

THE EFFECT OF STEAM ON THE ACT STEM BENCHMARK

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2024

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THE EFFECT OF STEAM ON THE ACT STEAM BENCHMARK

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THE EFFECT OF STEAM ON THE ACT STEM BENCHMARK

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A Dissertation  
Presented to  
The Faculty of the Graduate Education Department  
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Doctor of Education

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By

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## ABSTRACT

There has long been a need for a larger body of data supporting the difference in achievement among students educated in an environment rich in the arts. The 21<sup>st</sup> century has seen an emphasis on Science, Technology, Engineering, and Math (STEM) education to prepare students for future jobs in STEM fields. Global competition for technological advancement and commerce has fueled national funding for advancement in STEM. The arts are included in the STEAM equation to access the 21<sup>st</sup> century academic benefits of transdisciplinary learning. These benefits include innovation, creativity, critical thinking, and social skills such as communication and collaboration. Attracting students to engage in STEM coursework and preparing students for future careers in STEM also supports the addition of “A” in STEAM. This study provides data showing academic differences in achievement among students enrolled in schools using STEAM and those using STEM.

In 2015, the Academic College Test (ACT) added a student readiness benchmark test score for STEM. The ACT STEM Benchmark score was added to determine achievement showing higher education and career readiness for STEM fields. The STEM benchmark proved to be a valuable tool to access data showing a significant increase in achievement of students learning in STEAM environments for this study versus those who were using STEM. Due to the beginning of the COVID-19 global pandemic in 2020, the four years used in the study spanned from the ACT STEM Benchmark inception of 2015 through ACT test scores reported in 2019 and ensured data remained both reliable and valid. The study included longitudinal data over four years, showing ACT STEM Benchmark averages between schools designated as STEAM by using previous research defining the nine components of an effective STEAM school and those

using STEM. The DESE database was used to collect data from comparable school districts that reported ACT test scores.

The study explored the benefits of an arts-rich STEAM education, as determined by the conceptual and theoretical underpinnings of 21<sup>st</sup> Century Learning and John Dewey's pragmatic approach to progressive education using inquiry-based, socially interactive learning. Dewey's theories align with the four Cs of 21<sup>st</sup> century education, which include communication, collaboration, critical thinking, and creativity. This study fills a gap in research by providing current and relevant data to support student learning enhanced by creativity and the arts in STEAM schools.

# CHAPTER ONE

## INTRODUCTION

The future requires the building blocks of real-world 21<sup>st</sup> century education (Antoni, 2020; Battelle for Kids, 2019; Crompton, 2023; Kou, Konrath, & Goldstein, 2019). Training and equipping students with the education and skills needed for success in the 21<sup>st</sup> century is daunting for stakeholders (Idin, 2020; Singh, 2021). Rapid gains in global technology have created a world where educational systems prepare students for jobs and productive careers yet to be imagined. Current and future jobs require students to pursue higher education or career training, attain specialized skills in specific areas of STEM, and compete in a global job market requiring creativity, innovation, communication, and collaboration in the workplace and beyond (Aisley, Dick, Meletioui-Mavrotheris, & Paparistodemou, 2023; Dadlani & Soler, 2022; Pearce, 2022).

The use of STEM education has been associated with 21<sup>st</sup> century education nationally since a collaborative group of educational leaders, business and community members, and policymakers gathered to create and define the skills 21<sup>st</sup> century students need to be successful in life, work, and citizenship (Battelle for Kids, 2019; Crompton, 2023; Idin, 2020). More recently, the focus on creativity, innovation, and invention has incited the addition of “A” or arts in STEAM education in conjunction with a focus on digital literacy and social skills (Anisimova, Sabirova, & Shatunova, 2020; Koul, Sheffield, & McIlvenny, 2021). This study outlines the history, relevance, and importance of STEAM education with a focus on the academic achievement of students (Bowen & Kisida, 2019; Crompton, 2023).

Academic achievement was measured in this study using the STEM Benchmark Score enacted by ACT in 2015 (ACT, 2015, 2020; Crouse, Mattern, & Radunzel, 2015; Mattern, Radunzel, & Westrick, 2015). To the author's knowledge, no research has been conducted using the STEM Benchmark Score and how its measurement may reflect achievement in schools using STEAM. The "A" or art component of STEAM could affect achievement, but there is a gap in research supporting the inclusion of the arts and their benefit to student learning using STEAM. Recent studies supporting the arts as beneficial to students engaged in STEAM learning focused on the area of creativity, but data is minimal in the scientific measurement of creativity and the arts in academic achievement (Antoni, 2020; Brown, 2020; Tuttle, 2020). This study adds to research *t* test comparing these two independent variables. The independent variables were defined using prior research defining the unique qualities of both STEM and STEAM education. While both methodologies include integrating subjects across multiple disciplines, prioritizing problem-solving, and fostering a growth mindset, STEAM incorporates arts education, collaborative creative expression, innovation, and design thinking when problem-solving into its interdisciplinary curriculum. (Antoni, 2020; Battelle for Kids, 2019). The ACT STEM Benchmark score was used as the dependent variable in the study, and achievement data was created that may be useful to support the "A" in STEAM. This data may encourage all educational stakeholders, from school boards and policymakers to educational leaders and experts in curriculum design, to consider STEAM educational methods when educating students.

## **Theoretical Framework**

The theoretical framework used for this study is John Dewey's progressive education theory (Dewey, 1929; Dewey & Hinchey, 2019; Li, 2020). Engaging learners using experiential problem-solving and collaborative design is embedded in the educational methods of STEM and STEAM (Battelle for Kids, 2019; Crompton, 2023; 2023; Sadovnik, Cookson, Semel, & Coughlin, 2017). Teachers act as facilitators of learning in 21st-century classrooms, with students directing their learning using inquiry, critical thinking, creativity, and real-world problems (Antoni, 2020; Battelle for Kids, 2019). Educators and their students also bear a social responsibility to one another and the community in 21st-century learning models of collaboration and problem-solving. The idea of community in 21<sup>st</sup>-century learning models is not novel and was ingrained in the thinking of seminal educational theorist and pragmatist John Dewey (Dewey, 1929; Dewey & Hinchey, 2019; Li, 2020; Sadovnik et al., 2017).

Dewey's theory stresses students need to be actively engaged in contributing to their education and must possess the ability to adapt to their learning environment by linking prior knowledge and experiences to present learning (Dewey, 1929; Dewey & Hinchey, 2019; Li, 2020; Howard, O'Brien, Kay & O'Rourke, 2019; Sadovnik et al., 2017). Dewey recommended an interdisciplinary method of learning in which students can synergize their content knowledge, personal interests, and democratic interpersonal skills in many subjects to solve societal problems. Dewey's thoughts on student engagement, student-centered work as education, and the benefits of student contributions to a democratic society apply to the current expediency for innovation in the 21<sup>st</sup> Century Learning movement of STEAM (Battelle for Kids, 2019; Dewey, 1929;

Dewey & Hinchey, 2019; 1934, 1938; Li, 2020; Sadovnik et al., 2017; U.S. Department of Education, 2022).

The conceptual underpinning of this study aligned Dewey's theoretical teachings and philosophical thoughts with the incorporation of 21st century methods into educational models for student learning (Battelle, 2023; Dewey, 1938, Dewey & Archambault, 1966; Li, 2020; Sadovnik et al., 2017). Core literacy and numeracy subjects scaffold the four Cs of collaboration, critical thinking, creativity, and communication. Learning standards, assessments, curriculum, instruction, learning environments, and professional development for educators should support systems for 21st century learning (Burke, 2022; Crompton, 2023; Krueger, 2022). A melding of Dewey's progressive educational theory of interdisciplinary, experiential, and social learning and emphasis on conceptual 21st century education models, including achievement in STEAM, provide underpinnings for this study (Battelle for Kids, 2019; Crompton, 2023; Li, 2020; Sadovnik, et al., 2017). The arts are a tool to bind together the how, what, and why students learn, playing a role in what students can do with what they know (Dewey, 1938; Riley, 2023; Li, 2020). This study hypothesizes that STEAM may be the answer to a more effective STEM education, increasing the achievement of students and preparing them with socially interdependent learning skills for the 21<sup>st</sup> Century (Bryan & Guzey, 2020; Burke, 2022; Singh, 2021; Wu, Liu, & Huang, 2022).

Creating learning environments that allow academic and social skills to propel students forward in the 21<sup>st</sup> Century has caused a unique focus on learning models integrating the arts in STEAM education (Burke, 2022; Hughes, 2021; Krueger, 2022). Adding the “soft skills” of cultural awareness, leadership, adaptability, persistence or grit,

innovation, initiative, creativity, and curiosity are recognized as necessary for a nation's workforce to succeed (Bott & Horvath, 2020; Burke, 2022). Within the "soft skills" of 21<sup>st</sup> century learning, creativity remains one of the most challenging aspects of the four Cs to incorporate and measure using available achievement data in traditional education (Battelle for Kids, 2019; Singh, 2021; Tuttle, 2020).

### **Problem Statement**

Despite knowledge of what is needed for a well-rounded 21<sup>st</sup> century education, including STEAM, there is little data to measure the effect of creativity and the role arts play in academic achievement (Antoni, 2020; Dell'Erba, 2019; Krueger, 2022; Tuttle, 2020). There is a complex and important need for recent achievement data to fill a gap in research showing that STEAM education methods are affecting students' academic success in schools and preparing them for higher education or the workplace. (Dell'Erba, 2019; Singh, 2021). Collecting achievement data may support the use of STEAM and positively affect the students learning in this environment. The focus of this study is researching data supporting student achievement in arts-rich STEAM schools versus those students learning in a traditional STEM setting. If the difference in achievement between the subjects of the study, students learning in Missouri secondary schools, grades 9-12, in STEAM environment may achieve a higher rate in STEM subjects versus Missouri secondary students, grades 9-12, learning in secondary schools with traditional STEM educational settings difference in achievement is proven to be significant and measurable by this study's research tool, then there may be overreaching evidence of the need for STEAM education to benefit students in Missouri and the gap in the body of data showing the need for the arts in STEAM may be supported. The problem is the

literature has not fully addressed the need for data showing a significant difference in achievement scores of students lacking the benefits of STEAM education. Data may encourage inclusion and funding for STEAM education of students learning in Missouri Secondary Schools (Battelle for Kids, 2019; Department of Elementary and Secondary Education, 2022a, 2022; The United States Department of Education, 2022).

### **Purpose of the Study**

The purpose of this causal-comparative study is to test the theory of Dewey's progressive education when applied to 21st century education that compares the academic achievement of pupils learning in Missouri class 3, 4, and 5 secondary schools, grades 9-12, where STEAM curriculum is being used, to similar schools offering STEM curriculum to students learning at Missouri secondary schools class 3, 4, and 5, grades 9-12 (DESE, 2022a; Dewey, 1938; Dewey & Archambault, 1966; Li, 2020). The independent variable will be generally defined as Missouri class 3, 4, and 5 secondary students, grades 9-12, learning in Missouri schools. The dependent variable of interest will be defined as the average ACT STEM Benchmark score reported by Missouri class 3, 4, and 5 secondary schools, grades 9-12, where students are learning using STEAM or STEM from 2016-2019. The four Years selected for the study were chosen because the ACT STEM Benchmark Score was first reported in 2015 and 2019 reflects scores reported before the onset of the global COVID-19 pandemic of 2020 when the educational system experienced widespread global disruptions (ACT, 2015, 2020; Allen, 2022). Many schools resorted to virtual or hybrid instruction in 2020-2021, and a return to traditional instruction in 2021-2022 continued to affect the sample of ACT takers due to the disruption of learning (Allen, 2022). The time limit for the study reflects a four-

year period when a growing number of students were studying in arts-rich STEAM schools and taking the ACT exam alongside students studying in traditional STEM schools (Inomjonovna & Ashirboy, 2023; 21PSTEM, 2019; Zhou, 2020). Prior research will determine factors that define the research samples as STEAM schools or those using STEM (Battelle for Kids, 2019; DESE, 2022a, 2022; Psycharis, Kalovrektis, & Xenakis, 2020). The current research reflects on the benefits of arts-rich learning in student academic achievement. However, there is a gap in the research literature providing the availability of measurable data showing achievement in STEAM programs (Battelle for Kids, 2019; 21PSTEM, 2019; Tuttle, 2020).

This study aims to discover if there is a difference in students' academic achievement when learning in STEAM schools. The data provided in the study is obtained using the STEM Benchmark Score first incorporated into the ACT exam in 2015 (ACT, 2015, 2020; Crouse et al., 2015; DESE, 2022a). The STEM Benchmark Score is an average of math and science scores from the ACT exam intended to indicate the readiness of high school students to engage in STEM learning at the university level. Due to the onset of the COVID-19 pandemic in 2020, STEM Benchmark scores were valid and reliable through 2019 (ACT, 2015, 2020; DESE, 2022a; Klein, 2021; Milligan, 2020). The longitudinal data of average student ACT STEM Benchmark scores from the testing cycle beginning in 2015 and continuing through 2019 may provide a statistical difference in students educated in STEAM programs, thereby adding to data supporting the benefit of integrating highly effective arts into STEM curriculum (Anisimova et al., 2020; Antoni, 2020; Battelle for Kids, 2019; Krueger, 2022).

The researcher reviewed current professional literature to determine an overview of the history of STEM and STEAM education. A science, technology, engineering, and mathematics integrated curriculum has a rich history; arts integration into this design has a shorter historical timeline (Battelle for Kids, 2019; Zhou, 2020; Singh, 2021). Arts integration with cross-curricular purpose was explored to determine the framework of a STEAM learning model (Battelle for Kids, 2019; 21PSTEM, 2019; Silverstein & Lane, 2020). Current statistics and determinations regarding achievement in STEM and STEAM research provided expectations and a hypothesis regarding the possible effects of STEAM on student achievement (Battelle for Kids, 2019; 21PSTEM, 2019; Stem Careers Coalition, 2020). Research in STEAM will provide expectations and a hypothesis regarding the possible effects of STEAM on student achievement.

### **Research Questions**

The following questions helped guide the study:

RQ1: What is the difference in ACT STEM Benchmark scores from 2015-2016 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ2: What is the difference in ACT STEM Benchmark scores from 2016-2017 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ3: What is the difference in ACT STEM Benchmark scores from 2017-2018 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ4: What is the difference in ACT STEM Benchmark scores from 2018-2019 for students learning in a STEM environment versus those learning in a STEAM environment?

### **Null Hypotheses**

H<sub>01</sub>: There will be no statistically significant difference in ACT STEM Benchmark scores for students learning in a STEM environment versus those learning in a STEAM environment.

H<sub>02</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2016-2017.

H<sub>03</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2017-2018.

H<sub>04</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2018-2019.

### **Significance of Study**

The significance of this study is filling a gap in the literature where data is used to determine if STEAM programs and the use of arts integration in STEAM subjects make a difference in student achievement (Anisimova et al., 2020; Bautista, 2021; Dehner, 2021; Dell'Erba, 2019). A significant difference in the achievement according to the ACT STEM Benchmark score used as the dependent variable in this causal-comparative study may add to the scientific data in the literature supporting the use of STEAM education

(Wagner & Kingston, 2022; Wu et al., 2022). Adding to the current body of literature supporting student achievement in STEAM schools may affect the education of students in Missouri schools and beyond (Bautista, 2021; Crompton, 2023; DESE, 2022a, 2022). Results from this study may increase funding for STEAM education and the creation of STEAM schools at the state and district level in Missouri (DESE, 2022a). Student access to STEAM education by students will become easier and may attract students to STEM courses in secondary schools, higher education, and STEM careers (Anisimova et al., 2020; Crompton, 2023; DESE, 2022a, 2022). This will fulfill the goals of 21<sup>st</sup> century education by increasing academic achievement and attaining the soft skills of collaboration, critical thinking, creativity, and communication (Anisimova et al., 2020; Crompton, 2023; Wu et al., 2022). These skills apply 21<sup>st</sup> century educational goals to Dewey's seminal theory of progressive education where student-driven knowledge helps solve real-world problems in social settings benefiting student achievement, the educational community, and a 21<sup>st</sup> Century global society (Dewey, 1916, 1938; Doyle, 2019; Li, 2020).

### **Definition of Key Terms**

**ACT STEM Benchmark Score.** A student's STEM score is the average of his or her Math and Science scores. ACT created the STEM score and benchmark to determine whether students can succeed in STEM through higher education and careers (ACT 2015; Crouse et al., 2015)

**Class 3, 4, 5 Activities Enrollment Break.** Missouri schools are defined by the number of eligible students enrolled in activities; 199-434 (Class 3), 435-931 (Class 4), and 932+ (Class 5) (Missouri State High Activities Association, 2023).

**Interdisciplinary.** Integrates information, data, techniques, tools, perspectives, concepts, or theories from two or more disciplines or bodies of specialized knowledge (Gao, Li, Shen, & Sun et al., 2020).

**STEM.** Science, technology, engineering, and mathematics curriculum centered on education in the disciplines of science, technology, engineering, and mathematics (Hallinen, 2023).

**STEAM.** STEAM Education is an approach to learning that uses science, technology, engineering, arts, and mathematics as access points for guiding student inquiry, dialogue, and critical thinking (Riley, 2023).

**Transdisciplinary.** A transdisciplinary approach is, in essence, beyond the disciplines, where students and teachers use collaborative expertise to pose and solve problems in a way that foregrounds the problem outside a single discipline (Caton, 2021; Quigley & Herro, 2019).

**Twenty-first Century Skills (four Cs).** Skills used to refer to certain core competencies such as collaboration, digital literacy, critical thinking, problem solving, and creativity needed to help students thrive in today's world (Battelle for Kids, 2019).

### **Limitations**

The researcher did not have control of the following factors, although these may have affected the study results.

1. Test environment and fidelity was completed prior to ACT testing and reporting within each school as mandated.
2. Data was defined by the DESE data collection and ACT STEM Benchmark scores.

3. The study was limited to ACT STEM Benchmark scores from 2016-2019 because ACT began using the benchmark score in 2015.
4. The sample size and selection were determined by classification of size by MSHAA and DESE, Class 3, 4, and 5 schools.

### **Delimitations**

The researcher intentionally imposed the following factors to narrow the scope of research.

1. The population of this study included students in Missouri public high schools, grades 9-12, class 3, 4, and 5, as determined by MSHAA and DESE.
2. The theoretical underpinnings of this study focus on the progressive learning theory of seminal theorist John Dewey and the four Cs of 21<sup>st</sup> Century Learning, creativity, collaboration, communication, and critical thinking.
3. Students learning in Missouri secondary schools, grades 9-12, determined as Class 1 and 2 by MSHAA and DESE were not used in this study due to variables in the rural school districts' limited size and resources.
4. The population of this study included students engaged in STEAM versus STEM education based on prior research determining STEAM education characteristics.
5. The test scores used in the research were defined using the initial inception of the ACT STEM Benchmark Score in 2015 through 2019.

### **Assumptions**

The following assumptions were made during this study.

1. It was assumed that ACT scores are reliable and valid measures of student achievement in the years 2016-2019.
2. It was assumed that students were receiving comparable treatment in different
3. Missouri school districts, class 3, 4, and 5 as determined by MSHAA and DESE. It was assumed that prior research defined the population samples as students being educated in secondary schools, grades 9-12, using STEAM or STEM.
4. It was assumed that ACT STEM Benchmark scores were not reliable and valid measures of student achievement during the worldwide pandemic of 2020-2023, due to test optional university admissions and lack of physically safe testing environments.

### **Design Controls**

This study used a quantitative, causal-comparative design, looking for differences in school student achievement using an arts-enriched STEAM approach to learning versus STEM. The study's limitations include achievement data considered valid and reliable, which was obtained from the DESE open-source database. The study includes annual performance data on the ACT STEM Benchmark Score in Missouri secondary schools offering STEM or STEAM from 2016-2019. The dates are limited to a beginning date 2016 because this is the year ACT began using the STEM Benchmark Score in the annual ACT achievement testing. The last date the ACT is considered valid and reliable for student readiness of all test takers is 2019 because of the limitation of the number of tests taken within secondary high schools in 2020 due to the worldwide COVID-19 pandemic. The test environment and fidelity of the ACT STEM Benchmark

test score were completed before the study and assumed reliable and validated by the researcher, as ACT and DESE are considered reliable reporters of student data. Data processing was limited to the constraints and internal file structure of the IBM SPSS Statistics (Version 23) predictive analytics software (IBM Corporation, 2015).

Limitations of research also included the gap in scientific data indicating the overall academic achievement benefits of students engaged in study of the arts. The sample size and selection were determined by classification of size by the MSHAA and DESE, Class 3, 4, and 5 schools. The researcher was not without bias when it came to thoughts regarding fine arts education and creativity, as she is trained as a professional musician and fine arts educator, and is certified in the public school systems of Missouri and Texas.

Delimitations of the study included the following constraints the researcher intentionally imposed to narrow the scope of research. The population of this study was defined as students studying STEAM versus STEM curriculum in secondary schools, grades 9-12 in Missouri, determined as class 3, 4, and 5 by MSHAA and DESE. Students learning in Missouri secondary schools, grades 9-12, determined as Class 1 and 2 by MSHAA and DESE, were not used in this study due to variables in a rural school district's limited size and resources.

Prior research determined independent variables of schools using STEAM versus schools providing STEM curriculum. The research questions used in this study examine the Average ACT STEM Benchmark score of students learning in class 3, 4, and 5 secondary schools in Missouri, as determined by Missouri State High School Activities Association and DESE, from the inception of the ACT STEM Benchmark score through

2019. This study's objective was to provide data to fill a research gap showing the difference between students studying with the arts and creativity component (STEAM) and those learning exclusively with STEM curriculum. This data may assist in supporting academic programs integrating the arts into STEAM.

The theoretical underpinnings of this study focused on the progressive learning theory of seminal theorist John Dewey and the concept of the four Cs of 21<sup>st</sup> century learning: collaboration, critical thinking, creativity, and communication. These theories and concepts were combined to apply current research to the benefits of arts integration in STEAM subjects, the components of a 21<sup>st</sup> century education, and its effects on current societal and economic demands for global advancement. The extracted data used for research methodology was limited to current data extracted from ACT and DESE databases. A *t* test was used for statistical analysis of ACT STEM Benchmark data to indicate the difference in academic achievement between students learning with STEAM versus those learning with STEM. Data processing was limited to the constraints and internal file structure of the IBM SPSS Statistics (Version 23) predictive analytics software (IBM Corporation, 2015).

The researcher assumed ACT STEM Benchmark scores from Missouri secondary schools, 2016-2019, are valid and reliable measures of student achievement. It was assumed that ACT STEM Benchmark scores were not reliable and valid measures of student achievement during the worldwide pandemic of 2020-2023, due to test optional college admissions and lack of physically safe testing environments. It was assumed that students received equal treatment in different Missouri school districts. Design controls for this study included creating groups using prior research to define STEAM education

versus STEM education. Schools were determined by previous research by using STEM or STEAM education to ensure correct groupings. Prior research conducted by scholarly experts was used to establish requirements defining a STEAM education and the control group learning in an environment determined as lacking these requirements (Bautista, 2021; Dell’Erba, 2019; Hayden, 2022; Hughes, 2021; Singh, 2021; Silverstein & Lane, 2020; Wu et al., 2022).

### **Summary**

In Chapter One, the gap in literature shows a need exists for measurable data showing achievement in STEAM programs (Anisimova, et al., 2020; Brown, 2020; Dehner, 2021; Dell’Erba, 2019). The problem statement is introduced as a lack of current data supporting student achievement in arts-rich STEAM schools versus those students learning in a traditional STEM setting (DESE, 2022a, 2022; Idin, 2020; Singh, 2021). The purpose of this causal-comparative study is to test the theory of Dewey’s progressive education when applied to 21st century education that compares the academic achievement of pupils learning in Missouri class 3, 4, and 5 secondary schools, grades 9-12, with arts-rich environments where STEAM curriculum is being used, to similar schools offering STEM within Missouri secondary schools class 3, 4, and 5, grades 9-12 (DESE, 2022a; Dewey, 1938; Dewey & Archambault, 1966; Li, 2020).

In Chapter Two, the researcher reviewed professional literature to determine an overview of the history of STEM and STEAM education. A science, technology, engineering, and mathematics integrated curriculum has a rich history; arts integration into this design has a shorter historical timeline (Huser, 2020; Singh, 2021). Arts integration with cross-curricular purposes was explored to determine the framework of a

STEAM learning model (Battelle for Kids, 2019; Huser, 2020). In researching STEM and STEAM the successes and challenges of each were examined. The 21<sup>st</sup> Century element of creativity in STEAM education was applied to the conceptual idea of 21<sup>st</sup> century learning where educators and students bear a social responsibility in collaborative learning and problem-solving (Battelle for Kids, 2019; International Society of Technology Integration, 2020). The seminal thinking of the 20<sup>th</sup> Century progressive educational theorist and pragmatist John Dewey melded with current research on 21<sup>st</sup> century models of education. Dewey's belief that a student needs to be contributing to their education through inquiry, real-world problem solving, and socially engaged in learning supports the STEAM model and the benefits of arts integrated education (Dewey, 1938; Dewey & Archambault, 1966; Li, 2020).

In Chapter Three the methodology utilized in the quantitative study is set forth. The causal-comparative research design comparing two independent variables of secondary students, grades 9-12, learning in Missouri STEM or STEAM settings, and the dependent variable of ACT STEM Benchmark score averages, 2012019, are used in a *t* test distribution of statistics. The purpose of the data analysis was to discover the differences in score averages among STEM and STEAM schools with each grouping determined by prior research.

Chapter Four presents the significant findings of the study using data tables, graphs, and a narrative used to analyze and discuss the results of the research. The concluding chapter of this study analyzes data and provides the author's summary, conclusions, and recommendations for further study supporting the implementation of STEAM education. Based on research results, data, and analysis, student learners were

expected to benefit from academic achievement in a STEAM-centered educational setting.

## **CHAPTER TWO**

### **REVIEW OF RELATED LITERATURE**

#### **Introduction**

Analyzing the paradigm of 21<sup>st</sup> century education with a focus on academic achievement, wherein students are engaged in STEAM, prompted the researcher to explore literature for comprehensive data that defines and substantiates the effectiveness of the STEAM learning model (Burke, 2022; Debroy, 2021; Idin, 2020). The literature provided the history of STEM and STEAM and why it is needed to fulfill the requirements of an education where students are prepared to communicate, collaborate, think critically, and innovate with creativity in the 21<sup>st</sup> Century (Battelle for Kids, 2019; Idin, 2020; Singh, 2021). Seminal theorist John Dewey believed that a progressive education supported the inherent benefits of student engagement, inquiry-based thinking, transfer of knowledge, experiential learning, and real-world problems solving (Dewey, 1929; Dewey & Hinchey, 2019; Li, 2020; Sadovnik et al., 2017). Dewey's theories are also congruent with the 21<sup>st</sup> Century idea of art and creativity merging with the STEM disciplines in STEAM (Battelle for Kids, 2019; Graham & Brouillette, 2016; Dewey, 1929, 1934; Li, 2020; Sadovnik et al., 2017).

The literature the researcher reviewed addressed the integration of the arts into STEAM with innovative learning tools and methods such as Artificial Intelligence, gamification of content, Project Based Learning, and Social Emotional Learning for the purpose of effective communication and ascertaining the soft skills of collaborative teamwork, creativity, and perseverance (Battelle for Kids, 2019; Crompton, 2023; Kefalis & Drigas, 2019; Marr, 2022; Vasconcelos & Santos, 2023). The researcher found

minimal concrete data showing 21st Century research in how this translates into testing the knowledge of secondary school learners using STEAM (ACT, 2015, 2020; Burke, 2022; Gao et al., 2020; Idin, 2020; Debroy, 2021). This study applies Dewey's theory of progressive education to 21st century learning. Dewey's concept of collaborative student-driven problem solving using real-world situations and his belief that art enables students to explore different perspectives and make connections between ideas, fostering a deeper understanding of the world, provided a framework for this study using data showing the difference in academic achievement between two independent variables: secondary students, grades 9-12, in Missouri class 3, 4, and 5 schools who are learning in the collaborative educational setting using arts integration in STEAM versus those using STEM (ACT, 2015, 2020; DESE, 2022a; Dewey, 1916, 1934, 1938).

A thorough examination of the definitions of STEM (Science, Technology, Engineering, and Mathematics) and STEAM (STEM +Arts) revealed the distinctions inherent in both acronyms. This clarification proved crucial in establishing the parameters of the study population. While both methodologies include integrating subjects across multiple disciplines, prioritizing problem solving, and fostering a growth mindset, STEAM incorporates arts education, collaborative creative expression, innovation, and design thinking when problem solving into its interdisciplinary curriculum. (Hallinen, 2023; Riley, 2023). After the researcher reviewed each educational methodology separately, STEM and STEAM were applied to 21<sup>st</sup> century education using Dewey's progressive educational theory professing the need for education to be well-rounded, inclusive of transdisciplinary subjects, and relative to students (Battelle for Kids, 2019; Dewey, 1929; Dewey & Hinchey, 2019; Li, 2020).

Exploring the differences that emerge from students engaging in STEM programs versus STEAM programs, the researcher can provide insights into the diverse outcomes that arise when students participate in each program. In addition, it enables the researcher to offer a comprehensive analysis of the educational impact and potential benefits associated with each approach. The results of the study may benefit students by increasing the use of STEAM in secondary schools (Antoni, 2020; Brouillette & Grahm, 2019; Dell’Erba, 2019; Hayden, 2022; Hughes, 2021; Singh, 2021; Silverstein & Lane, 2020; Wu & Rau, 2019; Wu et al., 2022).

The purpose of this causal-comparative study is to test the theory of Dewey’s progressive education when applied to 21st century education that compares the academic achievement of pupils learning in Missouri class 3, 4, and 5 secondary schools, grades 9-12, where STEAM curriculum is being used, to similar schools offering STEM curriculum to students learning at Missouri secondary schools class 3, 4, and 5, grades 9-12 (DESE, 2022a; Dewey, 1938; Dewey & Archambault, 1966; Li, 2020). The independent variable will be generally defined as Missouri class 3, 4, and 5 secondary students, grades 9-12, learning in Missouri schools. The dependent variable of interest will be defined as the average ACT STEM Benchmark score reported by Missouri class 3, 4, and 5 secondary schools, grades 9-12, where students are learning using STEAM or STEM from 2016-2019. The four years selected for the study were chosen because the ACT STEM Benchmark Score was first reported in 2015 and 2019 reflects scores reported before the onset of the global COVID-19 pandemic of 2020 when the educational system experienced widespread global disruptions (ACT, 2023; Allen, 2022). Many schools resorted to virtual or hybrid instruction in 2020-2021, and a return to

traditional instruction in 2021-2022 continued to affect the sample of ACT takers due to the disruption of learning (Allen, 2022). The time limit for the study reflects a four-year period when a growing number of students were studying in arts-rich STEAM schools and taking the ACT exam alongside students studying in traditional STEM schools (Inomjonovna & Ashirboy, 2023; Institute of Arts Integration and STEAM, 2020; Zhou, 2020). Prior research will determine factors used to define the research samples as STEAM schools or those using STEM. While both methodologies include integrating subjects across multiple disciplines, prioritizing problem solving, and fostering a growth mindset, STEAM incorporates arts education, collaborative creative expression, innovation, and design thinking when problem solving into its interdisciplinary curriculum (Battelle for Kids, 2019; DESE, 2022a, 2022; Institute of Arts Integration and STEAM, 2020). The current research reflects on the benefits of arts-rich learning in student academic achievement, but there is a gap in the research literature providing the availability of measurable data showing achievement in STEAM programs (Battelle for Kids, 2019; Tuttle, 2020).

This study aims to discover if there is a difference in students' academic achievement when learning in STEAM schools. The data provided in the study is obtained using the STEM Benchmark Score first incorporated into the ACT exam in 2015 (ACT, 2015, 2020; Crouse et al., 2015; DESE, 2022a; Mattern et al., 2015). The STEM Benchmark Score is an average of math and science scores from the ACT exam intended to indicate the readiness of high school students to engage in university level STEM learning. Due to the onset of the COVID-19 pandemic in 2020, STEM Benchmark scores were valid and reliable through 2019 (ACT, 2015, 2020; DESE,

2022a; Klein, 2021; Milligan, 2020). The longitudinal data of average student ACT STEM Benchmark scores from the testing cycle beginning in 2015 and continuing through 2019 may provide a statistical difference in students educated in STEAM programs, thereby adding to data supporting the benefit of integrating highly effective arts into STEM curriculum (Anisimova et al., 2020; Antoni, 2020; Battelle for Kids, 2019).

The researcher reviewed current professional literature to determine an overview of the history of STEM and STEAM education. A science, technology, engineering, and mathematics integrated curriculum has a rich history; arts integration into this design has a shorter historical timeline (Battelle for Kids, 2019; Zhou, 2020; Singh, 2021). Arts integration with cross-curricular purpose was explored to determine the framework of a STEAM learning model (Battelle for Kids, 2019; Silverstein & Lane, 2020). Current statistics and determinations regarding achievement in STEM and STEAM research provided expectations and a hypothesis regarding the possible effects of STEAM on student achievement (Battelle for Kids, 2019; The Institute for Arts Integration and STEAM, 2020; 21PSTEM, 2019; Stem Careers Coalition, 2020). STEAM research will provide expectations and a hypothesis regarding the possible effects of STEAM on student achievement.

The organization of the researcher's review of literature begins with an outline of what is recommended for an education meeting the expectations of the 21<sup>st</sup> Century (Battle for Kids, 2019; Koul et al., 2021). Addressed is the use of the four Cs of a 21<sup>st</sup>-Century education known as collaboration, critical thinking, creativity, and communication and the innovation needed for competition globally in what is now called

the 4th Industrial Revolution (Koul et al., 2021; Schwab & Davis, 2018). Throughout the researcher's review of literature, the underpinning of Dewey's theory on progressive education and the arts as a learning tool for engagement and metacognition are presented. A historical overview of STEM and STEAM and their evolution as an educational tool is included. Teaching methodology and the difference in how STEM differs from STEAM education are discussed. A discussion of the benefits of arts integration in transdisciplinary learning concludes the literature review.

### **Twenty-first Century Education**

Students educated in the 21<sup>st</sup> Century must collaborate, think critically, communicate with digital literacy, and problem-solve with creativity (Battelle for Kids, 2019; Idin, 2020; Singh, 2021; Wills, 2021). Educational standards at the international, national, state, and district levels include required education in the fields of science, technology, engineering, and math (Gao e

t al., 2020; Koul et al., 2021; Horath & Bott, 2020; The United States Department of Education, 2022). The United States Department of Education (2022) states that it is more important than ever for students to be equipped with the knowledge and skills to succeed. Twenty-first Century Education has challenged educators globally to increase the number of students involved in STEM learning (Anisimov et al., 2020; Lund, Madgavkor, Manyiku, & Smit, 2020; Peralez & Arostegui, 2021; Huser, 2020; Wu et al., 2022).

The use of STEM education focuses on preparing students in specific fields, while STEAM education adds an arts component to the STEM curriculum to better equip students with interdisciplinary skills needed for the workforce (Battelle for Kids, 2019;

Idin, 2020). Both approaches aim to give students hands-on, real-world experience and prepare them for higher education and career paths in a variety of industries. The educational approaches of STEM and STEAM can help students develop critical thinking, problem-solving, and innovation skills, which employers highly value (Hayden, 2022; Singh, 2021). Today, elementary, secondary, and schools of higher education specializing in STEAM education may be found internationally and are answering the call for students to be prepared for real-world careers (Anisimova et al., 2020; Battelle for Kids, 2019; Dell’Erba, 2019; Hughes, 2021; Hayden, 2022; Jacobson & Sumida, 2020; Lathan, 2020; Lund et al., 2020; Marr, 2021a; Singh, 2021; Whitehouse, 2021; Wu & Rau, 2019; Wu et al., 2022).

Science and technology have been a concern of presidents from Franklin D. Roosevelt in his 1944 question of his Science Advisor, Dr. Vannevar Bush, inquiring how science and technology could help shape post war America, to the recent letter President Joe Biden presented to his Science Advisor, Dr. Eric Lander, concerning how the federal government can best support the future of Americans post pandemic (Biden, 2022). The same concern exists today for 21<sup>st</sup> century learning methods to inspire global citizenship, competition in innovation and technology among nations, and create urgency within the federal government, the U. S. Department of Education, and state education agencies to ensure the focus of education is to prepare students for real-world problems (Kou, Konrath, & Goldstein, 2019; Idin, 2020; White House, 2021; U.S. Department of Education, 2022; DESE, 2022a; National Science Board, National Science Foundation, 2021). Attracting students to STEM fields and increasing achievement and productivity

became a focus for the U.S. Department of Education (The United States Department of Education, 2022).

The urgency for educational standards to embrace collaboration, communication, critical thinking, and creativity as the 4 Cs of a 21<sup>st</sup> century education resulted in legislation and funding for STEM education (Obama, 2016, 2018, 2020). Data shed light on the fact that U.S. students were falling behind other countries in STEM education and creating a growing concern for the future of America (The United States Department of Education, 2022; Schwab, Cole, Desai, Hemann, Hummels, & Maltese, 2018). If American students could not successfully compete in STEM subjects, researchers feared that America would become deficient in 21<sup>st</sup> century STEM soft skills learned in both secondary and higher education, and career readiness necessary for a trained workforce and national prosperity (Pearce, 2021; Schwab et al., 2018). Competition on a worldwide stage was important as the STEM in education initiative took hold and remains a primary focus for student achievement today (Burke, 2022; Hallinen, 2023; Idin, 2020; The United States Department of Education, 2022).

Historically, the United States' urgency for STEM education has received funding from the last four presidential terms in the United States (National Board of Science, National Science Foundation, 2021; The United States Department of Education, 2022). The competition and need for STEM have driven education standards in the United States at the national, state, and district levels. Standards have been reconfigured to focus on 21<sup>st</sup> century skills (DESE, 2022; 21PSTEM, 2019; National Science Foundation, 2023; Pearce, 2021; Singh, 2021; The United States Department of Education, 2023). An articulated need for STEM as a problem-solving tool in a globally complex world

resulted in government funding for STEM and 21st century learning. In 2018, The White House published a five-year strategic plan to fund STEM education under the Trump administration (National Science and Technology Council, 2018). The plan superseded the previous five-year plan established in 2013 under the Obama administration (National Science and Technology Council, 2013). While the Trump administration proposed cuts to specific STEM educational grants within government agencies in the 2020 budget, the 2019 \$549 million set aside by the federal government in grant funds for STEM education remained intact (Mervis, 2020). The administration stated the importance of 21<sup>st</sup> century workforce development and providing STEM education opportunities for underrepresented populations in STEM fields and across disciplines (Ambrose & Schwarber, 2020). An increase in funding for Career Technical Education (CTE) to prepare American workers for jobs that are currently filled by workers from other countries was included (Ambrose & Schwarber, 2020).

Federal funds support the educational ideas of STEAM to ensure students receive access to education, which helps students achieve using national and state academic standards (U.S. Department of Education, 2022). Embracing STEAM became a focus to fulfill and better prepare students to meet these expectations (Battelle for Kids, 2019; Burke, 2022; DESE, 2022; Hayden, 2022; Xu, Williams, Gu, 2020; Huser, 2020; Gonser, 2021). Funding for education is attached to test scores, career and technical programs, professional development programs for teachers, and advancing technology within public and private schools at all levels, from early childhood to higher education (Thibaut et al., 2018; U.S. Department of Education, 2023). Funding and support for STEAM have

created an entire shift in how students learn in the U. S. and beyond (Anisimova et al., 2020; Xu et al., 2020).

### **International STEM programs in 21st century education.**

Internationally, today's teachers must be able to deliver curriculum using learning management systems, artificial intelligence, virtual education, hybrid education, a variety of technological tools, and creative methodology (Burke, 2022; Idin, 2020; Marr, 2022; Singh, 2021; U.S. Department of Education, 2022). Project-Based Learning, Blended Learning, Problem Based Learning, Inquiry Based Learning, STEM, and integrated learning using the STEAM curriculums are considered the most effective way to teach today's students in the United States and abroad, preparing students with foundational knowledge and a set of soft skills necessary for competing in today's career field (Anisimova et al., 2020; Dell'Erba, 2019; Jacobson & Sumida, 2020; Reiner, 2020; The United States Department of Education, 2022).

A compelling example of global collaboration in business, science, and education is the recent development of vaccines and antiviral medications to treat the worldwide COVID – 19 pandemic and its variants (Klein, 2021; Milligan, 2020; Modan, 2021). Countries raced to find ways to save lives and create medical technology to end the pandemic and provide a commodity to be sold and shared with the world (Klein, 2021; Milligan, 2020; Modan, 2021; Zhou, 2020). The COVID-19 pandemic beginning in 2020 is an example of a global society demanding employees to have knowledge related to critical thinking, creativity, communication, and collaboration on an international stage pertinent to human survival (Milligan, 2020; Zhou, 2020). The imperative responsibility of the education community is to assure students are prepared for 21<sup>st</sup> Century

expectations and challenges, which assure the United States of America's success in the workplace, global commerce, and perpetuation of human life in an ever-changing environment (National Science Foundation, 2021; Zhou, 2020).

Examples of countries outside the U. S. using new learning models to achieve educating students with 21<sup>st</sup> century thinking skills and providing insight into the importance of creativity and innovation in learning are abundant (Anisimova et al., 2020; Singh, 2021; Xu et al., 2020). Examining international examples of learning highlights the importance of achievement in STEM and STEAM learning (International Society for Technology and Education, 2020; Organization for Economic Cooperation and Development, 2020). The following examples are evidence of worldwide focus on 21<sup>st</sup> century education. In Russia, researchers and educators recognize a need for innovative educational technology and creative spaces for students to meet the needs of what is called Industry 4.0 (Anisimova et al., 2020). Urgency is recognized, and systemic changes are recommended to incorporate creative activity and production in students prepared to enter an evolving workforce (Anisimova et al., 2020; International Bureau of Education, 2021). In the Korean Peninsula, STEAM education is striving to improve an already advanced national program to train teachers and educate prepared students in STEAM using what is called The Wheel Model of multidisciplinary subjects (International Bureau of Education, 2021; Kim, Sinatra, & Seyranian, 2018). The National Institute of Education in Singapore is researching the use of Artificial Intelligence Thinking to enable STEAM students to better use inquiry, problem-solving, working in teams, and data-driven evidence-based reasoning skills (Singh, 2021). Initiatives to incorporate or improve STEAM education are taking place all over the

world in the examples mentioned above and additional advanced countries such as Australia, Great Britain, Israel, Canada, China, Singapore, and the United States (Anisimova et al., 2018; International Bureau of Education, 2021; Singh, 2021; Xu et. al, 2020).

Global findings show that all students may benefit from integrated STEAM lessons, which help learners envision situations and possibilities not directly observed using divergent thinking (Brouillette & Graham, 2019). Policy makers around the world and in the United States of America are increasingly focused on the role creativity and the arts play in STEM education and looking for opportunities to increase student access to STEAM education (Dell’Erba, 2019; International Society for Technology in Education, 2020; Programme for International Student Assessment, 2020). Examples of the international expansion of 21<sup>st</sup> Century Learning and achievement are student assessments such as the Program for International Student Assessment (PISA), which added a competency score for collaborative problem solving important in STEM education models and traditional scores for core subjects (National Center for Educational Statistics, 2020). International Society for Technology in Education (ISTE) standards for students include digital citizenship and computational learning to enable students to flourish in a 21<sup>st</sup> Century society (International Society for Technology in Education, 2020).

The U. S. Department of Education has supported 21<sup>st</sup> Century Learning with funding for professional development and the creation of programs to increase students' involvement in STEM learning. Added to the definition of a global learner in the U. S. are students who can investigate work, weigh different perspectives, communicate with

diverse audiences and act as leaders (U.S. Department of Education, 2022; Thibaut et al., 2018). Current progress in 21st century learning brings together the four Cs and translates them into success in human activities and involves socioemotional learning and intellectual learning (Debroy, 2021). The need for success in these areas is important because it does not translate to tasks machines can do as well as educated humans (Debroy, 2021; Schwab and Davis, 2018). The Fourth Industrial Revolution, also known as Industry 4.0, is described as different than any previous industrial period because it joins the material, digital, and biological world, shaping what it means to humankind and their success in the 21<sup>st</sup> Century (González-Pérez & Ramírez-Montoya, 2022; Schwab & Davis, 2018). The call for Education 4.0, where frameworks for harnessing modern technologies and educating students to use them effectively and ethically in Industry 4.0 are needed (Bonfield, Salter, Longmuir, Benson, & Adachi, 2020; González-Pérez & Ramírez-Montoya, 2022). These frameworks often include the inclusion of the arts and humanities into STEAM education. The 21st-century concepts of creativity and communication of needs for success in modern learning have shifted to empowering learners and teachers with hands-on tools and a vision for 21<sup>st</sup> century learning. Results for discovering ways to measure the success of achievement in these programs are based upon the original core idea of the four Cs to achieve real-world learning in the 21<sup>st</sup> Century (Burke, 2022; Gonzalez-Perez & Ramirez-Montoya, 2022; Idin, 2020; International Society of Technology in Education, 2020; Debroy, 2021).

### **Science, Technology, Engineering and Math (STEM) in Education**

An in-depth look at the definition of both STEM and STEAM is needed. Identifying the difference between both acronyms is important to define the population

for the study and to examine the history, success, and challenges of both STEM and STEAM. After examining each educational methodology, the merging of STEM and STEAM occurred in the study as STEAM became an educational methodology providing the benefits arts offer to education in the form of STEAM. The study seeks to discover if arts-rich schools using STEAM education create a difference in academic achievement using the tool of the ACT STEM Benchmark score initiated in 2015.

**Define STEM education.**

The educational strategy of integrating Science, Technology, Engineering, and Math is called STEM (Hallinen, 2023). This acronym is based on teaching using a curriculum that offers an interdisciplinary approach. Problem-solving and real-world application are a focus of STEM. Definitions include the terms interdisciplinary and transdisciplinary, along with statements about rigor, school community, and global connections (Caton, 2021; Gao et al., 2020; Hallinen, 2023; Quigley & Herro, 2019; Riley, 2023). A specific definition has not been agreed upon, and the debate continues about which disciplines should be included in STEM. The use of STEM has a common educational goal of increasing achievement and encouraging participation in the STEM fields at schools, higher education, and the workforce (World Economic Forum, 2022). The United States overarching goal is to maintain a global presence in the world's economic arena, using innovation and production instigated by STEM fields (World Economic Forum, 2022; U.S. Department of Education, 2023). On November 8 each year, America celebrates National STEM/STEAM Day. The STEM education movement advocates departing from segmented content areas and relating

teaching to real-world situations. Twenty-first Century skills are emphasized so students gain proficiency in collaboration, questioning, problem solving, and critical thinking (Gunn, 2017; Hallinen, 2023; Li, Wang, & Xiao, 2020; U.S. Department of Education, 2023).

### **Historical overview of STEM education.**

The era which encouraged the integration of technology and innovation was the decade of the 1950s, which saw the launch of the Russian satellite Sputnik. The drive for American competitiveness caused presidents Dwight D. Eisenhower and John F. Kennedy to challenge Americans to become leaders in science, technology, engineering, and math. The charge was closely followed by President Eisenhower, encouraging the creation of the National Aeronautics and Space Administration (NASA) government agency. A space program was the result of the legislation creating NASA. President Kennedy continued to support the program and saw the landing of the first American on the moon, along with many other accomplishments in the 1960s (Gunn, 2017; Hallinen, 2023; Marick Group, 2016; Perales & Arostegui, 2021). The 1970s and 1980s were eras of exploration for science. Innovations of this period that combined STEM were the first cell phone, artificial heart, Space Shuttle launch, and the first personal computer (Gunn, 2017; Hallinen, 2023; Li et al., 2020).

The acronym STEM evolved from many different acronyms that represented programs to advance science with the purpose of assuring that Americans were excelling and competing with the world in STEM through innovation and the advent of modern technology (Li et al., 2020; Lyons, 2020). In the 1990s, the National Science Education Standards and National Council of Teachers of Mathematics helped teachers plan lessons

based on standards and guidelines. The first time the acronym STEM was used to refer to science, technology, engineering, and mathematics was in the 1990s; however, it was initially coined as Science Mathematics, Engineering, and Technology (SMET) by American biologist Dr. Judith Ramaley, Assistant Director of Education and Human Resources at The National Science Foundation (NSF) in 1998. The NSF changed SMET to STEM in 2001 (Buchanan, 2023; Christenson, 2011; Hallinen, 2023; National Science Foundation, 1998). Also in 2001, the emergence of a public and private grant to support STEM education was spearheaded by Arizona Governor Janet Napolitano, inspiring other states to follow (National Science Foundation, 2020). The No Child Left Behind Act of 2001 tied federal funding to state assessments and established core standards in STEM subjects (National Science Foundation, 2020). In 2009, the Innovation America Task Force was established by Napolitano and the National Governors Association establishing strategies to create state level environments conducive to furthering STEM education (Thomasian, 2011).

In response to this report and findings from the Trends in International Mathematics and Science Study (TIMSS), President Obama introduced the Educator to Innovate initiative in 2009 (Obama, 2011, 2016). The president's program intended to help American students rise to the top of the pack in science and math achievement over ten years (Obama, 2016). Crucial elements of the initiative included funding for preparing over 100,000 teachers (about the seating capacity of the Los Angeles Memorial Coliseum) to teach in the STEM field by 2021 (Obama, 2016). Obama's 2014 budget invested \$3.1 billion (about \$10 per person in the US) in federal funds for STEM

education (The United States Department of Education, 2022). The funds were specifically for recruiting and supporting STEM teachers and STEM high schools (U.S. Department of Education, 2018, 2022).

President Obama equalized the call for STEM and the 21st Century with this generation's Sputnik moment in 2011 (Obama, 2011, 2016). The following presidential cabinets continued to place importance on STEM education with funding increases (Prabhakar, Young, & Raimondo, 2023). Since that time, the STEM curriculum has spread to many countries around the globe, such as Australia, China, France, South Korea, Taiwan, and the United Kingdom (Buchanan, 2023; Gunn, 2017; Hallinen, 2023; Marick Group, 2016).

#### **Successes of STEM education.**

Countries from around the world have created STEM programs for technical, vocational, and academic study and these initiatives encouraged global sharing of educational strategies to improve STEM (Burke, 2022). All reports and strategies agreed that STEM fields in the workforce are important as they are responsible for economic growth, competition for innovation, solving global problems, and creating jobs (Battelle for Kids, 2019; Burke, 2022; Crompton, 2023; Hallinen, 2023; Marick Group, 2016; U.S. Department of Education, 2022; National Science Foundation, 2021). The significance of the study was also determined by the history of STEM both in the United States and globally (Anisimova et al., 2018; Battelle for Kids, 2019; Burke, 2022; Huser, 2020; Idin, 2020; Jacobson & Sumida, 2020). The 20<sup>th</sup> Century launch of the Sputnik Satellite in 1957 by the Soviet Union, caused the United States to enact cold war reforms in science and engineering education to gain ground in the competition for space exploration,

technological advancement, and national security. The National Defense Education Act enacted a year later placed a focus on educational reform. Transforming education has continued into the 21<sup>st</sup> century. The past four presidential tenures of George W. Bush, Barack Obama, Donald Trump, and Joseph Biden have focused on reforming 21<sup>st</sup> century education (Handelsman & Smith, 2016; Li et al., 2020; U.S. Department of Education, 2016, 2018, 2022). The transformation has appeared in many types of standards-based education connected to accountability and funding for public education (National Science Foundation, 2021). No Child Left Behind (NCLB), Every Student Succeeds Act (ESSA), Common Core Standards, Next Generation Education Standards, and a more recent focus on state and local control of educational standards have continued to focus on STEM education and the development of high-quality STEM teachers (Borowski, 2019; National Science Foundation, 2021; President's Committee on Arts Education, 2011; Huser, 2020; U.S. Department of Education, 2022). The Bush NCLB Act of 2001 initiated the era of standards-based education (National Science Foundation, 2023; U.S Department of Education, 2023). In 2009, President Barack Obama presented the Educate to Innovate initiative to move American students from the middle to the top of the world in science and math achievement following the United States National Academies of Science, Engineering, and Medicine's 2005 publication of *Rising Above the Gathering Storm*, and test scores from U.S. students which showed underperformance in the STEM fields on international tests such as TIMSS and

PISA (Borowski, 2019; President’s Committee on Arts Education, 2011; U.S. Department of Education, 2016, 2018, 2022).

Competition for states to create innovative plans to improve educational practices and outcomes for a workforce prepared in STEM fields was enabled by a series of grants sponsored by the National Governors Association, emphasizing aligning standards with workforce expectations, data-based improvements to STEM education and application of highly effective STEM practices in Career and Technical Education (National Science Foundation, 2021). In addition, the administrations of Obama, Trump, and Biden have encouraged collaboration between public and private entities in STEM education and reaching underserved populations such as women and minorities with quality STEM education. Federal monetary investments increased access to rigorous STEM learning, as well as efforts to recognize young achievers in innovation, discovery, and ingenuity (Progress Report on the Implementation of The Federal STEM Education Strategic Plan, 2021; Modan, 2021; 21PSTEAM, 2019; Silverstein & Lane, 2020; United States Department of Education, 2016, 2018, 2022).

Emphasis on STEM fields and the arts reaches beyond the national and state level (Anisimova et al., 2020; Battelle for Kids, 2019; Dell’Erba, 2019; Hayman, 2017; Huser, 2020; Jacobson & Sumida, 2020; Marr, 2021c; World Economic Forum, 2022). The framework for 21<sup>st</sup> century learning includes STEM and the arts (Borowski, 2019). This framework is being used globally to discern what is needed for students to succeed in today’s world. A variety of stakeholders gathered to outline what specific skills and knowledge students need to be successful in the 21<sup>st</sup> Century (Borowski, 2019; President’s Committee on Arts Education, 2011; U.S. Department of Education, 2016,

2018, 2022). Core subjects of literacy and numeracy scaffold the four Cs of critical thinking, communication, collaboration, and creativity (Battelle for Kids, 2019; Borowski, 2019). Career readiness and technological proficiency are considered innovation skills. Learning standards, assessments, curriculum, and professional development for educators, are considered support systems for 21st Century Learning (Battelle for Kids, 2019). The arts may be infused throughout the STEM paradigm in highly effective STEAM education (Battelle for Kids, 2019; Catterall, 2017; Delaney, 2014; Dell’Erba, 2019; DESE, 2022).

The bipartisan STEM Education Caucus established by the U.S. Congress was formed because international comparisons showed that the U.S. ranked 21 of 30 countries on scientific assessments (The United States Department of Education, 2018). In addition, U.S. state governors have sought pathways to empower high school graduates with STEM knowledge to ready them for STEM post-secondary study or work. The National Governors Association has sought to assist in aligning state standards in STEM education, improve teaching and learning, and identify best practices in STEM education (Hallinen, 2023; The United States Department of Education, 2023). A regional focus on STEM has been a recent addition to 21st century education. The current administration and The United States Department of Education continued to fund STEM initiatives, with investing \$120 billion (about \$370 per person in the U.S.) in STEM grant funds for public education, grades K-12 in 2022 (U.S. Department of Education, 2023). The push for STEM education continued to support 21st Century initiatives (Hallinen, 2023; Li, , 2020; U.S. Department of Education, 2023).

### **Challenges for STEM education.**

There are many challenges for STEM education. The growth of STEM jobs continued to outpace students and professionals trained for STEM fields. The United States Department of Education (2018) reports that there are an estimated 8.65 million jobs needed in 2018, and only 16% of high school students interested in STEM careers are proficient in the math required. Half of high school first-year students indicated an interest in STEM before graduation. A skills gap exists in the manufacturing sector, with a shortage of 600,000 skilled workers (Marick Group, 2016; U.S. Department of Education, 2018). Data from the United States Bureau of Labor Statistics (2020) indicates that the STEM occupations projected percent of employment change will double between 2021 and 2031. The World Economic Forum lists the top three skills needed in 2020: complex problem-solving, critical thinking, and creativity (World Economic Forum, 2016). Emotional intelligence and cognitive flexibility are also ranked in the top ten skills needed for future jobs (World Economic Forum, 2016). There is a need to attract qualified students and workers to train for STEM fields to meet 21<sup>st</sup> Century expectations of global competition (Gunn, 2017; Hallinen, 2023; Marick Group, 2016; U.S. Department of Education, 2023; Thibaut et al., 2018).

### **Equity issues in STEM.**

Participation of women, minorities, and persons with disabilities continues to be a challenge for the STEM labor force (Burke, 2022). Likewise, diversity is lacking in students interested and scoring proficiently in skills needed for STEM fields (ACT, 2015, 2020; Hallinen, 2023; Nadeem, 2021; National Science Foundation, 2021; Temming, 2021; World Economic Forum, 2022). Education providing STEM is lacking in at-risk

schools and communities (Nadeem, 2021; Temming, 2021). Gender and racial gaps continued to expand, with the number of white students entering the U.S. STEM field in 2019 reported as 67% of all STEM jobs (Temming, 2021; World Economic Forum, 2022).

Diverse populations such as black STEM workers entering STEM fields reported at nine percent, Hispanics at eight percent, and Asians at thirteen percent (Nadeem, 2021; Temming, 2021). The percentage of college degrees in STEM mirrors the STEM jobs report and is, therefore, a concern for educators attempting to increase engagement in STEM education (Nadeem, 2021; Temming, 2021). While women are employed in half of all STEM occupations, they are primarily overrepresented in the health fields, with 74% of jobs being health related. Women continue to be underrepresented in the fields of computer science, physical science, architecture, and engineering (Nadeem, 2021; Temming, 2021).

There is a need to attract minorities to the STEM fields for diversity and the ability to compete globally with other nations (Gunn, 2017; Hallinen, 2023; Soffel, 2018b; Neuhauser & Cook, 2016). Underrepresentation of women, minorities, and persons with disabilities in STEM is related to STEM education (Nadeem, 2021; Temming, 2021). Increasing overall engagement and retention in STEM education happens through adding rigorous courses in math and science, increasing interest in STEM, using design thinking and creativity for innovation, and growing STEM to STEAM (Gunn, 2017; Herranen, Fooladi, & Milner-Bolotin, 2021).

### **Teacher professional development and STEM.**

Research shows that educators being trained to teach subjects have difficulty combining diverse disciplines and evolving technologies in STEM-based instruction (Lo, 2021; Ozturk, 2021). Teachers of traditional STEM subjects, such as math, science, technology, and engineering, are trained to teach and think using a process rather than a product-centered model (Lo, 2021). The design approach, also known as the “A” in STEAM, makes designing STEM curricula more accessible for all teachers (Battelle for Kids, 2019; Lo, 2021; Ozturk, 2021). Research indicates that professional development and general education for teachers of STEM are needed around problem-solving to design solutions for real-world problems (Lo, 2021; Ozturk, 2021). Engaging in professional training in a collaborative method that emphasizes the 21st-century skills of collaboration, creativity, communication, and critical thinking with a group of teaching colleagues from diverse subject matter is needed (Lo, 2021; Ozturk, 2021).

However, this is challenging to implement in the traditional school schedule (Ozturk, 2021). Designing a STEM curriculum appropriate for the specific needs of students requires expertise, experience, and a learning model reflecting Dewey’s ideal social, collaborative, experiential learning model (Borowski, 2019; Dewey, 1938; Li, 2020). Discovering and addressing the challenges for STEM education provides a segway to why STEAM education with a design component is an important part of the literature review.

### **Science, Technology, Engineering, Arts and Math (STEAM) in Education**

The literature around integrating the arts into STEAM is extensive. The framework in place for STEAM education includes STEAM objectives and how they were developed, along with the background and funding of today's STEAM effort. The

benefits of transdisciplinary education in STEAM include examples of learning success with the STEAM method (Caton, 2021; Catterall, 2017; Riley, 2023).

### **Define STEAM education.**

A curriculum enriched with STEAM is set forth in schools to meet the standards of 21st century education. Twenty-first Century education requires the elements of the four Cs, or critical thinking, communication, collaboration, and creativity (Battelle for Kids, 2019; Borowski, 2019, 2023; Riley, 2023; U.S. Government, 2016, 2018, 2022). These elements are broad ideas for ways to modernize learning methods and meet the needs of global education through career readiness, technological proficiency, and the ability to innovate using knowledge (Battelle for Kids, 2019; Framework, 2016; Riley, 2023; U.S. Government, 2011, 2016, 2018, 2023).

### **Historical overview of STEAM education.**

John Maeda, former President of Rhode Island School of Design, championed the STEM to STEAM movement, professing that design thinking and creativity are essential elements of innovation (Christenson, 2011; Maeda, 2013; STEM to STEAM, 2018; Yu, 2021). The following three minds are suggested as the original engineers of STEAM (Minces & Akshay, 2023; STEM to STEAM, 2018). Leonardo Da Vinci, Albert Einstein, and Steve Jobs are suggested as pioneers of STEAM for their use of both science and creativity (Minces & Akshay, 2023; Henriksen, 2014). Da Vinci was known as a master painter and mathematician (Minces & Akshay, 2023; STEM to STEAM, 2018). The iconic painting, Mona Lisa, exhibits what is known as the *golden ratio* or mathematical

definition of beauty. The painting's aesthetically pleasing proportions are found in nature (Minces & Akshay, 2023; STEM to STEAM, 2018). Albert Einstein was not only a world-renowned physicist but was also a violinist and pianist (Minces & Akshay, 2023; STEM to STEAM, 2018). Einstein believed that after reaching the highest technical level, art and science meet (Minces & Akshay, 2023; STEM to STEAM, 2018). Finally, Steve Jobs, the creator of Apple, believed that science and technology joined with the liberal arts and humanities, were the answer to innovation (Murugesan, 2022). These masters paved the way for the future of arts integration and STEAM (Henriksen, 2014; Maeda, 2013; Murugesan, 2022; Minces & Akshay, 2023; STEM to STEAM, 2018).

#### **Successes for STEAM education.**

Dewey's communal ideas found in progressive education are inherent in STEAM learning environments within the U. S. and abroad (Li, 2020). Dewey's belief that students learn best when able to drive their learning with social discourse and interactive exchange of real-world problem solving aligns with the global idea of 21<sup>st</sup> Century generative thinking and the four Cs of STEAM (Battelle for Kids, 2019; Dewey, 1929, 1934, 1938; Li, 2020). The following examples portray how Dewey's seminal thinking and the conceptual underpinning of 21<sup>st</sup> century education took on a global meaning (Battelle for Kids, 2019; Li, 2020).

Singapore's National Institute of Education authors How and Hung (2019) saw the need for educators to facilitate student learning skills by engaging in team learning, discussing STEAM concepts, and engaging in evidence-based, data-driven instruction. The environment in which Russian students learn is a concern of Anisimova, Sabirova & Shatunova (2020) in their discussion of design laboratories where science, technology,

and art united in a free exchange of learning competencies. The Korean Republic wheel model of STEAM education involves student discovery and problem-solving in an active learning style called the Performing Project Method, named for the process of completing a project in a hands-on manner (International Bureau of Education, 2021; Kang & Furtak 2021; Kim, 2016). Japanese authors and designers discussed the idea of generative thinking and design in learning and its potential for expanding creativity, much like the free experiential space Dewey saw as the ideal learning environment for students (Kijma, Maekawa, Yang, 2021; Fujimura, 2017). Italian researchers have attempted to add to the empirical evidence that the arts play in STEAM by experimenting with long-term intervention and the cognitive act and flow of creativity on science motivation and engagement (Alexopoulos, Paolucci, Sotiriou, Bogner, Dorigo, Fedi, Menasce, Michelotto, Paoletti, & Scianitti, 2021). Global exploration in 21st-century learning methods reflects Dewey's belief in authentic learning experiences, which provide deep learning and metacognition rather than prescribed rote learning of the previous traditional schooling methods (Anisimova et al., 2020; How & Hung, 2019; International Bureau of Education, 2021; Kang, 2018; Kim, 2016; Li, 2020; Li et al., 2020).

The objectives of a STEAM curriculum, where science, technology, engineering, arts, and mathematics intersect for a positive learning experience, is explained by Keane and Keane (2016) as a curriculum aligned with standards and supported by technological pedagogy. The objective of this process is to integrate disciplinary subjects to create a transdisciplinary focus (Keane & Keane, 2016; Riley, 2023). This focus challenges students to take 21<sup>st</sup> century skills to new levels of content knowledge and engagement and inspires students to continue their learning in STEM fields (Keane and

Keane, 2016; Partnership for 21<sup>st</sup> Century Learning, 2018). Continuing education in the STEM fields and contributing to a global society in need of these career paths is STEM's main purpose (Hallinen, 2023). The addition of the “A” in STEAM serves to increase motivation for learning and enhance the learning environment Riley, 2023). The Next Generation Science Standards move science learning from how science is learned to how science is used. Adding the arts, in the form of design, creation, and innovation, shifts the alignment of the disciplines of science, technology, engineering, and math to align with transdisciplinary education (Borowski, 2019; Hallinen, 2023; Keane & Keane, 2016; Pruitt, Shelton, Brown, & Larazzo, 2023; Riley, 2023).

#### **STEAM and at-risk students.**

Integrating the arts into the core curriculum has a profound effect on at-risk populations (Catterall, Dumais, & Hampden-Thompson, 2012; Nadeem, 2021; Temming, 2021; Yu, 2021). The National Endowment for the Arts conducted a study of the effects arts-related education has on at-risk populations. (Catterall et al., 2012). The report shows the relationship of arts activity to levels of academic performance and citizenship. The four longitudinal databases of at-risk youth span over nine years, from 1988 to 2007 (Catterall et al., 2012). While dated, the data is of significance to the success of arts integration (Silverstein & Lane, 2020). The findings of the study showed that socially and economically challenged youth who have high levels of arts engagement do much better than their peers in academic achievement and civic engagement (Catterall et al., 2012). The data included the core subjects of science and math, both subjects of the current STEAM movement (Catterall et al., 2012; Silverstein & Lane, 2020). Adding the “A” in STEAM is also an effective way to attract students who are at risk and addresses

the lack of minorities pursuing STEM education and jobs in the workforce (Nadeem 2021; Silverstein & Lane, 2020; Temming, 2021).

### **STEAM and early childhood.**

Final comments on the benefits of STEAM included the results of research in early childhood education and the use of STEAM (Linder & Eckhoff, 2020; Ludwig & Song, 2015). A study was funded by a grant from the United States Department of Education to apply Wolf Trap Foundation Institute for Performing Arts: Institute for Early Learning Through the Arts Education's professional development model to the STEAM subjects (Ludwig, Markline, & Song, 2016; U.S. Department of Education: 2016). The professional development model centers around the idea that dance, music, and drama can help young children master skills in various areas of learning. The model had already shown success in studies on performance art improving literacy and communication skills, and math was added after a study showed that early success in mathematics was an indicator of future success in all academic subjects (Ludwig et al., 2016). The Wolf Trap: Early Childhood Learning through the Arts study was conducted over four years and showed that kindergarten and pre-kindergarten students and their teachers benefitted from the arts immersion. The teachers were more likely to use performing arts as a part of math instruction, and students scored higher than the control group of teachers and students who did not receive the benefits of the Wolf Trap professional development for teachers. The results of this study suggested that the early childhood STEAM subjects are positively affected using performing arts integration. The focus was on math, because this is the first

STEM subject taught in public education, so one would wonder if the same would hold true for upper grades as well (Ludwig et al., 2016).

More recent observations of how to enhance early childhood education with STEAM align perfectly with Dewey's theory of hands-on experiential learning in a social setting that solves real-world problems (Dewey, 1929, 1938; Linder & Eckhoff, 2020; Yildirim, 2020). Engaging young children in inquiry-based learning centered around what to learn and how to learn, such as how to care for a classroom pet or how to grow a plant and what is needed to do this successfully, provides STEAM learning environments with 21<sup>st</sup> Century processes such as critical thinking, problem solving, communication, inquiry, reflection, and creative exploration of how to achieve the desired effect (Battelle for Kids, 2019; Linder & Eckhoff, 2020). The young students in an early childhood classroom use deep thinking and metacognition and are highly engaged in STEAM projects (Battelle for Kids, 2019; Linder & Eckhoff, 2020; Ludwig et al., 2016; Wan, Jiang, & Zhan, 2020). While these are common early childhood classroom experiences, the understanding of how these projects involve STEAM, Dewey's thinking, and 21<sup>st</sup> century education is examined through the above processes (Battelle for Kids, 2019; Dewey, 1929, 1938; Li, 2020).

### **Challenges for STEAM.**

Focus on standardized test scores and the push for STEM to improve the United States' standing in 21<sup>st</sup> century education caused the arts to take a back seat in education because the arts were not tested or considered as an immediate tool to improve U.S. students' test scores (Ewing, 2020; Huser, 2020). At this time in history, the arts were considered an important embellishment to learning rather than a valuable learning tool in

STEM (Ewing, 2020; Bowan & Kisida, 2019; SEADAE; State Education Agency Directors of Arts Education, 2020). Cuts in arts funding and the continued lack of adequate funding have been a historical issue and this has affected both research and the data provided to support arts integration (Ewing, 2020; SEADAE, 2020). The benefits of engagement and personal connection to learning in an art-rich education were lacking, with an emphasis on achievement in standardized test scores in math and science education (Aisley et al., 2023; Biden, 2022; Catterall, 2017, Education Unbound, 2018; Ewing, 2020; Bowen & Kisida, 2019; SEADAE, 2020).

The concept of intertwining disciplines is addressed by Quigly and Herro, (2019) as a transdisciplinary approach. This approach is seen as superior to a multidisciplinary or interdisciplinary approach to education. Transdisciplinary education begins with a problem seen from a seamless blend of subjects rather than trying to add elements of many disciplines to a project. This approach is seen as the best for STEAM education, but it is often difficult to apply due to the lack of instructor content knowledge or time for collaboration among teachers (Battelle for Kids, 2019; Bellisario, Donovan, & Pendergast, 2012; Biden, 2022; Caton, 2021; Catterall, 2017). The authors (Quigly & Herro, 2019) make a clear connection between problem-based education and the objectives of a STEAM curriculum (Caton, 2021).

Integrating the arts into curriculum is not a new strategy, but with the adoption of 21<sup>st</sup>-century skills, there has been a push for a more creative and innovative society (Battelle for Kids, 2019). While teachers and administrators

currently profess to embrace the arts, this is not always the case. Art must be an integral partner of an integrated curriculum such as STEAM and not considered a tool for other subjects (Antoni, 2020; Battelle for Kids, 2019; Biden, 2022). Authentic integration of the arts must take place through collaborative planning, adequate art resources, and professional development to train teachers (Battelle for Kids, 2019; Biden, 2022; Jacobs & Alcock, 2017; Riley, 2023).

### **Twenty-first century education and STEAM.**

The skills required for STEAM learning align with the ideal learning environment of Dewey, who believed students should have equal opportunity to explore, create, and experience knowledge (Dewey, 1938; Dewey & Archambault, 1966; Li, 2020). Dewey's theories are echoed in the efforts of the international community to create the optimal learning environment for students, increasing their academic achievement and ability to learn using 21<sup>st</sup> century skills (Dewey, 1938, Dewey & Archambault, 1966; Huser, 2020; Li, 2020). Twenty-first century thinking skills incorporate Dewey's social learning theory with the four Cs of collaboration, critical thinking, creativity, and communication (Battelle for Kids, 2019; Huser, 2020, Li, 2020). Twenty-first-century skills that are needed to function well as a student or career innovator cannot stand alone without considering the social-emotional learning and communicative skills needed for collaborative learning and the divergent thoughts and ingenuity needed for solving real-world problems such as stifling a worldwide pandemic (Kou, Konrath, & Goldstein, 2019; Marr, 2021a; Milligan, 2020; Zhou, 2020). These skills are learned best by interacting with others and through creativity and the arts in STEAM education (Battelle

for Kids, 2019; Brouillette & Graham, 2019; 21PSTEM, 2019; Silverstein & Lane, 2020; Stem Careers Coalition, 2020).

Despite global support for STEAM and 21<sup>st</sup> Century skills in education and the workplace, civilization is 21 years into the 21<sup>st</sup> Century and industry is still lacking workers with skills needed for ever increasing technology, innovation, and automation (Hallinen, 2023; Schwab & Davis, 2018; Schwab, 2022; World Economic Forum, 2022). The top three job skills defined as necessary in 2020 were complex problem solving, critical thinking, and creativity (Marr, 2021c; Whitehouse, 2023; World Economic Forum, 2016). The need to expand and diversify students and workers pursuing STEM fields has caused a push to look at student engagement, cross-curricular education, and ways to bring the creativity aspect of STEAM to life in the education system (Battelle for Kids, 2019; Marr, 2021c; Soffel, 2018; Yakman, 2019). The world turned to the arts and a decades-old idea of integrating the arts into the core curriculum to help solve this dilemma (Dewey, 1938; Li, 2020; Marr, 2021b; Yakman, 2019). The acronym STEAM became a common term among progressive thinkers looking for ways to attract students and incorporate skills into learning, which employers indicated students of STEM education were lacking (Yakman, 2019). These skills are often referred to as soft skills and involve social emotional skills for collaboration and communication among groups of learners, allowing for the innovation and creativity that critical thinking inspires and the idea of social learning that Dewey inspired (Dewey, 1916, 1938; Debroy, 2021; Doyle, 2019; International Society for Technology in Education, 2023; Li, 2020).

These skills along with attracting and engaging students in STEM learning are driving the addition of the arts in STEAM learning (Benus, Moss, & Tucker, 2018;

Boyle, Ludwig, & Wan, 2020; Bush, Jackson, & Mohr-Schrader, 2021; Henriksen, 2014; Penprase, 2020; Travis, 2019). A student's formal education is where these skills must be instilled in learners for students to be successful in higher education and a workforce centered around STEM fields (Battelle for Kids, 2019; Burke, 2022; Cruz, Bruhis, & Kellam, 2021). Establishing the importance of educating students in the 21<sup>st</sup> Century and the actions that various countries, business entities, and educational systems have taken to prepare today's students to be contributors to the world have defined an era in 21<sup>st</sup> Century Learning. This is the environment in which the evolution of STEM and STEAM has occurred (Cruz et al., 2021; Burke, 2022; Idin, 2020; Marr, 2021a; Pearce, 2021; Xu et al., 2020). In the first two decades of the 21<sup>st</sup> century, education has begun to shift from relying on textbooks and teacher-directed activities to education trends such as virtual offerings, maker space, project-based learning, blended learning, flipped learning, genius hour, and courses focusing on design modeling, coding, artificial intelligence and gamification (Burke, 2022; Lin, Huang, & Lin, 2021; Kimmerly, 2023; Kefalis & Drigas, 2019; Marr, 2021a; Zhou, 2020; Vasconcelos & Santos, 2023; World Economic Forum, 2022). Students are thinking critically, collaborating with their classmates and communities, and using digital tools to present and communicate their ideas (Battelle for Kids, 2019; Bui, 2021; Hand & Shim, 2019; Henriksen, 2014; Idin, 2020; International Society for Technology in Education, 2023; Marr, 2021a; Zhou, 2020). Students engaged in 21<sup>st</sup> Century learning methods and STEAM are leaving behind rote learning and memorization, advancing students on Bloom's Taxonomy of cognitive learning skills, and propelling students to self-actualization, problem-solving, and creativity on Maslow's Hierarchy of Needs and in Dewey's early concept of a progressive education

(Bloom, 1956; Boyle et al., 2020; Dewey, 1938; Henriksen, 2019; Pichère & Cadiat, 2015).

The United States Department of Education recognizes these same objectives are necessary for today's students to succeed. Students need rigorous learning in specific subjects and the application of innovative learning methods. The former presidential administration of President Barack Obama created a mandate that schools compete for funds to establish learning opportunities in the STEM fields, calling for over four billion dollars of mandatory spending and three billion dollars of discretionary spending on STEM Education. School districts followed this lead and established programs in STEM education. If the arts are included in the acronym, the programs may be called STEAM (Battelle for Kids, 2019; Institute for Arts Integration and STEAM, 2020; U.S. Department of Education, 2018, 2022).

Authors concerned with leadership and education view integrating the arts as a pathway for adding diversity into learning. Silo style thinking is seen as negative in 21st Century learning. Learners must invest in the world and work toward a global curriculum and technology, which drives new knowledge, supports economics, and personalized learning (Hargreaves & Shirley, 2009). Teachers who are wise see that learning through the lens of the arts forms powerful visual, auditory, kinesthetic connections and assists in understanding in content (Reeves, 2009). Student learners become a team compared to players of improvisational jazz. The team reacts with complexity but inherent ease. Students are spontaneous but move comfortably in emerging patterns toward solutions

(Bolman, 2008). Jacobson (2019) highlights design as a key area in STEAM education. Design has taken the form of architecture, engineering, and the arts. Infusion of the arts encourages a creative approach to design thinking and can serve educators in their roles as facilitators of learning. Jacobson describes the design as artistic, compositional choices made to find a creative solution to real-world problems, which often have economic impact tying solutions to 21st Century framework (Herranen et al., 2021; Jacobson, 2019; Riley, 2023).

### **Expectations and the Four Cs.**

The objectives of a STEAM curriculum, where STEAM, and math intersect for a positive learning experience, is explained by Keane and Keane (2016) as a curriculum aligned with standards and supported by technological pedagogy. This process's objectives are the integration of disciplinary subjects to create a transdisciplinary focus (Caton, 2021; Keane & Keane, 2016; Quigley & Herro, 2019). This focus challenges students to take 21<sup>st</sup> Century skills to new levels of content knowledge and engagement and inspires students to continue their learning in STEM fields (Battelle for Kids, 2019; Institute for Arts Integration and STEAM, 2020; Jacobson, 2019; Keane and Keane, 2016; Soffel, 2018a). The main purpose of STEAM is to continue education in the STEM fields and contribute to a global society in need of these career paths (Institute of Science and Technology Education, 2023; PowerSchool, 2023).

The Next Generation Science Standards (NGSS), completed in 2013 and still in use in 2023, move science learning from how science is learned to how science is used. Adding the arts, in the form of design, creation, and innovation, shifts the alignment of the disciplines of science, technology, engineering, and math to align with

transdisciplinary education (Keane & Keane, 2016; Shapiro & Krauss, 2021; Wieselmann, Roehrig, Ring-Whalen, & Meagher, 2021). School districts called for the expansion of STEM education in their Community School Improvement Plans, with district visions and missions following the national directive (Gonzales, Ritter, & Shelton, 2022; NGSS, 2023; Wieselmann, Roehrig, Ring-Whalen, & Meagher, 2021). District strategies listed STEM as an interdisciplinary approach to learning with rigor in Science, Technology, Engineering, and Math, collective commitments to achieve interdisciplinary learning, professional learning communities, and curriculums aligned to NGSS, Common Core, or State Standards in numeracy and literacy (DESE, 2022; Gonzales, Ritter, & Shelton, 2022; Wieselmann et al., 2021). States are challenged to provide an education that has a mission to prepare students as 21<sup>st</sup> Century Learners. While these entities use the acronym STEM, each also calls for innovation and creativity, which are distinctly arts-related concepts (Isaacson, 2014; Travis, 2019; Wu et al., 2022).

### **Creativity, brain research, and achievement.**

In the book *From STEM to STEAM*, Sousa and Pelecki, (2018), place science behind their conviction that the arts must be a part of a thorough education. The authors describe a brain study using electroencephalography (EEG) to discover that arts training required children to use concentrated attention and focus. Cognition was improved when strong emotions cemented learning in long term memory (Bellisario, Donovan, & Prendergast, 2012; Dell’Erba, 2019; Institute for Arts Integration and STEAM, 2020; Sousa & Pilecki, 2018). The science behind the inclusion of arts in STEAM education is important because focus, cognition, and an emotional connection to learning deepen knowledge and

increase student achievement (Brouillette & Graham, 2019; Hughes, 2021; Wu et al., 2022). Students remember more, in more detail, and can apply this to other learning events (Battelle for Kids, 2019; Brouillette & Graham, 2019; Institute for Arts Integration and STEAM, 2020; Sousa and Pilecki, 2018; Jacobson, 2019). The authors also list problem solving techniques that are related to arts learning. Ideas are paraphrased as the ability to change goals in the middle of a project, make a decision based upon instinct or without a rule, understand that problems can have more than one answer, the use of imagination as a tool, the ability to push the constraints of a system, the ability to see the world from a visual or design perspective, and work in a team with diversity, all of which are recognized as benefits of experience in art education (Erlich, 2015; Glass and Wilson, 2016; Larson, 2018; Sousa and Pelecki, 2013; Townsley, 2017). The benefits of arts learning such as students having an emotional connection to learning, student engagement to deepen cognitive retention, the transfer of learning from one subject to another, decision making and solving real-world problems align with Dewey's theory of progressive education, just as Dewey's theories align with STEAM and 21<sup>st</sup> Century learning (Dewey, 1929; Dewey & Hinchey, 2019; Koul et al., 2021; Li, 2020; Penprase, 2020; Sadovnik et al., 2017).

Creativity in education helps students engage in complex learning (Battelle for Kids, 2019; Şahinkarakaş & Tokoz Göktepe, 2022). Emotional responses encourage deeper learning and higher level thinking skills such as divergent thinking, collaborative knowledge building, personal empowerment, economic competitiveness, and problem-solving are products of arts integration (Riley, 2023; Institute for Arts Integration and STEAM, 2020; Şahinkarakaş & Tokoz Göktepe, 2022). The flexibility and originality of

an arts approach causes a cognitive process of associations, patterns, and ideas that would often be absent in traditional learning (Institute for Arts Integration and STEAM, 2020; Mersand, 2021).

The arts approach enhances social-emotional learning as students tackle rigorous curriculum comfortably by solving problems with a variety of methods (Evans, 2019; Bowen & Kisida, 2019). Collaboration among students creates multiple access points to knowledge, fostering shared responsibility and compromise (Evans, 2019; Farrington & Shewfelt, 2019; Kisida & Bowen, 2019). These attributes of STEAM are the soft skills desired in the workforce and are not easily taught or learned without collaboration among students with different learning styles and backgrounds (Antoni, 2020; Farrington & Shewfelt, 2019; Kisida & Bowen, 2019). Collaboration using digital tools may assist quiet students who are more comfortable adding their voice in the STEAM setting (Nadeem, 2021; Schwab & Davis, 2018; Temming, 2021; Yu, 2021). Learning through the arts in STEAM is less repetitive and moves fast, challenging students to think “on their feet” and collaborate for quick answers and entices a variety of diverse learners to participate (Farrington & Shewfelt, 2019; Temming, 2021). The global community had to use 21st Century skills of collaboration, critical thinking, communication, creativity, and necessary soft skills when solving a real-world problem of designing a vaccine for the deadly COVID-19 virus and its variants, as mentioned in the introduction to this study (Modan, 2021; Zhou, 2020).

Attracting students to STEM fields through this process becomes the motivation for STEAM (Travis, 2019; Wills, 2021). Students learning with STEAM are positively affected by the interdependent relationships between subject matter, process, and product

and have a growth mindset when responding to problems and changes in solutions (Battelle for Kids, 2019; Catterall, 2017; Chastain, 2014; Erkins, Schummer & Vogle, 2019; Nash, 2019; Şahinkarakaş & Göktepe, 2022; Travis, 2019).

### **Learning models using STEAM education.**

There are different learning models for integrating the arts into the core curriculum. Traditional schools teach the arts as separate subjects, required by the National Core Arts Standards (Shepherd, Faber, & Bradshaw, 2014). In the state of Missouri, DESE has Missouri Learning Standards centered around the National Core Arts Standards and includes the fundamental anchors of create, perform/produce/present, respond, and connect through the arts (DESE, 2022; Shepherd et al., 2014). Individual application of the standards applied to dance, media arts, music, theatre, and visual arts, equip students to understand the knowledge of process, techniques for production, exhibition for performance, principles and elements of art, and vocabulary to explain and evaluate art (DESE, 2022; Schepker-Mueller & Pasley, 2021). There is a focus on 21<sup>st</sup> Century thinking skills throughout the standards with assessment in the student's ability to not only create, but to collaborate, communicate, and think critically to solve problems as they produce art. There are terms in these standards that are found in STEAM objectives, such as process, production, exhibition, performance, principles, elements, perceptions, evaluations, interrelationships, disciplines, historical, and contexts. The researcher restates these to note the integration of core subject learning processes already exist in fine arts subjects and in Missouri public school learning standards (DESE, 2022; Schepker - Mueller & Pasley, 2021).

Arts integration takes many forms in public education. Project Based Learning (PBL) results in a public presentation or performance (Wagner & Kingston, 2022). This learning environment is becoming the norm for public education classrooms (International Society for Technology in Education, 2023; Kingston, deMonsabert, & Wagner, 2022; PowerSchool, 2023). Project Based Learning is also referred to as inquiry based and often uses technology. While this learning environment is both collaborative and inquiry based, it also uses STEAM learning objectives built around the creative process (Evans, 2019; Riley, 2023; Wagner & Kingston, 2022). Educational standards are the guide, but students are encouraged to think in unconventional ways to problem solve and present (Battelle for Kids, 2019; Chastain, 2014; Gidcumb, 2017; Glass & Wilson, 2016; Kingston et al., 2022; Jacobs & Alcock, 2017; Townsley, 2017; Wagner & Kingston, 2022).

The benefit of an integrated curriculum such as STEAM is evident in the processes of PBL and in the design aspects of final projects must use critical thinking and collaborative social skills and have a visual concept of what a product will look like (Riley, 2023; Wagner & Kingston, 2022). The PBL classroom is one where students work together in teams to solve real-world problems through inquiry-based, student-generated learning (Evans, 2019; Wagner & Kingston, 2022). The teacher acts as facilitator and plans projects that include educational standards tested in standardized tests (Kingston et al., 2022). Although the learning is not directly test driven, the focus in the PBL classroom is problem-solving with a product in mind (Kingston et al., 2022).

The PBL concept of problem solving being student-driven and the teacher acting as facilitator is not new and was proposed by Dewey in his theory of progressive education (Dewey, 1938; Gibbon, 2019; Li, 2020). Projects may extend over multiple weeks and have a public presentation of findings and ideas at the conclusion, which also requires Dewey's idea of social learning and a connection to the community (Dewey, 1938; Li, 2020; Jacobs & Alcock, 2017; Glass & Wilson, 2016; Townsley, 2017; Wagner & Kingston, 2022). This type of learning is rigorous, not only for the students but for the teacher, and implementing PBL effectively requires a completely different learning environment and a growth mindset (Glass & Wilson, 2016; International Society for Technology in Education, 2023; Jacobs & Alcock, 2017; Townsley, 2017; Wagner & Kingston, 2022). The practice of using PBL is a significant way the arts are integrated into STEM curriculum through the design process, creative brainstorming, and collaboration among students (Evans, 2019; Wagner & Kingston, 2022).

Another current method of STEAM learning is the Maker Space. A Maker is a person who creates something in a designated space (Adler-Beléndez, Hoppenstedt, Husain, Chng, & Schneider, 2020); Battelle for Kids, 2019. The current public-school Media Center, formerly known as library, often has a Maker Space, where students are encouraged to tinker with items such as circuitry, robotics, three-dimensional printing, origami, and more (Adler-Beléndez et al., 2020). Students use their imagination and STEAM knowledge to ignite an idea and move to creating from that starting point (Adler-Beléndez et al., 2020). This *making* can be solo or working in collaboration with others (Adler-Beléndez et al., 2020). Makers are crafters, inventors, learners, teachers, or community members. The Maker Space is a place to see STEAM learning in action

(Adler-Beléndez et al., 2020; Chastain, 2014; Gold Standard PBL, 2017; Jacobs & Alcock, 2017; Soffel, 2018a).

The final discussion of pathways for integrating the arts into the core curriculum is focused on Project Lead the Way (PLTW). Career readiness is the objective of these STEAM-oriented classes currently being funded in part by the federal and state government (Floerke, 2021; Gunn, 2017; Partnership for 21<sup>st</sup> Century Learning, 2018; Anisimova et al., 2020; Soffel, 2018a). The PLTW classes are primarily designed for middle or high school secondary students (Anisimova et al., 2020; Floerke, 2021). There are strands within the classes for engineering, biomedical sciences, computer science, and design at the secondary school level (Floerke, 2021). The PLTW program for middle school is called Gateway, and the lesser-known elementary program is called Launch (Floerke, 2021). These classes focus on the use of STEAM subjects and prepare students for careers in the STEAM fields (Anisimova et al., 2020; Floerke, 2021; PowerSchool, 2023). This program also functions as vocational education for the 21<sup>st</sup> Century (Anisimova et al., 2020; Crayola Professional Services, 2016; Floerke, 2021; Framework, 2016; Gunn, 2017; Partnership for 21<sup>st</sup> Century Learning, 2018; PowerSchool, 2023; Soffel, 2018a).

Within the different pathways exist technologies that are constantly evolving. Students and teachers using STEAM education are also engaged in blended learning where teachers design a curriculum that provides choices in ways to use technology or hands-on materials for learning (Gonzalez-Perez & Ramirez-Montoya, 2022). Virtual learning and flipped learning have leaped

forward as tools for education in both the public schools and private sectors due to the necessity of remote learning during the COVID-19 pandemic of 2020-2023 (Gonzalez-Perez & Ramirez-Montoya, 2022; Modan, 2021; Zhou, 2020). Augmented Reality (AR) and gamification of learning are two of the latest additions to STEAM curriculum (Kefalis & Drigas, 2019; Vasconcelos & Santos, 2023). Technology in learning may also be a centerpiece of STEM schools, so the design aspect of how technology is used assists in defining the STEAM school from one focused STEM exclusively (Gonzalez-Perez & Ramirez-Montoya, 2022; Modan, 2021; Zhou, 2020).

Project Based Learning, Maker Space, Project Lead the Way, and creative technologies are three unique avenues for students to benefit from the objectives of a STEAM education (Battelle for Kids, 2019; Silverstein & Lane, 2020). The benefits of these types of learning are related to the benefits of interdisciplinary or transdisciplinary learning (Gao et al., 2022; PowerSchool, 2023). Core subject areas from the STEM field are joined to create a synthesis of learning through deeper understanding, more involved engagement, innovation, and assessment of learning objectives through a product or performance event (Chastain, 2014; Crayola Professional Services, 2016; Jacobs & Alcock, 2017; Partnership for 21<sup>st</sup> Century Learning, 2018; PowerSchool, 2023; President's Committee on Arts and Humanities, 2011; Silverstein & Lane, 2020; Soffel, 2018a; Wagner & Kingston, 2022).

When the researcher began this study, STEAM was novel, and educators placed immense value on the addition of the art and design portion of STEAM to equip learners for 21st-century learning, higher education, and careers in STEM fields (Koul et al., 2021; Travis, 2019). Today, the extent to which STEAM or STEM is used in an effective

manner varies widely among states and school districts, but STEAM is used globally as an effective pedagogy for teaching 21st century education (Singh, 2021; Wu et al., 2022). One of the greatest challenges in this study has been to define the qualities that define STEAM education taking place in Missouri high schools using a vast amount of literature on the what, the how, and the why, but little concrete data to support academic achievement related to STEAM focused learning (Pearce, 2021; Li et al., 2020).

### **Define STEAM school versus STEM school.**

Schools with successful STEAM curriculum are defined as those with quality teacher support where educators of diverse courses have shared planning and scheduled time to collaborate, tinker with resources and materials, and design STEAM units with specific learning standards from each discipline (Institute for Arts Integration and STEAM, 2020; Kingston et al., 2022). Schools defined as STEAM schools should have a space for making, innovating, and creating (Institute for Arts Integration and STEAM, 2020; Kingston et al., 2022). Schools should provide adequate space for STEAM, such as an innovation center or media hub, and classrooms with a space for creating (Institute for Arts Integration and STEAM, 2020; Kingston et al., 2022). Students should be engaged collaboratively solving real-world problems that are current and meaningful, involve the scientific research cycle, and are product, project, or performance based (Dewey; 1929, 1934, 1938; Wu, 2022). Students learning in a STEAM environment should be allowed to think critically, make mistakes, explore, and innovate using the arts and give valued reflection and feedback using student surveys and polls. The STEAM school should be deeply connected to its community and all stakeholders, regardless of ethnicity, language barriers, and disabilities (Nadeem, 2021; Temming, 2021). These 21<sup>st</sup>

Century qualities of a STEAM school are congruent with the thinking of seminal theorist John Dewey, who believed in student driven, experiential learning, and solving real world problems by connecting deeply rooted prior learning to newly created innovation in the 20<sup>th</sup> century (Dewey, 1929, 1938; Institute for Arts Integration and STEAM, 2020; Kingston et al., 2022).

### **Summary**

The review of literature for this study defined the difference between STEM and STEAM education initiatives. Given what we know about the use of STEAM in education, the problem is a lack of concrete and current statistical data supporting the use of the arts component in STEAM. The literature review created an understanding and history of both STEM (Science, Technology, Engineering, and Mathematics) and STEAM and their use in 21st-century education. The theoretical underpinning of Dewey's progressive education, which includes experiential learning through student-driven problem solving, transdisciplinary learning including the arts, and student collaboration to solve real-world problems, supports the learning methodology of STEAM education. Identifying the difference between STEM and STEAM education is also important to define the study population and examine the history, success, and challenges of both STEM and STEAM.

The addition of an ACT university readiness benchmark score in 2015 revealed the need to bolster STEM programs in America. The data indicated that STEM achievement is below expectations, and America must discover new ways of improving student achievement in rigorous courses (ACT, 2015, 2020). The arts play a role in the idea of what students can do with what they know (Silverstein & Lane, 2020). Creativity,

innovation, and the arts are important in the successful implementation of the STEM fields (Wu et al., 2022). The rationale for this study links the need for improved academic achievement with STEAM and addresses the gap in literature where concrete data is needed to show a significant difference in learning outcomes with STEAM versus STEM (Koul et al., 2021; Will, 2021).

Reviewing literature about creativity, and its influence on achievement, along with examining the pathways for using STEAM in the classroom, has provided background knowledge supporting the quantitative study based on the achievement effect of arts enhancement in STEAM. The use of the dependent variable, ACT STEM Benchmark score averages within Missouri secondary schools, grades 9-12, over a period from 2016 through 2019, is expected to show a difference in achievement between the two independent variables, students learning in STEAM schools and those learning using STEM.

Chapter Three will review the methodology of this research on student achievement by comparing schools with traditional STEM education and those schools offering STEAM education to students. The population of the research sample is discussed with criteria for determining STEM or STEAM schools using prior research. Community demographics and a detailed description of the schools defined as STEM or STEAM schools with similar populations will be followed by test comparison data in this quantitative study.

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **Introduction**

The review of literature in Chapter Two established the definition and characteristics of STEM and STEAM schools, which are the two independent variables for this causal comparative quantitative study (Hallinen, 2023; Pelham & Blanton, 2019; Riley, 2023). The STEAM focused curriculum was examined for the benefits of infusing STEM curriculum with art and design (Battelle for Kids, 2019; Idin, 2020; 21PSTEAM, 2019). The benefits of STEAM were reviewed in the literature by examining contemporary educational pedagogical methods (Battelle for Kids, 2019; Wagner & Kingston, 2022; Kimmerly, 2023). Prior research established a gap in the need for data to support achievement using STEAM education (Bowen & Kisida, 2019; Tuttle, 2020). The subjects of this study may be affected by encouraging stakeholders to support the use of STEAM curriculum for all students in Missouri public secondary schools, grades 9-12 (Battelle for Kids, 2019; DESE, 2022a, 2022; Wagner & Kingston, 2022; Kou, Konrath, & Goldstein, 2019; Institute for Arts Integration and STEAM, 2020; U.S. Department of Education, 2023). The hypothesis is that being exposed to the STEAM curriculum through course offerings and enrollment will lead to an increase in academic achievement. This achievement will be measured using the dependent variable of ACT STEM Benchmark scores for the years 2016 to 2019. The methodology of this study is outlined in Chapter Three.

## **Purpose of Study**

The purpose of this causal-comparative study is to test the theory of Dewey's progressive education when applied to 21st century education comparing the academic achievement of pupils learning in Missouri class 3, 4, and 5 secondary schools, grades 9-12, where STEAM curriculum is being used, to similar schools offering STEM within Missouri secondary schools class 3, 4, and 5, grades 9-12 (DESE, 2022a; Dewey, 1938; Dewey & Archambault, 1966; Li, 2020). The independent variable will be generally defined as Missouri class 3, 4, and 5 secondary students, grades 9-12, learning in Missouri schools. Students learning in rural districts classified as class 1 and 2 were not included in this study due to the variables of limited size and resources. The dependent variable of interest will be generally defined as the average ACT STEM Benchmark score reported by Missouri class 3, 4, and 5 secondary schools, grades 9-12, where students are learning using STEAM or STEM from 2016-2019. Prior research will determine factors used to define the research samples as STEAM schools or those using STEM (Battelle for Kids, 2019; DESE, 2022a; Institute of Arts Integration and STEAM, 2020). The current research reflects on the benefits of arts-rich learning in student academic achievement, but there is a gap in the research literature providing the availability of measurable data showing achievement in STEAM programs (Battelle for Kids, 2019; Tuttle, 2020).

This study aims to discover if there is a difference in students' academic achievement when learning in STEAM schools. The data provided in the study is obtained using the STEM Benchmark Score average reported by each school within the research sample categories of school designated as STEAM and STEM using prior

research (Battelle for Kids, 2019; DESE, 2022a, 2022; Institute of Arts Integration and STEAM; 2020). The STEAM Benchmark Score was first incorporated into the ACT exam in 2015 (ACT, 2015, 2020; Crouse et al., 2015; DESE, 2022a; Mattern et al., 2015). The STEM Benchmark Score is an average of math and science scores from the ACT exam intended to indicate the readiness of high school students to engage in university level STEM learning. Due to the onset of the COVID-19 pandemic in 2020, STEM Benchmark scores were valid and reliable through 2019 (ACT, 2015, 2020; DESE, 2022a; Klein, 2021; Milligan, 2020). The longitudinal data of selected schools' student average ACT STEM Benchmark score from the testing cycle beginning in 2016 and continuing through 2019 may provide a statistical difference in students educated in STEAM programs, thereby adding to data supporting the benefit of integrating the arts into STEM curriculum (Anisimova et al., 2020; Antoni, 2020).

Chapter Three will introduce descriptive research methodology to study achievement in Science, Technology, Engineering, and Math (STEM) and the integration of arts in STEAM. The rationale for using this method is defined using test scores in schools defined as STEM or STEAM schools by prior research (Battelle for Kids, 2019; DESE, 2022a, 2022; Institute of Arts Integration and STEAM; 2020). Statistical test data will be used for the qualitative causal comparison study. The research sample was defined as secondary schools, grades 9-12, as defined by DESE, who use STEM and STEAM (DESE, 2022a). This study's purpose was to determine how the arts may effectively increase achievement in STEM subjects.

The researcher reviewed current professional literature to determine an overview of the history of STEM and STEAM education. A science, technology, engineering, and

math integrated curriculum has a rich history; arts integration into this design has a shorter historical timeline (Zhou, 2020; Singh, 2021). Arts integration with cross-curricular purpose was explored to determine the framework of a STEAM learning model (Battelle for Kids, 2019; Silverstein & Lane, 2020). Current statistics and determinations regarding achievement in STEM and STEAM research provided expectations and a hypothesis regarding the possible effects of STEAM on student achievement (Battelle for Kids, 2019; The Institute for Arts Integration and STEAM, 2020; 21PSTEM, 2019; Stem Careers Coalition, 2020).

### **Research Questions**

The following questions helped guide the study:

RQ1: What is the difference in ACT STEM Benchmark scores from 2015-2016 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ2: What is the difference in ACT STEM Benchmark scores from 2016-2017 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ3: What is the difference in ACT STEM Benchmark scores from 2017-2018 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ4: What is the difference in ACT STEM Benchmark scores from 2018-2019 for students learning in a STEM environment versus those learning in a STEAM environment?

## **Null Hypotheses**

H<sub>0</sub>1: There will be no statistically significant difference in ACT STEM Benchmark scores for students learning in a STEM environment versus those learning in a STEAM environment.

H<sub>0</sub>2: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2016-2017.

H<sub>0</sub>3: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2017-2018.

H<sub>0</sub>4: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2018-2019.

The results of this study may show a significant difference between the variable, provide important data in education, and cause schools to maintain an environment rich in creativity, problem solving, innovation, communication, collaboration, and critical thinking needed for the 21<sup>st</sup> century education of students.

## **Variables and Measurement**

The Dependent Variable is defined as ACT STEM Benchmark score averages reported to DESE by the schools defined in the study from 2016-2019. The two independent Variables in this study are defined as arts rich STEAM schools and traditional STEM schools using literature review and prior research (Battelle for Kids, 2019; The Institute for Arts Integration and STEAM, 2020; 21PSTEM, 2019; Stem

Careers Coalition, 2020). This quantitative causal comparative study will apply the independent variables in a *t* test to determine if there is a significant difference in the achievement of students learning in arts rich STEAM education versus traditional STEM school settings (Creswell & Creswell, 2023). These variables were entered and tabulated using IBM SPSS Statistics (Version 23) predictive analytics software (ACT, 2015, 2020; DESE, 2022a, 2022; IBM Corporation, 2015).

### **Participants**

Secondary school students attending class 3, 4, and 5 schools in the state of Missouri educated using STEM or STEAM were defined by reviewed literature and prior research (DESE, 2022a; The Institute for Arts Integration and STEAM, 2020; Missouri State High School Activities Association, 2023; 21PSTEM, 2019; Stem Careers Coalition, 2020). The characteristics defining the two independent variable populations were provided by Missouri DESE on its open-source website (ACT, 2015, 2020; DESE, 2022a). Missouri schools are defined by the number of eligible students enrolled in activities; 199-434 (Class 3), 435-931 (Class 4), and 932+ (Class 5) (Missouri State High School Activities Association, 2023). Students learning in rural districts classified as classes 1 and 2 were not included in this study due to the variables of limited size and resources.

The data was then dissimilated to determine the two cluster sample populations tested. Annual statistical data was reported by DESE and utilized to determine class 3, 4, and 5 high schools housing students in grades 9-12 (DESE, 2022a, Missouri State High School Activities Association, 2023). The ACT STEM Benchmark average score for achievement comparisons in the study was reported annually from 2015 through 2019

(ACT, 2015, 2020; DESE, 2022a). Reliability and validity are determined by utilizing data reported by ACT and sourced from the DESE open-source website. This data is employed to compare the independent variables within the study. The sample size of each independent variable was representative of the target population of students engaged in STEM or STEAM in the state of Missouri (ACT, 2015, 2020; DESE, 2022a; Missouri State High School Activities Association, 2022).

### **Selection/Sampling**

The population selection for the study was conducted using reviewed literature and prior research. A checklist was used to discern STEM from STEAM schools. There were research-based questions used to frame thought on each checklist item. While both methodologies include integrating subjects across multiple disciplines, prioritizing problem solving, and fostering a growth mindset, STEAM incorporates arts education, collaborative creative expression, innovation, and design thinking when problem solving into its interdisciplinary curriculum. (Battelle for Kids, 2019; DESE, 2022a, 2022; The Institute for Arts Integration and STEAM, 2020; 21PSTEM, 2019; Stem Careers Coalition, 2020). The schools were limited to class 3, 4, and 5 secondary schools in Missouri, grades 9-12, offering STEM or STEAM curriculum (ACT, 2015, 2020; DESE, 2022a; Missouri State High School Activities Association, 2023). The defined schools were then used for a *t* test comparison study of ACT STEM Benchmark achievement average scores. The large sample size provided significant data with a small standard of mean error (Pelham & Blanton, 2019).

## **Research Setting**

The research setting for the study was Missouri. Students attending class 3, 4, and 5 secondary schools, grades 9-12, who participated in the ACT test administered by ACT, were the participants. Secondary schools reported ACT data to DESE, and students took the ACT test in high schools serving students in grades 9-12, or at ACT administered sites. The two samples to be tested were defined as STEM or STEAM using reviewed literature, prior research, curriculum offerings, and participation in those courses (ACT, 2015, 2020; DESE, 2022a, 2022). Missouri's Department of Secondary and Elementary Education open - source website and ACT provided data for samples and test data to be charted and analyzed using IBM SPSS Statistics (Version 23) predictive analytics software (ACT, 2015, 2020; DESE, 2022; IBM Corporation, 2015).

## **Research Design**

Initial steps in the research design involved establishing two distinct controlled cluster samples, STEAM or STEM schools, using reviewed literature and prior research. While both methodologies include integrating subjects across multiple disciplines, prioritizing problem solving, and fostering a growth mindset, STEAM incorporates arts education, collaborative creative expression, innovation, and design thinking when problem solving into its interdisciplinary curriculum (Battelle for Kids, 2019; The Institute for Arts Integration and STEAM, 2020; 21PSTEM, 2019; Stem Careers Coalition, 2020). The quantitative causal-comparative research design of the study involved comparing these two distinct variables. The first step involved determining each of two controlled cluster samples, STEM or STEAM schools (Battelle for Kids, 2019; The Institute for Arts Integration and STEAM, 2020; 21PSTEM, 2019; Stem

Careers Coalition, 2020). Design controls for the determination of samples included a comparable checklist of each form of school data. A statistical power analysis was used to determine a participation percentage of STEM or STEAM schools that ensured statistical power to reject the null hypothesis, determine the effect size of 0.05 chance of making a Type I error, and ensure variability in dispersion of data (Cohen, Manion, & Morrison, 2018; Creswell & Creswell, 2023). Design controls also included using the review of literature to define STEM, science, technology, engineering, and mathematics, curriculum centered on education in the disciplines of science, technology, engineering, and mathematics versus STEAM, an approach to learning that uses STEAM as access points for guiding student inquiry, dialogue, and critical thinking (Hallinen, 2023; Riley, 2023). Defining STEM versus STEAM objectives determined correct groupings for samples. The confidentiality of students and schools was ensured by using numerical entry into IBM SPSS Statistics (Version 23) predictive analytics software (IBM Corporation, 2015).

The second step involved gathering longitudinal data from 2016-2019 ACT tests and grouping each by year from the DESE database and ACT (ACT, 2015, 2020; DESE, 2022a). Data was then analyzed using IBM SPSS Statistics (Version 23) predictive analytics software in a comparison *t* test to reject the null hypothesis (IBM Corporation, 2015). Data for variables was extracted from the DESE open-source database and ACT and is considered reliable and valid.

### **Instrumentation**

Tools for acquiring accurate data determining a secondary school as a STEM school or one with arts enhanced STEAM curriculum was determined by prior research,

curriculum offerings, participation in those courses, and a checklist provided by each district's curriculum specialist or administrator. The Missouri DESE open-source database was used to extract information and provide design controls for samples and longitudinal data acquired from ACT STEM Benchmark scores. Statistical Package for Social Sciences software was used to analyze, test, and compare the mean of the two variables. ACT STEM Benchmark scores were gathered and grouped from the two samples over four years. The historically significant *t* test was used to find the difference in the mean of achievement variable using the samples of STEM and STEAM public high schools (Pelham & Blanton, 2019; IBM, 2015).

### **Procedures**

A comparable descriptive sample of class 3, 4, and 5 Missouri secondary schools housing grades 9-12 was determined by using data reported by DESE and MSHAA including population numbers, curriculum offerings, and participation in the courses. The samples were selected and defined by schools offering STEM curricula and those offering STEAM-based curricula determined by prior research and a checklist survey completed by school administrators or curriculum specialists and added by the researcher. The data gathered from each school was compared using design controls of like or unlike course offerings and student participation. Data from DESE provided the annual ACT STEM benchmark average score recorded by each school group and was then divided into groupings of 2015-2016, 2016-2017, 2017-2018, and 2018-2019 to address each subcategory of the research question. Selected schools reported data to DESE, which was approved as an open-source website for the public. A checklist of items, which can be found in Appendices, was used to select samples created using prior research, curriculum

offerings, and reviewed literature (Battelle for Kids, 2019; Institute for Arts Integration and STEAM, 2020). The checklist determined coursework standard in arts-rich STEAM schools (Battelle for Kids, 2019; Institute for Arts Integration and STEAM, 2020). The data produced from the process defined the schools to be STEM or STEAM schools providing two samples to compare. Individual students and school names were assured of confidentiality by the fact that names are not reported in DESE data for individual students and school names were replaced with an anonymous numerical listing in IBM SPSS Statistics (Version 23) predictive analytics software (IBM Corporation, 2015). The researcher extracted ACT STEM Benchmark scores from participating schools in 2016-2019 and use IBM SPSS Statistics (Version 23) predictive analytics software to perform statistical analysis in the form of a *t* test over two means for the ACT STEM Benchmark and a grouping of years for each subset research question (IBM Corporation, 2015). The test showed a significant difference (.05 or TBA) in achievement according to state reported data for average ACT STEM benchmark scores (ACT, 2015, 2020; DESE, 2022a; IBM Corporation, 2015).

### **Data Analysis**

The study provided spreadsheet data, graphs, and charts to determine samples for IBM SPSS Statistics (Version 23) predictive analytics software analysis (IBM Corporation, 2015). This data was organized with responses in sorting order. Prior research, population size, curriculum offerings, and participation in these courses provided detailed data determining specific characteristics of STEM or STEAM school samples. The DESE website data provided four years of longitudinal scores for ACT STEM Benchmark from 2016-2019 as reported from Missouri public high schools on the

DESE website and ACT. Data extracted determined the variables used to define the samples for statistical analysis. Reliability and validity of the data are secured using longitudinal data from a public web site reporting statistical data about Missouri school districts annually and ACT. Statistical Package for Social Sciences software was used to analyze and test the two samples, STEM and STEAM high schools in a *t* test (ACT, 2015, 2020; DESE, 2022a; IBM Corporation, 2015). The variable of ACT STEM Benchmark from 2016-2019 was used to determine significant difference (.05 or TBA) in achievement of schools designated as STEAM. This research project was designed to collect data, which determined the result of *t* test comparison indicating results from achievement data extracted from the DESE database and ACT. This research was to determine the impact of STEAM education on achievement.

Limitations the researcher did not have control of during the study included the test environment and fidelity, which was completed prior to and during the ACT testing. The ACT STEM Benchmark scores were reported within each school district as mandated by the state. The average ACT STEM Benchmark score average was defined by DESE and collection was from the open-source data website. The longitudinal data were extracted and recorded by year from 2015, the score's inception, and continued through 2019, before the Covid-19 global pandemic affected the reporting of scores. The study was informed by the gap in research providing scientific data indicating the impact on academic achievement of students engaged in education using creativity and the arts in STEAM. The analysis of data was limited to the constraints and internal file structure of IBM SPSS Statistics (Version 23) predictive analytics software (IBM Corporation, 2015). The sample size and selection were determined by classification of size by

Missouri State High School Activities Association and DESE, Class 3, 4, and 5 schools. Students in rural districts classified as classes 1 and 2 were not included in this study due to the variables of limited size and resources. The researcher was not without bias when it came to thoughts regarding fine arts education and creativity, as she is trained as a professional musician and fine arts educator and certified in the public-school systems of Missouri and Texas.

Delimitations intentionally imposed by the researcher were that the study population was defined as students studying secondary education, grades 9-12, in Missouri high schools designated by Missouri High School Activities Association and the DESE as class 3, 4, and 5, who were already engaged in STEM or STEAM education. The theoretical underpinnings of the study focused on the seminal progressive learning theory of John Dewey, and the four Cs of 21<sup>st</sup> century education; creativity, critical thinking, collaboration, and communication. Students learning in rural districts classified as class 1 and 2 were not included in this study due to the variables of limited size and resources. The population included only class 3, 4, and 5 Missouri high schools serving grades 9-12, defined as STEAM versus STEAM schools by prior research determining STEAM education characteristics. The test scores used in the research for the study were defined using the initial inception of the ACT STEM Benchmark Score in 2015, through 2019.

### **Summary**

In Chapter Three the methodology utilized in this quantitative study was set forth. The causal-comparative research design compared two independent variables of secondary students, grades 9-12, learning in Missouri STEM or STEAM settings, and the

dependent variable of ACT STEM Benchmark score averages, 2016-2019, were used in a *t* test distribution of statistics. The purpose of the data analysis was to discover the differences in score averages among STEM and STEAM schools with each grouping determined by prior research.

Chapter Four presents the significant findings of the study using data tables, graphs, and a narrative used to analyze and discuss the results of the research. The concluding chapter of this study analyzes data and provides the author's summary, conclusions, and recommendations for further study using the implementation of STEAM education.

## **CHAPTER FOUR**

### **FINDINGS AND RESULTS**

#### **Introduction**

The future requires the building blocks of real-world 21<sup>st</sup> century education (Antoni, 2020; Battelle for Kids, 2019; Crompton, 2023; Kou et al., 2019). Current and future jobs require students to pursue higher education or career training, attain specialized skills in specific areas of STEM, and compete in a global job market requiring creativity, innovation, communication, and collaboration in the workplace and beyond (Aisley et al., 2023; Dadlani & Soler, 2022; Pearce, 2022). The use of STEM education has been associated with 21<sup>st</sup> century education nationally since a collaborative group of educational leaders, business and community members, and policymakers defined the skills 21<sup>st</sup> century students need to be successful in life, work, and citizenship (Battelle for Kids, 2019; Crompton, 2023; Idin, 2020). More recently, the focus on creativity, innovation, and invention has incited the addition of “A” or arts in STEAM education (Anisimova et al., 2020; Koul et al., 2021).

This study outlined the history, relevance, and importance of STEAM education with a focus on the academic achievement of students (Bowen & Kisida, 2019; Crompton, 2023). The proposed problem centered around the lack of current data supporting the use of arts integration in STEAM (Anisimova et al., 2020; Koul et al., 2021). The study sought to gain insight into academic achievement using the dependent variable of the ACT STEM Benchmark score average 2016-2019. Two independent variables, secondary high schools in Missouri, grades 9-12, using STEM or those using the arts and design component in STEAM education, were used to determine if STEAM

improved the ACT STEM Benchmark score average. The literature review provided a group of thought-framing questions proposed to Missouri school leaders to determine if their high school was considered STEM or STEAM (Hallinen, 2023; Riley, 2023). This determination provided groupings of data for analysis.

Chapter Four will report the findings from this study to determine how this information will contribute to the data and literature of STEAM in education. The purpose of the causal-comparative study research questions and null hypotheses are stated for each question. The purposive samples were determined as STEM or STEAM schools based on a checklist survey, with participants being Missouri educational leaders. Data was analyzed, cleaned, and prepared for reporting the study's findings. Research findings are displayed in tables; the researcher reports and analyzes descriptive statistics.

### **Purpose of Study**

The purpose of this causal-comparative study is to test the theory of Dewey's progressive education when applied to 21<sup>st</sup> century education comparing the academic achievement of pupils learning in Missouri class 3, 4, and 5 secondary schools, grades 9-12, where STEAM curriculum is being used, to similar schools offering STEM within Missouri secondary schools class 3, 4, and 5, grades 9-12 (DESE, 2022a; Dewey, 1938; Dewey & Archambault, 1966; Li, 2020). The independent variable will be generally defined as Missouri class 3, 4, and 5 secondary students, grades 9-12, learning in Missouri schools. Students learning in rural districts classified as class 1 and 2 were not included in this study due to the variables of limited size and resources (DESE, 2022a). The dependent variable of interest will be generally defined as the average ACT STEM Benchmark score reported by Missouri class 3, 4, and 5 secondary schools, grades 9-12,

where students are learning using STEAM or STEM from 2016-2019. Prior research will determine factors used to define the research samples as STEAM schools or those using STEM (Battelle for Kids, 2019; DESE, 2022a; Institute of Arts Integration and STEAM, 2020). The current research reflects on the benefits of arts-rich learning in student academic achievement, but there is a gap in the research literature providing the availability of measurable data showing achievement in STEAM programs (Battelle for Kids, 2019; Tuttle, 2020).

### **Research Questions**

The following questions helped guide the study:

RQ1: What is the difference in ACT STEM Benchmark scores from 2015-2016 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ2: What is the difference in ACT STEM Benchmark scores from 2016-2017 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ3: What is the difference in ACT STEM Benchmark scores from 2017-2018 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ4: What is the difference in ACT STEM Benchmark scores from 2018-2019 for students learning in a STEM environment versus those learning in a STEAM environment?

## **Null Hypotheses**

H<sub>01</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs versus those educated in STEAM programs based upon ACT STEM Benchmark scores from 2015-2016.

H<sub>02</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs versus those educated in STEAM programs based on ACT STEM Benchmark scores 2016-2017.

H<sub>03</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2017-2018.

H<sub>04</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2018-2019.

Each research question and related null hypothesis were examined through the analysis of quantitative ex post facto data using the SPSS statistics tool. The independent-sample *t* test was utilized to compare the means of STEM and STEAM high schools in Missouri. Cohen's *d* was calculated to determine the standardized difference between the means. Cohen's *d* can be cautiously interpreted using the effect size of 0.2 as a small effect size, 0.5 as a medium effect size, and 0.8 as a large effect size (Cohen et al., 2018; Cresswell J. W. & Cresswell J. D., 2023).

## **Descriptive Statistics**

### **Samples.**

The researcher collected a response sampling through a two-question checklist survey distributed to Missouri secondary school administrators and curriculum specialists. The two independent samples were determined by STEM or STEAM schools based on a checklist survey. Survey participants were educational leaders who used thought-framing questions based on prior research and a review of the literature to outline the qualities of STEM or STEAM schools (Battelle for Kids, 2019; Institute of Arts Integration and STEAM, 2020). Survey participant responses were grouped into STEM (Group 1) or STEAM (Group 2) by checking yes or no in the two-question survey. The researcher held respondent email addresses confidential. Purposive sampling was used to align with the study and improve the rigor and trustworthiness of the data obtained (Pelham & Blanton, 2019).

#### **Demographics.**

The demographics of the independent samples are outlined by the Missouri School Directory from the DESE website as Missouri high schools, grades 9-12, Class 3, 4, and 5, who report ACT data to DESE (DESE, 2022a). The researcher used the Missouri School Directory to contact administrators and educational specialists throughout the state (DESE, 2022a). Over 300 districts were contacted about disseminating the survey. Due to the anonymity of the survey, it is not clear how many different school districts are represented in this study. Of the responses, there were 34 schools determined STEM and 32 schools determined STEAM based on the checklist survey (Hallinen, 2023; Riley, 2023). Responders consisted of superintendents, principals, fine arts administrators, and arts department leaders from school districts from a wide variety of districts spanning the state. The respondents who did not have a specific connection to a Missouri secondary

school and reported ACT statistics to DESE were eliminated. After determining the validity of the samples, organizing the data provided by the Google Form and the subsequent spreadsheet, the clean data was averaged and arranged into an Excel spreadsheet for entering data.

### **Data Analysis and Findings**

The researcher surveyed secondary school leaders from the state of Missouri to determine the independent variables (Hallinen, 2023; Riley, 2023). The independent variables of Missouri Class 3, 4, and 5 high schools, using STEM or STEAM education were examined to determine efficacy levels for achievement using the dependent variable of the ACT STEM Benchmark score average from 2016-2019. Research data was used to address the four research questions. Once the number of survey responses exceeded 108, the data were downloaded, processed, and analyzed using the SPSS statistics tool (IBM Corporation, 2015). Microsoft Excel was utilized to filter, sort, and total the data.

The independent samples *t* test was utilized to compare the means in ACT STEM Benchmark score averages for the four years of the study (Pelham & Blanton, 2019). The *t* test assisted the researcher in determining the difference between scores for secondary schools using STEM or STEAM education. Measurement of the dependent variable in the study, ACT STEM Benchmark averages reported by STEM or STEAM high schools over four years, 2016-2019, occurred before the COVID-19 pandemic and were considered reliable and valid (Klein, 2021).

After running the independent samples *t* test for each of the research questions, the researcher reported the differences in the means of the independent variables, STEM or STEAM schools. The means showed no statistically significant difference in the mean

(2016,  $p = 0.17$ , 2017,  $p = 0.17$ , 2018,  $p = 0.05$ , 2019,  $p = 0.08$ ) alpha being .05. Cohen's  $d$  was used to determine effect size using a two-sided  $p$  with a 95% confidence interval of lower and upper levels (Cohen et al., 2018; Cresswell J. W. & Cresswell J.D., 2023). The null hypotheses failed to be rejected in each year of the study. Although the researcher hypothesized there would be a significant difference in academic achievement using the ACT STEM Benchmark Average, the demographics of each sample are discussed as a possible reason for the study findings.

#### **Data cleaning.**

The checklist survey data was collected using a Google Form, which created a spreadsheet of responses indicating the participant's determination of a STEM or STEAM high school. The surveys were sent out over a six-week period and 108 participants completed the survey. The researcher cleaned the data from the Google Forms spreadsheet and eliminated surveys that were not connected to a Missouri secondary school, grades 9-12, reporting ACT data. Several checklist survey respondents answered for a school of higher education, private music school, or music industry not reporting ACT scores to DESE. These respondents were members of Missouri Music Educators Association who were provided the survey link. Due to the factor of their relation to the study, their responses were eliminated from the study. Sixty-six surveys, 34 surveys indicating STEM high schools, and 32 indicating STEAM high schools, were used for the study.

The clean data was then downloaded into Microsoft Excel, where the STEM and STEAM ACT Benchmark Score averages were calculated. The average was calculated using Excel to find the ACT STEM Benchmark score enacted in 2019 (Crouse et al.,

2015). Using the clean data, the ACT STEM Benchmark score for each independent variable of STEAM or STEM high schools was then transferred to SPSS to run an independent variable  $t$  test. The data was cleaned for errors made during the transfer and checked for accuracy. The SPSS independent  $t$  test was then used to reject or fail to reject the null hypotheses.

### **Findings.**

The independent samples  $t$  test was used to analyze the data to answer the four research questions. Sixty-six valid responses from educational leaders across Missouri determined the independent variables of STEM or STEAM education within their grades 9–12 high school. An independent samples  $t$  test was run to determine if there was a difference in achievement based on the dependent variable of the ACT STEM Benchmark score average over the years 2016-2019.

### ***Research Question 1***

What is the difference in ACT STEM Benchmark scores from 2015-2016 for students learning in a STEM environment versus those learning in a STEAM environment?

### ***Null Hypotheses 1***

There is no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2016-2017.

Table 1 presents the mean and standard deviation for the ACT STEM Benchmark score average for 2016. An independent samples  $t$  test was run to determine differences

in students learning in Missouri STEAM high schools, grades 9-12, and those learning in Missouri STEM high schools, grades 9-12.

**Table 1**

*ACT STEM Benchmark Average 2016*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	19.38	1.27	0.22
Group 2	STEAM	31	19.99	2.10	0.38

An independent samples *t* test was performed to compare the differences in the ACT STEM Benchmark Average mean levels ( $M = 19.38$ ,  $SD = 1.27$ ) which were slightly lower than the STEAM ACT STEM Benchmark mean levels ( $M = 19.99$ ,  $SD = 2.10$ ).

Levene's test for equality of variances tested the assumption that the variances in STEAM and STEM were approximately equal in 2016. The result of the Levene's test indicated that the two groups are not equal in variance;  $p = 0.02$ . The adjustment given by SPSS allowed the independent samples *t* test to be performed with reliability.

Table 2 presents an analysis of the data to answer RQ1 pertaining to the STEM Benchmark Average in 2016, using the independent samples *t* test.

**Table 2**

*Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages*

*t test for Equality of Means for 2015-2016*

	<i>t</i>	<i>df</i>	One-sided <i>p</i>	Two-sided <i>p</i>	<i>M</i> <i>Diff</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances not Assumed	-1.40	48.47	0.08	0.17	-0.61	0.44	-1.49	0.27

The two-sided  $p$  difference for the two groups was  $t(48.47) = -1.40; p = 0.17$ . A small effect size existed with Cohen's  $d = -0.36$  for 2016. Therefore, the null hypothesis for Research Question 1 ( $H_01$ ) failed to be rejected.

***Research Question 2***

What is the difference in ACT STEM Benchmark scores from 2016-2017 for students learning in a STEM environment versus those learning in a STEAM environment?

***Null Hypothesis 2***

There is no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2016-2017.

Table 3 presents an analysis of the data to answer RQ1 pertaining to the STEM Benchmark Average in 2017, using the independent samples  $t$  test.

**Table 3**

*ACT STEM Benchmark Average 2017*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	19.39	1.32	0.23
Group 2	STEAM	31	19.98	2.03	0.36

An independent samples  $t$  test was performed to compare the differences in the STEM ACT Benchmark Average mean levels ( $M = 19.39, SD = 1.32$ ) which were slightly lower than the STEAM ACT Benchmark Average mean levels ( $M = 19.98, SD = 2.03$ ).

Levene's test for equality of variances tested the assumption that the variances in STEAM and STEM were approximately equal in 2017. The result of the Levene's test indicated that the two groups are equal in variance;  $p = 0.07$ .

Table 4 presents an analysis of the data to answer RQ1 pertaining to the STEM Benchmark Average in 2017, using the independent samples *t* test.

**Table 4**

*Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages*

*t* test for Equality of Means 2016-2017

	<i>t</i>	<i>df</i>	One-sided <i>p</i>	Two-sided <i>p</i>	<i>MD</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances Assumed	-1.39	63	0.09	0.17	-0.58	0.42	-1.42	0.26

The two-sided *p* difference for the two groups was  $t(63) = -1.39; p = 0.17$ . A small effect existed with Cohen’s  $d = -0.34$  in 2017. Therefore, the null hypothesis for Research Question 2 (H02) failed to be rejected.

***Research Question 3***

What is the difference in ACT STEM Benchmark scores from 2017-2018 for students learning in a STEM environment versus those learning in a STEAM environment?

***Null Hypotheses 3***

There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2017-2018.

Table 5 presents an analysis of the data to answer RQ1 pertaining to the STEM Benchmark Average in 2018, using the independent samples *t* test.

**Table 5***ACT STEM Benchmark Average 2018*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	18.91	1.44	0.25
Group 2	STEAM	31	19.78	2.08	0.37

An independent samples *t* test was performed to compare the differences in the STEM ACT Benchmark Average mean levels ( $M = 18.91$ ,  $SD = 1.44$ ) which were slightly lower than the STEAM ACT Benchmark Average mean levels ( $M = 19.78$ ,  $SD = 2.08$ ).

Levene's test for equality of variances tested the assumption that the variances in STEAM and STEM were approximately equal in 2018. The result of Levene's test indicated that the two groups are equal in variance;  $p = 0.14$ .

Table 6 presents an analysis of the data to answer RQ1 pertaining to the STEM Benchmark Average in 2018, using the independent samples *t* test.

**Table 6***Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages**t test for Equality of Means 2017-2018*

	<i>t</i>	<i>df</i>	One-sided <i>p</i>	Two-sided <i>p</i>	<i>MD</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances Assumed	-2.00	63	0.25	0.05	-0.88	0.44	-1.76	0.00

The two-sided *p* difference for the two groups was  $t(63) = -2.00$ ;  $p = 0.05$ . A medium effect size existed with Cohen's  $d = -0.50$  for 2018. Therefore, the null hypothesis for Research Question 3 ( $H_03$ ) failed to be rejected.

***Research Question 4***

What is the difference in ACT STEM Benchmark scores from 2018-2019 for students learning in a STEM environment versus those learning in a STEAM environment?

***Null Hypotheses 4***

There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2018-2019.

Table 7 presents an analysis of the data to answer RQ1 pertaining to the STEM Benchmark Average in 2019, using the independent samples *t* test.

**Table 7**

*ACT STEM Benchmark Score Average 2019*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	19.73	1.62	0.28
Group 2	STEAM	31	20.52	1.97	0.35

An independent samples *t* test was performed to compare the differences in the STEM ACT Benchmark Average mean levels ( $M = 19.73, SD=1.62$ ) which were slightly lower than the STEAM ACT Benchmark Average mean levels ( $M = 20.52, SD = 1.97$ ).

Levene’s test for equality of variances tested the assumption that the variances in STEAM and STEM were approximately equal in 2019. The result of the Levene’s test indicated that the two groups are equal in variance;  $p = 0.33$ .

Table 8 presents an analysis of the data to answer RQ1 pertaining to the STEM Benchmark Average in 2019, using the independent samples *t* test.

**Table 8***Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages**t test for Equality of Means 2018-2019*

	<i>t</i>	<i>df</i>	<i>One-sided p</i>	<i>Two-sided p</i>	<i>MD</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances Assumed	-1.78	63	0.04	0.08	-0.79	0.45	-1.68	0.10

The two-sided  $p$  difference for the two groups was  $t(63) = -1.78; p = 0.08$ . A small effect size existed with Cohen’s  $d = -0.44$  in 2019. Therefore, the null hypothesis for Research Question 4 (H<sub>04</sub>) failed to be rejected.

### Summary

The statistical analysis and findings of this study explored the differences in academic achievement when comparing the ACT STEM Benchmark averages of students learning in Missouri high schools, grades 9-12, using STEAM or STEM education. The four research questions were explored, and the data collected. After the data were collected and examined, all four null hypotheses were rejected. There appeared to be no statistical significance between students learning using STEM and those using STEAM for the four years examined.

This chapter included the sampling, demographics, data cleaning, research questions, null hypotheses, data analysis, and findings and results. Comparisons were based on the information collected using the DESE database reporting of ACT STEM Benchmark averages of Missouri high schools, grades 9-12, using STEM or STEAM education. The schools were determined as using STEM or STEAM education by a checklist survey completed by educational leaders in Missouri school districts.

Within the relevant findings from the tests in this study, there should have been no significant outlier and normal distribution of survey scores. Finally, a homogeneity of variances should have been present, meaning there should have been an equal spread of scores across the means. However, 2016 was the only year where there was homogeneity of variances. The adjustment given by SPSS allowed the independent samples *t* test to be performed with reliability. The researcher accepted the null hypotheses until evidence to reject, or fail to reject, the null hypotheses was found. Chapter Five presents a summary of the causal-comparative study. It discusses the alignment to review of literature from Chapter Two, conclusions to the study, and recommendations for future exploration of this topic.

## **CHAPTER FIVE CONCLUSIONS AND RECOMMENDATIONS**

### **Introduction**

Chapter Four included a thorough report of the data acquired in this causal-comparative quantitative study. The survey results determined no significant statistical difference between Missouri high school students, grades 9-12, learning in STEAM schools or STEM schools. The null hypotheses failed to be rejected for the four years of the study, 2016-2019. The researcher provided an overview of the study by stating the purpose of the study, gap in literature, problem statement, the four research questions, and the null hypotheses. Chapter Four also included data analysis and findings, including representations of data from the independent  $t$  test in the form of tables and discussion.

In Chapter Five the researcher will provide further discussion of the study's results by examining the independent variables of STEM or STEAM schools determined by the study's checklist survey. The gap in the review of literature showing research providing scientific data indicating the impact of STEAM on academic achievement is addressed. Further discussion of the study's results and an in-depth description of the study's findings, how they align with the hypotheses, and conclusions centers around the implications of this study for the current body of literature and recommendations for future research on this topic.

### **Purpose of the Study**

The purpose of this causal-comparative study was to test the theory of Dewey's progressive education when applied to 21<sup>st</sup> century education comparing the academic achievement of pupils learning in Missouri class 3, 4, and 5 secondary schools, grades 9-12, where STEAM curriculum is being used, to similar schools offering STEM within

Missouri secondary schools class 3, 4, and 5, grades 9-12 (DESE, 2022a; Dewey, 1938; Dewey & Archambault, 1966; Li, 2020). The independent variable was generally defined as Missouri class 3, 4, and 5 secondary students, grades 9-12, learning in Missouri schools. Students learning in rural districts classified as class 1 and 2 were not included in this study due to the variables of limited size and resources. The dependent variable of interest was generally defined as the average ACT STEM Benchmark score reported by Missouri class 3, 4, and 5 secondary schools, grades 9-12, where students were learning using STEAM or STEM from 2016-2019. Prior research determined factors used to define the research samples as STEAM schools or those using STEM (Battelle for Kids, 2019; DESE, 2022a; Institute of Arts Integration and STEAM, 2020). The current research reflected on the benefits of arts-rich learning in student academic achievement, but there was a gap in the research literature providing the availability of measurable data showing achievement in STEAM programs (Battelle for Kids, 2019; Tuttle, 2020).

This study aimed to discover if there was a difference in students' academic achievement when learning in STEAM schools. The data provided in the study was obtained using the STEM Benchmark Score average reported by each school within the research sample categories (Battelle for Kids, 2019; DESE, 2022a, 2022; Institute of Arts Integration and STEAM, 2020). The STEAM Benchmark Score was first incorporated into the ACT exam in 2015 (ACT, 2015, 2020; Crouse et al., 2015; DESE, 2022a; Mattern et al., 2015). The STEM Benchmark Score is an average of math and science scores from the ACT exam intended to indicate the readiness of high school students to engage in university level STEM learning. Due to the onset of the COVID-19 pandemic

in 2020, STEM Benchmark scores were valid and reliable through 2019 (ACT, 2015, 2020; DESE, 2022a; Klein, 2021; Milligan, 2020). The longitudinal data of selected schools' student average ACT STEM Benchmark score from the testing cycle which began in 2015 and continued through 2019 did not provide a statistical difference in students educated in STEAM programs or add to statistical data supporting the benefit of integrating the arts into STEM curriculum (Anisimova et al., 2020; Antoni, 2020).

Descriptive research methodology was introduced in Chapter Three to study achievement in Science, Technology, Engineering, and Math (STEM) and the integration of arts in STEAM. The rationale for using descriptive methodology was to apply the ACT STEM Benchmark average test score to discover a possible difference in schools defined as STEM or STEAM by prior research (Battelle for Kids, 2019; DESE, 2022a, 2022; Institute of Arts Integration and STEAM, 2020). Statistical test data from the independent samples was used for the quantitative causal comparison study. Schools were compared using the review of literature for descriptions STEM arts integrated STEAM. The research sample was defined as Missouri secondary schools, grades 9-12, as defined by DESE, who use STEM and STEAM (DESE, 2022a). This study's purpose was to determine how the arts may effectively increase achievement in STEM subjects.

### **Research Questions**

The following questions helped guide the study:

RQ1: What is the difference in ACT STEM Benchmark scores from 2015-2016 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ2: What is the difference in ACT STEM Benchmark scores from 2016-2017 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ3: What is the difference in ACT STEM Benchmark scores from 2017-2018 for students learning in a STEM environment versus those learning in a STEAM environment?

RQ4: What is the difference in ACT STEM Benchmark scores from 2018-2019 for students learning in a STEM environment versus those learning in a STEAM environment?

### **Null Hypotheses**

H<sub>01</sub>: There will be no statistically significant difference in ACT STEM Benchmark scores for students learning in a STEM environment versus those learning in a STEAM environment.

H<sub>02</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2016-2017.

H<sub>03</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2017-2018.

H<sub>04</sub>: There will be no statistical difference in academic achievement of students educated in STEM programs and those educated in STEAM programs based on ACT STEM Benchmark scores 2018-2019.

The results of this study did not show a significant difference between the variable, but final discussion proposes that schools benefit from maintaining an environment rich in creativity, problem solving, innovation, communication, collaboration, and critical thinking needed for the 21<sup>st</sup> century education of students.

### **Limitations**

Limitations the researcher did not have control of during the study included the test environment and fidelity, which was completed prior to and during the ACT testing. The ACT STEM Benchmark scores were reported within each school district as mandated by the state. The average ACT STEM Benchmark score average was defined by DESE and collection was from the open-source data website. The longitudinal data were extracted and recorded by year from 2015, the score's inception, and continued through 2019, before the COVID-19 global pandemic affected the reporting of scores. The study was informed by the gap in research providing scientific data indicating the impact on academic achievement of students engaged in education using creativity and the arts in STEAM. The analysis of data was limited to the constraints and internal file structure of IBM SPSS Statistics (Version 23) predictive analytics software (IBM Corporation, 2015). The sample size and selection were determined by classification of size by Missouri State High School Activities Association and DESE, Class 3, 4, and 5 schools. Students in rural districts classified as classes 1 and 2 were not included in this study due to the variables of limited size and resources. The researcher was not without bias when it came to thoughts regarding fine arts education and creativity, as she is trained as a professional musician and fine arts educator and certified in the public-school systems of Missouri and Texas.

## **Delimitations**

Delimitations intentionally imposed by the researcher were that the study population was defined as students studying secondary education, grades 9-12, in Missouri high schools designated by Missouri High School Activities Association and DESE as class 3, 4, and 5, who were already engaged in STEM or STEAM education. The theoretical underpinnings of the study focused on the seminal progressive learning theory of John Dewey, and the four Cs of 21<sup>st</sup> century education; creativity, critical thinking, collaboration, and communication. Students learning in rural districts classified as class 1 and 2 were not included in this study due to the variables of limited size and resources. The population included only class 3, 4, and 5 Missouri high schools serving grades 9-12, defined as STEAM versus STEAM schools by prior research determining STEAM education characteristics. The test scores used in the research for the study were defined using the initial inception of the ACT STEM Benchmark Score in 2015, through 2019.

## **Summary of Findings**

The research was examined from the perspective of two independent variables: Missouri high school students learning in secondary schools, grades 9-12, using STEM or STEAM. These two variables were determined using prior research and a checklist survey where educational leaders indicated their high school used STEM or STEAM education (see appx. A). Data was requested from DESE and ACT for the ACT STEM Benchmark Averages of Missouri Class 3, 4, and 5 high schools, grades 9-12. Both applications for data were approved, but identical data at ACT proved to be financially restrictive for the research. The Missouri DESE helped by providing an Excel

spreadsheet with all school districts' ACT averages in math and science. The ACT STEM Benchmark average score for a high school is an average of the math and science scores. DESE provided the data for the years 2016-2019. School leaders were contacted by email over a six-week period and requested to complete the Checklist Survey. The survey was provided as a Google Form, and a spreadsheet of answers was generated indicating STEM or STEAM. Each respondent provided an email contact kept in confidentiality by the researcher. Once the 108 minimum threshold was exceeded, data was processed and analyzed using SPSS software on the 65 valid responses (IBM Corporation, 2015). Invalid responses were deleted because the respective school or organization did not report annual data to DESE. Deleted responses were from university professors and arts-related businesses because the survey was provided through the Missouri Music Educators Association to increase survey responses. Sixty-six valid responses reporting ACT data to DESE from a Missouri high school, grades 9-12, were determined as STEAM or STEM on the checklist survey. Independent sample *t* tests were used to analyze data aligned with the research questions to compare differences in the means of ACT STEM Benchmark score averages from 2016-2019.

The first hypothesis tested showed STEM schools had a slightly lower ACT STEM Benchmark score average for 2016 ( $M = 19.38, SD = 1.27$ ) compared to STEAM schools ( $M = 19.99, SD = 2.10$ ), a minimal difference  $M = -.61, 95\% CI [-1.49, .27]$ ,  $t(48.50) = -1.40, p = 0.17$ , and existed with Cohen's  $d = .356$ . Therefore, the null hypothesis for Research Question 1 ( $H_01$ ) failed to be rejected. Data indicated there was not a statistically significant difference in ACT STEM Benchmark score averages of STEM and STEAM,  $p = 0.17$ .

The second hypothesis tested showed STEM schools had a slightly lower ACT STEM Benchmark Score for 2017 ( $M = 19.39$ ,  $SD = 1.32$ ) compared to STEAM schools ( $M = 19.98$ ,  $SD = 2.03$ ), a minimal difference  $M = -.58$ , 95% CI [-1.42, .26],  $t(63) = -1.39$ ,  $p = 0.17$ , and existed with Cohen's  $d = .344$ . Therefore, the null hypothesis for Research Question 2 ( $H_02$ ) failed to be rejected. Data indicated no statistically significant difference in STEAM and STEM ACT STEM Benchmark average scores in the study samples,  $p = 0.17$ .

The third hypothesis tested showed STEM schools had a slightly lower ACT STEM Benchmark Score for 2018 ( $M = 18.91$ ,  $SD = 1.44$ ) compared to STEAM schools ( $M = 19.78$ ,  $SD = 2.08$ ), a minimal difference of  $M = -.88$ , 95% CI [-1.76, .000],  $t(63) = -2.00$ ,  $p = 0.05$ , and existed with Cohen's  $d = .496$ . Therefore, the null hypothesis for Research Question 3 ( $H_03$ ) failed to be rejected. Data indicated no statistically significant difference in STEAM and STEM ACT STEM Benchmark average scores in the study samples,  $p = 0.05$ .

The fourth hypothesis tested showed STEM schools had a slightly lower ACT STEM Benchmark Score for 2019 ( $M = 18.91$ ,  $SD = 1.44$ ) when compared to STEAM schools ( $M = 19.78$ ,  $SD = 2.08$ ), a minimal difference of  $M = -.88$ , 95% CI [-1.68, .10],  $t(63) = -1.78$ ,  $p = 0.08$ , and existed with Cohen's  $d = .442$ . Therefore, the null hypothesis for Research Question 4 ( $H_04$ ) failed to be rejected. Data indicated no statistically significant difference in STEAM and STEM ACT STEM Benchmark average scores in the study samples,  $p = 0.08$ .

This study showed no statistical significance in the STEAM and STEM ACT STEM Benchmark averages in 2016-2019. Although the researcher anticipated there

would be a difference in these two demographics, the results can be viewed positively in that the ACT STEM Benchmark scores were, in general, progressively higher in both STEM and STEAM for each of the four years studied. Other factors for the results of the study are to be considered in the following Discussion of Findings.

### **Discussion of Findings**

When reviewing the results of this survey to determine the differences in STEAM or STEM education, a statistically significant difference was not noted in the four years of the study, 2016-2019. The null hypothesis failed to be rejected in 2016, with a  $p = 0.17$ . In 2017, the null hypothesis failed to be rejected with a  $p = 0.17$ . In 2018, the null hypothesis failed to be rejected with a  $p = 0.05$ . In 2019, the null hypothesis failed to be rejected with a  $p = 0.08$ . The effect sizes in each of the dependent variable categories were small. These small differences indicated no statistically significant difference between the two independent variables for the four years of the study. While no statistically significant differences were noted, one area to consider is that the mean scores ate an increase in science and math ACT average scores from 2016-2019, except a slight decrease of mean for STEM in 2018. This average math and science ACT score is the ACT STEM Benchmark score enacted in 2015 (Crouse et al., 2015). Attention to STEM or STEAM used in the high school classroom may have improved student ACT STEM ACT STEM Benchmark scores.

The study used prior research to create thought-framing questions centered around the majority of items that must be present for a school to be considered STEAM. These items are dedicated arts and design courses or programs, a strong emphasis on incorporating arts and design principles into STEM, opportunities for students to engage

in creative and artistic projects in STEM, specialized facilities, equipment, or resources to support STEAM, partnerships or collaborations with design related industry, extracurricular activities, clubs, or competitions focused on arts and design, and career guidance for students and professional development for teachers focused on STEAM (Hallinen, 2023; Riley, 2023). In these thought-framing questions there are references to the addition of arts and design in STEM.

### **Implications**

The findings for this study did not find a statistical significance in the academic achievement of students learning in Missouri high schools, grades 9-12, class 3, 4, and 5, using STEAM or STEM education. While the researcher hypothesized there would be a statistically significant difference between the two variables in the years 2016-2019, the findings led the researcher to believe the two variables have very similar characteristics and benefits for learning. These similarities and common benefits may have created some inaccuracies in the determination of STEAM or STEM high schools.

Educational leaders, teachers, and other stakeholders may be confused about whether a school uses STEM or STEAM education due to varying interpretations and implementations of these educational approaches (PowerSchool, 2023; Psycharis et al., 2020; Riley, 2023). While STEM education focuses on the core disciplines of science, technology, engineering, and mathematics, STEAM incorporates the arts into the curriculum to promote creativity, innovation, and interdisciplinary learning (Riley, 2023). The confusion arises from the diversity of approaches within educational institutions, with some schools emphasizing a strict STEM curriculum, while others integrate arts-based activities and projects into their STEM programs (PowerSchool, 2023). Additionally, the

lack of standardized definitions and guidelines for STEM and STEAM education can contribute to the uncertainty surrounding which approach a school may be following, leading to misconceptions and misunderstandings among stakeholders (PowerSchool, 2023; Riley, 2023). Within the study, some schools reported that they were both STEM and STEAM, a school with STEAM in its formal name reported that they were STEM, and some schools reported that they were neither, despite having Project Lead the Way and advanced math and science courses that were STEM related (Lyons, 2020; Silverstine & Lane, 2020; Wu et al., 2022). This historical confusion of how to use the STEM or STEAM acronym may have affected the study's outcome.

Another reason STEAM schools are difficult to define, when separated from STEM schools, is how the arts and design components are integrated into STEAM (Lo, 2021; Ozturk, 2021). The largest challenge for STEAM integration in schools is scheduling time for common planning among arts-related educators and core STEM teachers in the traditional secondary school schedule (Lo, 2021; Ozturk, 2021; PowerSchool, 2023). An effective STEAM unit requires addressing both an arts standard and a traditional STEM standard, requiring collaboration among specialists in various fields who may not feel comfortable integrating subject matter (Lo, 2021; Ozturk, 2021).

The theoretical underpinning of this study centers around the progressive education ideas of Dewey, who believed the arts are a tool to bind together the how, what, and why students learn, playing a role in what students can do with what they know (Dewey, 1938; Riley, 2023; Li, 2020). This study hypothesized that STEAM may be the answer to a more effective STEM education, increasing the achievement of students and preparing them with socially interdependent learning skills for the 21<sup>st</sup> century (Bryan &

Guzey, 2020; Burke, 2022; Singh, 2021; Wu et al., 2022). While the study failed to reject the null hypotheses from 2016-2019, the use of STEAM may have improved skills needed for STEM education and the building blocks of 21<sup>st</sup> century learning, such as collaboration, critical thinking, communication, and creativity (Burke, 2022; Singh, 2021).

Dewey recognized the importance of the arts in collaborative learning and there is a considerable body of research suggesting the arts have a profound impact on brain development, enhancing cognitive functions, emotional well-being, and overall mental health (Dewey, 1934, 1938; Sousa & Pilecki, 2018; Wagner & Kingston, 2022). Engaging in artistic activities such as music, dance, painting, and theater stimulates various regions of the brain, promoting neural connections and enhancing neural plasticity (Sousa & Pilecki, 2018; Wagner & Kingston, 2022). Studies have shown that participation in the arts can improve memory, attention, and problem-solving skills and enhance creativity and critical thinking (Wagner & Kingston, 2022). Moreover, emotional expression and social interaction involved in artistic pursuits contribute to emotional regulation, empathy, and social skills development (Dewey, 1934, 1938; Sousa & Pilecki, 2018; Wagner & Kingston, 2022). The arts have the power to reduce stress, anxiety, and depression, promoting mental wellness and resilience (Wagner & Kingston, 2022). The arts play a vital role in shaping brain development by fostering creativity, cognitive abilities, emotional intelligence, and overall well-being (Dewey, 1934, 1938; Sousa & Pilecki, 2018; Wagner & Kingston; 2022; Yu, 2021).

Research conducted on the benefits of the arts provides data supporting the arts in education (Wagner & Kingston, 2022; Yu, 2021). This study was informed by the gap in

research providing scientific data indicating the impact on academic achievement of students engaged in education using creativity and the arts in STEAM. The benefits of the arts on achievement are difficult to quantify and demonstrate through data due to the subjective nature of artistic expression and the multifaceted impact of arts on individuals (Anisimova et al., 2020; Yu, 2021). Unlike traditional academic subjects that can be easily measured through standardized tests and quantitative data, the arts involve creativity, emotion, and interpretation, making it challenging to assess their influence on achievement in a quantifiable manner (Anisimova et al., 2020; Wagner & Kingston, 2022). Additionally, the benefits of the arts extend beyond academic success, influencing personal growth, emotional well-being, and social development, which are not always captured effectively through data-driven metrics (Yu, 2021). The holistic and individualized nature of artistic experiences further complicates the process of showcasing their impact on achievement through data analysis, highlighting the limitations of relying solely on quantitative measures to evaluate the significance of arts education (Riley, 2023; Yu, 2021). The researcher attempted to test the differences between STEAM and STEM education in Missouri high schools, grades 9-12, class 3, 4, and 5, and failed to reject the null hypotheses in each of the four years. The quantification of the benefits of the art and design component in STEAM is difficult to test using the ACT or any other standardized test method.

Creativity and the arts have a transformative effect on education by enhancing learning experiences, fostering critical thinking skills, and promoting holistic development (Anisimova et al., 2020; Wagner & Kingston, 2022). Incorporating creative practices such as visual arts, music, drama, and dance into the curriculum encourages

students to think outside the box, explore diverse perspectives, and express themselves uniquely (Riley, 2023; Yu, 2021). Creative activities stimulate imagination, innovation, and problem-solving skills, empowering students to approach challenges with creativity and adaptability (Quigley et al., 2020; Wagner & Kingston, 2022). Engagement with the arts also nurtures emotional intelligence, empathy, and self-expression, contributing to social and emotional development (Riley, 2023; Yu, 2021). By integrating creativity and the arts into education, schools create an enriching and dynamic learning environment that inspires curiosity, collaboration, and lifelong learning skills (Singh, 2021). The arts not only enhance academic achievement but also cultivate well-rounded individuals who are equipped with the creativity and critical thinking skills necessary to succeed in a constantly evolving world (Dewey, 1934, 1938; Sousa & Pilecki, 2018; Wagner & Kingston, 2022; Yu, 2021). However, providing measurable data to support these ideas through a test score remains difficult and continues to leave a gap in the literature of scientific data indicating the impact on academic achievement of students engaged in education using creativity and the arts in STEAM (Koul et al., 2021; Will, 2021).

In one section of the Review of Literature, early childhood education that incorporates STEAM is discussed (Sousa & Pilecki, 2018; Wan et al., 2020). The principles of providing young learners with a holistic and interdisciplinary approach to learning and development in a STEAM-based early childhood education setting is one of the purest forms of STEAM education (Dell’Erba, 2019; Institute for Arts Integration and STEAM, 2020; Sousa & Pilecki, 2018). Children engage in hands-on activities and exploratory experiences that integrate concepts from science, technology, engineering, arts, and mathematics (Dell’Erba, 2019; Sousa & Pilecki; Yildirim, 2020). Through play-

based learning, children are encouraged to explore, experiment, and create (Sousa & Pilecki, 2018; Yildirim, 2020). This fosters creativity, critical thinking, problem-solving skills, and collaboration, also known as 21<sup>st</sup> century thinking skills (Singh, 2021; Sit, 2022). Activities such as building structures with blocks, creating art projects inspired by nature, conducting simple science experiments, and using technology tools for interactive learning all contribute to a well-rounded educational experience that nurtures a child's curiosity, imagination, and love for learning (Singh, 2021; Sit, 2022). By incorporating STEAM principles into early childhood education, educators create a rich and stimulating environment that supports the development of essential skills and prepares young learners for future academic success (Dell'Erba, 2019; Institute for Arts Integration and STEAM, 2020; Sousa & Pilecki, 2018). Revisiting this form of STEAM may help STEAM schools create curriculum, space, schedules, and student choice attracting more interest and diversity in STEAM (Nadeem, 2021; Temming, 2021).

Another example of effective STEAM schools are often magnet schools due to their specialized focus, innovative curriculum, and diverse learning opportunities (Yu, 2021; Wu, 2022). Magnet schools are designed to attract students from a wide range of backgrounds and offer unique academic programs that cater to specific interests and talents (Quigley et al., 2020). In the case of STEAM schools, the magnet school model allows for a concentrated emphasis on STEAM disciplines, providing students with in-depth exploration, hands-on experiences, and interdisciplinary learning opportunities in these fields (Dewey, 1934, 1938; Wu, 2022). Magnet schools often have partnerships with industry experts, universities, and cultural institutions, enabling students to engage in real-world projects, internships, and enrichment activities that enhance their STEAM

education (Singh, 2021). Additionally, magnet schools typically have a diverse student body and dedicated teachers with expertise in STEAM disciplines, creating a supportive and collaborative learning environment that fosters academic excellence and innovation (Nadeem, 2021; Temming, 2021). Overall, the magnet school model aligns well with the specialized focus and rigorous standards of the best STEAM schools, making them a popular choice for students seeking high-quality education in STEAM fields (Power School, 2023; Wu, 2022; Yu, 2021).

Students choose to learn in a STEAM magnet school. This choice can have a significant impact on academics in STEAM education by promoting engagement, motivation, and personalized learning experiences (Singh, 2021). When students can make choices about their learning paths, projects, and areas of interest within the STEAM curriculum, they are more likely to feel ownership and investment in their academic pursuits (Dewey, 1934, 1938; 21PSTEM, 2019; PowerSchool, 2023). By allowing students to explore topics that resonate with their passions and strengths, educators can foster intrinsic motivation, curiosity, and a sense of autonomy in learning (Dewey, 1934, 1938; Wu, 2022). Student choice promotes creativity, problem-solving skills, and critical thinking as students navigate through open-ended projects and real-world challenges (Singh, 2021). Additionally, personalized learning experiences based on student interests and preferences can lead to greater academic achievement, higher levels of student satisfaction, and a deeper understanding of STEAM concepts (Quigley et al., 2020). Overall, student choice in STEAM education empowers learners to take ownership of their academic journey, fostering a culture of innovation, collaboration, and lifelong learning (Singh, 2021). Both the concepts of the purest form of STEAM in early

childhood education and magnet schools that provide student autonomy and choice align with Dewey's theory of progressive education, with collaborative learning that is both social and student driven (Dewey, 1934, 1938; Sousa & Pilecki, 2018; Wan et al., 2020). Real-world problem-solving with the community and the larger whole of society in mind also resonates with Dewey's philosophy and 21st-century education (Dewey, 1934, 1938; Singh, 2021).

### **Recommendations for Further Research**

This quantitative causal-comparative study sought to find a difference in academic achievement between students learning in Missouri STEAM high schools, grades 9-12, class 3, 4, and 5, and those learning in Missouri STEM high schools, grades 9-12, class 3, 4, and 5 from 2016-2019. Although no statistical significance was found in years 2016-2019, this information may still be of value to administrators and other educational stakeholders. Interestingly, the overall math and science ACT average improved in small increments each year of the study, except STEM in 2018. This average is the ACT STEM Benchmark. This information could encourage secondary schools and their communities to identify the characteristics of a STEAM school and benefit from the qualities of STEAM that improve academics, diversity, and overall participation in STEAM courses, along with career and college participation in STEAM fields.

To continue and improve the research in this area, the researcher recommends the following:

1. Conduct this study using a qualitative method to receive more specific feedback from administrators and educational leaders regarding their determination of STEAM or STEM. This would also allow the researcher to identify schools using STEAM

methodology that should be listed as STEAM. This recommendation is based upon responses to the checklist survey where the responder seemed unsure of their status as STEAM or STEM. It is the researcher's belief that many superintendents and administrators took the survey to see what was considered as STEAM or STEM within their related high school.

2. Replicate this study expanding achievement measures used, such as ACT, SAT, and MAP or state standardized test scores in math and science. Data may also include participation percentage in STEAM courses, arts courses, and college and career readiness.
3. Expand the study to include other achievement measures, such as college and career success, other standardized tests such as state standardized tests in math and science, the SAT, NAEP, graduation rate, and participation in STEAM related courses.
4. Explore data indicating the diversity of students participating in STEM or STEAM and examine how to include more participants in STEAM learning.
5. Research what schools are currently successful with STEAM education and why.
6. Expand the study beyond the high school level, grades 9-12. Examining data from middle schools and elementary schools may lead to why high schools are successful or not successful integrating the art and design components of STEAM.

## **Conclusion**

Developing STEAM education to be an effective and quantifiable measure of academic achievement has been challenging due to the subjective nature of the art and design component or “A” in STEAM (Quigley et al., 2020). Recognizing that the benefits of the arts in STEAM reach far beyond a single test score is important (Antoni,

2021; Battelle for Kids, 2019; Crompton, 2023). A gap in the literature where quantifiable data may show a difference in students learning in STEAM environments versus STEM exclusively still exists (Wagner & Kingston, 2022; Yu, 2021). Educational stakeholders may need to move beyond looking at a single test score or a set of scores to measure the benefits of the arts in STEAM (Antoni, 2021; Battelle for Kids, 2019; Crompton, 2023).

Based upon the responses provided on the checklist survey, the ability to define what STEAM looks like when used in today's high school setting is also needed (Hughes, 2021; Riley, 2023). The acronym has been historically divisive and misunderstood based on the literature review of this study (Lyons, 2020; Silverstine & Lane, 2020; Wu et al., 2022). Establishing a universal rubric for what should be present in a STEAM school would be helpful for researchers, administrators, and educational stakeholders (Yu, 2021; PowerSchool, 2023). With this information, further research may provide a statistical difference in achievement between students learning in STEAM versus STEM schools.

The purpose of this causal-comparative study was to test the theory of Dewey's progressive education when applied to 21st-century education that compared the academic achievement of pupils learning in Missouri class 3, 4, and 5 secondary schools, grades 9-12, where STEAM curriculum is being used, to similar schools offering STEM curriculum to students learning at Missouri secondary schools class 3, 4, and 5, grades 9-12 (DESE, 2022a; Dewey, 1938; Dewey & Archambault, 1966; Li, 2020). The researcher recognized a gap in the literature review where there was a need to discover if there could be data supporting a significant difference in academic achievement when using STEAM versus STEM in Missouri high schools.

Although the study findings did not show a significant difference between the independent variables of STEAM and STEM and failed to reject the null hypotheses in the four years tested in RQ1, RQ2, RQ3, and RQ4, there was a steady rise in the STEM Benchmark Score average of the testing period. The researcher outlined reasons a statistical difference was not present throughout the study. The first being it is difficult for educational leaders to define the difference between STEAM and STEM because of historical differences in opinion of what the acronym should reflect (PowerSchool, 2023; Psycharis et al., 2020; Riley, 2023). The second being because of the subjective nature of the benefits of integrating the arts and design component in STEAM, it is difficult to quantify it with a single achievement measurement or test (Anisimova et al., 2020; Yu, 2021).

The respondents in this study appeared to find it difficult to label their school as STEAM or STEM and the researcher found that despite an extensive review of the literature supporting STEAM, the two acronyms of STEAM or STEM were often exchanged for one another indicating that a universal rubric for STEAM is needed to enable further research (Lyons, 2020; Silverstine & Lane, 2020; Wu et al., 2022). The lack of statistical significance between achievement of students learning in STEAM schools or STEM schools for four years, when tested using the dependent variable of ACT STEM Benchmark score average, indicates that there is little difference in the learning taking place in schools defined as STEAM or STEM by this studies measurement.

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## APPENDIX A

### STEM or STEAM Checklist

#### Introduction:

Welcome to a succinct survey designed by researcher Tricia Zinecker to assess whether schools are primarily focused on STEM (Science, Technology, Engineering, and Mathematics) or have integrated arts and design subjects to become STEAM (Science, Technology, Engineering, Arts, and Mathematics) oriented. This survey provides a quick and efficient means to evaluate a school's curriculum and educational approach. All participants and assessed schools will maintain complete anonymity through assigned numbers when utilizing IBM SPSS Statistics (Version 23) predictive analytics software for data analysis.

The researcher aims to categorize schools into STEM or STEAM, creating two independent variables. The dependent variable will be the ACT STEM Benchmark Score, an addition to the ACT test in 2015. The study investigates whether the average ACT STEM Benchmark Scores reported from 2015 through 2019 show a significant difference between schools emphasizing STEM or STEAM. This research addresses a literature gap, utilizing concrete data to potentially support the integration of arts in STEAM education. The findings will contribute to a doctoral dissertation for the Doctorate in Educational Leadership program at Southwest Baptist University.

1. Read the questions: Take a moment to review the two questions presented in this survey. These questions are carefully crafted to evaluate the presence and emphasis of STEM, arts, and design subjects within the school's educational framework.

2. Consider the school's curriculum: Consider the courses and programs offered by the school. Evaluate whether there is a strong emphasis on STEM subjects, such as science, technology, engineering, and mathematics. Additionally, consider whether arts and design subjects are integrated into the curriculum alongside STEM subjects.

3. Assess the school's resources and initiatives: Reflect on the resources and initiatives available at the school that support STEM and arts and design education. This may include specialized facilities, equipment, extracurricular activities, partnerships with relevant industries or organizations, and career guidance or professional development opportunities in STEM or arts and design fields.

4. Answer the questions: Based on your evaluation of the school's curriculum, resources, and initiatives, select the response that best represents the school's focus. Choose the option that aligns with whether the school is primarily STEM-focused or if it has successfully integrated arts and design to become STEAM-focused.

5. Submit your responses: Once you have answered the two questions, submit your responses to complete the survey.

By utilizing this two-question survey, the researcher aims to gather valuable insights into the nature of a school's educational focus. The results will help inform the study, and data may support discussions, policies, and practices related to STEM and arts integration in schools, ultimately contributing to enhancing educational experiences for students. Thank you for your participation!

1. Does the school curriculum prioritize science, technology, engineering, and mathematics (STEM) subjects?

Please check:

Yes

No

**Consider: A majority of the following items will be present with a yes response.**

- Are there dedicated STEM courses or programs offered at the school?

Is there a strong emphasis on teaching and learning in science, technology, engineering, and mathematics?

- Are there opportunities for students to engage in hands-on experiments, projects, or research in STEM subjects?

- Are there specialized STEM facilities, equipment, or resources available to support STEM education?

- Are there partnerships or collaborations with STEM-related industries, organizations, or institutions?

- Are there extracurricular activities or clubs focused on STEM subjects?

- Are there STEM-related competitions, events, or initiatives organized by the school?
- Are there STEM-related career guidance or counseling services available to students?
- Are there STEM-related professional development opportunities for teachers?

2. Does the school integrate arts and design into its STEM education, making it STEAM?

Please check:

Yes

No

**Consider: A majority of the following items will be present with a yes response.**

- Are there dedicated arts and design courses or programs offered at the school?
- Is there a strong emphasis on incorporating arts and design principles into STEM subjects?
- Are there opportunities for students to engage in creative and artistic projects within the context of STEM education?
- Are there specialized arts and design facilities, equipment, or resources available to support STEAM education?
- Are there partnerships or collaborations with arts and design-related industries, organizations, or institutions?
- Are there extracurricular activities or clubs focused on arts and design within the STEM framework?
- Are there STEAM-related competitions, events, or initiatives organized by the school?
- Are there STEAM-related career guidance or counseling services available to students?
- Are there STEAM-related professional development opportunities for teachers?

## APPENDIX B



COLLEGE OF PROFESSIONAL PROGRAMS  
1600 University Avenue  
Bolivar, Missouri 65613  
(417) 328-2099

December 1, 2023

Re: The Effect of STEAM on the ACT STEM Benchmark

Dear Ms. Zinecker,

On December 1, 2023 a review of your application and supporting documents for the above named research proposal was completed. The Research Review Board (RRB) for Southwest Baptist University has determined that the proposed research project meets the criteria for Exempt status as per policy 1.15.3 (A.1) in the faculty guidelines. As per the above policy "If the project is certified exempt, the principle investigator need not resubmit the project for continuing RRB review as long as there are no modifications in the exempted procedures". The study has now been approved, therefore, work on the project may begin. If any modifications to the exempted procedures are made, the RRB will need to complete a new review of the changes to determine if the project remains Exempt or if further review is necessary.

Congratulations on the approval of your project, we wish you well during its completion.

Sincerely,

A handwritten signature in cursive script that reads "Colleen Shuler".

Colleen Shuler  
Chair, Research Review Board  
Assistant Professor of Education

## APPENDIX C

Dear Dr. [REDACTED],

Good day. My name is Tricia Zinecker, and I am completing research for my doctoral dissertation in Educational Leadership from Southwest Baptist University. My study centers around achievement when comparing schools focusing on STEM or STEAM. Please fill out this **two-question checklist** on this Google Form to see if your high school is considered a STEM or STEAM school based on the perimeters of this study.

All data will be entered numerically and will not identify individual emails or school names per the RRB approved by Southwest Baptist University. Upon completing this two-question Google Form, your email WILL be entered into a random drawing for a **\$100.00 Amazon gift card**.

This research will provide insight into academic achievement that may affect the education of secondary students in Missouri and beyond.

Thank you for your time and consideration.

Sincerely,

Tricia J. Zinecker

"Art is the signature of a civilization." ~ Beverly Sills



**Tricia Zinecker**  
Music/Art Educator  
Republic Middle School  
688 E Hines St  
Republic, Missouri 65738  
417.732.3640, Ext. 4016

**APPENDIX D**

Mar 3, 2024,  
6:26 PM

Tricia Zinecker <[tricia.zinecker@republicschools.org](mailto:tricia.zinecker@republicschools.org)>

to 

Hello! Thank you for filling out the STEM or STEAM Checklist survey. I am trying to categorize your survey, and to do so, I need a school you are connected to in some way. I currently have 33 STEM schools and 31 STEAM schools. If you could provide a school name, I will not use it in the study other than to list it as a number 1-STEM 2-STEAM. I greatly appreciate your time.

Tricia J. Zinecker  
Fine Arts Educator  
Republic School District

## APPENDIX E

**Table 1**

*ACT STEM Benchmark Average 2016*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	19.38	1.27	0.22
Group 2	STEAM	31	19.99	2.10	0.38

**Table 2**

*Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages*

*t test for Equality of Means for 2015-2016*

	<i>t</i>	<i>df</i>	One- sided <i>p</i>	Two- sided <i>p</i>	<i>M</i> <i>Diff</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances not Assumed	-1.40	48.47	0.08	0.17	-0.61	0.44	-1.49	0.27

**Table 3**

*ACT STEM Benchmark Average 2017*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	19.39	1.32	0.23
Group 2	STEAM	31	19.98	2.03	0.36

**APPENDIX E CONTINUED**

**Table 4**

*Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages*

*t test for Equality of Means 2016-2017*

	<i>t</i>	<i>df</i>	One-sided <i>p</i>	Two-sided <i>p</i>	<i>MD</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances Assumed	-1.39	63	0.09	0.17	-0.58	0.42	-1.42	0.26

**Table 5**

*ACT STEM Benchmark Average 2018*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	18.91	1.44	0.25
Group 2	STEAM	31	19.78	2.08	0.37

**Table 6**

*Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages*

*t test for Equality of Means 2017-2018*

	<i>t</i>	<i>df</i>	One-sided <i>p</i>	Two-Sided <i>p</i>	<i>MD</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances Assumed	-2.00	63	0.25	0.05	-0.88	0.44	-1.76	0.00

**APPENDIX E CONTINUED**

**Table 7**

*ACT STEM Benchmark Score Average 2019*

		<i>N</i>	<i>M</i>	<i>SD</i>	Standard Error Mean
Group 1	STEM	34	19.73	1.62	0.28
Group 2	STEAM	31	20.52	1.97	0.35

**Table 8**

*Independent Sample Test for STEM and STEAM ACT STEM Benchmark Averages*

*t test for Equality of Means 2018-2019*

	<i>t</i>	<i>df</i>	<i>One-sided p</i>	<i>Two-sided p</i>	<i>MD</i>	<i>SD</i>	<i>LL</i>	<i>UL</i>
Equal Variances Assumed	-1.78	63	0.04	0.08	-0.79	0.45	-1.68	0.10