There are report meetings between school staff and students (student council) about school activities
Information booklets about school procedures are circulated among parents
Our school website contains information for parents (on their child's achievements and about school activities)
Our school website contains study materials for students (lesson and article summaries?

Analyzing and Interpreting Information

Teachers work together to plan educational activities
Staff meetings evaluate ways to implement school decisions
Staff meetings are held to form a school vision
Meetings are held to evaluate students' behavior
Meetings are held to set evaluation methods for students' achievements
Meetings are held to evaluate students' academic achievement

Online Information

Teachers use an online superintendent/district's site to adjust study materials and teaching methods (samples of final exams with answer key, final exam materials, articles)
Online information resources provide teachers with professional feedback.

Appendix C

Informed Consent

TITLE OF STUDY:

Examining K-12 STEAM Implementation through the Lens of Organizational Learning

Principal Investigator: William Grillo

This consent form is part of an informed consent process for a research study and it will provide information that will help you to decide whether you wish to volunteer for this research study. It will help you to understand what the study is about and what will happen during the study.

If you have questions at any time during the research study, you should feel free to ask them and should expect to be given answers that you completely understand.

After all your questions have been answered, if you still wish to take part in the study, you will be asked to sign this informed consent form.

The researcher will also be asked to sign this informed consent. You will be given a copy of the signed consent form to keep.

You are not giving up any of your legal rights by volunteering for this research study or by signing this consent form.

FINANCIAL INTERESTS:

The researcher claims no financial interests associated with this study.

ABOUT THE STUDY

A. Why is this study being done?

The purpose of this study is to understand how K-12 STEAM implementation is supported by Organizational Learning Mechanisms (Schecter & Atarchi, 2014) with both urban and suburban settings.

B. Why have you been asked to take part in this study?

<u>Qualitative Interview Participants</u>

You have been selected as part of a sample of school leaders and teachers with direct knowledge of applying STEAM learning frameworks within K-12 contexts.

Quantitative Survey Participants

You have been selected as part of a sample of teachers with direct knowledge of implementing STEAM pedagogy. You are positioned to reveal the organizational learning mechanisms present within your context that support the implementation of new practice.

C. Who may take part in this study and who may not?

Only school leaders with direct knowledge of STEAM implementation and STEAM content teachers were invited to participate in this research study.

D. How many subjects will be enrolled in this study?

This study plans to select twelve interview participants from previously selected urban and suburban school districts. The highest possible response rate to the Organizational Learning Mechanism Questionnaire is desired as part of the research design.

E. How long will my participation in the study take?

Interview sessions may be on average around 30 minutes. The quantitative survey takes around 10 minutes to complete.

F. Where will the study take place?

This study is set in three urban and three suburban K-12 school districts in New Jersey. Interviews will be proposed to take place in a setting convenient to the participant while quantitative surveys can be completed online.

G. What will you be asked to do if you take part in this research study?

The researchers request that interview participants reveal as much relevant information as prompted by questions within the researcher's interview protocol. Survey participants are asked to answer survey questions in honest to the best of their ability.

H. What are the risks/discomforts you might experience if you take part in this study?

There are no risks or discomforts anticipated based on the questions asked to selected participants.

I. Are there any benefits for you if you take part in this research study?

Participants will be notified in regards to the completion of this study for the benefit of viewing findings and conclusions associated with STEAM implementation and organizational learning. It is possible you will find no benefit to participating.

J. What are your alternatives if you don't want to take part in this study?

Your alternative is to not participate in this study.

K. How will you know if new information is learned that may affect whether you are willing to stay in this research study?

During the course of the study, you will be updated about any new information that may affect whether you are willing to continue taking part in the study. If new information is learned that may affect you, you will be contacted.

L. Will there be any cost to you to take part in this study?

There is no cost associated with participating in this study.

M. Will you be paid to take part in this study?

Participants will not be paid any sum of money.

N. How will information about you be kept private or confidential?

All efforts will be made to keep your personal information in your research record confidential, but total confidentiality cannot be guaranteed. Your personal information may be given out, if required by law. Presentations and publications to the public and at scientific conferences and meetings will not use your name and other personal information

O. What will happen if you are injured in this study?

If you are injured in this study and need treatment, contact *(Input Counseling Services, Healthcare provider, Wellness Center, etc. here)* and seek treatment.

We will offer the care needed to treat injuries directly resulting from taking part in this study. Rowan University may bill your insurance company or other third parties, if appropriate, for the costs of the care you get for the injury. However, you may be responsible for some of those costs. Rowan University does not plan to pay you or provide compensation for the injury. You do not give up your legal rights by signing this form.

If at any time during your participation and conduct in the study you have been or are injured, you should communicate those injuries to the research staff present at the time of injury and to the Principal Investigator, whose name and contact information is on this consent form.

P. What will happen if you do not wish to take part in the study or if you later decide not to stay in the study?

Participation in this study is voluntary. You may choose not to participate or you may change your mind at any time.

If you do not want to enter the study or decide to stop participating, your relationship with the study staff will not change, and you may do so without penalty and without loss of benefits to which you are otherwise entitled.

You may also withdraw your consent for the use of data already collected about you, but you must do this in writing to*:*

William Grillo
15 S Sunnycrest Drive
Little Silver, NJ 07739
Grillow0@students.rowan.edu

If you decide to withdraw from the study for any reason, you may be asked to participate in one meeting with the Principal Investigator.

Q. Who can you call if you have any questions?

If you have any questions about taking part in this study or if you feel you may have suffered a research related injury, you can call the Principal Investigator:

If you have any questions about your rights as a research subject, you can call:

Office of Research Compliance
(856) 256-4078– Glassboro/CMSRU

What are your rights if you decide to take part in this research study?

You have the right to ask questions about any part of the study at any time. You should not sign this form unless you have had a chance to ask questions and have been given answers to all of your questions

AGREEMENT TO PARTICIPATE

I have read this entire form, or it has been read to me, and I believe that I understand what has been discussed. All of my questions about this form or this study have been answered.

Subject Name:____

Subject Signature:___________________________ Date:_____________

Signature of Investigator/Individual Obtaining Consent:

To the best of my ability, I have explained and discussed the full contents of the study including all of the information contained in this consent form. All questions of the research subject and those of his/her parent or legal guardian have been accurately answered.

Investigator/Person Obtaining Consent:____

Signature:_____________________________ Date: ___________________