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Categorizing Makerspaces: Identifying Best Fit Models for School Administrators

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Categorizing Makerspaces: Identifying Best Fit Models for School Administrators

by

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Abstract

This exploratory study analyzed the similarities and differences of how select K-12 school administrators describe and characterize their own existing makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed. Current efforts emerging from the literature to categorize makerspaces based on descriptions of facilities, equipment, location, and management styles have been shown to be an ineffective way to compare and contrast individual makerspace implementations for the purpose of studying the educational outcomes they produce or help to support within a school setting. The United States Department of Education's Every Student Succeeds Act (ESSA) emphasizes the use of evidence-based activities, strategies and interventions in the design of education programs from prekindergarten through adult education" (U.S. Department of Education, 2023, p.1), and highlights that the main indicator of quality is clear evidence of impact based on rigorous research. There is an abundance of research regarding the educational impact makerspaces can have for students but is presented from a global perspective. The district and school level needs statements made by administrators are focused internally on specific desired outcomes for their individual schools. The lack of an effective model of categorization for makerspace implementations makes it difficult for school administrators to identify and review existing implementations that match their educational goals and work best in their schools before investing in their own makerspaces and served as the foundation for this exploratory study.

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Chapter 1: Introduction

"Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand."

-Confucius, circa 450BC

"Know what you own and know why you own it." - *Peter Lynch*

Juxtaposing a quote from a 5th-century B.C. philosopher and a famous 25th-century investment manager may seem an unlikely combination, but for K-16 school administrators it captures the essence of a concern involving the growing interest and pressure to build makerspaces within their schools, colleges, and universities. Implementing a makerspace often involves a significant investment on the part of the organization either in equipment and supplies, staff time, or allocation of physical space, and quite often all three. Identifying a best fit model of implementation and an assessment strategy is essential to ensuring the sustainability of any educational program or endeavor however, the wide variety of implementation models surrounding makerspaces makes gathering the kind of information needed to identify a best fit model a sincere challenge for administrators.

A makerspace is described throughout the literature as a physical location with varying combinations of resources, supplies, specialized tools, and designated staff, all dedicated to providing students with opportunities to design, problem solve and create physical artifacts in a purposeful manor. (U.S. Department of Education, 2016) Makerspaces embody the constructivist education theory that people learn best through the experiences they have while actively engaged in hands-on projects. The project is central to the process and the learning comes from the skill building, analysis, iteration, inquiries, and merging of multiple bodies of knowledge to complete the project (Martinez & Stager, 2013). Makerspaces are also being employed to involve and engage students in STEM (Science, Technology, Engineering and Math) education topics and mindsets. “There is a strong case for increased STEM and inquiry-based education, and this need can be fulfilled by the Maker model” (Taylor, 2016, p. 4). Taylor’s work compared the 21st century skills and learning objectives of the P21 initiative, (Partnership for 21st Century Learning) with the results of a 2015 survey in which 51 respondents with a median of 450 visitors each year were asked about perceptions of makerspaces and the most common activities in their respective makerspaces (Taylor, 2016). Taylor makes two very powerful statements that concisely summarize his findings: “The Maker Movement has a place in education, and classroom makerspace laboratories are the place to start.”, and “the Maker Movement is a forward-thinking model for education and will enhance any campus when it is implemented correctly” (Taylor, 2016, p. 20).

The message for administrators and school decision makers is that a rush to implement a makerspace without considering how it will connect with and enhance the mission and goals of the school may yield a poor investment. For school improvement efforts, administrators in the United States are asked to follow the Evidence-Based Practices (EBP) model outlined in the U.S. Department of Education’s Every Student Succeeds Act (ESSA). The office of Elementary and Secondary Education states that “The main indicator of quality for EBPs (including specific interventions, activities and strategies implemented at the school or district levels) should be clear evidence of impact based on rigorous research” (Leveraging evidence-based practices for local school improvement, 2020, p. 1). From the review of relevant literature, the challenge for administrators is that the implementation strategies of makerspaces are so widely varied that identifying a "best fit" model matching their own school improvement goals to review and study to meet the EPB guidelines is a challenge.

Statement of the Problem

A review of related literature shows that the growing interest in the K-16 community to invest in makerspaces has led to efforts to categorize makerspace implementations for the purposes of comparison, study, and review. The current efforts emerging from the literature to categorize makerspaces based on descriptions of facilities, equipment or location have been shown to be ineffective. The lack of a model of categorization makes it difficult for school administrators to identify and review models that they believe would match their educational goals and work best in their schools.

Purpose of the Study

The purpose of this study was to analyze the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed.

Research Questions

This study was designed to consider the following research questions to address the research problem:

1. How are makerspace facilities and use described and characterized by select K-12 school administrators?
2. What are the overarching reasons select K-12 school administrators have implemented a makerspace facility?

3. What common themes emerge from the implementation and use descriptions of makerspaces by school leaders?
4. If common themes emerge from the implementation and use descriptions of makerspaces by school leaders, what are the distinctive or specific attributes identified in those themes that could be used to separate makerspaces into specific categories?

Conceptual Framework

This study involved trying to determine if there were attributes or themes within the current practice descriptions and purpose statements of makerspaces by the administrators that represent them that could lead to a new way of categorizing makerspaces not currently in use. The qualitive research methodology known as Constructive Grounded Theory was the conceptual framework that guided the data gathering and analysis related to the interviews. Constructivist Grounded Theory (CGT) focuses on generating new theories through inductive analysis of the data gathered from participants. This methodology involves a repetitive comparison of the data to itself to reveal issues of importance to the participants and then comparison of that data with the codes and themes that emerge from the analysis and articulated by the researcher (Mills et al., 2006).

Research Methodology Overview

This study utilized a mixed method approach of data collection that involved the analysis of both survey data and interview responses from school administrators. Ten survey questions were used to frame and guide the interviews and participants were given the interview questions to consider in advance of the interviews. The analysis of the interview responses followed a qualitative research process of coding, grouping, and identifying relationships between the phrasing of responses known as Constructivist Grounded Theory (CGT). This research analysis process focuses on generating new theories from the gathered and emerging data and avoids formulating hypotheses before collecting data (Charmaz, 2014). To gather the data needed to answer the proposed research questions administrators of K-12 schools with current makerspaces were located using publicly available data such as news articles or mentions of the school's makerspace on school and district websites. An introduction letter containing information about the study and a link to an online survey created using Google Forms was sent to administrators around the country. Included in the survey questions was the ability to choose if the administrator would be interested in talking further about their makerspaces through an interview that would take place at their school or via a video conference. The interview data that was collected was entered into an online software called DELVE that is used by researchers to organize and help in the analysis of qualitative data.

Delimitations

Other instances of makerspaces do exist in communities around the world and range from for-profit businesses to non-profit community centers and programs. Though many of these makerspace implementations have educational components associated with them, the focus of the study is specifically on makerspace implementations in K-12 settings. Post-secondary efforts to implement makerspaces contribute to the interest in makerspaces by the K-12 community and were included in the literature review. The following delimitations were employed to outline the scope of the study and to keep the focus of the data collection aimed at the research questions.

1. The survey and participation invitations were only sent to the identified K-12 administrators of schools that have implemented makerspaces and not to any representatives of post-secondary institutions, for-profit businesses or non-profit community centers that have implemented or are based on makerspaces.
2. The K-12 and post-secondary administrators of schools that have implemented makerspaces were identified through articles published in public news media sources, through public postings about a makerspace on school district websites, or through other publicly available lists related to the subject of K-12 makerspaces.

Assumptions

The following considerations were assumed to be true regarding the survey data:

1. The responses from the identified administrators of the schools with makerspaces accurately described the current implementation practices, vision, and goals of the makerspaces they represent.
2. The responses given represent those of the K-12 school's districtwide vision for the makerspace.

Definition of Terms

The following definitions are provided for clarity and understanding of terms and phrases used throughout the study.

Makerspace. An environment or facility that provides resources, materials, and equipment for students to conceive, create, collaborate, and learn through making. (About the Challenge, n.d.)

Fab Lab. The educational outreach component of MIT's Center for Bits and Atoms (CBA), an extension of its research into digital fabrication and computation. A Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, to invent (The Fab Foundation, 2022).

Maker Movement. The maker movement is a cultural trend that places value on an individual's ability to be a creator of things as well as a consumer of things. In this culture, individuals who create things are called makers. Makers come from all walks of life, with diverse skill sets and interests. The thing they have in common is creativity, an interest in design and access to tools and raw materials that make production possible (Make Magazine, 2021).

Maker Faire. An event designed to be forward-looking, showcasing Makers who are exploring new forms and new technologies. But it is not just for the novel in technical fields—Maker Faire features innovation and experimentation across the spectrum of science, engineering, art, performance, and craft (Make Magazine, 2021).

Project-based Learning. The emphasis of project-based learning is on developing an interactive environment for learning in the classroom where students can actively explore problems and challenges from the real world and gain a deeper understanding (Karimi et al., 2023).

Problem-based Learning. Problem-based learning is a student-centered technique where students will gain knowledge about a subject or course by working through an open-ended problem discovered in the material (Karimi et al., 2023).

Summary

The review of relevant literature reveals a growing body of research pointing to the positive impacts of implementing makerspaces in K-12 and post-secondary institutions, an increasing number of those institutions are investing significantly in makerspaces, and there is a growing support system to fund the implementations from both the public and private sectors. The literature also points to a need in the makerspace community for a means to categorize makerspace implementations for the purpose of evaluation, comparison, and future study. For K-12 and post-secondary administrators looking to make data driven decisions based on comparative analysis of existing implementations of makerspaces or to identify best fit models that align with their own vision and goals for a makerspace, the current efforts to categorize K-16 makerspaces based on descriptions of facilities, equipment or location make gathering that data a sincere challenge.

Chapter 2: Review of Related Literature

The purpose of the review of related literature offered in this work is to outline the pressure and incentives educators are facing to invest in makerspaces, learn what strategies they use to frame their vision for makerspaces, and to determine how the value of those makerspaces is articulated. The chapter is structured to address the following themes: makerspace movement in education, makerspace movement a national priority, makerspace models, and considerations for implementation.

Conceptual Framework

Educators strive to provide impactful hands-on educational experiences to positively impact student learning. Makerspaces offer an instructional approach of active learning and developing skills in an environment that supports student-centered learning, student engagement, belonging and equity, and student identity development (Nadelson, 2021). Makerspaces also support 21st century learning that includes critical thinking, communication, collaboration, and creativity (Busch, 2018). For school improvement efforts, administrators in the United States are asked to follow the Evidence-Based Practices (EBP) outlined in the U.S. Department of Education's Every Student Succeeds Act (ESSA) the office of Elementary and Secondary Education states that "The main indicator of quality for EBPs including specific interventions, activities and strategies implemented at the school or district levels should be clear evidence of impact based on rigorous research" (Leveraging evidence-based practices for local school improvement, 2020, p. 1). An obstacle that administrators face when attempting to gather such data and base their plans for a makerspace in their own schools is that there are wide disparities in the way makerspaces are implemented managed and resourced (Mersand, 2020). This disparity makes it a challenge for administrators to identify the best fit models of implementation to review, study or emulate.

Guided by constructive grounded theory, this exploratory qualitive study used an inductive approach together and analysis of data gathered from participants to analyze the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed.

Constructivism and Experiential Learning Theory

Constructivism is a learning theory based on the research and ideas presented by education theorists Jean Piaget and Lev Vygotsky about how knowledge is gained by the learner through meaningful experiences during which they build their understanding of a concept by questioning, modeling, determining patterns and then defending their ideas (Fosnot, 2005). Furthering Piaget and Vygotsky's theories of constructivism as a model for how learning happens, John Dewey's research emphasized that all genuine education happens through experiences on the part of the learner (Dewey, 1938). Drawing on the work of Piaget, and Dewey, in 1984, Kolb introduced Experiential Learning Theory which emphasizes the central role that experience plays in the learning process. The theory outlines four vital steps in the learning process: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). Problem Based Learning and Project Based learning are two common approaches for operationalizing experiential learning theory in the classroom (Wurdinger & Carlson, 2010) and Makerspaces are being used by many teachers to implement, enhance and support Project Based Learning and Problem-Based learning (McKay & Glazewski, 2016).

Project and Problem Based Learning

Problem Based Learning is a teaching strategy that asks students to generate, present and explain a proposed solution to an authentic problem where a clear solution or formula-based answer is not known. To complete this work students, employ investigation strategies and expand on a range of skills and knowledge related to the problem (Wirkala & Kuhn, 2011).

Project-Based Learning also involves active learning but differs from problem-based learning in that students are asked to produce a physical model or artifact to demonstrate their mastery of the content where learners are provided with specifications for the desired product (Savery, 2006). A summary conclusion of four separate studies about the impact of Project based learning by the George Lucas Educational Foundation found that embedding PBL in courses can yield significant positive effects on student learning and achievement. Another positive aspect of participating in Project Based Learning and Problem based learning is that it also encourages the development of 21st century skills, attitudes, and behaviors (Dole et al., 2017).

21st Century Skills Framework

Designed by the Partnership for 21st century skills (P21), this framework used by educators across the United States to support students in acquiring essential skills to be successful in today’s world. The framework for 21st century skills is known as the "four Cs" of 21st century learning, these include critical thinking, communication, collaboration, and creativity (National Research Council, 2012). While critical thinking, communication, collaboration, and creativity have always been important, educators have seen an increased focus on these soft skills and other "21st century skills" as occupations incorporate digital technology, and subsequent changes in the nature of work have increased demand for analytical, problem-solving, and interpersonal skills. (National Research Council, 2012).

Integrating making and makerspaces into the curriculum encourages students to collaborate on projects, one of the essential 21st skills (Saracino et al., 2021). The activities and learning that take place in makerspaces have been found to have a high level of alignment to the knowledge and skills outlined in the National Education Association" 21st century skills framework (Taylor, 2016). In 2021, Danielle Saracino and a team of researchers compared a range of modes of learning at Georgia Tech University and James Mason University makerspaces to understand how competencies, learning communities, and learning models were integrated into various curriculum (Saracino et al., 2021). Analyzing over 1000 pages of testimony from participants highly involved in the respective makerspace activities, Saracino and her team found that while learners' modes of learning varied, students gained comparable content knowledge and competency from their makerspace experience. In their presentation at the American Society of Engineering Education in July of 2021 the team presented as part of their finding that, "integrating making into the curriculum encourages students to collaborate, one of the essential 21st century skills" (Saracino et al. ,2021, p. 8).

Review of the Research on Issues Relevant to the Study

Makerspace Movement in Education

Martinez and Stager (2013) credit artificial intelligence and constructionist movement pioneer Seymour Papert as the "Father of the Maker Movement" (p. 17). Papert's work with renowned psychologist Jean Piaget along with his expertise in mathematics and love of computers earned him a position at Massachusetts Institute of Technology (MIT). While at MIT Papert's love of computers, interest in education and observations of how well children mastered content when they were involved in building or making a project, led to a lifelong advocacy of experiential learning for all children. In 1968, Papert codeveloped a computer programming language specifically for children called LOGO for the express purpose of allowing children to create original programs using a computer. Later in 1980, Papert coined the term "Mindstorms" proposing the idea that having students program computers to create something of their own engages deeply in the related math, science and other core subjects while at the same time building a mastery of the technology itself. The LEGO company incorporated a computer control system into their product lines and named their product "LEGO Mindstorms" in his honor (MIT Media Lab, 2016) The LEGO company's early sponsorship of the MIT Media Lab which he co-founded and the learning by doing culture of the MIT Media Lab influenced the creation of what is widely considered the first makerspace, the MIT FABLAB. (Martinez & Stanger, 2013)

In 2003 Professor Neil Gershenfeld created a Laboratory at MIT of computer-controlled machines, at the time only found in industry, with the purpose of introducing students in technology related majors to these machines and how to use them (Thompson, 2018). The entire idea of building a lab for anyone to create things came from the course he offered entitled *How to Build Almost Anything*. The course was originally targeted at students in technology related fields, but Dr. Gershenfeld observed that students from a variety of backgrounds took the course and noted the elevated level of correlation between the quality of learning and student ownership of the idea and projects (Martinez & Stager, 2013). In 2005, Make Magazine began to publish and focus articles on maker related projects and making communities. Then in 2008, the first

FABLAB created specifically within a School of Education was opened by Paulo Blikstein of Stanford University for the purpose of having teachers and graduate students design new projects and activities to be used in K-12 Education and to take place in a makerspace within the school (Martinez & Stager, 2013). By 2009, more than one thousand FabLab models had opened worldwide, and the Stanford model gained more attention and inspired schools across the nation to invest in their own makerspaces (Thomson, 2018).

Founded in 2002, the New Media Consortium's New Horizon Project goal has been to bring together education experts from around the world to produce annual reports detailing trends in the use of K-16 technologies for teaching and learning. The goal has been to provide the educational community with analysis of the research in the field and help decision makers optimize the effectiveness of their decisions regarding educational technology investments (NMC Horizon Report, 2015). In 2015 makerspaces appeared in both the K-12 and Higher Education reports and were highlighted as one of six "Important Developments in Educational Technology" that were "very likely to drive technology planning and decision-making over the next five years" (NMC Horizon Report, 2015, p. 34). In 2018, The New Media Consortium was acquired by EDUCAUSE who has continued the Horizon Reports but focuses on Higher Education. In the 2018, Horizon Report makerspaces were again highlighted as one of the six technology developments that, "have the potential to foster real changes in education particularly in the development of progressive pedagogies and learning strategies, the organization of teachers' work, and the arrangement and delivery of content" (NMC Horizon Report, 2018, p. 37).

In January of 2017, District Administration Magazine released a special report about makerspaces in K-12 schools that reached more than 200,000 K-12 leaders with subscribers in virtually every school district in the United States. (About Us, 2024) The special report highlighted makerspaces from around the country and includes the data from more than 250 campus leaders on the scale of their makerspaces and the impact on learning in their districts. Dr. Gary Stager reported that makerspaces have implications for every discipline in a K-12 setting (DA Special Report, 2017). Continuing the trend, in 2021, a special issue of *The Journal of Education Research* cited positive findings related to makerspaces that include student-centered learning, student engagement, belonging and equity, and student identity development and concludes that the range of learning activities and student outcomes justify the use of makerspaces in K-12 education (Nadelson, 2021).

There are similar findings when looking at makerspaces in post-secondary institutions. Though makerspaces at the university level emerged initially from within engineering and technical programs, there are important benefits for a wide range of university programs. In a study of university makerspaces and their impact specifically on mechanical engineering programs at the U.S. Coast Guard Academy and Yale University, researchers made it a point in their findings to highlight that, "…it is essential to note that experiences at both institutions support the notion that higher education makerspaces also help export design skills into the broader community" (Wilczynski & Adrezin, 2016, p. 6).

In 2017, a study from the American Society of Engineering Educators (ASEE) analyzed the impact university makerspaces have on the success of engineering and engineering technology students, researchers found that the makerspace activities attributed to an increase in diversity and retention and to a smaller but still positive effect on student performance and grades (Longo et al., 2017). Wigner et al. (2016) found that the problem-solving environment offered thorough makerspaces leads to skills and experiences that assist engineering programs working to maintain or acquire ABET (Accreditation Board for Engineering and Technology) accreditation. Wilczynski and Adrezin add that the university engineering program accreditation board "favors a spectrum of design experiences spanning the student's undergraduate program." and that "...higher education makerspaces have the potential to help achieve and maintain accreditation" (2016, p. 6).

Makerspace Movement a National Priority

Nealy 15 years ago, in 2009, President Obama ignited the nation's curiosity and interest in makerspaces with his Educate to Innovate campaign. This nationwide movement supported new and innovative ways to develop the next generation of builders, inventors, and makers in interactive environments like science events, fairs, and robotics competitions training and reform (National Archives and Records Administration, n.d.). The initiative led to 2014's first White House Maker Faire in Washington D.C. highlighting the use of makerspaces in education (A brief history of makerspaces, 2018). President Obama then launched the President's Nation of Makers Initiative in which the president called on more organizations to support the growing community of Makers (Nation of Makers, 2022). This national call in 2014 attracted NationofMakers.org, Institute of Museum and Library Services, the Congressional Maker Caucus, and a number of sponsors like Chevron, Infosys Foundation, and the Consumer Technology Association to become involved and an annual Capitol Hill Maker Faire in Washington, D.C. has been hosted since 2018 to promote and support all aspects of the maker movement (Nation of Makers, 2022). This national event, a growing number of educational institutions investing in makerspaces, and a growing body of knowledge and research showing the impact makerspaces have on education have captured the attention of both public and private organizations and industry leaders and fueled the maker movement. In 2014 with the importance of makerspaces in the national spotlight, Ohio Representative Tim Ryan and Mark Takano formed the Congressional Maker Caucus and in 2017 proposed a house bill entitled The Shop Class Act. If approved, this legislation would amend the Carl D. Perkins Career and Technical Education Act of 2006 to require state education agencies to allow funding directly for makerspace efforts at the K-12 and post-secondary level (Ryan, 2017). The language of the bill is vital to understand how states were expected to support both the training of teachers and efforts to implement makerspaces:

> (1) professional development programs to ensure that public school teachers of career and technical education develop a higher level of academic and industry knowledge and skills in maker education (a hands-on learning approach that encourages students to imagine, create, innovate, tinker, and collaborate through the process of manufacturing, testing, and demonstrating their ideas); and
>
> (2) support for maker education and makerspaces (a community space that provides access to tools, technology, and knowledge for learners and entrepreneurs, that results in the prototyping or creation of physical goods, and that supports the development of educational opportunities for personal growth, workforce training, and early-stage business ventures). (H.R. 2308 - 115th Congress, 2017-2018: Shop class act)

In March of 2016, the U.S. Department of Education (DOE) launched a nationwide challenge to design makerspaces entitled “The CTE Makeover Challenge” (U.S. Department of Education, About the Challenge, 2018). The DOE offered and then awarded $200,000 in prize money to winning entries. Those winning entries were showcased during the World Maker Faire in New York City in October 2016. (U.S. Department of Education, 2016) The competition is one of three sponsored by the U.S. Department of Education to “… foster making through experimentation with technology, engineering, and science while preparing students to succeed in the modern economy” (U.S. Department of Education , ,2016, p. 1) In 2019, Representative David Scott introduced the Makers Act during the first section of the 116th congress. The purpose of the legislation is to encourage the formation and study of Makerspaces and directs the National Science Foundation to award grants to institutions of higher education to support the research and development of Makerspaces (H.R.2518–116th congress (2019-2020): Makers Act). In April of 2023 Congressman David Scott and Representatives Mark Takano, Drew Ferguson and Brian Fitzpatrick reintroduced the MAKERS Act to the 118th congress (Scott, 2023). June of 2014, the year of the first White House Maker Faire in Washington D.C. An award search at the U.S. national Science Foundation’s website entering the award search identifier of “makerspace” at http://nsf.gov/awardsearch/ documented that The National Science Foundation has issued over 60 grants to investigators totaling over 30 million dollars to organizations in 21 states and the District of Columbia related to the study and improvement, and implementation of makerspaces in K-12 and postsecondary settings.

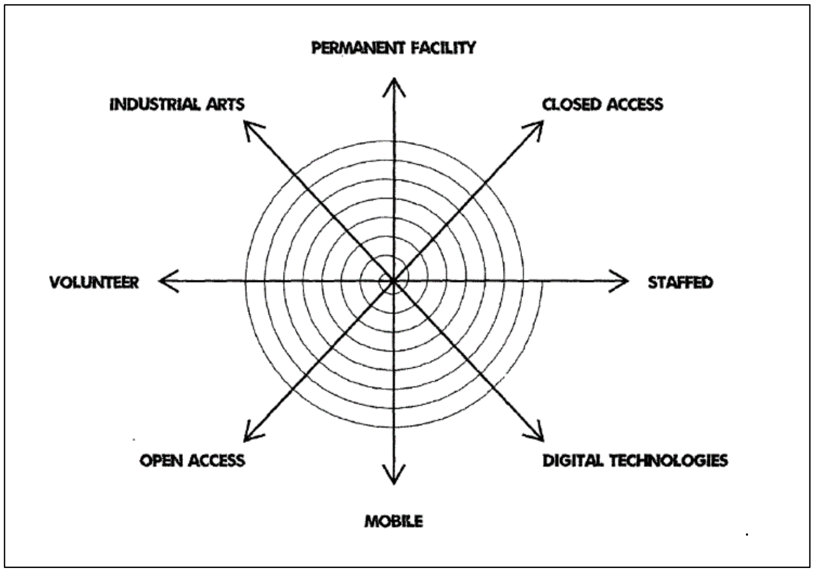
Categorizing Makerspaces

One of the most challenging aspects of trying to define a best practice model of a makerspace to meet is that there is a wide array of ways makerspaces have been envisioned and a seemingly equal number of implementation strategies (Bonagura, 2017). Bonagura's (2017) guide for administrators recommends there is no right or wrong way to create a makerspace because each school is different, so each makerspace is unique. Though flexibility is welcomed, school administrators and educators strive to launch new initiatives based on best practices in efforts to best serve their students and their school's needs. Under the U.S. Department's Every Student Succeeds Act (ESSA) administrators are encouraged to follow evidence based practices as they work to implement new initiatives in their schools. (U.S. Department of Education, 2023) While Bonagura (2017) offers valuable insight on defining vision and goals for a makerspace, it offers administrators little help in identifying and connecting with fellow makerspaces with similar educational characteristics and needs to learn from before investing in their own makerspaces.

Given the uniqueness of makerspaces, attempting to define, organize and categorize makerspaces by their attributes is a challenging task. Sheridan et al. (2014) compared three distinct public makerspace implementations and found the sites were serving different clientele from a makerspace aimed at serving mostly school age children to a makerspace that serves primarily adult entrepreneurs. They looked for common attributes and three themes emerged, 1) multidisciplinary fuels engagement and innovation, 2) makerspaces have a marked diversity of learning arrangements, and 3) learning is in and for the making (Sheridan et al., 2014, p. 531). Davee et al. (2015) surveyed 51 makerspaces and found great inconsistency with 45 different descriptions and names reported. However, three broad categorizations of makerspaces emerged; 1) dedicated Makerspaces where all the tools and resources are located in one location; 2) distributed Makerspaces where tools are resources are located in multiple sites throughout an organization; and 3) mobile makerspaces where tools and resources are housed on a trailer or bus and moved from site to site (Davee et al., 2015). A review of 150 studies on makerspaces concluded that there were wide disparities in the settings, materials, components and materials of the way makerspaces were described in the study (Mersand, 2020). Focused on the university setting, Barrett et al. (2015) presented at the American Society of Engineering Education (ASEE) their review of forty undergraduate university programs rated in the U.S. News and World Report top 100 (U.S. News, 2018). They found no common standard in terms of what components constitute a makerspace and concluded that maker spaces in academia, like those available to the public, come in many different shapes and sizes (Barrett et al., 2015). In 2017, Dousay outlined her makerspace framework to assist with defining the various operational characteristics to consider that "…may help stakeholders evaluate immediate and long-term needs and capabilities" (2017, p. 71). Each line within her multidimensional framework represents a range of operational options to assist decisions makers in making informed choices regarding the infrastructure and resources required to launch a makerspace and build a thriving makerspace community (Dousay, 2017).

Figure 1

Dousay Makerspace Framework



Wilczynski, Director of the Yale Center for Engineering Innovation and Design, believed that "the higher education makerspace community would benefit from an enterprise-wide classification system" (Wilczynski, 2017, p. 1). He went on to explain that "such a classification system will be helpful to improve current spaces and guide the development of future spaces" (Wilczynski, 2017, p. 1). Wilczynski proposed five characteristics for consideration–scope, accessibility, user-base, footprint and management/staffing–and using these, he evaluated seven higher education makerspaces. He found that grouping spaces by similarities across these attributes offered an efficient framework for comparison for an initial step, and recommended additional characteristics could add value in defining possible makerspace models to consider (Wilczynski, 2017).

In a National Science Foundation funded study presented at the American Society of Engineering Education (ASEE) entitled "A Review of University Makerspaces" a team of researchers looked at 40 makerspaces from undergraduate university programs rated in the *U.S. News and World Report* top 100 in 2015. The result of the report is a listing of the comparison of equipment, staffing organization, location, and scheduling, and current usage of these makerspaces. The authors note that, “There is no standard as to what components constitute a makerspace. As a result, the maker spaces in academia, like those available to the public, come in many different shapes and sizes” (Barrett et al., 2015, p. 3).

From its origins in the laboratories and classrooms of the Massachusetts Institute of Technology in the 1970s the makerspace model and the positive impacts a makerspace can have on student learning and engagement have become a focal point of interest for both K-12 and postsecondary communities. The addition of makerspaces in K-16 educational settings has gained both vocal and financial support from a wide array of individual donors, industry donors, and even the proposal of specific changes in long term government funding to support their creation and implementation in schools. Parallel to this growing momentum of implementations has been the work of researchers to identify and articulate and categorize the key attributes of a makerspace, what it looks like in practice, and how to best assess the value of a makerspace once it is in place.

Summary

The literature reveals that the enormous range of implementation strategies, day-to-day practices, and even physical characteristics of makerspaces have made it a sincere challenge for researchers to effectively categorize those implementations for the purpose of comparison and study. This challenge is then translated directly to school administrators following evidence-based practices who wish to identify, study and learn from makerspace implementations that would be a best fit model for their respective schools before investing in a makerspace. The next chapter, Chapter 3, discusses the research design of the study in detail, including subject population and response, and study design.

Chapter 3: Methodology

This chapter describes the design of this exploratory mixed methods study. The information presented includes a description of the participants, the instrument for data collection, research design and research questions, data analysis, human subject approval, timeline, and procedures.

There is a lack of understanding regarding categorizations of makerspaces by descriptions of the tools, equipment, physical locations, or access management styles. These models show to be of little use when trying to effectively characterize makerspaces for the purposes of comparison, study or review. Existing literature highlights the importance for K-12 administrators to link the way they implement and invest in a makerspace to the vision, goals and needs of their respective school settings. However, there is little to no information available to guide K-12 administrators on the various categories of makerspaces to consider in order to meet the needs of their organizations. The purpose of this study was to analyze the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed.

Description of the Participants

Participants in this study were K-12 administrators in schools with established makerspaces. The schools and their administrators were identified through public postings of news articles about K-12 makerspaces, public posting of makerspace facilities on school or school district websites or published lists of schools with makerspaces that were part of the literature on makerspaces. Once a school with and established makerspace was identified, an introduction letter approved through the IRB process was emailed to the principal or head of school that included information about the study and an invitation to complete the online survey with a web link to that survey. One hundred ninety-five letters of introduction were emailed to schools in 40 states and the District of Columbia with 18 respondents completing the survey or a response rate of 10%. The 19 survey responses represent schools from 11 states and included 10 high schools, two 7-12 schools, one middle school, three K-8 schools, and two elementary schools. Of the 19 survey respondents, six were contacted and interviewed. The six administrators interviewed represent schools in five states, Illinois, California, Minnesota, Ohio, and Texas, and include three high schools, one 7-12 school, and two K-8 schools. To follow IRB guidelines and ensure that personal identities remain confidential, the citations regarding quotes from participants used in this documentation contain pseudonyms.

Data Collection

The data represented in this study was gathered through a mixed method approach that involved an online survey and statements from interviews with K-12 school administrators. The survey was generated and distributed using a Google Forms document and the web link for this survey was included in the introduction and information letter emailed to school administrators. The survey questions were derived from use case models highlighted in the literature review. The survey questions then allowed administrators to directly self-identify how their makerspaces were being used in practice at their respective schools and included a 5-point Likert scale that offered a range of responses from “not used for this purpose or in this manner” to “used for this purpose almost exclusively throughout the school year” for each question. The survey was set so that participants could only see and access their own responses and so that they did not have access to any of the summarized data generated from the responses of others. This data was then combined with the findings of the interview process.

Included in the online survey was the ability to indicate interest in being interviewed about the school's makerspace at the school site or via a video conferencing medium. The video conferencing software used in this study was Zoom. Of the 19 administrators who completed the survey and identified an interest in the interview portion of the study, six were contacted and interviewed. Each of the interview participants was provided interview questions (Appendix B) in advance of the interviews.

Research Design

The research design of this study utilized a mixed method approach of data collection that involved the analysis of both survey data and interview responses from school administrators. Ten survey questions were used to frame and guide the interviews and participants were given the interview questions to consider in advance of the interviews. The analysis of the interview responses followed a qualitative research process of coding, grouping, and identifying relationships between the phrasing of responses known as Constructivist Grounded Theory (CGT). This research analysis process focuses on generating new theories from the gathered and emerging data and avoids formulating hypotheses before collecting data (Charmaz, 2014).

Four research questions were employed to frame the model used to gather data for this study:

1. How are makerspace facilities and use described and characterized by select K-12 school administrators?

2. What are the overarching reasons select K-12 school administrators have implemented a makerspace facility?
3. What common themes emerge from the implementation and use descriptions of makerspaces by school leaders?
4. If common themes emerge from the implementation and use descriptions of makerspaces by school leaders, what are the distinctive or specific attributes identified in those themes that could be used to separate makerspaces into specific categories?

Data Analysis

Information from each question from the online survey was used to generate bar graphs and pie chart graphs as is part of the Google Form functionality. The results of the survey data were then noted and compared to and incorporated with the final analysis of the interview data. Each of the administrators interviewed received a list of 10 questions that framed the interview in advance of the interview. Statements and quotes from the interviews were captured through note taking or through the recording of the video conference with permission of the participants. Recorded interviews were turned into direct text using the Transcribe function of Microsoft Word and then the comments and statements from the six participants were entered into the qualitative data analysis software entitled Delve (https://delvetool.com/). Using this software and following the model of Constructivist Grounded Theory practice, an iterative process of grouping similar statements from participants into codes yielded sixteen different codes (Charmaz, 2014). These 16 codes were then evaluated for similarities and grouped into four different themes related to how participants described and defined the purpose and use of their makerspaces.

Human Subjects Approval

To ensure that the rights and welfare of subjects participating in this study are adequately protected, all requirements set forth by the St. Cloud State University Institutional Review Board (IRB) were strictly adhered to. The terms of consent presented in the survey allowed for voluntary participation on the part of respondents by the completion of the survey and follow all the requirements set forth and approved by the St. Cloud State University IRB (see Appendix C for consent form and IRB approval). Throughout the study all identifying data were kept secure and kept in accordance with IRB protocol. All data including the interview recordings have been stored securely in accordance with IRB and institutional research policies of St. Cloud State University.

Procedures and Timeline

The proposal to the dissertation committee for this study took place on October 18th of 2022 at St. Cloud State University and IRB approval for this study as approved by the committee was granted on February 6th of 2023. From February 19th through the end of June 2023 this researcher employed a repetitive process of identifying K-12 schools with current makerspace implementations through internet searches of district websites, news articles and research papers in batches of 25 to 30 and then in-turn sending letters of introduction and information about the study directly to administrators via email. The process of scheduling interviews based upon the survey responses and analyzing data was iterative with the researcher revisiting existing data and then adding new data based on completed interviews throughout the process (Charmaz, 2014).

Once the target of securing five interviews as established by the dissertation committee was achieved, the process of identifying schools and sending introduction letters shifted to analyzing the data with the inclusion of a sixth interview that took place based on the final rounds of incoming data from participants.

Summary

This study used a mixed methods design to analyze the similarities and differences of how select K-12 school administrators describe and characterize their makerspace. Data were collected from 18 schools, with six follow-up interviews with school administrators. The quantitative data were analyzed utilizing descriptive statistics and qualitative data coded following the model of Constructivist Grounded Theory practice. The next chapter, Chapter 4, discusses the research results of the study in detail.

Chapter 4: Results

There is a growing interest in the K-16 community to invest in makerspaces which has led to efforts to categorize makerspace implementations for the purposes of comparison, study, and review. A challenging aspect of trying to identify a makerspace model to study and review to meet a given school's goals is the wide array of ways makerspaces have been envisioned and implemented (Mersand, 2020). Trying to group or categorize makerspaces by their physical attributes, equipment purchases, and management structures also proves very difficult as there are no standards as to what comprises a makerspace (Barrett et al., 2015). The wide variety of makerspace implementations and lack of standards to define them adds to the challenge for administrators to identify and review existing makerspaces that reflect their own educational interests and meet the Department of Education's guidelines for evidence-based practices when investing in education programs which highlights clear evidence of impact based on rigorous research. (U.S. Department of Education, 2023)

Research Problem

The current efforts emerging from the literature to categorize makerspaces based on descriptions of facilities, equipment or location have been shown to be an ineffective method for categorizing makerspaces for the purposes of comparison, study and evaluation. The lack of a model of categorization makes it difficult for school administrators to identify and review models that they believe would match their educational goals and work best in their schools.

Research Purpose

The purpose of this exploratory mixed method study was to analyze the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed.

Research Questions

This study was focused on the following four research questions:

1. How are makerspace facilities and their use described and characterized by select K-12 school administrators?
2. What are the overarching reasons select K-12 school administrators have implemented a makerspace facility?
3. What common themes emerge from the implementation and use descriptions of makerspaces by school leaders?
4. If common themes emerge from the implementation and use descriptions of makerspaces by school leaders, what are the distinctive or specific attributes identified in those themes that could be used to separate makerspaces into specific categories?

Research Design

Constructivist Grounded Theory (CGT) which focuses on generating new theories through inductive analysis of the data gathered from participants. This methodology involves a repetitive comparison of the data to itself to reveal issues of importance to the participants and then comparison of that data with the codes and themes that emerge from the analysis and articulated by the researcher (Mills et al., 2006). To gather data his study utilized a mixed method design of gathering data. A quantitative survey containing questions about current usage practices was sent to K-12 school administrators who have active makerspaces in their schools. Each question in the survey was based on models of use found in the literature review and asked participants to rate their current use practices on a 5-point Likert scale. The survey data were combined with qualitative data from the analysis of commentary gathered from one-on-one interviews with 6 of the 19 survey respondents.

Study Participants

The quantitative survey was disseminated to 195 K-12 school administrators in 40 states and the District of Columbia. Each of the 195 schools had a makerspace implementation and were identified through public postings on their district websites or news articles about the school's makerspace. The response from the survey included 19 participants representing schools from 11 states completed the survey, a response rate of 10%. All respondents were lead administrators and those respondents represented ten high schools, two 7-12 schools, one middle school, three k-8 schools, and two elementary schools. The quantitative survey that was emailed to administrators contained an option for respondents to indicate if they would be willing to participate in an interview about their makerspace facility and how it was utilized in their school. Six survey respondents that reported they would be interested in the interview were contacted and given 10 interview questions in advance of the scheduled interviews. The six respondents represented schools from both public and private sectors and between all six schools represented the entire K-12 spectrum of grade levels. These interviews took place during June, July, and August of 2023 and analysis of the data were iterative and ongoing throughout the interviewing process as is recommended when using the constructivist grounded theory methos of research as in this study.

Quantitative Data–Online Survey

This exploratory study used a mixed method strategy to gather data and examine how school administrators described the purpose their school implemented a makerspace and how administrators describe their makerspaces to determine if there were themes or attributes within those descriptions that could be used as the basis for a system for categorizing makerspaces not currently in use. The following Survey questions were designed to allow administrators to indicate a best fit model of how their makerspaces are being used in practice based upon use descriptions from the literature review.

As the study was focused on the descriptions and reasons administrators implement and support their makerspaces the following question was designed to learn the level of involvement of the administrator in the initial implementation of their school's makerspace.

Tables 1

Survey Respondent's Makerspace Implementation Involvement

Involvement Question from the survey: "How would you best describe your involvement in the implementation of the makerspace at your school?"

	N	19
Involvement in Makerspace Implementation	**Number**	**Percent**
Main lead/co-lead of the team that envisioned, designed, and implemented	8	21.1%
Part of the team that envisioned, designed, and implemented	4	42.1%
N/A, Makerspace was in place and a resource when I became principal	7	36.8%

The data from Table 1 revealed that 12 of the 19 respondents were directly involved in the design and implementation of their school's makerspace with 8 of the 19 of respondents being a lead or co-lead, and four of the 19 were part of the design and implementation team.

The study looked at makerspaces across the K-12 grade level spectrum. The following research question was designed to understand what grade levels the respondents were referring to when choosing use case scenarios in the other survey questions.

Table 2

Primary Users of Makerspace by Grade Level

Grade Level Question from the survey: "What grade levels make use of the space at your facility?"

	N	19
Primary Users of Makerspace, by Grade Level	**Number**	**Percent**
Primary elementary school (grades k-4)	2	10.5%
Primary middle school (grades 5-8)	2	10.5%
Primary high school (grades 9-12)	8	42.1%
Primary elementary and middle schools	3	15.8%
Primary middle and high schools	4	21.1%
*(*reported as "Other")*	N	19
Makerspace has Community Connection	**Number**	**Percent**
Community uses reported	2	10.5%
Community uses not reported	16	84.2%

Of the 19 respondents, nine represented schools that included some combination of primary, middle and high school grade levels. Each respondent reported that the makerspace was used by the range of the grade levels they represented. This resulted in 5 of the 19 schools using makerspaces with their elementary grade students, 9 of the 19 schools using makerspaces with their middle school students, and 12 of the 19 schools represented using makerspaces with their high school level students. The primary use question of the survey also included a free response section and 2 of the 19 respondents reported that their makerspaces were also used by the community in one instance for community events and another listed for adult education classes.

Makerspaces Use Case Scenarios–Online Survey

The survey participants were given five descriptions of makerspace use case scenarios derived from the research and literature review of this study along with a 5-point Likert scale of choices to identify how each description of use best fit with their own experiences. The five scenarios were Project Based Learning, open ended problem solving, closed or managed access, open access, and open exploration.

The following description of use from the survey describes a use case where the makerspace is used to support Project Based Learning activities which ask student to produce a project or artifact that shows understanding or mastery of a specific or targeted set of learning objectives for a given lesson.

Table 3

Makespace Used for Project-Based Learning

Use Description Choice from the Survey: To what extent is the makerspace at your school used for Project Based Learning – (activities connected with a course or curriculum designed to support a specific or targeted set of learning objectives or skill development)

	N	19
Extent Used for Project Based Learning	**Number**	**Percent**
Almost exclusively throughout the school year	5	26.3%
Very often throughout the school year	9	47.4%
Often throughout the school year	3	15.8%
A few times throughout the school year	2	10.5%
Not used for this purpose	0	0.0%

Each of the 19 survey respondents reported that their makerspaces were used at some level for Project Based Learning activities. Project Based Learning activities are linked to given course lessons or curriculum and designed to support a specific or targeted set of learning objectives or skill development (Savery, 2006). Table 3 also shows that 14 of the 19 respondents use their makerspaces very often or almost exclusively for project-based learning throughout the school year.

The following description of use from the survey describes a use case where the makerspace is used to facilitate open-ended problem-solving activities. In the review of literature this kind of activity is also known as Problem-Based Learning**.**

Table 4

Makespace Used for Open-ended Problem Solving

Use Description Choice from the Survey: To what extent is the makerspace at your school used for Open Ended Problem Solving – (activities or projects where the problem drives the resources that are needed to visualize, prototype or fabricate suggested solutions)		
	N	19
Extent Used for Open Ended Problem Solving	**Number**	**Percent**
Almost exclusively throughout the school year	5	26.3%
Very often throughout the school year	9	47.4%
Often throughout the school year	2	10.5%
A few times throughout the school year	1	5.3%
Not used for this purpose	2	10.5%

Seventeen of the respondents reported that they also use their makerspaces for open-ended problem solving for activities also referred to in the literature as Problem Based Learning. These are activities or projects where a given overarching problem rather than a specific lesson or curriculum goal drives the activity and the learning about the topic that are needed to visualize, prototype, or fabricate suggested solutions (Wirkala & Kuhn, 2011). Two of the respondents reported that they do not use their makerspace for this purpose.

The following description of use from the survey describes a use case where open access time to the makerspace is managed or scheduled for teachers and students to use the makerspace to work on products or artefacts specifically related to their course work.

Table 5

Closed or Managed Makespace Access

Use Description Choice from the Survey: "To what extent is the makerspace at your school used for Closed or Managed Tool and Resource Access – (concentrated areas where specialized tools, equipment and support materials are housed and maintained and made available and students and staff are required to schedule time in the space or receive permission from an administrator or manager to produce digital or physical prototypes or fabricate products related to assignments or a curriculum goal)"

	N	19
Extent Used for Closed or Managed Tool and Resource Access	**Number**	**Percent**
Almost exclusively throughout the school year	2	10.5%
Very often throughout the school year	4	21.1%
Often throughout the school year	4	21.1%
A few times throughout the school year	5	26.3%
Not used for this purpose	4	21.1%

The survey asked participants to report access to their makerspaces in terms of having closed or managed access where scheduling time in the space was required for students to fabricate artifacts related to their coursework. Six of the 19 respondents reported a managed or scheduled structure was used very often or almost exclusively throughout the school year. Four of the respondents reported that access to their respective makerspaces was not used for the purpose of a managed or scheduled access to the makerspace to work on course related projects.

The following description of use from the survey describes a use case where open lab time or open access time to the makerspace is structured so that teachers and students may use the makerspace as needed to work on products or artefacts specifically related to their course work.

Table 6

Open Access to Makespace

Use Description Choice from the Survey: "Open Tool and Resource Access – concentrated areas where specialized tools, equipment and support materials are housed and maintained and made available to students and staff anytime throughout the workday. Students and teachers come and go as needed to produce digital or physical prototypes or fabricate products related to assignments or a curriculum goal."

	N	19
Extent Used for Open Tool and Resource Access	**Number**	**Percent**
Almost exclusively throughout the school year	4	21.1%
Very often throughout the school year	5	26.3%
Often throughout the school year	4	21.1%
A few times throughout the school year	2	10.5%
Not used for this purpose	4	21.1%

Table 6 shows details of respondents reporting open access to their makerspace for students and staff throughout the workday to work on projects related to course assignments. Nine of the respondents reported that open access for their students to work on course related projects in the makerspace throughout the school year was employed very often or almost exclusively throughout the school year. Four respondents reported that their makerspaces were not used for the purpose of open access for work on course related projects.

The final makerspace usage description in the online survey was in relation to open exploration, where the makerspace was open to students and faculty to explore personal interests or topics related to the tools and resources housed in the makerspace that are not directly tied to a specific assignment or curriculum goal.

Table 7

Open Exploration Usage

Use Description Choice from the Survey: "Open Exploration – the makerspace is open and available for faculty and student use to explore a personal interests or topics related to the tools and resources housed in the makerspace that are not directly tied to a specific assignment or curriculum goal"

	N	19
Extent Used for Open Exploration	**Number**	**Percent**
Almost exclusively throughout the school year	3	15.8%
Very often throughout the school year	7	36.8%
Often throughout the school year	1	5.3%
A few times throughout the school year	2	10.5%
Not used for this purpose	6	31.6%

Table 7 shows an almost even split among the 19 respondents when looking at both the higher and lower ends of the Likert scale about using their makerspaces to support personal interest projects or projects not directly related to the school curriculum. Ten of the respondents reported that their makerspaces were arranged and used for the purpose of open access for students to work on projects of personal interest and not related to their course work. Six of the respondents reported that their makerspaces were not used for the purpose of having open access for open exploration where students work on projects of interest not related to their course work.

Summary Notes on Quantitative Survey Data

Analysis of the quantitative survey data looking at the five use cases described as a whole revealed that all 19 respondents reported more than one use case for their makerspaces. Ten of the 19 survey respondents reported that they used their makerspaces for all five of the use descriptions in the survey. Five of the 19 respondents reported they use four of the five models in practice. Of the remaining four respondents, two of the 19 respondents reported they use three of the five models in practice and two of the 19 respondents reported they use two of the five models described in practice.

Qualitative Data–One-on-One Interviews

Survey respondents were given an option to indicate interest in participating in an interview that would be conducted at their school or via an online video conferencing option. I contacted and interviewed six lead administrators, as interest in the interview process came in from survey respondents over the three months of data collection. The interview group included one administrator each from Illinois, California, Ohio, and Texas, and two from Minnesota. These interview participants represented three high schools, one middle-high school with grades 7-12, and two elementary-middle schools with grades K-8. Following protocols for the protection of human subjects, pseudonyms are used to protect participant identities. Table 7 offers an overview of the participants' location and involvement in the implementation of the school's makerspace as reported on the online survey. Table 8 is followed by a brief introduction to each of the participants that highlights some of the comments from the interviews that each had stated about their respective makerspaces.

Table 8

Interviewee Pseudonym and Demographics

Pseudonym	School Level	State	Implementation Role
Lucie	Elementary and middle school (K-8)	Minnesota	Makerspace was in Place
Nathan	Elementary and middle school (K-8)	Ohio	Makerspace was in Place
Jack	Middle and high school (7-12)	Minnesota	Main Lead or Co-Lead
Sue	High school (9-12)	Texas	Main Lead or Co-Lead
Alice	High school (9-12)	California	Part of the Implementation team
Molly	High school (9-12)	Illinois	Part of the Implementation team

Introduction to the Interview Participants

Lucie

Lucie is the principal of a private K-8 school in Minnesota who talked about the importance of design thinking and the project-based learning activities that her school's makerspace provides students. Lucie stated that one of her goals for this school's makerspace is to help expose teachers in all areas of the school to PBL activities in hope that they might begin to incorporate these kinds of activities it enhances the lessons they offer their students.

Nathan

Nathan is the principal of a Private K-8 school in Ohio who stated that his school's mission statement includes the promise of a rigorous and relevant academic experience for its students and that he believes the activities that take place in his school's makerspace delivers of both of those components. Though the makerspace was in place before he became principal, he helped to bring the makerspace into their curriculum offerings as part of the daily school curriculum. He helped to add it as a "special" in addition to PE, art, and music for all students.

Jack

Jack is the principal of a Minnesota public 7-12 school who reported that their makerspace is used from the 6^{th} grade through 12^{th} grade. Of special note Mr. Hodges stated that their makerspace was used to fill a gap in their stem offerings in the 6^{th}, through 8^{th} grades offering projects and activities that introduced or reinforced open-ended problem-solving skills at that level and then helped to serve as a foundation for the more open exploration and open resource the makerspace served at the high school level. He also saw one role of the makerspace to help "Infuse STEM ideas into the whole of the curriculum."

Sue

Sue is an administrator at a Texas public 9-12 high school that stated that they emphasized working to integrate the Gold Standard Project Based Learning essential design elements developed through the Buck Institute of Education into the activities that take place in their makerspace. She also states the importance of highlighting the makerspace skills students learn when working on their projects and how those skills are tied to careers.

Alice

Alice is the principal of a private 9-12th grade all girls high school in California who stated that one of drivers for implementing their makerspace was to offer a resource to help ensure that their curriculum was relevant and that their makerspace is open to all classes for use. She stated that they see their makerspace not as an end in itself but as a resource for students to explore problem solving and to learn new skills. She also stated that she believes the equipment in the makerspace will evolve with available technology but that, “people are always going to have to learn how to solve problems”, and “…we’re going to need a space for people to create”.

Molly

Molly is the principal of a Public 9-12th grade High school in Illinois who told me that their makerspace was used almost exclusively for open exploration by the students and additionally used very often for open ended as well as project-based learning activities. “Our initial goal was to expose people to different technologies”. She emphasized that they wanted to “get the technology into the hands of the students and staff and kind of just wee where it would go.” “We really like this space because we see a lot of diversity, we have every single grade level, different races, genders and a variety of different students in that space.”

Research Question 1–Qualitative Data

Research Question 1: How are makerspace facilities and their use described and characterized by select K-12 school administrators?

The Problem this study focused on was that current efforts emerging from the literature to categorize makerspaces based on descriptions of facilities, equipment or location have been shown to be an ineffective method for categorizing makerspaces for the purposes of comparison, study and evaluation. The lack of a model of categorization makes it difficult for school administrators to identify and review models that they believe would match their educational goals and work best in their schools.

The purpose of this exploratory mixed method study was to analyze the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed. Interviewees were given twelve questions in an interview guide prior to the interviews to help frame each interview (see Appendix B: Qualitative Interview Guide) of the 12 questions in the guide. Questions 2, 3, 6, and 11 from the guide were the most direct with respect to Research Question 1: How are makerspace facilities and their use described and characterized by select K-12 school administrators?

Those interview questions were:

2. Please describe how teachers access or reserve the space.
3. Please describe how students access the space.

6. Please describe some examples of the projects or activities that have taken place in your makerspace.
11. How would you describe and characterize your makerspace to a visiting school administrator?

When asked during the interview to describe and characterize their makerspace to a visiting school administrator, participants included descriptions of how their makerspaces were accessed by students and faculty, how they were integrated into the curriculum offerings, and how they were used as a resource by their students and faculty. The administrators that represented elementary and middle school grades described classes and more teacher led and structured activities. Lucie told me,

> We have a makerspace class period for 3rd, 4th, and 5th grade with a dedicated makerspace teacher that focuses on hands-on, design thinking activities. We also use the makerspace activities to build partnerships with local universities and our makerspace became the foundation for our VEX robotics team and is the center for many after school clubs we have for our students."

Nathan also described a dedicated class with a dedicated teacher at their school in which all of the grade levels of the school had weekly attendance. He stated, "We integrated it as a school special. So, in addition to, you know, your traditional PE art, music, we added makerspace in there, in place of computer class." "… a special that all of our students K to 8 go to at least once a week." Jack told me that a makerspace was used as a class at the middle school level and served as a connection between elementary and high school class offerings. Jack stated, "For us the makerspace (class) fills the STEM gap between what we are doing at the elementary level and at the high school level." In contrast, high school administrators Sue, Alice, and Molly described their makerspaces serving as a more open resource and supportive role. Sue described theirs as "We have one big makerspace fabrication lab at our high school, and we have makerspace classrooms at the middle school." Alice stated, "I think I would say it, (the makerspace) supplements various curriculum areas and supports various curriculum areas. It's not an end in itself in that it can be used by different departments." Molly stated, "I really think that our makerspace is successful because it allows students to pop in whenever they have a free period. There is no structure unless there's a class coming in and then we help them with using different equipment, but this is an unstructured space that is really just allowing our students to blossom with their creativity. If you want to see that in action, you should come see our place."

Regarding the descriptions related to open or managed access to their makerspaces which was a question in the online survey portion of this study that all of these administers completed, it should be noted that all six of the administrators interviewed told me that they had faculty members assigned or designated to facilitate and manage the makerspace at their respective schools. Nathan's commented about his K-8 makerspace teacher, In the 6th grade. The students participated in what's called Invention Convention… and so that's the project that the teacher uses to teach the students about the design process, how to start from scratch, conceive of an idea and work it into fruition." "… the makerspace **teacher** also teaches some math classes." An example of dedicated staff at the high school level but not in the role of makerspace class instructor is high school principal Alice's description of her makerspace coordinator, Alice stated,

> …we have a teacher who is the coordinator … (his) vision was that everybody, you know, everybody could come in and use this so he was very proactive in talking to teachers about … 'is there something you're doing in your class at some point that we can bring your students down to the (makerspace) and do it?'

In each case these faculty facilitators or makerspace teachers design and offer problem solving or project-based activities in the makerspace, however at the elementary and middle school levels these activities were part of a formal makerspace class where those at the high school level were either in support of or an expansion of another class activity or based on student interest in an extracurricular club or after school structure.

Research Question 2–Qualitative Data

> *What are the overarching reasons select K-12 school administrators have implemented a makerspace facility?*

The interview questions directly related to Research Question 2 from the interview guide (see Appendix B: Qualitative Interview Guide), were designed to help determine if there might be themes or similarities in the overarching reasons administrators implemented their makerspaces that could add the descriptions of the activities and practices taking place in the school makerspaces. Questions 1, 7, 8, 10, and 12 from the guide were the most direct with respect to Research Question 2: What are the overarching reasons select K-12 school administrators have implemented a makerspace facility?

Those interview questions were:

1. What were the needs of the school that prompted the adoption of a makerspace?

7. Please describe to what extent the makerspace facility has supported the student learning goals and mission of the school.
8. If you have a mission statement or statement of purpose for the Makerspace, could you share that with me and if you do not, please suggest what such a statement should convey to the students, staff, and community?
10. Describe strategies you use to evaluate the effectiveness and value of the makerspace to the school.
12. Could you describe a scenario in the future where you would no longer need the makerspace?

Among the most common responses from the group were mention of adding, supporting, or expanding rigor, relevance, STEM (Science, Technology, Engineering and Mathematics) related curricular activities, and access and exposure to emerging technologies. Nathan defined how the makerspace helped in addressing the mission of the school. He stated,

> I guess the main thing I want to communicate is the fact that our school mission is written in such a way that we are promising a certain type of education, mainly one that's rigorous and relevant. I think the makerspace checks those boxes pretty easily. It's not the only way that we do those two things, but it's I think it's one of the most visible ways that we do those two.

Molly described how access and exposure to the equipment, tools and processes were among the main reasons their school implemented their makerspace. She said,

> …we just wanted to open it (the makerspace) up to students to use on their own and then start to show it to teachers. So really our goal was just to expose people to

different technologies and that was it. That was how we started off. We just wanted to get the technology into the hands of students and staff and kind of just see where it would go.

During our interview Lucie told me that at her school they have added a makerspace class with a dedicated staff to address several goals. These were to increase the depth of knowledge and rigor in their science classes, add a platform to demonstrate high quality STEM activities, and demonstrate problem-solving activities and curriculum for the rest of the staff with the hope that those teachers would bring more problem solving and project-based learning into their own subject areas. Alice talked with me about the importance of skill building in addition to access and exposure to the technology in their makerspace, stating,

> … the idea came to have a place where they (the students) could learn to create and try out designs that, maybe they'll use in the future, maybe they won't, but they would have those skills. So, it’s a way to build the skills that many of them are going to need in the jobs that they go to.

In addition to the descriptions of how their makerspaces were accessed and reasons they implemented makerspaces, statements and descriptions regarding the support of creative thinking activities as an additional focus of the makerspaces were highlighted in the conversations with all six participants. Supporting creativity and design thinking were described often as highlighted in these responses from four of the participants: Lucie explained, “The activities that take place in our makerspace class period are design based and focused on promoting critical thinking. We want students to get into the mindset of, ‘Design, test, build, modify'." In a description of a particular project done in their makerspace, Nathan stated,

> … that's the project that the (makerspace) teacher uses it to teach the students about the design process, how to start from scratch, conceive of an idea, work it into fruition, and then how to basically, you know, pitch their finished product as something that's going to enhance this or that aspect of everyday life. We have one student this past year, she did really well and went all the way to nationals.

Jack told me, "Our makerspace is a place to be creative. Our goal is to provide resources so they (the students) can try things risk free." As part of her description of the makerspace at her school, Molly stated, "…this is an unstructured space that is really just allowing our students to blossom with their creativity."

The interview questions allowed the participants to comment both on the overarching vision and goals their schools have for their makerspaces and in the structure and purpose of the activities that take place in their makerspaces each year. The data from the six interviews and 19 survey responses were then analyzed to see if common themes emerged from the data that could answer research question 3.

Research Question 3–Qualitative Data

What common themes emerge from the implementation and use descriptions of makerspace by school leaders?

Analysis of the statements and commentary of interview participants was done using a process known as Constructivist Grounded Theory (Charmaz, 2014). This process uses an iterative method of data collection and data analysis by grouping similar comments and statements from the interviews into codes then repeating this process comparing new data to existing data as the interviewing process of participants proceeds and then refining these codes into common themes (Charmaz, 2014). Coupled with the data from the quantitative online survey, the results of this study yielded the following four themes about why these administrators invest in makerspaces and how they are used in practice.

1. Adding or supporting Problem Based Learning
2. Adding or supporting Project Based Learning
3. Providing exposure and access to a wide range of fabrication tools, and processes.
4. Adding or enhancing rigor and relevance

Theme 1: Adding or Supporting Problem Based Learning

Though they share the same acronym, (PBL), Problem Based Learning differs from Project Based Learning in that Problem Based Learning focus on students gaining knowledge about a subject by working through an open-ended problem rather than the goal of students gaining a deeper understanding of a given subject matter through the completion of the project (Karimi et al., 2023). A strong theme that emerged from the interviews with participants was a desire to see their makerspace implementations both enhance current efforts within their schools to incorporate Problem Based Learning (PBL) activities or to broaden the scope of subject areas within their schools that incorporated PBL in their curriculum. Alice stated,

> …they (the students), have to know how to work as a team. They have to know how to collaborate, and they have to know how to problem solve. One of the good things about it, (the makerspace), is if they try something one way and it doesn't work, OK, it didn’t work. Why didn't it work? What could you do differently then next time?

Lucie told me, “We want kids to learn to embrace and expect failure of design testing and learn from that to move forward with the design.” Molly described how their makerspace supported a product design course, “We have a class called ‘Incubator’ and students actually create products.” She went on to tell me, “…the first iteration of their product is within the makerspace and then they’ll go to some type of manufacturer to say OK, so this is what we want it to look like or this is what we’re thinking, and they actually help them to create it using other materials. So, it’s pretty awesome.”

Theme 2: Adding or Supporting Project Based Learning

A second theme that emerged from the interviews with participants was a desire to see their makerspaces support and encourage Project Based Learning activities in all areas of study. Lucie told me that, “One of the Goals of the Makerspace classes is to use the activity examples as a way to expose other teachers to Project Based Learning ideas and activities in hope that they might begin to design and adopt activities to enhance their own classroom curriculum.” Sue stated that they were working to make sure the projects they are doing in the makerspace met the essential elements of the Gold Standard of Project Based Learning (PBL) published by the Buck Institute of Education which includes seven essential project design elements; A Challenging Problem or Question, Sustained Inquiry, Authenticity, Student Voice and Choice (students make decisions about the project) Reflection, and Critique and Revision(Students give, receive and apply feedback). (Buck Institute for Education, 2019.). Sue told me,

> …everything needed to be tied to PBL, like the PBL works gold standards so that we’re solving real problems. So, I think that we perfected that part this year. What I've been tasked with this summer is to meet with all of those cluster area teachers, and we're

> looking at their courses and their curriculum and my natural thing is going to be to be adding PBL.

Nathan talked about how the skills learned in the makerspace activities could help meet learning objectives in different subject areas of the school. He stated,

> … the efficiency gain has come from basically integrating that, *(makerspace skills and experiences),* into the classroom so that those skills can be worked on as part and parcel of other things that the classroom teacher is doing. Maybe in language arts or math to meet those separate learning objectives…

Theme 3: Providing Exposure and Access to a Wide Range of Fabrication Tools, and Processes

A topic that was commented on in each of the conversations with the interview participants but to varying levels of importance was the interest in providing access to a wide variety of fabrication and prototyping tools. Molly explains, "…our goal was just to expose people to different technologies and that was it. That was how we started off. We just wanted to get the technology into the hands of students and staff and kind of just see where it would go." Molly went on to say, "I just think that you have to have a variety of different equipment that students can try out to see what they are interested in. I think if you only have one or two things it might deter some students like, "well, I'm not interested in that." But if you have six different things, then they can kind of explore and see what works best for them." Alice and Jack both tied exposure to the tools in the makerspace to their interest in fostering and supporting creativity. Alice stated, "I just think it's the opportunity that you make available to students. I think it's just really important to expose them to things. I think in exposing students to these tools creates their curiosity and creativity comes out of curiosity." Jack explained, "Our makerspace is a place to be creative. Our goal is to provide resources so they can try things risk free."

3D Printers, LASER engravers , green screens, robotics equipment, and digital sewing machines were among the many examples of equipment mentioned in the conversations but the overall intent became clear that the makerspace was envisioned to be the place where students could access and experiment with an array of equipment and tools that would be either too cost prohibitive to place in multiple classrooms or would be placed in the makerspace in addition to other areas of the school to ensure student access during the school day.

Theme 4: Adding or Enhancing Rigor and Relevance

The fourth and final theme that emerged from the data centered around adding or enhancing the rigor and relevance of the current curriculum. Nathan told me,

> The main thing I want to communicate is the fact that our school mission is written in such a way that, you know, we we're promising a certain type of education, mainly one that's rigorous and relevant and I think the makerspace checks those boxes pretty easily. It's not the only way that we do those two things, but I think it's one of the most visible ways that we do those two.

Though several of the administrators I interviewed did mention STEM (Science, Technology, Engineering and Mathematics) based activities as examples of how the makerspace was helping to enhance the rigor and/or relevance of curricular offerings, the descriptions of how the makerspace activities were adding to the school in this regard covered a much wider range of curriculum that is typically associated with STEM. Alice explained, "It can also be a way for students to build the skills that they're going to need no matter what they're doing. We're not necessarily using it to train just students who want to be engineers.” Sue stated, “…the maker skills are tied to careers. That's the way we do it. That's all tied eventually to accountability. That's what works with us.” In the following excerpt from our interview Molly describes how the addition of their makerspace has helped an entrepreneurial business course that is very popular with students.

> We have grown this program. It's really big now. We had 25 teams this year and they literally create their business from the ground up. So, usually the first iteration of their product is produced within the makerspace and then they'll actually go to the point where they're speaking with a manufacturer…... it's pretty awesome.

Regarding the interest in adding to or enhancing rigor and relevance, it is important to note that many of activities and projects described by administrators throughout the interview process also had a wide range of direct impact from the makerspaces. In some examples the entire activity took place in the makerspace guided by a dedicated makerspace staff member and during scheduled hours of class for the makerspace, and in others as in the entrepreneurial business course example above, the makerspace played a smaller but important role. It should be noted that the theme of Adding or Enhancing Rigor and Relevance regarding the school’s curricular offering was derived from the many mentions in the interview data. Though the possibility that a makerspace could add or support rigor and relevancy were mentioned in the literature, it was not listed repeatedly as a primary use case scenario in the literature and was not included in the quantitative survey as a choice for participants. The analysis of the commentary and descriptions from the administrators interviewed suggest that its should be included in any future work related to this study.

Research Question 4–Qualitative Data

The final research question guiding this study involved reviewing the data to determine if specific or distinctive attributes related to the themes emerged that might be used to separate individual makerspace implementations into specific categories or classifications.

> *Research Question 4: If common themes emerge from the implementation and use descriptions of makerspaces by school leaders, what are the distinctive or specific attributes identified in those themes that could be used to separate makerspaces into specific categories?*

The analysis of the data from both the survey and interviews indicates that each of the makerspaces represented spans the range of the usage scenarios and themes identified. The analysis did not reveal any specific attributes related to any of the themes that emerged from the study. As an example, in each makerspace Project Based Activities were a goal and were taking place or they were not. Two attributes about the themes as a group did emerge from the data. The first was that there was a differentiation in the hierarchy of value placed on each of the themes by the respondents in both amount of use and reasons for implementing their respective makerspaces. The second attribute that emerged about the themes taken as a group was that there was a preference for more managed access at the lower grade levels and a preference for more open access at the higher grade levels. Regarding the differences in the hierarchy of importance placed on each of the themes, Molly a high school principal told me,

> …we just wanted to open it (the makerspace) up to students to use on their own and then start to show it to teachers. So really our goal was just to expose people to different technologies and that was it. That was how we started off. We just wanted to

get the technology into the hands of students and staff and kind of just see where it would go.

Though the tools and technologies in the makerspace played a role, Sue also representing a high school emphasized the importance Project Based Learning played regarding their makerspace. Sue told me, "…everything needed to be tied to PBL, like the PBL works gold standards so that we're solving real problems."

As mentioned, administrators were also divided when it came to their descriptions regarding whether their makerspaces had open access for students and staff versus a structured curriculum or course. In this data set there was clearly a split between middle school and high school grade levels with open access the preference of the upper grade levels and a more structured access by the middle and elementary grade levels. Alice a high school principal stated, "So the idea came to have a place where they, (the students), could learn to create and try out designs the maybe they will use in the future, maybe they won't but they will still have those skills." In contrast Nathan, a K-8 principal stated, "I wanted all of our students to benefit from it and to have it as part of the daily school curriculum, so we integrated it as a school special. So, in addition to your traditional PE, art, and music we added Makerspace in there in place of computer class."

Synthesis

For school administrators in k-12 education who have implemented makerspaces in their schools, they report using their makerspaces for more than a singular or focused purpose and value for a makerspace. Every survey respondence showed participants having multiple functions and educational objectives for their makerspaces. More than half of respondents indicated their use descriptions of all five uses; project-based learning, open-ended problem solving, managed access (classes or scheduled time), open access (but class related activities), and open exploration (not related to a class).

Follow-up interviews with k-12 administrators led to the following four themes regarding how makerspaces are being used in practice and why they are being implemented:

1. Adding or supporting problem-based learning; where students generate and present a proposed solution to a problem where a clear answer is not known,
2. Adding or supporting project-based learning; where students demonstrate mastery of a concept or lesson through the production of artifacts,
3. Providing exposure and access to a wide range of fabrication tools, and processes; student access to 3D printers, computer-controlled lathes, plasma cutters, automated sewing machines etc., and
4. Adding or enhancing rigor and relevance, where students are assimilating and applying knowledge.

Adding or enhancing rigor and relevance, theme 4, is an additional reason how makerspaces are being used and implemented in practice and was not prevalent in the existing literature. Additionally, no distinctive or specific attributes about any of the four themes individually emerged from the interview data. This meant that for example within the theme of Adding or Supporting Project Based Learning, no data emerged to describe distinct ways Project Based Learning was being done in one situation from another. This might have possibly led to “levels” of Project Based Learning that could be used to help researchers further define and describe a makerspace implementation. The data from this study showed that either a makerspace was supporting Project Based Learning activities, or they were not. This held true for the other three themes as well.

The level of priority and emphasis placed on each of the themes differed among participants. This was an important finding in that in one instance a main purpose for the makerspace was to provide open access to the tools and equipment housed in the space (theme 2 Providing exposure and access to a wide variety of fabrication tools and processes) and to a lesser degree the space was hoped to be used for project-based learning. In a separate instance these priorities were reversed. Trying to compare these two different makerspaces to each other or fit them with a category without considering this level of priority would not yield an accurate model of comparison.

Preference for more managed access in the lower grade levels and a more open access at the higher grade levels likely led to differing descriptions of how the physical spaces were arranged, the range of equipment and tools available in the spaces, how and when they were used by students during the day from the participants in the interviews.

The range of descriptions is directly congruent with the findings in the literature review and in turn supported the difficulty of trying to categorize makerspaces by their physical attributes that researchers in the literature were documenting.

Summary

The data from the online survey and from the analysis of the commentary from the interview participants lead to four themes related to how makerspaces are used in practice and the overarching reasons they were implemented. These four themes were: Adding or supporting Problem Based Learning, Adding or supporting Project Based Learning, providing exposure and access to a wide range of fabrication tools and processes and adding or enhancing rigor and relevance. These themes were derived from the overlap of mentions in the commentary and multiple uses reported by each of the survey respondents as opposed to small groups of respondents commenting on or indicating one specific theme and another small group indicating a separate theme which would have yielded the same list of themes. This data shows that these administrators see value in, and use makerspaces for, multiple reasons rather than to address a singular educational goal. The data from both the survey and the interviews also reveals that the administrators do not value each of the themes in the same hierarchy. Though the activity in their makerspaces may reflect all four of the themes the emphasis on which of the themes was most important to them varied. An additional finding from the data was that there was a clear preference for a more structured access or actual makerspace class at the elementary and middle school grade levels and a preference for a more open access and less structure at the high school grade levels.

Chapter 5: Discussion and Conclusions

This chapter provides a summary of the results presented in Chapter 4 and the findings, conclusions, and recommendations based on those results. This exploratory study analyzed the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed.

An examination of the literature revealed that the physical descriptions of the spaces, equipment, and management structure of the spaces coupled with a wide array of implementation strategies makes it difficult for researchers and administrators to categorize makerspaces for the purposes of study and evaluation (Wilczynski, 2017). This exploratory study analyzed the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed.

The purpose of this exploratory mixed method study was to analyze the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to begin to develop a model of characterizing makerspaces for the purpose of study, comparison and evaluation that is not currently being employed and was guided by the following research questions:

1. How are makerspace facilities and use described and characterized by select K-12 school administrators?
2. What are the overarching reasons select K-12 school administrators have implemented a makerspace facility?

3. What common themes emerge from the implementation and use descriptions of makerspaces by school leaders?
4. If common themes emerge from the implementation and use descriptions of makerspaces by school leaders, what are the distinctive or specific attributes identified in those themes that could be used to separate makerspaces into specific categories?

Research Question 1

Research Question 1: How are makerspace facilities and use described and characterized by select K-12 school administrators?

The literature revealed that there were no common standards as to what components define a makerspace (Barrett et al., 2015), and that there was great disparity in the way makerspaces were described (Mersand, 2020). One common attribute that all makerspaces share that was found in the literature is that they all involve student engagement and learning through the production of artifacts using the tools, equipment and resources found in those spaces (Sheridan et al., 2014, p. 531).

A significant finding from the online survey was that all 19 of the online survey respondents reported that their makerspaces were used to some extent for Project Based Learning activities with fourteen respondents reporting that their spaces were use very often or almost exclusively for this kind of learning. Project Based Learning involves the students producing a physical or digital artifact connected with a course lesson and designed to support a specific or targeted set of learning objectives or skill development. The students show mastery of a skill or concept through the production and demonstration of or presentation about the artifact they have created (Savery, 2006). Of the 19 respondents 15 reported that they use or also use their makerspaces for Problem Based Learning activities with six of the 19 indicating that they use their spaces very often or almost exclusively for this kind of activity. Project Based Learning focuses on students gaining knowledge about a subject by working through an open-ended problem rather than the goal of students gaining a deeper understanding of a given subject matter through the completion of the project (Karimi et al., 2023). Hands-on fabrication of physical and digital artifacts by the students was clear in the descriptions from the interviews of this study. Nathan stated, "…the (makerspace) teacher uses it to teach the students about the design process, how to start from scratch, conceive of an idea, work it into fruition, and then how to basically, you know, pitch their finished product as something that's going to enhance this or that aspect of everyday life." Jack stated, "Our makerspace is a place to be creative. Our goal is to provide resources so they (the students) can try things risk free." Lucie described her school's Makerspace by telling me, "The activities that take place in our makerspace class period are design based and focused on promoting critical thinking. We want students to get into the mindset of, 'Design, test, build, modify'." In her description Molly stated, "We just wanted to get the technology into the hands of students and staff and kind of just see where it would go."

Another descriptive characteristic that this study revealed was related to how the spaces were managed and accessed by students to achieve the goals set for the spaces. The survey data showed a range of access between fully open access to managed or scheduled access for students with nine of the 19 respondents identify that they have open access for their students very often or almost exclusively throughout the school year and six of the 19 indicating a managed access very often or almost exclusively throughout the year. The analysis of the data in this study revealed a clear preference for a structured makerspace class at the elementary and middle school levels and a preference for more open access for students at the high school level. This split of access between middle school and high school was only a strong preference that emerged from this study. Instances or scenarios where open access to the makerspace at the elementary levels and structured access at the middle and high school levels were reported in the conversations I had with administrators and in the literature review.

Research Question 1: Discussions and Conclusions

In the descriptions of their own makerspaces, each of the six interviewees focused very little time on the equipment or the physical characteristics of in their makerspaces and most of their comments were about the projects that students had built and the learning and opportunities that those activities provided for their students. This is an important finding regarding the efforts to categorize makerspaces. The data from the interviews coupled with the findings from the online survey offers two important findings from the study. The first is that administrators from the study were clear in that they invest in makerspaces for multiple reasons and that these administrators define their investments in makerspaces by the outcomes the spaces generate for students. This also suggests that these administrators might look to compare their own makerspaces to others in the same way when looking to improve or expand their own efforts rather than focusing on the physical attributes of makerspaces as they are described in the literature. The data regarding a strong preference for a more structured form of access at the lower grades and a more open access at the upper grade levels is also a noteworthy finding in that the way access is organized for students may limit or discourage open exploration projects or activities in one option and encourage or remove barriers in the other. How the access structure affects the range of activities in a makerspace seems to play a role in the effort to categorize makerspaces by how they are used in practice and should be considered for any future study.

Research Question 2–Review

Research Question 2: What are the overarching reasons select K-12 school administrators have implemented a makerspace facility?

Research question 2 was to learn how the descriptions of how the makerspaces were used in practice matched the reasons for their implementation or if those stated reasons would yield any additional descriptive data.

The results from both the survey data and interviews of this study revealed that the school administrators who participated in the study reported and described multiple reasons for implementing their respective makerspaces. All 19 of the respondents of the survey reported multiple uses for their makerspaces. Of the 19 survey respondents 10 reported that they used their makerspaces for all five of the use descriptions in the survey which were, Problem Based Learning, Project Based Learning, managed access to the space for course related activities, open access to the spaces for course related activities and open exploration projects not related to any course work. Five of the 19 respondents reported they use four of the five models in practice. Finally, two of the 19 respondents reported they use three of the five models in practice and two of the 19 respondents reported they use two of the five models described in practice. Commentary from the interviews also captured this multiuse–multipurpose vision that the administrators have for their makerspaces in greater detail. Nathan defined how the makerspace helped in addressing the mission of the school. He stated,

> I guess the main thing I want to communicate is the fact that our school mission is written in such a way that we are promising a certain type of education, mainly one that's rigorous and relevant. I think the makerspace checks those boxes easily. It's not the only way that we do those two things, but I think it's one of the most visible ways that we do those two.

Lucie told me that at her school they have added a makerspace class with a dedicated staff to address several goals. Lucie explained,

> We have a makerspace class period for 3rd 4th and 5th grade with a dedicated makerspace teacher that focuses on hands-on, design thinking activities. We also use the makerspace activities to build partnerships with local universities and our makerspace became the foundation for our VEX robotics team and is the center for many after school clubs we have for our students.

Alice talked about how the makerspace in her school served a range of classes and disciplines, “I think I would say it, (the makerspace) supplements various curriculum areas and supports various curriculum areas. “It’s not an end in itself in that it can be used by different departments.”

Research Question 2–Discussion and Conclusions

The multipurpose vision on the part of school administrators regarding why they have implemented and supported their own makerspaces is a significant finding from the study in that is shows that any continuing effort to categorize and evaluate makerspaces by the how they are used in practice and valued by administrators would need take the multiple numbers of reasons administrators have reported that they invested in their own makerspaces into account before attempting a means of categorization. The makerspaces described in this study are used for many purposes at once and attempting to categorize or compare one makerspace to another by any single reason given would not be a complete picture of that makerspace and in turn would be an incomplete or inaccurate model of placing a makerspace into a category.

A related and equally important finding from this exploratory study is that these administrators did not attach equal values to each of the multipurpose reasons they listed or described, nor did they value them in the same hierarchy. For Sue making sure the projects done in the makerspace met the essential elements of Project Based Learning were a priority, Sue told me,

> …everything needed to be tied to PBL, like the PBL works gold standards so that we're solving real problems. So, I think that we perfected that part this year. What I've been tasked with this summer is to meet with all of those cluster area teachers, and we're looking at their courses and their curriculum and my natural thing is going to be to be adding PBL.

For Molly their school's initial main goal was access to the technologies for students, she stated, "So really our goal was just to expose people to different technologies and that was it. That was how we started off. We just wanted to get the technology into the hands of students and staff and kind of just see where it would go." These two findings from the study show that a model for categorization that did account for multiple uses at once and multiple reasons for implementing the makerspace as suggested, should also take into account how the prioritization of those reasons on the part of the administration affect the way the makerspace is used in practice and theses differences if not taken into account may also miss represent how a makerspace is categorized.

Research Question 3–Review

Research Question 3: What common themes emerge from the implementation and use descriptions of makerspaces by school leaders?

The purpose of the study was to explore if descriptions of how makerspaces were used in practice and statements about the reasons, they were put in place could yield the foundation of a model of describing and categorizing makerspaces not currently in use. This process required the grouping of similar descriptions and commentary to see if common themes would merge. The data from the 19 survey responses and six interviews were analyzed to see if common themes emerged from the data that could answer Research question 3.

The interview questions allowed the participants to comment both on the overarching vision and goals their schools have for their makerspaces and in the structure and purpose of the activities that take place in their makerspaces each year. Analysis of the statements and commentary of interview participants was done using a process known as Constructivist Grounded Theory (Charmaz, 2014). This process uses an iterative method of data collection and data analysis by grouping similar comments and statements from the interviews into codes then repeating this process comparing new data to existing data as the interviewing process of participants proceeds and then refining these codes into common themes (Charmaz, 2014).

Those four themes that emerged were:

1. Adding or supporting Problem Based Learning

2. Adding or supporting Project Based Learning
3. Providing exposure and access to a wide variety of fabrication tools and processes
4. Adding or enhancing rigor and relevance

Research Question 3–Discussion and Conclusions

These four themes were mentioned both directly by name and by description from participants throughout the interview process. A noteworthy finding from this study is that at least two of these themes appeared in every one of the interviews with most of the participants describing three or all four of themes in our interviews as they related to their own makerspaces. These themes were derived from the overlap of mentions in the commentary and multiple uses reported by the survey respondents as opposed to small groups of three to five respondents commenting on or choosing one specific theme and no others and another small group of three to five respondents choosing a different theme and no others. If the participants had responded in this singularly focused way for each of the themes, it would have yielded the same list of themes but not the same meaning. This overlapping data shows that these administrators see value in, and use makerspaces for, multiple reasons at once rather than to address a singular educational goal. This is an important distinction in that it supports the findings from research questions 1 and 2 regarding the multiuse–multipurpose vision administrators have of their makerspaces and that further attempts to categorize makerspaces based on the way they are used in practice and the reasons they are implemented will have to take into account that makerspaces are being used for multiple purposes at once.

Any strategy then to try and categorize makerspaces based on the finding of this study should not single out one theme or single use case to evaluate and compare to another makerspace but rather the strategy should employ a model that includes all these themes as the data suggests. Lucie told me, “We want kids to learn to embrace and expect failure of design testing and learn from that to move forward with the design.” Sue stated, “everything needs to be tied to PBL (Project Based Learning)”.

Research Question 4–Discussion and Conclusions

> *Research Question 4: If common themes emerge from the implementation and use descriptions of makerspaces by school leaders, what are the distinctive or specific attributes identified in those themes that could be used to separate makerspaces into specific categories?*

The four themes found in this study based on how makerspaces are used in practice and what goals they were implemented to achieve did not yield any distinctive or specific attributes within themselves. As an example, Adding or Supporting Problem Based learning was one of the themes that emerged however, though some of the projects described in the category of Problem Based Learning were larger in scope than others or supported one class or another, no specific attributes about Problem Based Learning that could be used to separate this theme into distinct levels of quality , depth or distinction were evident in the data. This held true for the other three themes as well. Two significant findings did emerge from the analysis of the data about the themes as a group. The first finding was related to the Theme “Adding or enhancing Rigor and Relevance”, and the second regarding the priority each administrator placed on each of the themes. In the review of literature there was only mention that makerspaces could add rigor and relevance to a curriculum but unlike the other three themes it was not repeatedly listed as recurring or primary use case for makerspaces and so was not included as a choice in the online survey. Rigor and relevance were mentioned directly and referred to often during the interviews. Nathan stated, "… it's written into our mission statement that we provide an academic experience that's rigorous and relevant and the makerspace delivers on both of those components." Alice reflecting on why she wanted to invest in a makerspace told me, "I think the impetus came that our curriculum really has to, you know, in education, we always have to be relevant to prepare the (students) for the world they're going to live in" and "So it's a way to build skills and those are the skills that many of them are going to need in the jobs that they go to." Sue also talked about workplace skills learned in their makerspace," the maker skills are tied to careers. That's the way we do it. That's all tied eventually to accountability." These and similar comments from the interview participants led to the inclusion of rigor and relevance as a theme in the study and suggests that they should be included in any continuation of the work this study represents.

The second finding related to the analysis of the four themes that emerged from the study is that the level of priority and emphasis each administrator I interviewed placed on what emerged as themes were not the same even with the new rigor and relevance distinction. As an example, some of the administrators placed the greatest emphasis on exposure to a range of technologies as a highest priority while others placed their emphasis on all the learning activities meeting Project Based Learning standards. As an example, in my interview with Molly she stated, "So really our goal was just to expose people to different technologies and that was it. That was how we started off. We just wanted to get the technology into the hands of students and staff and kind of just see where it would go." During our conversation Molly also described how the makerspace has helped an entrepreneurial business course,

> We have grown this program. It's really big now. We had twenty-five teams this year and they literally create their business from the ground up. So, usually the first iteration of their product is produced within the makerspace and then they'll actually go to the point where they're speaking with a manufacturer…... it's pretty awesome.

Though her initial primary goal for the makerspace was exposure to technology for her students, the Problem Based Learning role it plays for the entrepreneurial business course is important to the complete picture of her support for her school's makerspace as well.

Though the data did not yield distinctive attributes within any of the given themes individually, the different levels of emphasis and priority given to each of the themes supports the findings from research question three and suggests that a component of a new model for characterizing makerspaces based on the findings of this study lies in quantifying those levels of priority and emphasis.

Limitations

Though this study provided both survey and interview data from multiple states and representation from a full range of K-12 schools it could have benefited from a higher participation rate. Limitations encountered during the study included:

1. Data collection for this study took place during June, July and August of 2023, and this may have contributed to the 10% return rate from the 195 contact letters emailed directly to K-12 administrators.
2. All six of the administrators that were interviewed were heavily involved in the implementation, initial support, or the visioning of their school's makerspace. This may not be a factor in the context of the questions asked in the interview, but

additional studies should be considered to determine if it has any effect or bias on the data.

3. This study based the use in practice descriptions of makerspaces given as choices for self-identification in the quantitative survey on those found in the literature review. The data may have produced additional themes or insights if an option were given to administrators to input any reasons for inventing in makerspaces that were not listed

Based on these limitations, my two recommendations for future makerspace research with k-12 administrator participants are 1) to conduct interviews during the school year when participants are likely more accessible to expand the interview pool of administrator participants, and 2) include more opportunities within survey and interview questions for administrators to include any reasons for their support of a makerspace that were additional to those found in the literature review. These adjustments may minimize bias related to the data based on that involvement and could possibly reveal additional themes related to how and what purpose makerspaces serve in the school.

Implications for Practice–Insights for Administrators

Selecting a model for a makerspace is challenging for k-12 administrators since there are many design aspects and categories to consider (Bonagura, 2017; Davee et al., 2015; Dousay, 2017; & Sheridan et al., 2014). Literature suggests that physical attributes and operations options may help decision makers in making determinations as they consider options for their makerspace. While operational models and physical attributes are important, this study indicates that outcomes are a significant consideration for administrators.

Describing makerspaces by physical characteristics such as equipment lists, size of the facility, location, or how they are organized do not provide an effective means of comparing or contrasting one makerspace to another for the purpose of comparison, evaluation or categorization. Rather it is more important to describe and analyze a makerspace through the lens of its mission statement or set of educational objectives first, and then how a given implementation of a makerspace is meeting those goals and objectives in practice. This strategy holds promise as a possible model for categorizing makerspaces.

Current research regarding how makerspaces are used in practice and the educational impacts have for students have been reported from a global perspective and do not thoroughly describe and define individual makerspace implementations. To be able to compare one makerspace implementation to another for the purpose of categorizing makerspaces, more information regarding outcomes and goals is needed to be more beneficial.

Based on the findings of this study, to categorize makerspaces in general by the reasons they are implemented or the learning activities that they support, I recommend administrators planning a makerspace for their school use the following makerspace considerations framework:

1. Research existing models
    a. Conduct your makerspace research with outcomes in mind and avoid information about equipment purchases, facility descriptions or models of managing makerspaces until action item SEVEN on this list.
2. Consider your desired makerspace outcomes

a. Define outcomes you want and need your makerspace to provide by detailing the learning activities or objectives you want to see happen in the makerspace, using the following themes:

i. Adding or supporting problem-based learning,

ii. Adding or supporting project-based learning,

iii. Providing exposure and access to a wide range of fabrication tools, and processes

iv. Adding or enhancing rigor and relevance.

3. Consider other outcomes

a. Define any additional or related outcomes you want or need, in addition to the themes in 2a.

4. Consider multiple outcomes

a. Decide if you will want or would consider multiple outcomes from your makerspace at the same time or throughout the same school year.

5. Prioritize your defined outcomes

a. Define the hierarchy of importance you have for each of the outcomes you have identified.

b. Consider that outcomes you have not listed or listed as lower priorities may emerge or evolve into levels of greater importance once your space is in place and future support may be needed to include those changes.

6. Gather expertise from peers

  a. Seek out administrators and makerspace directors with established makerspaces within your professional network to identify implementations that are being used for the same reasons and outcomes you have identified.
  b. Collect details and discuss in terms of in-practices use and learning outcomes rather than facility descriptions.
7. Consider physical and operational aspects
  a. Using the information gathered in steps 1-6, determine optimal physical or operational aspects that support your desired outcomes and how those components support those outcomes.
8. Develop your implementation plan
  a. Begin planning the design and operation of your own makerspace with the information you learned from your interviews and with your desired learning objectives for the space in mind.

Implications for Research–Insights for Researchers

This exploratory study has revealed how a model for characterizing makerspaces based on how they are used in practice and described by their administrators could be framed. Based on the findings from this study, I recommend future researchers consider the following:

1. Models to categorize makerspaces based on how they are used and supported in practice should consider that makerspaces can serve many functions at once and that focusing on a single use case or outcome for comparison between makerspaces may not offer an accurate description of any given makerspace.

2. A possible structure to begin to frame a new model for characterizing makerspaces based on the findings of this study should include a means of quantifying the hierarchy of usage priorities based on the themes that emerged from the interviews.
3. Any future study on makerspace categorization based on how they are used in practice should include a means of quantifying the amount of open access to structured makerspace class ratio of use.
4. Any future study should include options for administrators to add use case scenarios not addressed in survey or interview questions which might yield additional usage themes not highlighted in this study.

There is a sincere opportunity for researchers to study how, why and to what degree the physical attributes of any given makerspace (equipment, facility layout, management strategy, etc.) contribute to the desired outcomes or themes that emerged from this study. There is merit in working to categorize individual makerspaces by the outcomes they generate or how they are used in practice to achieve desired learning objectives, but actual implementation of a makerspaces involves investment in those physical attributes. Any defined correlation between the things administrators need to purchase and how they directly support the desired learning objectives would help to ensure a more effective investment on the part of the school.

Final Thoughts and Reflections

Two important findings that I have learned that laid the foundation for this study are, that administrators define need statements for their individual schools in terms of desired outcomes, and that the current literature and research describes or categorizes individual makerspaces by their physical attributes such as the way the space or facility is laid out, the equipment available within the space or the way the space is managed. There is no correlational research or documentation describing how, or what aspects of the physical attributes directly contribute to produce the desired outcomes. There are hundreds of ways described in the literature to implement a makerspace and there are no standards as to what comprises an effective makerspace. The good news for administrators and supporters of makerspaces is that the research regarding the positive impact makerspaces can have for students is abundant and identifies many of the desired learning objectives administrators want for their schools, however, that research is presented in a global fashion. If as this exploratory study suggests, a model for categorizing makerspaces based on themes representing the reasons makerspaces have been implemented and the purposes they are used for in practice were established, it would offer a more direct connection for administrators between the specific outcomes they have identified and the kind of makerspace they should invest in to achieve those outcomes.

Summary

This study highlights the challenges faced by educational administrators considering options of makerspaces to support their students and educational community based on current methods of defining or categorizing makerspaces. The study analyzed the similarities and differences of how select K-12 school administrators describe and characterize their own makerspace facilities to try and determine if there were themes based on how those makerspaces were being utilized in practice that could form the foundation of a means of categorization for makerspaces that was not currently being used. Four themes emerged from the study: adding or supporting problem-based learning, adding or supporting project-based learning, providing exposure and access to a wide range of fabrication tools, and processes and, adding or enhancing rigor and relevance. Each of these themes described both how the spaces were being used in practice and the educational vision or objectives that led to their implementation. The study also found that administrators can have multiple reasons and educational goals for implementing a makerspace and that even if the list of multiple goals for a makerspace implementation are the same, they may not be prioritized by the administration in the same order. These priority differences can affect how a makerspace is used in practice and how access to the makerspace by students and teachers is managed.

This study offers evidence that focusing on articulating the educational objectives and purpose statements that lead to the implementations of makerspaces rather than the descriptions of their physical and operational attributes could lead to a more effective means of categorizing makerspaces for the purpose of study, evaluation, and review.

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Appendix A

Quantitative Survey Instrument

1. What is your first and last name? (prefix ? Ms. Mr. Mrs. Dr.)
2. What is your preferred email contact information?
3. How many years have you been the principal at your school?
4. What is the approximate student population size of your school?
   - 0-250
   - 251-500
   - 501 -750
   - 751-1000
   - 1001 – 1250
   - 1251-1500
   - 1501-1750
   - 1751-2000
   - 2001-2250
   - 2251-2500
   - 2501-2750
   - 2751-3000
   - 3001-3250
   - 3251-3500
5. What would best describe the location of your school
   - Rural,
   - Suburban
   - Metro
6. How many years have you had the Makerspace at your school? This is our first year (9 months or less)
   - 1
   - 2
   - 3
   - 4
   - 5
   - 6
   - 7
   - 8
   - 9
   - 10
   - 11
   - 12
   - 13

- o 14
- o 15
- o 16
- o 17
- o 18
- o 19
- o 20

7. How would you best describe your involvement in the implementation of the makerspace at your school?
   - The makerspace was already in place and a resource for the school when I became the principal
   - I was not the lead but was part of the team that envisioned, designed and implemented the space
   - I was the main lead or co-lead on the team that envisioned, designed, and implemented the space

8. What grade levels make use of the makerspace at your facility? *(Please choose all that apply)*
   - *Kindergarten*
   - *1st grade*
   - *2nd grade*
   - *3rd grade*
   - *4th grade*
   - *5th grade*
   - *6th grade*
   - *7th grade*
   - *8th grade*
   - *9th grade*
   - *10th grade*
   - *11th grade*
   - *12th grade*

9. What departments or areas of study use the makerspace on a regular basis? (*Please choose all that apply)*
   - *Math*
   - *Science*
   - *Social Studies*
   - *Language Arts*
   - *Technology Education /Career and Technical Education*
   - *Art*
   - *Music*

- *Theater*
- *Physical Education*
- *Extra-Curricular activities*
- *Other (please specify)*

10. To what extent do each of the descriptions below describe the use of the makerspace facility at your school?

    Project Based Learning – activities connected with a course or curriculum designed to support a specific or targeted set of learning objectives or skill development
    - Not used for this purpose
    - seldom used for this purpose
    - used for this purpose occasionally
    - used for this purpose very often
    - used for this purpose almost exclusively

    Open Ended Problem Solving – activities or projects where the problem drives the resources that are needed to visualize, prototype or fabricate suggested solutions
    - Not used for this purpose
    - seldom used for this purpose
    - used for this purpose occasionally
    - used for this purpose very often
    - used for this purpose almost exclusively

    Closed or Managed Tool and Resource Access – concentrated areas where specialized tools, equipment and support materials are housed and maintained and made available and **students and staff are required to schedule time in the space or receive permission** from an administrator or manager to produce digital or physical prototypes or fabricate products related to school assignments or curriculum goals.

    - Not used for this purpose
    - seldom used for this purpose
    - used for this purpose occasionally
    - used for this purpose very often
    - used for this purpose almost exclusively

    Open Tool and Resource Access – concentrated areas where specialized tools, equipment and support materials are housed and maintained and made **available to students and staff anytime throughout the workday** to produce digital or physical prototypes or fabricate products related to school assignments or curriculum goals.
    - Not used for this purpose
    - seldom used for this purpose
    - used for this purpose occasionally
    - used for this purpose very often
    - used for this purpose almost exclusively

Open Exploration – the makerspace is available for faculty and student use to openly explore a personal interest or topic related to the tools and resources housed in the makerspace that is not directly tied to a specific assignment or curriculum goal

- Not used for this purpose
- seldom used for this purpose
- used for this purpose occasionally
- used for this purpose very often
- used for this purpose almost exclusively

11. Are there additional items regarding your Makerspace implementation that you would like to share?

12. Would you be willing to participate in a short live interview about your makerspace implementation? (This interview can take place over Zoom or in person with a visit by the researcher to your school and will work around your schedule.)
    - Yes, please contact me again via email to set up an interview date and time.
    - Not at this time thank you

13. Would you be interested in receiving information about the results of this study when it is complete?
    - Yes, thank you
    - Not at this time, thank you

Appendix B

Qualitative Interview Guide

1. What were the needs of the school that prompted the adoption of a makerspace?
2. Please describe how teachers access or reserve the space.
3. Please describe how students access the space.
4. Which discipline/field of study/class, uses the space most often throughout the school year??
5. When is the makerspace used most often during the school day, during the school week and during the school year?
6. Please describe some examples of the projects or activities that have taken place in your makerspace.
7. Please describe to what extent the makerspace facility has supported the student learning goals and mission of the school.
8. To what extent has the use of the makerspace changed over time?
9. If you have a mission statement or statement of purpose for the Makerspace, could you share that with me and if you do not, please suggest what such a statement should convey to the students, staff, and community?
10. Describe strategies you use to evaluate the effectiveness and value of the makerspace to the school.
11. How would you describe and characterize your makerspace to a visiting school administrator?
12. Could you describe a scenario in the future where you would no longer need the makerspace?

Appendix C

Consent Form and IRB Approval

Implied Consent
I hope this message finds you at the beginning of a great week.
I am a doctoral program student at St. Cloud State University studying K-12 Makerspaces with a focus on their implementation through the eyes of the school principal. I learned of your school's makerspace through an article written in (insert publisher, article title and date).

One of the issues that my research has identified is that school administrators looking to tour, research and learn from other implementations either to add a new makerspace or expand their current ones have had little success in simply trying to tour another school's makerspace in their area. The overwhelming number of ways makerspaces are implemented, used in practice, and categorized makes identifying a model that was implemented to address the same needs as the ones they have identified a sincere challenge. To date much of the data on makerspace implementations centers on describing or classifying makerspaces by some combination of the equipment available, the physical spaces where they are located, the staff that manage the space, and summary descriptions of the projects produced in the space.

The purpose of my study is to analyze the similarities and differences of how K-12 school leaders describe and characterize their own makerspace facilities to begin to develop a model for describing and classifying makerspaces that is not currently being employed. I hope to learn if there are themes related to the specific needs that current makerspaces are addressing in practice that could be used as a means of classifying makerspaces and intern help to mitigate the challenges mentioned.

If you are willing to help me with gathering this data, I have included a link to a very brief survey comprised of check box choices and one- or two-word responses. If the results of this study are of interest to you and your makerspace team the survey also includes a check box to send the results of the work your way as well as an option to participate in an in-person interview at your location or via Zoom at a later date.

Here is the link to the survey (*link to a Google Form Survey will be inserted here*)

Thank you for your time and consideration regarding the invitation to complete the survey about your makerspace.

Respectfully,
Mark Schroll

Institutional Review Board (IRB)
720 4th Avenue South AS 101, St. Cloud, MN 56301-4498

IRB PROTOCOL DETERMINATION:

Exempt

February 6, 2023

To: Mark Schroll
Email: mschroll@stcloudstate.edu

Faculty Mentor/Advisor: John Eller

Project Title: Characterizing Makerspaces: Identifying Best Fit Models for School Administrators

The Institutional Review Board has completed review of your protocol request to conduct research involving human subjects.

Your project has been: Approved

Expiration Date:	**N/A**
SCSU IRB#:	**41343812**

Please read through the following important information concerning IRB projects based upon the IRB determination listed at the top of this letter:

ALL PROJECTS:

- The principal investigator assumes the responsibilities for the protection of participants in this project. Any adverse events must be reported to the IRB as soon as possible (ex. research related injuries, harmful outcomes, significant withdrawal of subject population, etc.).
- The principal investigator must seek approval for any changes to the study (ex. research design, consent process, survey/interview instruments, funding source, etc) by completing an IRB Modification/Revision Request Form.
- The IRB reserves the right to review the research at any time.

ADDITIONAL FOR EXPEDITED AND FULL BOARD REVIEW PROJECTS:

- Expedited and full board review projects are up for annual renewal (1 year from your approval date, or on the expiration date listed on the approval stamp) and the principal investigator is *required* to report the status of the project *prior to the expiration date* by completing one of the following:
  - Continuing Review Form: Request to extend the project as either subject recruitment/enrollment continues or data collection continues and the project has not concluded.
  - Final Report Form: Indicate project completion as data collection is complete (data anaylsis may continue).
    - *You will receive an email reminder approximately one month in advance of the expiration date. NOTE: if a report form is not submitted timely, the protocol will be closed and a new submission will be required.*
- Approved consent form(s) and recruitment document(s) display the formal SCSU IRB stamp which is indication of official approval and lists expiration dates. These are the forms to be used during the project study. *If a renewal is requested and approved, new consent forms will be officially stamped and reflect the new approval and expiration dates.*

Feel free to contact the IRB for assistance at 320-308-4932 or email ResearchNow@stcloudstate.edu and reference the SCSU IRB number when corresponding for expedited response. Additional information can also be found on the IRB website https://www.stcloudstate.edu/irb/protocol.aspx.

Sincerely,
IRB Chair:
William Collis-Prather
Program Director
Applied Clinical Research

IRB Institutional Official:
Dr. Claudia Tomany
Associatee Provost for Research
Dean of Graduate Studies