FOSTERING 21ST CENTURY SKILL DEVELOPMENT BY ENGAGING SECONDARY STUDENTS IN INNOVATION LEARNING CENTERS

by

KANDRA AQUILLA SINGLETON MALONE

(Under the Direction of Roger Hill)

ABSTRACT

This study was designed to understand and examine the experiences of students within innovation learning centers (ILCs) through student feedback on their experiences, with the aim of impacting and guiding the future use of these unique spaces. Essentially, this study sought to guide the direction of curriculum instruction as it relates to career and technical education (CTE). Fully understanding student involvement and contextual factors within ILCs can provide necessary insight to address students' needs as they prepare for the emerging world of work.

A qualitative interview study was conducted to understand participants' views of participating in an ILC. Eight participants were interviewed for this study. Purposeful sampling was used to select the participants. Participants who were enrolled in "Engineering Applications" and that also took the prior two classes, "Foundations of Engineering" and "Technology and Engineering Concepts" in the pathway were selected. The data were collected through semi structured interviews using an interview protocol. For this study, hand coding and Microsoft Excel were used to organize the data. A two-pass coding process was used, including in vivo and axial coding. Themes and subcategories were related back to the research questions. Overall, the

study findings explained the research questions concerning how knowledge is constructed and the skill development associated with students' experiences and involvements within an ILC.

The presence of participants' voice and feedback in this paper have contributed to these students being active participants in their learning and their personal impact with ILC involvement. Participants described their overall experience beneficial to their learning as well as their preparation to postsecondary plans. The enlightening findings of this smaller-scale study must now be further enhanced through a large-scale study with more attention to ILCs that are embedded in other pathways. Understanding the impact of ILCs embedded in other pathways would serve as a comparison to how knowledge is constructed and personal and professional skills are developed.

INDEX WORDS: Innovation learning centers, makerspaces, Fab Labs, learning labs, hackerspaces, 21st century skills, skill development

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DEDICATION

This dissertation is dedicated to my grandparents. Their prayers are still manifesting in my life, even today. They always instilled integrity, hard work, kindness, and to simply smile. I will never forget the lessons they taught me and I'm forever grateful.

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I would like to thank my dissertation committee for their guidance as well as my village of supporters throughout this process. Special thanks to my family and friends for being there for me on the days I needed you the most. I could never repay you for all of the love, support, and space that you allowed me. Also, I'd like to thank the eight students who willingly participated in this study. Without you, this study would not be possible!

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CHAPTER 1

INTRODUCTION

Career and technical education (CTE) must continuously keep up with radical change in relation to the workforce. Due to its increasing dependence on technology, the emerging world of work requires higher intellectual skills and postsecondary education or training for initial entry into the workplace (Rojewski & Hill, 2017). Examining the preparation of today's students and how they construct knowledge is critical to how we are shaping their success in the world of work. Rojewski and Hill (2017) posed a question for researchers to consider concerning employment and work: How well is today's CTE preparing students to cope with a world that is radically transforming with regard to employment and work? We must reexamine CTE, with feedback from students, in regard to curriculum and research to understand the structural changes that need to be made to help prepare our students for work after secondary school.

Concerns regarding how to strengthen our economy, as well as complaints from employers that too many students graduate from high school and/or college without the knowledge and skills needed to fill jobs, have sparked a renewed interest in CTE (Stringfield & Stone, 2017). Addressing the United States skills gap, which is generally defined by the Society for Human Resource Management as an imbalance between the supply of and demand for skilled workers, necessitates ensuring that students are graduating with the proper skills to become successful, employed citizens in the workforce or are prepared to continue their education and training. CTE is supporting the United States in meeting the challenges of student achievement, economic development, and global competitiveness. The response of public education to this

conceptualization of college and career readiness has led to the development of career clusters and career pathways, spearheaded by the National Association of State Directors of Career Technical Education Consortium. Career pathways are the most recent effort in the United States to improve the transition of youth from high school to the workplace. Tech Prep, programs of study, and youth apprenticeships were earlier federal CTE initiatives that attempted to respond to these demands (Stringfield & Stone, 2017). Career pathways build on these earlier efforts with the goal of preparing students for postsecondary education and career success and include a comprehensive and structured approach to delivering curriculum and CTE. The current framework classifies the coursework necessary to support each career cluster and pathway but still lacks an explicit focus on noncognitive employability skills and certain technical skills necessary for successful transitions to careers and/or postsecondary education.

Curriculum standards have changed over time to reflect what students must know as they become adults in an increasingly complex and technological society. Problem- and project-based learning, as well as collaborative learning that aligns with a student-centered approach, are increasingly emphasized. Traditional classrooms, however, are not always equipped to encourage these forms of learning experiences. In response, the concept of makerspaces and innovation learning centers (ILCs) have been introduced within the realm of CTE. Currently, many ILCs are used as an extension to the curriculum incorporating standards. For example, engineering students learn a phenomenon and then practice within their ILC. Dousay (2017) described the emphasis on such informal exploration translating to a wide variety of spaces; however, more prominence in secondary education needs to be focused on formal learning. Some ILCs exist that have a more formal learning structure, but more are needed. Understanding

and examining student experiences within ILCs will further explain the benefits and challenges that students encounter within these unique spaces.

ILCs are also known as makerspaces, learning labs, think tanks, or transformative learning spaces. In addition, these learning spaces may use different names, such as Fab Lab, hackerspace, studio, or digital commons (Koh & Abbas, 2015). ILCs provide a safe and creative environment within which students can explore questions and ideas, build, design, collaborate, fail and try again. ILCs may include flexible learning spaces that allow for movement and hands-on exploration. Broadly, these spaces refer to the growing emphasis on do-it-yourself and do-it-together projects and are closely related to the hacker ethics of sharing, collaboration, and learning through deconstruction and reconstruction (Van Holm, 2017).

Makerspaces and ILCs have received local and national attention, particularly for their potential to help launch new entrepreneurs. ILCs provide a flexible, creative, and supportive environment to aid innovation as members transform products from ideas to reality (Van Holm, 2017). Educational makerspaces and maker education have the potential to revolutionize the way we approach teaching, but, to my knowledge, no studies have yet sought to determine what students are getting out of these learning environments within CTE. Most of what has been studied about makerspaces and the maker movement concerns the history and models of makerspaces and learning labs, how specific sites such as libraries and museums have developed their makerspaces, how to start a makerspace, and sample project suggestions (Kurti et al., 2014). The limited research regarding these ILCs more specifically relates to the experiences from a librarian perspective. Researchers have not yet addressed the experiences and the benefits that students gain from participating within these spaces, especially from a student perspective.

Accordingly, this study focused on examining and understanding student experiences within ILCs. The ILC that was studied is connected to an engineering and technology pathway class, as identified by the Georgia Department of Education; the students in this class participate in the ILC to bring learning standards to life. The state of CTE is at a critical point where transformative planning will need to take place to reform how we currently educate our population. Due to substantial changes in the economy, technology, and society in the emerging digital economy, new problems have arisen that require a new set of skills emphasizing creativity, innovation, and co-creation (Androutsos & Brinia, 2019).

Purpose Statement

This generic qualitative study, which comprised multiple student interviews, discovered how students construct knowledge and their skill development through makerspace experiences designed for secondary learners involved in ILCs at one secondary school in the northeastern region of Georgia. Including the voice of the student, also known as student voice theory, aims to add value to educational research and practice through exploring student perspectives on their own education. Researching secondary-student experiences in ILCs can help researchers determine best-practice approaches to how ILCs are utilized in the future. Exploring student experiences within these spaces can assist educational leaders in developing a foundational approach to how knowledge is constructed such spaces. Currently, a gap exists in the research, which has yet to document the voices of students involved in ILCs. Therefore, this study formally documented the results of their involvement. Additionally, exploring student engagement within these spaces can provide secondary students with the specific career preparation skills needed to succeed regardless of occupational choice (Rojewski & Hill, 2017).

Rojewski and Hill's (2017) framework for 21st century career and technical education curricula was utilized as a foundation throughout this study. This framework highlights a need to begin thinking differently about the role of CTE in preparing students for a rapidly changing workforce by emphasizing three aspects of work and work preparation: career navigation, work ethic, and innovation. This framework also poses several questions that help guide the direction of the present research, for example, "How can K-12 schools best prepare young people for the world of work?" With this framework at the center, CTE programs can share and express a common mission, in addition to the objective of specific skill development (Rojewski & Hill, 2017).

This dissertation sought to facilitate research in interpreting the personal student experience by formally documenting and recognizing students as the stakeholders within the education system who experience the most impact from that system. As participatory members, students have a vested interest in their education. As educational systems continue to seek change, a key component in the decision-making process is the valuable input of students and their shared experiences. For research to continue evolving, however, it is imperative to consider feedback and shared experiences from those who participate directly in the studied environment (in this case, school makerspaces). As students are largely represented through numerical data in quantitative studies, incorporating student voice into research can provide authentic data directly from the source. This study prioritized student experiences and allowed students a voice to provide insight and potentially create theory that was furthered explored in this research. Research practitioners have often neglected the voices of those whose experiences exert a direct impact on their research studies. Johnston et al. (2020) noted that students have personal insights about how their educational experiences affect their academic outcomes. Accordingly, student

voice was used as one of the pillars guiding this study within the conceptual framework. Lastly, this study considered and helped promote a more inclusive practice of documenting students' personal experiences to be considered in future research and potential decision-making processes.

Research Questions

The following research questions will be used to anchor this study:

(1) How do students construct knowledge through participation in an ILC?

(2) How do students describe their personal development as a result of participating in an ILC?

(3) How do students describe their professional skills development as a result of participating in an ILC?

Conceptual Framework

Maxwell (2013) described a conceptual framework as the system of concepts, assumptions, beliefs, and theories that supports and informs a research study. The framework entails the main things to be studied—the key factors or variables and the presumed relationships among them. My study was informed by existing literature, student interviews, and myself as the researcher. The conceptual framework for this work by Rojewski and Hill (2017), as illustrated in Figure 1 served as an initial guide for my study and offered an avenue for me to make sense of the themes and concepts derived from my findings.

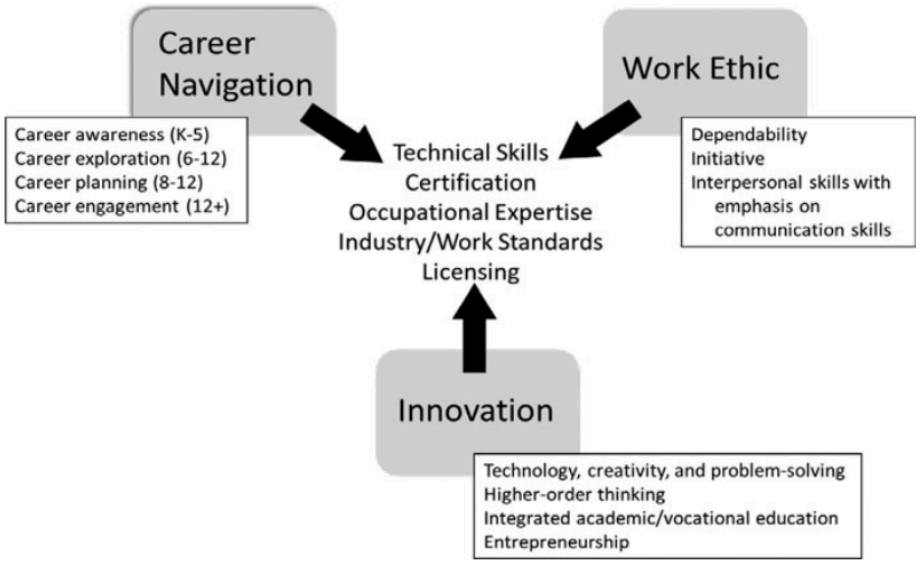

Figure 1. A framework for developing and implementing workforce education in the 21st century. Reprinted from "A Framework for 21st-Century Career-Technical and Workforce Education Curricula," by J. W. Rojewski and R. B. Hill, 2017, *Peabody Journal of Education*, *92*, p. 186. Copyright Taylor & Francis Group, LLC.

Career Navigation

Career navigation begins at an early age. In elementary school, career day is a day on which students are exposed to careers that are generally highly visible in their daily lives—police officers, firefighters, teachers, construction workers, and a host of other careers. Students may even dress as a member of their future career for such events. Exposure to careers at the middle-school level may look similar, but students may be introduced to a different variety of careers—engineers, computer science professionals, entrepreneurs, and many others. In eighth grade, students typically visit the high school for a rising 9th-grade program. Typically, during this time, school clubs, organizations, and career pathways are present for students to begin getting

exposure to various fields, as in Gwinnett County Public Schools (GCPS) they will be picking a career pathway during their freshman year, as designated by the Georgia Department of Education. At the high-school level, students may even go beyond the school building to participate in extended learning opportunities (e.g., field trips) and visit workspaces to visualize a particular career. For example, at South Gwinnett High School, prior to the pandemic, students were able to visit the Federal Reserve Bank of Atlanta. As part of the field trip, students were able to have a panel discussion with various employees in different roles there. For example, students were able to ask questions about what a day in the life of a financial analyst looks like. This discussion was followed by a tour of the bank, in allowable areas, where they were able to observe employees at work. They were able to observe the cash operation specialists and supervisors, the robot that carries the bundles of cash, and the employees who perform various maintenance functions in the cash operations area.

Based on such exposure, or lack thereof, students have to decide which career pathway they will be assigned during their high school journey. Given their often-limited personal experience at their age, many students do not know what they want to be when they grow up, so they struggle with choosing a career pathway. Although many students have the option to explore careers, they do not take advantage of all the resources, programs, and opportunities that are available to them. GCPS feature schools outside of students' home schools that are specifically fit for students seeking a technical specialty such as cosmetology, automotive, exercise physiology, or culinary arts. Therefore, if the school in which the student is zoned for does not offer their career interest, there are plenty of other options. Unfortunately, there are still students who are not sure what career pathway to choose, so it becomes a guessing game, and

students rely on their teachers and school counselors to help guide them and place them in the pathway that best fits their personality, skill set, or supports a future goal for the student.

Georgia's Career Clusters allow students to select an area of interest from seventeen clusters available (Georgia Department of Education, n.d.). CTE programs are embedded in a career pathway that directly correlates to potential careers. Depending on each specific program, teachers expose students to various careers within the pathway through incorporating guest speakers, site visits, and career exploration panels. Secondary CTE programs today are still preparing students for jobs through the career pathways they select. While in high school, students are planning for their future careers. For example, the ILC that will be studied herein is connected to an engineering pathway. GCPS's Academic, Knowledge, and Skills (AKS) standards incorporate learning standards that allow students to match engineering job titles with qualifications and responsibilities and participate in activities related to career interests. Additionally, students can participate in a co-curricular student organization, the Technology Student Association (TSA), that helps demonstrate the development of various skills. The interview questions established within this study have helped provide details on how students are exploring their careers while participating in this ILC. As work-based learning programs expand in most schools, students have the opportunity to participate in job shadowing experiences, internships, practicums, and apprenticeships as part of their occupational training (Scott & Sarkees-Wircenski, 2008).

While such approaches are a decent start, particularly for students who know what they want to study further in college and/or the work they want to do after high school, CTE must continue to emphasize skills outside the technical aspect, such as problem-solving and other interpersonal skills. The example offered by this study sheds light on the benefit and competitive

advantage that students interested in pursuing an engineering career obtain through participation in ILC spaces at the high-school level.

Work Ethic

Interpersonal skills, also known as employability skills, are currently embedded in the CTE curriculum. However, Rojewski and Hill (2017) promoted a need for greater emphasis on teaching work ethic attributes more deliberately. The interpersonal skills that students develop as they prepare for their future careers through their pathways are transferable regardless of the career they select. Rojewski and Hill (2017) stated that special attention should be paid to skills for success in the 21st century workplace, including communication and collaboration skills.

Personal development education (PDE) includes interpersonal and interaction skills that are required for students to succeed in globally focused 21st century colleges and careers (Jacobson-Lundeberg, 2016). Jacobson-Lundeberg (2016) found that communication is a gateway skill, leading to other, more complicated 21st century skills such as critical thinking, problem solving, stress management, and risk taking. Another finding of this study suggested a need to communicate in order to collaborate. Collaboration is also a gateway skill that is essential for students to acquire. Communication and collaboration skills can help people be vulnerable, thereby promoting their capacity for successful human relations (Jacobson-Lundeberg, 2016). The current study highlighted how students are developing and utilizing these skills within the ILC through student interviews.

Innovation

As workplace needs continue to evolve, innovation must be at the core of how teachers are facilitating learning within a classroom setting. Rojewski and Hill (2017) suggested that workforce education programs should increase their current efforts to encourage innovation and

creativity. Traditional education as is currently practiced will have to be enhanced to promote innovation skills that align with the 4Cs as labeled by the Partnership for 21st Century Skills: critical thinking, communication, collaboration, and creativity. ILCs provide a space for students to innovate and utilize these specific skills. They also allow students to actively construct knowledge rather than participate in rote learning through a simplistic right/wrong assessment approach.

Researchers have suggested that making, which is associated with learning methodologies such as constructivism, can create the appropriate conditions for students to be creative and critical, solve problems, and work in groups (Valente & Blikstein, 2019). Unlike traditional teaching approaches, which are dominated by direct and unilateral instruction and generally assume a fixed body of knowledge that the student must know (Shah, 2019), constructivist or student-centered learning poses a question to students, who then work together in small groups to discover one or more solutions. Environments such as ILCs and makerspaces have great potential to contribute to progressive education and create multiple paths for students to learn more relevant topics through curiosity, inquiry, and problem-based approaches.

In this study, students were able to discuss and share their views of the meanings they have constructed through their participation in ILCs and recognized that they were co-constructors of the data that I as a researcher was collecting. In constructivism, each individual constructs knowledge and his or her experience through social interaction (Given, 2008). According to Merriam and Tisdell (2016), qualitative researchers are interested in understanding this constructed meaning, that is, how people make sense of their world and their experiences. Constructivism essentially composes reality as experiential and partially subjective through an individual epistemological approach.

Innovation through problem-solving can be a difficult skill to teach if students are strictly bound to multiple-choice, right/wrong responses. Therefore, there are many benefits to students learning while doing in an ILC. How students are able to see various outcomes, cope with more than one right answer, and accept failure for certain projects that may not go as planned are transferable skills that enhance their interpersonal skillset. Students may also feel that they are not creative enough to generate innovative ideas, which might impact their ILC experience. As the teacher, guiding students to think about various options may spark their curiosity levels, thereby increasing their creative confidence.

Student Voice Theory

Considerable research has focused on makerspace education, grounded in work by philosophers Jean Piaget and Seymour Papert; the findings of these studies have been utilized to highlight the benefits of makerspace education overall. Papert emphasized the importance of learning through "hands on" and "heads in" learning, in which the learner is involved in building something of interest to him/her and, in doing so, is faced with unexpected problems for which there is no preestablished explanation (Valente & Blikstein, 2019, p. 252). The self-determination theory, developed by Deci and Ryan (1985) and later expanded (Ryan & Deci, 2017), outlined the basic psychological needs that must be met in order for a user to be intrinsically motivated to continue a task—in this context, to continue using the makerspace (Fitzsimmons, 2020, p. 7). Although other theories were considered for potential use as a foundation such as self-efficacy and experiential learning, simply highlighting the benefits of ILCs was not the ultimate goal of this study. This study sought instead to emphasize and highlight the feedback obtained directly from student voices. Therefore, student voice theory was

the best option to allow students to share their voices and feedback as it related to their experience within the makerspace.

Utilizing student voice theory allows students to be coresearchers and active participants rather than merely sources of data (Johnston et al., 2020). Students have a right to influence their educational journey and its outcomes. Cook-Sather (2020) supported the importance of consulting with students when conducting research, especially interview-based research, to analyze educational practices, make recommendations, and effect change in schools. Johnston et al. (2020) noted that although student voice research that considers students as active participants faces obstacles, investing in developing methods for overcoming these challenges is nevertheless a worthwhile endeavor (Johnston et al., 2020, p. 544).

This study's emphasis on student perspective is aligned with its aim to understand student voices. Research on student and school settings has often neglected the power of the student voice. While most school reforms seek to change students, student voice approaches situate students as agents in the reform process (Mitra, 2018, p. 473). Boske and Diem (2012) noted that "including and honoring the students' perspective not only yields richer and more authentic results, but it also increases student engagement" (p. 22). Although making learning more meaningful and relevant is a topic of increasing interest, the necessary inclusion of student voice is sorely lacking from the existing research.

Gonzalez et al. (2017) justified student voice research as an approach that is mindful of student perspectives on issues within the education field. Their study further argued that K-12 students are ready to engage in reform efforts that impact their education (Gonzalez et al., 2017). Although student voice research has been criticized due to a lack of action resulting from sharing student voices, such critique does not negate the fact that students are the primary stakeholders in

their own education, and accordingly, their narratives should be included in research for further consideration and planning.

Myself as the Researcher

As the researcher, I am informed by my epistemological orientation and how I make sense of the world as a CTE teacher. These contributions have shaped how I developed and designed my interpretation of the findings. My conceptual framework has guided and impacted my study through my understanding that I am the primary instrument for data collection and data analysis. Merriam and Tisdell (2016) described this positionality as an advantage in that the researcher can expand his or her understanding through nonverbal as well as verbal communication, process information (data) immediately, clarify and summarize material, check with respondents for accuracy and interpretation, and explore unusual or unanticipated responses. Because the human instrument has shortcomings and biases that can exert a significant impact on the study, however, approaching the research through a conceptual framework has helped guide my inquiry and maintain scholarly rigor.

Subjectivities Statement

My interests in the topic of this study are grounded in professional convictions developed through working in the CTE field. Searching for ways to improve how students are prepared for life after high school has become a passion for understanding how we, as teachers, are preparing students. After becoming interested in ways that students can learn by doing rather than through experiencing a one-way approach to teacher-delivered instruction, I began to wonder how we can improve teaching and learning.

Furthermore, as a CTE business education teacher, I am passionate about preparing my students, to my best ability, for college and/or careers by equipping them with the knowledge

and skills to succeed. Based on feedback that I have gathered from industry professionals and higher education personnel, I have realized that a majority of students leaving secondary education are not well-equipped for the rapidly evolving world of work—a reality that I feel a responsibility to improve. Researching examples of how certain schools are incorporating ILCs led me to focus on students' narratives through utilizing a semi structured interviewing technique. However, there is a lack of literature that records student voices within these spaces, thereby providing vital context for the skills they are developing. Although I realize that I cannot generalize my findings, I can utilize information found through my study to guide future research and instruction projects.

Importance of the Study

This study was designed to understand and examine the experiences of students within ILCs. Student feedback on their experiences helped elevate student ideas and contributions about how learning occurs. Documenting the student experience acknowledged their lived experiences and recognized the diversity of students' values and opinions. Recognizing student voices has the potential to prompt educational reforms and can help inspire new approaches to teaching and learning. Fully understanding student involvement and contextual factors within ILCs can provide the necessary insight to address student needs and interests. Recognizing their lived experiences potentially allows students to co-design and even lead some of their approaches to learning.

In earlier decades, work was more stable and predictable, and CTE programs were able to focus mostly on training students for technical jobs (Rojewski & Hill, 2017). Despite the increasing interest of scholars in research on CTE and related topics, much is yet to be fully comprehended about student experiences within ILCs that are directly situated within a CTE

setting. CTE is where we train students for the world of work. Therefore, more research is needed to emphasize the necessity of more relevant, innovative curriculum. Research that observes ILCs and documents student perspectives will make a difference in how CTE programs construct their future programs. Specifically, the more knowledge that is gained from this research, the more the results of this study can enhance student experiences that are currently taking place within ILCs and/or guide the practice of establishing ILCs within various CTE programs. Additionally, an increased understanding of how learning is constructed can enhance professional development opportunities to deliver resources and support for teachers who will begin an ILC or inform policy change that will support teachers who are directing ILCs.

CHAPTER 2

LITERATURE REVIEW

Historically, the need for learning and innovation skills can be traced back to Socrates and the Sophists, who were considered the first professional teachers (Larson & Miller, 2011). Developing students' skills for the future was also recommended long ago by John Dewey, who proposed an education that was grounded in experience and allowed students to interact with an ever-changing world (Larson & Miller, 2011, p. 121). Although we cannot predict the future, particularly long-term labor market needs, to ensure that we are preparing students for postsecondary success, career and technical education (CTE) must do more than help students pass tests. Whether the goal is traditional college or alternative programs, one way to address this issue is by incorporating innovation learning centers (ILCs) within CTE pathways, which will help engage students as they develop into accountable, empowered, and successful workers who possess the necessary skills for modern work, such as innovation, creativity, communication, collaboration, critical thinking, and problem-solving. This dissertation emphasized the need to understand what students can do with knowledge and how they apply what they learn in authentically constructed contexts.

This chapter reviews the literature on the history of public education and examines ways to prepare students for 21st century work through ILCs to lay the foundation for the research methods discussed in Chapter 3. First, a brief history of public education is provided, followed by an explanation of the national and local expansion of CTE. Then, the ideas comprising my

conceptual framework are explained in further detail, after which, existing research on important thematic concepts such as globalization and constructivism is discussed in relation to my topic.

A Brief History of Public Education

Throughout its development in America, public education has attempted to fill various roles that have benefited not only society as a whole but also individuals. As Kober et al. (2020a) noted, "Other purposes include preparing young people for civic life, bringing together a diverse population, promoting equity, providing community and social services, and more" (p. 1). Prior to the development of modern public schools, many children were excluded from education for various reasons, including income, race, gender, and geographical location. The children who had access to instruction were educated through numerous formats:

> Church-supported schools
>
> Local schools organized by a group of parents
>
> Tuition schools set up by traveling schoolmasters
>
> Charity schools for children of the wealthy
>
> Boarding schools for children of the wealthy
>
> Home schooling
>
> Work apprenticeships with embedded reading, writing, and math concepts. (Kober et al., 2020b, p. 1)

The Early Era: Common Schools

Although its exact mechanics remain subject to debate, a long-standing objective of schooling is to create good citizens. The establishment of the common school movement pushed for the development of public schools to serve multiple purposes (Kober et al., 2020b). Horace Mann, the spokesperson of the common school movement, was a Massachusetts legislator and

secretary of the state's board of education during the 1830s. He heavily advocated that public schools be accessible and free of charge through state funding. Mann and other proponents of "common schools" emphasized that a public investment in education would benefit the whole nation by transforming children into literate, moral, and productive citizens (Kober et al., 2020b, p. 3). Later, Mann's approach centered around the economics of common schools. Mann is largely credited with Massachusetts becoming the first state to establish a system of free public schools (Persky, 2015).

The Growth of Public Education

As history demonstrates, some public schools throughout the 19th century grew at a faster pace than those in other communities, such as rural areas and other parts of the country. Attending high school was out of the ordinary until the 20th century. Kober et al. (2020b) highlighted some key statistics regarding school attendance throughout the 19th and 20th centuries. For example, in 1830, slightly more than half (approximately 55%) of school-aged children (ages 5–14) were enrolled in public schooling; by 1870, approximately 78% of children aged 5–14 were enrolled (Kober et al., 2020b, p. 4). High school completion rates have also soared: whereas in 1910, only 14% of Americans ages 25+ had earned a high school degree, this rate had increased to 55% by 1970 and to 90% by 2017 (Kober et al., 2020b, p. 4).

In 1958, Hofstra University started its experimental college, which promoted a shared set of pedagogical principles that included interdisciplinary and independent study, essentially sharing a common mission of bringing liberal education to an extended group of students (Higginson, 2019). Experimental colleges added value to the growth of funding and various educational sectors such as community colleges. These experimental colleges were foundational for liberal arts education, as detailed in Higginson (2019):

> Liberal intellectuals saw liberal education as essential for democracy because they believed it resolved social fragmentation and created independent, open-minded citizens. Yet, late 1950s educators were concerned that liberal education might be at risk because overspecialization increasingly gave students a disjointed education with little common knowledge. (p. 206)

These concerns remain valid today, as education, including CTE, is increasingly specialized. Thus, it is important for researchers to consider how to ensure that students do not merely receive a fractured, factual education with no understanding of how to practice independent inquiry.

Public education will continually reflect our values as a society. How society views education will impact our future. As education has continued to shift over time to expand access for all, including minoritized and marginalized populations, there continues to be a need to proactively address urgent and relevant needs to improve the quality and overall system of public education.

Career and Technical Education (CTE)

CTE has played a critical role in the development of the United States secondary education system dating back to the vocational education movement of the early 20th century. The vocational education movement would not have been possible without the essential support provided by the Smith-Hughes Vocational Education Act of 1917 (Manley, 2011). This act contributed to the partnerships among federal, state, and local governments and continues today with the Carl D. Perkins Career and Technical Education Improvement Act of 2006, followed by additional Perkins legislation.

The History of CTE

From its inception, CTE has provided a strong knowledge base and skill set for citizens. To understand the importance of CTE, it is important to recall its history. Imperatore (2019) offered a brief history of CTE as follows:

I. The Awakening (1776-1826): This period introduced the right to free public education for children in the United States, as there was a need to educate future leaders. Apprenticeships were yielding to formal schooling in certain trades. During the first 50 years of the United States, public education was widely limited to boys. However, in the early 1800s, girls began to enter schools to prepare for teaching careers.

II. Independent Action (1826-1876): In the early 19th century, the workforce and the public education system started to work together to create a continuous stream of workers for different jobs. During this time, certain schools specialized in training students to enter a certain area in the workforce. This specialization began to open doors that, ultimately, created a basic framework for CTE. The idea began to spread to women's colleges in the 1840s. The idea of public high schools was explored as a way to continue to educate citizens.

III. The Vocational Education Age Emerges (1876-1926): The first manual training school was established in St. Louis, Missouri, in 1879, laying the foundation for a more modern era of CTE. The school combined hands-on learning with traditional classroom learning. The first trade school was opened in New York in 1881. Near the turn of the 20th century, agricultural education started to thrive, with agriculture schools opening up which, in turn, encouraged the passing of legislation to support the growth of CTE.

> IV. Coming of Age (1926-1976): The first mass acceptance of CTE came after World War I, and the movement spread in the following years. CTE education expanded to include adult education and retraining citizens to reenter the workforce. World War II caused a surge in CTE, as technical skills were needed for defense purposes. (p. 1)

Federally, the role of CTE began over 100 years ago. As noted by Imperatore (2019), CTE began with the Smith-Hughes Vocational Education Act of 1917. This was the first major investment in secondary vocational education and offered states funding for education with a particular focus on agriculture, homemaking, and trade and industry. Vocational education has expanded over time to represent people in all communities. Regardless of the field of study, the funding through such legislation is inclusive of academically and economically disadvantaged and disabled students. Furthermore, additional Vocational Act amendments have since passed to include postsecondary education and equal opportunities for women and girls. In more recent history, Imperatore (2019) noted that the Strengthening and Career and Technical Education for the 21st Century Act (Perkins V) provided additional updates to allow more flexibility at the local level to better serve special populations and encourage innovation through a competitive grant program.

Understanding the historical beginnings of skill development training further magnifies the realization that the world is rapidly changing, and some systematic shifts have the potential to change the nature of work. To prepare the workforce for this changing world of work, necessary skills must be developed that are in line with industry standards. In-demand skills are needed now, and other skills will be needed as the future of work evolves due to fast-paced changes in technology, robotics, artificial intelligence, and other ways we perform work. Such changes will directly result in new jobs for those workers who possess the necessary skills. Automation alone

is expected to result in the elimination of many entry-level jobs that serve as a direct pathway to careers for underprepared individuals, including young workers (Afranie & Gardner Clagett, 2020). It is thus crucial to prepare young people with the needed skills to ensure lifelong career success.

The Expansion of CTE

CTE as we know it prepares students to fill middle-skill jobs that require certifications and, in many cases, a college degree, as well as other STEM occupations. However, CTE is no longer a segmented vocational and technical skills training track for those who do not want to pursue postsecondary degrees; today, it is a system for all students who want to achieve in the 21st century workplace. As CTE expands its efforts to prepare students for the workforce, skill training is primarily situated in pathway programs, with 17 career clusters and more than 79 pathways. Essentially, the partnerships formed between secondary and postsecondary institutions and industry ensure that CTE programs align with industry needs while providing students with authentic, relevant, and engaging learning experiences (Boettcher, 2017).

Boettcher's (2017) research demonstrated how CTE programs are expanding to assist in 21st century skill development. In 2017, a Wisconsin school, Altoona Intermediate and Middle School Fabrication Laboratory (Fab Lab), enabled students in grades 4–12 to participate directly in project-based learning in design, engineering, and fabrication. This particular Fab Lab allows for students to gain hands-on experiences through the use of laser engravers, 3D printers, and LEGO robots. Courses including welding, metal fabrication, engineering, and computer-assisted design have been developed through this program in conjunction with local technical colleges. This program has produced industry-standard certifications for students to utilize. These direct

experiences give students the first-hand opportunity to gain the skills they need to be successful, engage them in specific career navigation, and potentially help with their academic courses.

Evaluating and making the necessary shifts within our educational approaches is essential to prepare for economic shifts. The current challenge for secondary students today is how well-equipped they are to handle the nature of work that will evolve throughout their working lives. Heyward (2019) compared six core qualities that compared traditional vocational education to what is currently expanding in CTE:

Schools are trying to stay well-informed to the changes in career whereby connecting students to careers that are in-demand. With advisory board committees and other community partners, schools can continually review curricula that match field competencies. Schools are also preparing students for career and post-secondary success, by providing opportunities to increase their skillsets. New CTE programs are deliberately ensuring post-secondary success through offering multiply pathways to careers and college by offering advance placement classes, industry credentials through end-of-pathway assessments, and dual enrollment opportunities with technical colleges. Many CTE courses deliver a relevant learning experience where learning is interactive and often supplemented through project-and/or problem-based and hands on learning (Heyward, 2019). Destigmatizing CTE has played a role in equity where it's no longer just considered a pathway for those unlikely to succeed in a traditional academic program. Innovative CTE programs recognize the value of ensuring all students can participate. New CTE challenges the belief that learning only occurs within the school walls; however, collaboration must take place with employers, city agencies, trade unions, and universities that potentially lead to industry-recognized credentials (Heyward, 2019). Lastly, Heyward (2019)

suggests that programs must be responsive and sustainable. Regular review of curricula and updating course offerings must be a continuous effort to ensure student success.

Much of the expansion of CTE is aligned with the growing need for 21st century skills in the labor market (Dougherty & Macdonald, 2020). CTE will continually allow students to apply what they learn in authentic contexts. As society and the workforce changes, CTE must keep pace with current changes to remain relevant and viable. To ensure relevancy, real-world connections between the classroom and the workplace must continue with the presence of opportunities such as dual enrollment and industry-recognized certifications (Boettcher, 2011). As we look into the future, better connections among industry representatives, funding, and programming have to be made available to deliver high-quality CTE programming (Boettcher, 2011).

CTE and Skills Development in Gwinnett County

Current skill development in GCPS is centered around CTE. Gwinnett County's Academies and Career & Technical Education department supports GCPS's vision of becoming a system of world-class schools by facilitating unique and personalized real-world, hands-on, career-ready experiences to promote students' success in college and career endeavors. The mission of the Academies and Career & Technical Education department is to promote high-quality instructional practices and community partnerships while preparing students for postsecondary education and employment (Gwinnett County Public Schools Career and Technical Education, n.d.). Today's CTE is an enhancement of vocational education and is currently considered a cutting-edge, rigorous, and relevant program that prepares youth and adults for a wide range of high-wage, high-skill, high-demand careers in established and emerging industries.

In GCPS, CTE educates students through a range of 17 career clusters, such as hospitality and tourism, business, information technology, finance, and health science. Additionally, within those career clusters are more than 79 pathways, which offer industry certifications, postsecondary certificates and degrees. For example, in GCPS, the health science cluster features specific pathways such as allied health and medicine, biotechnology research, emergency medical responder, exercise physiology, health information management, patient care, pharmacy, and sports medicine. Local schools have the ability, based on availability, to decide which pathway best matches the interests of their students. Depending on the school system and program, business partners may further enhance the program with the goal of helping usher students into fulfilling employer needs in high-skill, high-wage, high-demand industries. In both Gwinnett County and the nation as a whole, CTE prides itself in preparing students to be college- and career-ready by providing academic skills, job-specific skills, employability and technical skills.

Innovation Learning Centers (ILCs)

Research has suggested that human beings thrive on the ability to be self-sufficient and utilize tools to enhance their lives by designing and building efficient and effective systems (Namasivayam et al., 2020). One way to learn such capacities is through ILCs, which are also known as makerspaces, learning labs, or transformative learning spaces. In addition, these learning spaces may use different names, such as Fab Lab, hackerspace, studio, or digital commons (Koh & Abbas, 2015). Through access to sophisticated tools and resources, ILCs offer students a space in which they can take an individualized approach to problem-solving and establish a sense of community with like-minded individuals, allowing for collaboration and the communication of ideas.

Fab Labs are laboratory spaces focused on fabrication and other 3-D printing and tools. Hackerspaces are more focused on programming while working with circuits and other hardware resources. Makerspaces have manifested in various versions, including creative environments situated in local libraries, schools, and other public spaces. Each ILC is unique, and how it contributes to its local community is shaped by its members, students, or founders. Some ILCs have a more entrepreneurial focus and offer services similar to incubators or co-working spaces with the benefit of onsite tools. Other spaces can be found in libraries and media centers and often emphasize open access to tools and the application of new learned skills to community projects. Many ILCs tend to fall between those two extremes, providing a flexible, creative environment to aid innovation and support as makers and learners transform products into real-world, applicable solutions. Makerspaces are the latest expansion of access and opportunity to help push society over the tipping point of engagement with design (Van Holm, 2015). In a research study, Davis (2018) found that reasons for planning a makerspace included promoting community outreach, promoting learning and literacy, promoting libraries as relevant, promoting the maker culture, providing access to expensive machinery, and complementing digital repository or digital scholarship projects.

ILCs and Makerspaces in Student Environments

One reason makerspaces and similar spaces are gaining traction is the hands-on approach they promote, which is highly motivating for young learners and further enhances their awareness of STEM-based activities. School-based makerspaces add value and skill development for students by providing them with safe spaces to engage in problem solving and to design solutions to those problems (Martinez & Stager, 2019). Students of all ages are able to hone a variety of skills while designing tangible artifacts within ILCs. Kurti et al. (2014)

suggested that ILCs significantly enhance the iterative learning experience of students who engage with these spaces. They also found that participating in ILCs invites curiosity, inspires wonder, encourages playfulness, and celebrates unique solutions (Kurti et al., 2014).

Most students in primary education are heavily involved in hands-on learning. However, as students progress through their educational journey, education moves away from hands-on learning activities towards a cognitive approach to learning. Because the ability for students to use their hands to develop artifacts offers intrinsic motivation for learning, it is logical to provide students beyond primary school with an equally motivating space in which they can make their design dreams come true through a making approach. Most often, ILCs are equipped with heavy, sometimes expensive, equipment that is generally operated by certified instructors. At the very core of a makerspace lies an ill-structured problem, i.e., a learner wanting to learn a new skill or create something he or she has never attempted before, with many ways to approach and solve the problem (Dousay, 2017).

Exposure to career and academic opportunities through ILCs provides a pathway to transitioning from secondary to postsecondary education and/or a career. Within the secondary setting, career pathways may be thought of as multiple efforts to align existing systems and educational structures to improve students' transition from secondary education to work or postsecondary education and training with the goal of obtaining one or more industry-recognized credentials (Stringfield & Stone, 2017). In this approach, education is not necessarily merely more schooling for everyone; the purpose of such schooling is to prepare the next generation for a world of work that is unpredictable, given the changing pace of technology and productivity. There is a need for specific and relevant technical skills. Employer-recognized credentials are valuable, particularly when they are stacked with degrees, diplomas, or skill certifications, and

offer ramps to labor market success. ILCs assist in preparing students for an unknowable future by providing exposure to career and academic opportunities. Furthermore, for older students, making combines disciplines in ways that enhance the learning process for diverse student populations and open doors to unforeseen career paths (Martinez & Stager, 2019). Not only does the maker mindset empower students to seek out STEM or creative field-related jobs, but jobs and industries emerge that are dependent on their interests and needs, which are rapidly developing in our changing society.

Existing Research on ILCs

New makerspaces are cropping up in schools, in community centers and organizations, and in museums and public libraries, which presents a growing need for professional development to help K–12 educators answer common questions such as "what is a makerspace," "why should I bother with a makerspace," "how do I run a makerspace," and "how do I teach from a makerspace?" In a research study, Davis (2018) found that reasons for planning a makerspace include promoting community outreach, promoting learning and literacy, promoting libraries as relevant, promoting the maker culture, providing access to expensive machinery, and complementing digital repository or digital scholarship projects. Most research involving ILCs has centered on issues such as how to implement a space; capacities of makerspaces to address professional development; case studies of programs, whether incorporated into libraries or community centers; and the contributions of these spaces (Kurti et al., 2014). Neither the research on ILCs nor most ILCs themselves have focused on examining student experiences and their perspectives in the space.

Traditional school libraries and media centers exist primarily to provide information for consumption. Large collections of various print and digital materials are organized in these well-

ordered spaces. The advent of emerging technologies has encouraged users to access knowledge, reconstruct it, and share it both physically and virtually through a variety of modes (Kurti et al., 2014). Due to evolving technologies, there has been a movement away from ILCs as sites of direct consumption toward collaborative spaces for knowledge building, making, tinkering, and collaborating. Considerable enthusiasm has generated positive press around these spaces. However, research that measures their impact is sparse. Oliver (2016) framed a study not only to answer the "what" and "why" questions but to adequately address and motivate educators to dig deeper in addressing best practices for maker leaders. This study emphasized a strong need for educator preparation to understand the technologies, management issues, and pedagogies associated with making. Particularly, targeted professional development activities can help educators understand the scope of makerspaces. These activities can be customized to mirror the needs of a given site. For example, educators who are new to making should be introduced to project specialty areas that are commonly found in ILCs.

Research initiatives have emerged to evaluate the targeting of making activities, assess and implement ILCs, train facilitators, and evaluate the competencies that exist for instructors. A cross-case comparative analysis conducted by Sheridan et al. (2014) examined three makerspaces to understand how different makerspaces functioned as learning environments and found several shared distinctive features. These spaces fostered a diverse set of learning methods that consisted of solo exploration, one-on-one or small group projects, collaborative projects, and structured classes. One of the most visible differences in the various learning arrangements within the three spaces were the typical durations of making. Differences in the duration of projects reflect, perhaps, the relationship between the makers and the space itself (Sheridan et al., 2014, p. 521). Another commonality across the three makerspaces was the design process, in

which learners exemplified iterative learning by working through ideas, materials, tools, and processes using increasingly complex methods. Within this study, themes developed that illustrated how makerspaces fuel engagement and innovation; the diversified learning arrangements and learning in these spaces deeply embeds the experience of making (Sheridan et al., 2014).

While educational leaders have grappled with how to enhance traditional educational practices, schools and teachers have begun to view makerspaces as a way to promote learning and innovation skills, such as the 4Cs as defined by the Partnership for 21st Century Skills: critical thinking, communication, collaboration, and creativity (Dousay, 2017). Dousay (2017) also noted that makerspaces blend formal and informal learning. Whereas formal learning allows for teachers to help students master tools and equipment safety, informal learning occurs when the student is able to decide which project or activity to undertake (Dousay, 2017). Moreover, Namasivayam et al. (2020) found that such spaces are able to attract students to produce their own designs, thereby increasing intentional learning and promoting creativity and innovation. Makerspaces represent the latest expansion of access and opportunity to help push society over the tipping point of engagement with design (Van Holm, 2015).

Student Voice Theory

Mitra (2018) defined student voice as the means through which students enhance or participate in decisions regarding their education. There are various ways to involve students in educational efforts, such as seeking feedback driven by the teacher or principal; student-led campaigns to facilitate change within a school; or student-adult partnerships to encourage reform efforts (Conner et al., 2022). It is necessary for those seeking to improve students' educational experiences to attend to their perspectives, solicit their ideas, and take their feedback (Conner et

al. 2022, p. 755). Conner et al. (2022) sought to uncover the connection between student voice and the impact of student engagement. Their study found that student voice has become seen as a powerful driver of desired student outcomes. In my personal experience, when students are able to share their opinion on their learning process, in a constructive manner, we teachers can develop a better understanding of their needs and how we can better meet them.

One of the goals of student voice research is students' active engagement. Christenson et al. (2012) provided a detailed definition of student engagement, which

> refers to the student's active participation in academic and co-curricular or school-related activities, and commitment to educational goals and learning. Engaged students find learning meaningful and are invested in their learning and future. It is a multidimensional construct that consists of behavioral, cognitive, and affective subtypes. Student engagement drives learning; requires energy and effort; is affected by multiple contextual influences; and can be achieved for all learners. (pp. 816–817)

Often and informally known as the ABCs of learning grounds, student engagement began to be considered in relation to student voice with Ryan and Deci's (1985, 2017) self-determination theory, which included the important elements of autonomy, belonging, and competence.

Autonomy

Incorporating autonomy-supportive teaching strategies into instruction provides numerous benefits for both students and teachers (Cheon et al., 2020). Teachers must first learn how to support students' autonomy, which they accomplish by learning how to take their students' perspectives and presenting learning activities in ways that appreciate and support student autonomy (Cheon et al., 2020, p. 2). Teachers must also set clear expectations and provide feedback along the way. Schmidt et al. (2018) stated that choice is one way to increase

students' perceived autonomy that has generated considerable scholarly attention (p. 25). Additionally, some teachers believe that student choice is beneficiary. However, some researchers, such as Flowerday et al. (2004), found either no effects or negative effects of choice on motivational outcomes such as engagement.

Belonging

The academic examination of the need to belong has its beginnings in Maslow (1968). Meeting the emotional needs of students, especially after the COVID-19 pandemic, continues to be a challenge in modern education. In past decades, increased attention in education research has been given to the importance of fulfilling the need to belong (Korpershoek et al., 2020). This feeling of belongingness is often defined in the literature as a sense of school belonging, or the extent to which students feel personally accepted, respected, included, and supported by others in the school social environment (Korpershoek et al., 2020, p. 641). One notable finding of this study was that students who perceived their classroom as mastery goal oriented and felt positively about the overall classroom climate also felt a stronger relationship with the school (Korpershoek et al., 2020).

Competence

Conner et al. (2022) defined competence as students knowing how to achieve certain results and feeling efficacious in doing so (p. 756). According to Morkhova et al. (2022), the "set of personal qualities" of a student, developed through experience, helps students acquire knowledge and mastery "as well as the experience of their personal understanding, processing, and application in professional activities"—in other words, their "professional competence" (Morkhova et al., 2022, p. 9986). Furthermore, the importance of digital competence, specifically, for social inclusion, employability, and quality of life has been widely recognized

(Kumpulainen et al., 2020, p. 1). A variety of benefits have been proposed to be directly relevant to digital competence as a result of participating in makerspaces (Kumpulainen et al., 2020).

Constructivism

According to Sharkins et al. (2017), constructivist classrooms empower students to find their own solutions at their own pace, often from among multiple potential options, rather than focusing on a single received "correct" answer. In constructivist approaches, students are asked to explain the thought process that led to their answer, rather than simply rehearse the knowledge they have passively received. This type of learning is also typical of ILCs. Martinez and Stager (2019) have noted how constructivism is often misunderstood as meaning that learning only occurs alone; on the contrary, learning is often socially constructed by talking and collaborating with others. Jean Piaget's belief that children construct their own knowledge within a community of learners and should be supported in the development of moral and intellectual autonomy harmonizes with Lev Vygotsky's views on the impact and importance of culture as well as scaffolding to help children learn more together than they could on their own (Sharkins et al., 2017).

Skill Development

Educational curriculum developers across the world should look for solutions and new ways to integrate critical thinking skills approaches, such as creativity, problem-solving, communication, collaboration, and analytical thinking, into secondary school curricula (Ongesa, 2020). As concepts such as globalization and global citizenship have emerged, the needs of workforce education have rapidly changed. We are currently in an era termed Globalization 3.0 due to its rapid technological advances. This era is unique because of the newfound power of individuals to collaborate and compete on various global platforms.

Skills for a Globalized World

Globalization has further demonstrated the need for students to acquire knowledge, skills, and attitudes to successfully live, work, and take action as citizens in an interconnected world. To support students in developing multiple, intersecting civic and cultural identities and participating as citizens in a global community, teachers must also be equipped with specific skills, knowledge, and attitudes (Wagner-Tichnor et al., 2016). Wagner-Tichnor et al. (2016) further explained that global citizenship is a "layered citizenship" through which individuals possess the knowledge, skills, and attitudes that foster productive and socially just participation in inextricably connected local and global communities. For example, North Carolina's teaching standards require that teachers embrace diversity in the school community and in the world and promote global awareness and its relevance to the subjects they teach (Harrison, 2013).

The power of individuals to work and survive by competing globally is producing knowledgeable and well-rounded workers. Americans will perform well under such competition if our education systems produce knowledgeable workers who create idea-based goods and can connect "knowledge pools" worldwide, which demands high-tech (hard) skills as well as teaming, collaboration, and communication (soft) skills (Jacobson-Lundeberg, 2016, p. 10).

CHAPTER 3

METHODS

The purpose of this general qualitative study is to examine and understand student experiences within innovation learning centers (ILCs) at one secondary school in Gwinnett County, Georgia. Public education is at a critical intersection regarding how to move towards more innovative approaches. As educators, it is time for us to rethink and reform how we prepare students for their life after high school to include 21st century work. Current reforms are needed within public education to plan for a transformative learning experience for students. This study helps establish a foundation for revamping education by listening directly to students who are currently participating in ILCs and by examining those narratives to allow important themes to emerge from this data.

The conceptual framework illustrated in Chapter 1 was utilized as a foundation throughout this study to guide in understanding student experiences. This framework highlights how student experiences within ILCs were examined through the overarching categories of use of career navigation, work ethic, and innovation. This study sought to provide direction and clarification to career and technical education (CTE) and its future goals for all students. Learning about the student experiences within these spaces has the potential to reform teaching and learning. Documenting student feedback could spark interest in creating additional makerspaces that are embedded in various CTE pathways. This conceptual framework provided direction to make sense of thematic concepts that emerge from my findings.

Research Questions

This study sought to answer the following three research questions:

(1) How do students construct knowledge through participation in an ILC?

(2) How do students describe their personal development as a result of participating in an ILC?

(3) How do students describe their professional skills development as a result of participating in an ILC?

Research Design

A Generic Qualitative Study

Conducting a generic qualitative study allowed me the flexibility to collect data and present in a less rule-bound format, unlike most qualitative research methods. Although many other qualitative research methodologies exist, a qualitative interview study was most suitable for this study. One advantage of a generic qualitative study is that it is not bound by a specific set of guidelines and step-by-step procedures (Caelli et al., 2003, p. 4). Kahlke (2018) found that adapting this broader philosophy of research design brings to light new tools and approaches, prevents premature closure, challenges the relevance of findings, and keeps the work fresh and exciting (p. 2). As Caelli et al. (2003) explained, generic qualitative studies share many characteristics with other qualitative research, but "rather than focusing the study through the lens of a known methodology, they seek to do one of the following things: either they combine several methodologies or approaches or claim no particular methodological viewpoint at all" (pp. 3–4).

One disadvantage of using a generic qualitative approach is that it is not bound to a specific philosophical foundation and simply offers a summary of data. Therefore, it is often seen

as lacking in methodological clarity. Readers may be "left to speculate about the research approach, by piecing together clues based on data collection or analysis methods" (Caelli et al., p. 12). Thus, to counter the assumption that a study without a methodological foundation is not sufficiently rigorous, certain measures were employed in the research design to ensure rigor in this qualitative study.

The purpose of this generic qualitative study, also referred to as a generic qualitative approach, was to examine and understand students' own perspectives and experiences within an ILC. To accomplish this goal, a conceptual framework was used to guide this study through examination of existing literature, student interviews, and myself as the researcher. Relying on a qualitative approach, refined through a qualitative interview design, allowed the student interviewees to express their viewpoints on their experiences and learning outcomes in ILCs. Merriam and Tisdell (2016) have noted that qualitative researchers are interested in understanding the meaning people have constructed; that is, how people make sense of their world and the experiences they have in the world.

Through student interviews, this qualitative interview study provided viable responses about direct student experiences within an ILC. The data collected provided a foundation for understanding how ILCs are preparing students to adequately meet the demands of an emerging workplace. Hearing directly from students who are involved daily in these spaces guided subsequent research to determine what experiences students encounter, what skills students are gaining, and how the work being done in these spaces assists in navigating students' future careers.

Participant Recruitment and Selection

I obtained the appropriate permission to conduct research at South Gwinnett High School's (see Appendix A) makerspace program in Gwinnett County. This particular group was used as it was an identifiable makerspace of which I was aware within Gwinnett County Public Schools (GCPS). Since I am a current employee at this particular research site, gaining access to student and school data was permissible. This engineering pathway program is a class option directed by a CTE teacher. This makerspace program offers various positions that focus on specific areas and roles, such as 3D printing, laser cutting, poster/banner creation, organizer, or generalist.

Sampling

For this study, participants were recruited through purposeful sampling. In purposeful sampling, researchers intentionally select individuals and sites to learn more about or understand the central phenomenon (Creswell & Guetterman, 2019). Researchers may pose referral requests during an interview or through informal conversations with individuals at the research site (Creswell & Guetterman, 2019). The justification for using purposeful sampling was to identify participants who met certain criteria. Since I was conducting research at a site where some students were unknown to me, purposeful sampling was the most appropriate approach, as it helped me accumulate new, information-rich cases (Merriam & Tisdell, 2016). For example, I wanted to involve students who had spent time in the makerspace program and could provide detailed responses based on their experiences within the program. Because students must select this pathway themselves to participate in the makerspace, I decided to inquire about their decision to participate in the program as well.

After obtaining approval from my local school, school district, and institutional review board (see Appendix B), I proceeded with contacting the teacher of the engineering pathway. I spoke with her directly after school about my research study to obtain her permission to make a class announcement. She taught two third-level engineering classes, so I wanted to be able to select participants from both class periods. We coordinated a day on which I could come and make the announcement. All potential participants who explicitly expressed interest by providing their school and parent email addresses were given a consent form (see Appendix C). On the form, a time commitment was established as well as details regarding face-to-face interviews. The minor consent form (see Appendix D) was also sent via email to the student's parent/guardian if they were under the age of eighteen, as a majority of participants in this study were considered minors. Students who were eighteen or older were given the 18+ consent (see Appendix E). Students who returned the form to consent to study participation were qualified to move forward as participants in this study.

Sample Size

In purposeful sampling, the size of the sample is determined by informational considerations. If the purpose is to maximize information, the sampling is terminated when no new information is forthcoming from new sampled units; thus, redundancy is the criterion (Merriam & Tisdell, 2016). Bogdan and Biklen (2007) described data saturation as the point of diminishing returns where the researcher learns a decreasing amount for the time spent; she may begin hearing the same responses to interview questions or seeing the same behaviors in observations with no new insights. For example, I started hearing some of the same skills mentioned repeatedly, such as critical thinking, problem-solving, and teamwork. Additionally, since the participants matriculated through the same pathway, I would hear similar experiences

and challenges that they shared. Additionally, they all recommended this pathway for similar reasons – translation to other fields, transferable skills, and an overall fun experience. The maximum number of students interviewed was achieved when data saturation was met, but there was no preestablished number of participants. Once data saturation was achieved, I did not further pursue participants for this study.

Advantages and Limitations

The advantage of using this particular program was that it was an identifiable group to whom I had access as a current employee of the school system. In this research study, students had their voices heard as it relates to a program with which they were directly involved on a daily basis. Before outcomes are determined from ILCs, more foundational work needs to be considered as we move towards transforming education. Students providing data on their full experience will assist researchers in determining the benefits, outcomes, or limitations that these spaces may provide. Furthermore, such research could possibly lead to the recognition and implementation of enhancements to ILCs throughout GCPS.

Data Collection

The primary source of qualitative data collection for this generic qualitative study was semistructured interviews, which were collected face to face with students and audio-recorded. Interviews lasted an average of 30 minutes. Prior to the start of interviews, I completed an IRB application and submitted the application to the University of Georgia to obtain approval for the recruitment materials and permission to conduct the study. I met all policies, requirements, and protocols before and during the research process.

Interviews

An interview is a purposeful discussion between two or more people that is focused on a research topic and questions. Interviews may follow a thematic, topic-centered, biographical, or narrative approach, depending on the goals; for example, the researcher may have a number of topics, themes, or issues he/she wishes to cover, or a set of starting points for discussion, or "stories" he/she would like to invite the interviewee to tell (Merriam & Tisdell, 2016). Most qualitative research operates from the perspective that knowledge is situated and contextual, and therefore, the job of the interviewer is to ensure that the relevant contexts are brought into focus so that the situated knowledge can be produced (Mason, 2018). Another interviewing style to consider is anchor interviewing, in which the interview questions are "anchored" to what has been previously observed (Merriam & Tisdell, 2016). Interviews can also provide additional information that was missed in observations and can be used to check observation accuracy (Maxwell, 2013).

Following the classroom announcement to invite participants for my study, I began scheduling and conducting interviews during the school day. All interviews were conducted during a 90-minute advisement period. This advisement period occurs weekly, and students are allowed to use the time at their discretion to study or participate in enrichment activities, club activities, and tutoring. Interviews were conducted over a three-week period in the fall semester, that began in October. Students who expressed initial interest were excluded from the study if their consent forms were not voluntarily returned. All participants were current students in the program (i.e., not newly enrolled), had a working knowledge of the makerspace, and were coherently able to answer interview questions.

There are advantages and disadvantages to the use of interviews. One of the primary advantages of interviewing is the ability to control specific information that will generate detailed data. A disadvantage is that information can be filtered through the lens of the interviewer. Structured interviews tend to be prescriptive and impersonal, limiting the amount of divergent information. In contrast, unstructured interviews are similar to impromptu conversations with little direction. While there is potential for insightful data generation through both approaches, the targeted data may not be addressed adequately through a sole focus on one or the other. Utilizing a semistructured approach provides the organization of a structured interview but allows for the dialogic nature of an unstructured interview. Semistructured interviews are geared towards open-ended questions so that each participant can best voice his or her unconstrained experiences. A qualitative interviewer must be ready to make on-the-spot decisions about the content and sequence of the interview as it progresses and to keep everything running smoothly (Mason, 2018).

I used probing or follow-up questions to obtain additional information or to clarify the participant's meaning. Probes can be as simple as seeking more information or clarity about what the person has just said (Merriam & Tisdell, 2016). This approach also enabled a fluid conversational approach. An interview protocol, notated in Appendix F, was established to address potential probes, to which I referred during these interviews.

Preliminary Interview Questions

In giving thought to uncovering responses that would help answer my research question, I constructed the below preliminary questions. I was able to informally pilot the questions with two students, who were not part of this study. The following preliminary interview questions

were developed to prepare for conducting interviews with corresponding numbers that connected back to research question:

1. What is your role in the makerspace program? (i.e., job title) – This question could possibly uncover themes of career navigation to which a student may be directed through involvement within ILCs. (#1)
2. What does a day in the makerspace look like? Could you go through what your routine looks like? – This possible routine could uncover possible career planning and exploration that might be part of students' daily routines in the ILC. (#1)
3. What have you gained from being in this program so far? – Learning what skills or other abilities the student's participation has enhanced could uncover how ILCs assist students in skill attainment vs. a specific career objective. (#2)
4. What skills have you acquired while participating in this program? – This question could uncover specific skills that are transferable to the workplace. (#1, #2 & #3)
5. What do you plan to pursue after high school? – This question was geared towards the connection between students' current role within the ILC and/or skills obtained in preparing them for the workforce or a foundational skill that is resilient to rapid change. (#2 & #3)
6. Would you say being in this program is helping you work towards that goal? If so, explain. – This sought encourage students to draw connections to determine if ILC involvement is linked to their career aspirations and development. (#1) Additionally, work ethic may be uncovered in this question to fully understand whether interpersonal skills have been acquired. (#3)

7. What convinced you to choose this academic pathway within this school? – Understanding student initiatives may uncover work ethic and tap into career awareness skills. (#3)
8. Explain the last project that you worked on while in this makerspace. –This question could further provide details of the student experience. (#1, #2, & #3)
9. What were some of the challenges that you experienced? –This question could provide guidance to students' perceptions about their performance. (#3)
10. How did you work through those challenges? –Understanding how they worked through their challenges could help explain their confidence and/or lack of their performance. (#3)
11. When you arrived at a solution, what were your thoughts about solving the problem? – This question could provide details regarding their self-efficacy and the confidence in their work. (#3)
12. Please provide details about whether you would promote this program to other students. If you were to promote this program to other students in your school, what would you convey to them as reasons they should apply? If you would not promote this program, what is missing? – This question could help further understand student experiences within the ILC as well as the knowledge they have gained through their participation. (#2 & #3)

Data Analysis

Once the first interview was completed, data analysis began. Analysis involves working with the data, organizing it, breaking it into manageable units, coding it, and synthesizing it while searching for patterns (Bogdan & Biklen, 2007). The goal was for field notes from

interviews to be transcribed within 48 hours of completion. Data organization is key in qualitative research, as vast amounts of information are gathered during a study. In some instances, multiple student interviews occurred weekly. Interviews were transcribed using a speech recognition software program, Temi, and analyzed within a maximum of four days.

Mechanics of Data Organization

The steps that I took to accomplish work in a systematic and replicable fashion included understanding the mechanics of working with the data. Organization is a high priority when analyzing data. For this study, data included interview transcripts and my field notes taken during each participant interviews. My mechanics refer to the actual methods of physically sorting the material into piles, folders, or computer files to facilitate access to my notes. All material was securely locked and kept together. Developing a filing system allowed me to locate data in a clear and systematic manner. Along with physical organization, I also adopted a digital filing scheme for my data in a chronological order, based on when the data was collected. Bogdan and Biklen (2007) have also suggested that researchers write down notes to themselves, which might include lists of ideas and diagrams that sketch out relationships noticed during data collection. During data collection I took notes. Mechanical techniques of working with data are invaluable because they give direction to post fieldwork efforts (Bogdan & Biklen, 2007).

Interview Transcription

Interviews were transcribed with a software application known as Temi. Temi was my preference for interview transcription because I was familiar with the program and found it both easy to use and affordable. Temi allowed simple editing and reviewing, custom timestamps, speaker identification, and transcript exportation. I reviewed each transcript for accuracy to ensure that what Temi had transcribed was what the actual participant had stated. Because I had

audio-recorded the interviews, I was able to go back and replay the interviews to accurately account for their statements.

It is important not to overestimate the representational or reflective qualities of interview transcripts (Mason, 2018). A transcription is always a partial record of an interaction because it inadequately demonstrates the nonverbal aspects of an interaction – even if the research attempts to insert or link these in the form of annotations, fieldnotes, hyperlinks or software-enabled processes (Mason, 2018). Additionally, it is important to recall that judgements are made by the transcription program about which verbal utterances to turn into text, and how to do so, and for some verbal utterances there are simply no written translations (Mason, 2018). Therefore, I did not assume that transcriptions provided a fully accurate record of my interviews. I also recorded own observations and notes as well as interpretations and experiences directly from the interview.

Coding

After the interviews were transcribed, coding began. Coding is the process of segmenting and labeling text to form descriptions and broad themes in the data (Creswell & Guetterman, 2019). In everyday qualitative research parlance, codes may be defined as thematic, descriptive, conceptual, axial, interpretative, analytic, or hierarchical, but they usually have in common the idea of examining a cross-sectional data sample in the search for common themes and indexing these for easy retrieval and comparison (Mason, 2018, p. 206). Coding is used to expand the volume of data, not reduce it. Themes are similar codes aggregated to form a major idea in the database (Creswell & Guetterman, 2019).

I familiarized myself with the data by continuously reading and re-reading the interview transcripts, which allowed me to fully immerse myself within the research. For this study, I hand

coded the data and used Microsoft Excel for organizational purposes. I wrote notes in the margins of the transcripts as I was reading through, exploring the data. I started out with a broad set of codes from the interview transcripts and listed them in the Excel spreadsheet. I put an ‘x” each time that code was described to keep track of the occurrences. I color-coded codes that were similar and lumped them under the themes. The themes were determined as: knowledge construction, skill development, personal development, learning environment, and benefits of an ILC. For example, for skill development: I explicitly asked the participants, “What skills have you acquired while participating in this program?” I listed all of the skills that were mentioned and counted their occurrences, which allowed me to determine the subcategories for each theme. Another example, with knowledge construction, I was looking for ways that students learn throughout their learning process. Asking participants about the challenges they experienced and how they resolved them exemplified they were reflecting on their previous experiences through trial and error. This landed me at the subcategories of productive struggle, recall, experimentation, and analyzing.

In first-round coding, in vivo coding/open was utilized. In vivo coding is associated with the earlier stages of coding one’s data, when concepts or categories are being identified or developed (Given, 2008). In vivo codes allow the researcher to state codes in the participant’s actual words (Creswell & Guetterman, 2019). The aim of creating an in vivo code is to ensure that concepts stay as close as possible to research participants’ own words or to use their own terms because they capture a key element of what is being described. Some common examples are vernacular or memorable terms used by participants to describe a feature or type of person relevant to their social world (e.g., “hot-rodder,” “old-fashioned guy”) (Given, 2008). In vivo coding may, however, create problems of reliability and validity later in the research process

because generalizing across cases can be difficult (Given, 2008). Essentially, in vivo coding helps qualitative researchers maintain a connection to the terms used within their data while assuming more formal methods of analysis such as concept and theory building (Given, 2008).

In the second step, axial coding was utilized to input key words and commonalities into themes. Axial coding is the process of grouping one's open codes ((Merriam & Tisdell, 2016, p. 206). Locating similarities and keywords were helpful to identify themes. These themes were grouped together by similarities.

Verification

General qualitative studies and their data and results cannot be directly generalized to a wider population. Therefore, it is imperative to validate one's findings by determining their accuracy or credibility through strategies such as triangulation or member checking (Creswell & Guetterman, 2019). Triangulation is verification of the facts through examining many sources of data, thereby leading to a fuller understanding of the phenomena (Bogdan & Biklen, 2007; Creswell & Guetterman, 2019). Within triangulation, each source of information must be examined to potentially locate evidence that supports a theme. Maxwell (2013) further explained that triangulation reduces the risk that the researcher's conclusions will reflect only the biases of a specific method and allows the researcher to gain a more secure understanding of the issues within the study. Triangulation for this study included rich and thick description from the participant responses. There were accounts that supported direct quotes from each participant that supported reliability and validity of this study. Therefore, it supports a report that is accurate and credible.

Member checking was utilized to further verify this study. The member check is a strategy most often used to optimize the validity of qualitative research findings (Given, 2008).

Research participants were asked to evaluate whether the research accurately rendered their experiences that were the target of study. Member checking is an ongoing process that is fundamental to data collection. Member checking can also be a separate event occurring sometime after primary data collection has been completed with each individual participant and may occur as soon as some analysis has been derived (Given, 2008). Member checking raises a host of ethical questions, such as the following: What data or interpretations are research participants in a position to validate? What is the right course of action should participants decide that researchers got it wrong? (Given, 2008). To that end, member checking requires clarity of purpose. For this study, after data was collected, I simply gave a copy of the final interview transcript to each participant and ensured that what I presented was what the participant had stated. There were no disagreements with the interview transcripts.

Representation of Findings

The final interviewees were each assigned a pseudonym that was also identifiable within the table of contents. For each participant, a brief biography is presented for background purposes that included their student profile data, which noted their pseudonym, age, grade, and future aspirations. Their profiles were used to convey individual experiences within the ILC. Chapter 4 presents these participant profiles. Chapter 5 presents the findings. Chapter 6 discusses the findings as well as my conclusions, the implications and limitations of this study, and recommendations for future research.

CHAPTER 4

PARTICIPANT PROFILES

This qualitative study explored student experiences and involvements in an innovation learning center (ILC). The following questions were used to guide this study:

(1) How do students construct knowledge through participation in an ILC?

(2) How do students describe their personal development as a result of participating in an ILC?

(3) How do students describe their professional skills development as a result of participating in an ILC?

Semistructured interviews were the primary data collection method. These interviews were audio-recorded and transcribed using the software application Temi, as described in Chapter 3. In this chapter, I briefly describe the setting of the ILC and then present profiles of each participant that provide brief biographical details as well as their experiences in the ILC.

ILC Setting

A photograph of the classroom and lab space that was used for this study is available in Appendix G. The classroom workspace, in this study, was the computer lab, which is where students receive instructions from their teacher with any pre-lab work, such as an induction activity or bell ringer. These are used to introduce and set the foundation for the lesson. The workspace consists of various tools, such as the band and miter saw, 3D printers, and other commercial grade equipment. Students also prepare their safety gear before entering the lab workspace.

Participants

To recruit participants, a class announcement was made in the two sections of the third-level engineering class. Fourteen students were interested in participating in this study and were given consent forms approved by the institutional review board. However, only eight students turned in consent forms to formalize their participation. All students had taken the two prerequisite classes: "Foundations of Engineering" and "Technology and Engineering Concepts." All participants were enrolled in the third class of the pathway, "Engineering Applications," when interviews were conducted. Participant demographics are summarized in Table 1. As a researcher, this seemed typical that most intended to pursue engineering, as they are a part of this specific pathway. However, for the ones that didn't, it provided a different viewpoint

Table 1

Participant Demographics

Name	Age	Grade	Gender	Intended Career Plans
Amos	17	12	Male	Chemical engineering
Deon	17	12	Male	Psychology or computer science
Marcus	17	12	Male	Civil engineering
Nicole	17	12	Female	Film & media; journalism
Paige	17	12	Female	Finance
Randall	18	12	Male	Mechanical engineering
William	18	12	Male	Engineering or culinary arts
Yasir	18	12	Male	Mechanical engineering

Amos' Account

Amos and I met in an open classroom within the school building. When asked about what a day in the makerspace looked like, he shared that he usually walks to class with a friend who is in the class, gets situated, and logs into the computer:

> "There might be some type of bell ringer up front that we have to do. If not, we wait for the teacher to get started and either go onto this CAD program called Onshape or we'll go in the lab and start working."

He further explained that the workspace is a free space with the teacher being the facilitator. When asked what he had gained from being in this program, he jokingly replied "increased ear ringing" from the loud machinery. We proceeded with the interview, and he explained how he had gained an understanding of "actually managing power" tools. Amos emphasized the importance of safety in the lab, saying of power tools that "while they're useful they are very dangerous."

When asked if this program was helping him towards his goal of becoming a chemical engineer, he stated,

> "That I would say so; I mean, I'm getting more exposure to engineering disciplines and for whatever reason chemical engineering doesn't work out for me, I can always see what other disciplines there has because engineering is just that much of a vast career path. There's a lot of options."

I asked what convinced him to choose this pathway, which he appeared to find difficult to answer. He stated that he liked the robotics, which drew him towards the pathway. He mentioned that

> "I always thought it was very interesting how people were able to build these machines and they would be able to function on their own or create like a prosthetic or whatever out of just raw materials. Things like that."

He recounted that the last project he had worked on in the space was more of a review of how to square a board:

> "In order to square a board, we had to take it through a bunch of different processing, making sure to do the right measurements and of course be careful not to injure ourselves at all."

When asked about any challenges that were encountered, he stated,

> "It was mostly just trying to keep everything steady and in an orderly fashion because you have to be focused on what you're doing that if you have one little slip up, something bad can happen. There was one point when I was using the jointer and while I was moving it, it felt like my board was starting to get stuck, so I started getting a bit more concerned, but I'm just like – keep pushing, keep pushing."

He explained that nothing bad happened and they were able to successfully finish. Lastly, when asked if he could provide details of whether he would promote this program, he replied,

> "I would honestly. I mean if you want to work with power tools or if you just find something about engineering that's interesting, because at its core engineering is problem-solving, then I think it would definitely be worth their time."

He further mentioned that if students have a math or science interest, engineering is also suitable.

Deon's Account

Deon and I met in person in a collaborative workspace in the school's media center. Deon was also a student in my finance class, so this was not our first time meeting. Deon began by describing what a day in the makerspace looked like. No one was assigned a role; instead, everyone in the class could basically do what needed to be done. He explained that this year was a "little more strict, but still relatively open." Deon further explained what he had gained from being in this program, immediately mentioning critical thinking. I asked if he could elaborate more on this response, to which he replied, "It's more like finding solutions to problems that you

normally wouldn't think about because a lot of problems are already on Google or everyone else knows that already." He mentioned that he was more of a person who enjoys working by himself, but the ILC has helped him be more open to working with others.

Deon had a few options for his future career plans, such as the military and/or going to college to pursue psychology or computer science. When asked if this program was helping him towards that goal, he explained how having the skills to "create things and working with other people and thinking more will translate well." Deon enlightened me that this engineering pathway was not his first choice. He wanted to do computer science, but he was still glad that he was currently in this pathway. He was also enrolled in a computer science class that year.

I asked Deon to describe his most recent project. He explained that they were making a trinket box, which he described as "pretty simple for now." He also referred to another project for which they had to devise something that was useful in their daily lives. He and his group decided to build a sled that could be pushed and pulled during a workout. The biggest challenge they experienced while creating this sled was procrastination and "mainly getting the materials because we were all cheap." When asked to provide details about whether he would promote this program to other students, he said "Yes, it's a fun experience in that I feel like all people need to know how to build things in general." When I asked him if I had omitted anything that he would like to add, he emphasized that the experience was fun and that he had had really good teachers throughout the pathway, which made a difference.

Marcus' Account

Marcus and I met in person in a classroom within the school building. We had had a few interactions, as he was also enrolled in a peer facilitation class that I taught. However, he worked throughout the building, so I did not interact with him on a daily basis. We started off the

interview with him describing the makerspace. Marcus talked about how students work, sometimes in groups and sometimes alone. He also elaborated on their safety measures before class started and while they were working in the lab. When asked what he had gained from being in the program, he stated "Well, I mean I don't want to say nothing, but not much." I asked him to elaborate more, and he explained, "That most of the stuff that we're learning, it's stuff I researched already before I took the class because I wanted to be an engineer."

Marcus mentioned that he planned to pursue civil engineering upon graduation. He explained that the pathway has helped him learn the basics of all the machines: "If I started civil engineering and I didn't know none of the machines, I would have to start from square one, but now I'll be a little ahead of other people." Marcus said that his enjoyment of "build[ing] stuff" was his motivating factor for choosing this pathway. He further explained a current project, a trinket box. He and his group wanted to be different by making the box pentagon-shaped rather than a regular square. Their main challenge was cutting angles and ensuring accurate measurements. When asked if he could provide details about whether he would promote this program to other students, he said that he would recommend it, elaborating: "It's not for the weak. It's not for people who don't want to get their hands dirty. You have to be mature because if you're in the workspace, you can't be playing, or you'll get hurt."

Nicole's Account

Nicole and I met in-person in a classroom within the school building. I had met Nicole during an engineering fair the prior school year, at which I judged her project. Nicole explained her version of what a day in the makerspace looked like, beginning with safety procedures. Sometimes students were assigned to groups, and other times, they were on their own. She explained, "We ask for help when we need it. We are allowed to operate the machines on our

own." She stated that students had substantial experience operating the machines. She brought up the fact that they had not been able to operate the machines in her previous pathway class due to the impact of the COVID-19 pandemic. However, her previous teacher had still walked them through how to use the machines via Zoom.

When asked what she had gained from being in the program, Nicole responded that she had learned a lot, for example, that the "Internet is very useful." She recalled how she had had no idea what to do for the engineering fair, but she used her resources to come up with her innovation. She further explained that she's learned that "there are no set rules for anything; you're going to have to go off the page here and there." Nicole emphasized that she wants to see more diversity in the engineering field. She was one of just two females who volunteered to participate; however, I noticed that when I made the classroom announcement, there were very few female students enrolled in either class. Nicole had originally requested a different pathway in the business academy, so she mentioned that, regarding her assignment to engineering, "I just saw that as something telling me that I needed to be the one, like the few women in the field."

At the time of the interview, Nicole hoped to pursue a major in journalism. Lately, she had also been considering a career in math and/or accounting because "engineering is definitely a lot of math and precision. I will check my calculations over and over again." She acknowledged that the knowledge she has learned in the engineering program can help her in the future. When asked about her last project and the challenges she had experienced, she began sharing about building a birdhouse. She explained how the measurements were challenging and precision played a role, especially with the need for exact ruler readings. Ultimately, although the measurements were not fully accurate, her group was still able to construct the birdhouse, and Nicole asserted that the "bird would've been fine."

When asked if she could provide details about whether she would promote this program to other students, she responded, “I absolutely would.” I asked her to elaborate more, to which she responded that she was motivated by other students’ strong desire to create and improve: “I really feel like in school, I really do feel like there are some classes that aren’t necessarily preparing you for what you need, but this is definitely a class that does.” She explained that her participation had given her a glimpse of how the engineering world feels and “it’s not even just for engineers, it’s for anybody that wants to know how to design and fix things on your own.”

Paige’s Account

Paige and I met in a classroom within the school building. I had had a few previous encounters with Paige, as she was also enrolled in my peer facilitation class, but she also worked throughout the school building. We began the interview discussing what a day in the makerspace looked like for her. She described how sometimes there would be work on the board, similar to a bell ringer or question of the day. Sometimes they would start with the computer program, but they had a weekly project in the lab. When asked what she had gained from being in this program so far, she replied, “the perspective of an engineer.”

Paige planned to pursue finance after school, so when asked whether this program was helping her work towards that goal, she stated that it was. After further elaborating, she explained that it had helped her work together with people: “It’s helped me to be open minded to different possibilities and situations.” When asked what convinced her to choose this pathway, she informed me that “for the longest time I wanted to be Tony Stark from Iron Man. I used to just want to innovate. I was inspired so engineering was something I was happy to do.” She described her most recent project, a trinket box, for which they were placing measurements on a large piece of wooden board to ensure that they were correct. The biggest issue for her group to

consider was the added thickness to the boards, so they had to perform proper calculations and subtract a number of dimensions from their measurements; she mentioned that her group had had several iterations of that process.

When asked whether she could provide details about whether she would promote this program to other students, she replied that she certainly would. She further explained that "it opens up your mind to other ideas; finding efficient ways to make things happen. Even though it is called the STEM academy, particularly the engineering pathway, it goes along with different other pathways." I asked if I had omitted anything that she would like to add, and she stated that the pathway was fun and that they had a great teacher.

Randall's Account

Randall and I met in a collaborative workspace within the media center. Randall was also one of my finance students, so I had known him since the beginning of the school year. We jumped right into the interview discussing the makerspace. He explained it as a free opportunity workspace but that tasks were assigned. When asked about what a day in the makerspace looked like, he explained that every day was kind of a new adventure for them. He stated that "it was very amazing to feel the power in your hands but at the same time being careful because the machines could malfunction at any time." When asked about what he had gained from being the in the program, he mentioned the tools that he had been able to learn how to use, as well as coding and the Arduino board to help program robotics and other items.

Randall planned to pursue mechanical engineering. When asked whether this program was helping him work towards that goal, he strongly agreed: "I feel like if this program wasn't in this school, I would've been lost a long time ago. I wouldn't be able to decide which pathway or

major I wanted to do." Randall was originally enrolled in a business pathway but made the change to engineering.

Randall described his last project as creating a deer from wood. He used tools in the lab such as the band and miter saw. Cutting the deer out proved to be the hardest part for him and his group due to the curved lines. He described the measurements as quite challenging and that he and his group were making "errors after errors." He could not wait to get back to class to obtain assistance. Despite this difficulty, his group persevered to finish the project. When asked whether he would promote this program to other students, he said that "I definitely recommend this program. You get a glimpse into the real world while having a teacher there to guide you." He also pointed out that he thought engineers make a lot of money.

William's Account

William and I met in a classroom within the school building. We had never had any previous interactions, but we jumped right into the interview with no issues. William began explaining a day in the makerspace, beginning with the safety checks. He also mentioned that some of the machines had been down recently and that he and his friends had been able to get one working again. He mentioned that the makerspace was not a free-for-all space because that sounded chaotic—it was instead a controlled environment. He stated that students had access to tools that they could use any time with supervision.

When asked what he had gained from being in this course so far, he replied that his new teacher had helped him get to know Onshape really well, which had brought him a new outlook "where we use [Onshape] to define our constraints and actually see the material in the finish[ed] product before we put it together." William planned to start at a two- or four-year college with the potential of pursuing trade school. His backup plan was to explore culinary arts, as he was

inspired by his father, a chef. William felt that the pathway that he was in was providing "a good boost" to his future goals. When asked what convinced him to choose this pathway, he stated that "I was kind of upset when they didn't put me in computer science, but over time it just kind of grew on me." He further explained that he really liked the environment of the makerspace. Although he felt some people judged him, "as you learn those people, it's more of a constructive criticism and they're just trying to look out for you, so you don't make future mistakes."

William described his last project as building a box and how he had begun by using an exploded view. He explained that his teacher reiterated for them to simply take their time and break down certain steps instead of immediately going into the project. Some of the challenges he experienced while making the box were the technological aspects of the measurements and how every time he measured something, it would come out different. He emphasized his teacher really being a "guided hand" for them. When asked if he would recommend this pathway, he said, "Of course. I'd say even if you didn't have an interest in the field. I feel like the aspects that are applied to engineering can be used through other fields in life."

Yousif's Account

Yousif and I met in a classroom within the school building. We had had no prior interactions before this interview. We started off discussing a day in the makerspace and how students used the lab to build ideas and the makerspace to start building from scratch. Basically, Yousif stated that students started by teaming up in groups of various sizes, after which they began to design their specific ideas. Yousif also mentioned that they utilized Onshape to build their 3D object, test any malfunctions or flaws, after which they proceeded to the makerspace to build it. When asked what he had gained so far from being in this program, he mentioned many technical aspects of the available tools and machines. Yousif was a dual-enrollment student who

planned to pursue mechanical engineering. When asked if this program was helping him work towards that goal, he agreed. He stated that it "basically gives me an idea of what I would go through in real life."

Yousif began discussing a recent project in which he built a bridge to see how much pressure it could hold. The challenge that he experienced was being able to make it strong enough to withstand massive pressures and remain standing. His group needed to find a way to make the bridge strong enough, so they had to ensure a strong foundation. The main challenge they experienced was "the base kept ruining." They were limited on the supplies they could use, so if the base ended up being too weak, they would have to start over.

When asked what convinced him to choose this pathway, he stated that "I've always been into solving problems and I've always had the idea of thinking outside the box and finding my own solutions for different things." He compared the process to math having equations for different things, and he was always able to find an easier equation to solve a problem. Yousif continued by stating that the engineering pathway is a very "creative pathway where you can pursue anything you think of." When asked if there were any other reasons for his choice, he stated, "I would say it's a pathway where you can pursue your dreams, so if you have anything on your mind, you can make it come true."

CHAPTER 5

PRESENTATION OF FINDINGS

The purpose of this study was to examine student experiences, particularly knowledge construction and skill development, within innovation learning centers (ILCs). The first three chapters of this dissertation outlined the need to examine how educators are preparing students for postsecondary success. Involving students in ILCs is one approach to addressing this need. Chapter 2 detailed the history of education and how it has evolved over time, Chapter 3 defined the methodological design used in this study, and Chapter 4 presented each student's own words to convey their unique voices and experiences.

The research questions guiding this study were as follows:

(1) How do students construct knowledge through participation in an ILC?

(2) How do students describe their personal development as a result of participating in an ILC?

(3) How do students describe their professional skills development as a result of participating in an ILC?

This chapter presents the findings regarding the eight students who participated in this study. Semistructured interviews were conducted with each participant to collect data. In their interviews, participants responded to approximately 12 interview questions (see Appendix A). The students were all enrolled in the third-level engineering class, "Engineering Applications."

For this study, I transcribed interviews with the assistance of a transcription software application, Temi. I read through the transcripts and corrected any errors to produce clean copies.

After I verified that the transcriptions were accurate, I began the coding process. I utilized hand coding and Microsoft Excel to organize the data. I conducted a two-pass process using open and axial coding. Open coding creates initial categories of information about the research being studied by segmenting information (Creswell & Guetterman, 2019). In this phase, typically researchers identify categories and subcategories (Creswell & Guetterman, 2019). To start this process, I printed and read all interviews by question, selected keywords for every question, and input this information into a Microsoft Excel file, which represented a raw pass-through of the data. I continued reading the interview transcripts, uncovering words or phrases that appeared frequently. This information was categorized in the Microsoft Excel document.

Next, I conducted axial coding to input those keywords and commonalities for themes. Axial coding is the process of grouping one's open codes (Merriam & Tisdell, 2016, p. 206) by relating categories and properties and refining the category scheme (Merriam & Tisdell, 2016, p. 229). Once the axial coding was complete, I located similarities among the keywords and identified themes. Last, I grouped themes by their similarities and placed them into categories.

Overall, the study findings explained the research questions on how knowledge was constructed and the skill development associated with students' experiences and involvements within an ILC. Further conceptualization during data analysis identified five primary categories to explain student experiences in an ILC: knowledge construction, skill development, personal development, learning environment, and ILC benefits.

Table 2 illustrates the themes and categories that relate to the research questions. In the section below, I expand and discuss details of the identified themes. The bolded portions identify the overarching theme, with the subcategories under each main theme. For example, for research question 1, participants identified that they construct knowledge through productive struggle,

recall, experimentation, and analyzing. Additionally, their learning environment was a contributing factor to how they construct new knowledge, with the corresponding subcategories of a strong emphasis on workspace safety in a controlled area, their teacher as a guide, the ILC being the place where they hone in to construct their ideas and designs, and a place where they are able to have fun.

Table 2

Research Questions and Related Themes

Research Question 1: How do students construct knowledge through participation in an innovation learning center (ILC)?		
	Subcategories	**Student Related Quotes**
Theme 1: Knowledge Construction		
	Productive struggle	"I know every single group was literally struggling to get to it, but we pushed through."
	Recall	"The difficult thing about that was just mostly trying to remember all the steps in the program to get through."
	Experimentation	"It's kind of like a guiding hand put with trial and error."
	Analyzing	It's analyzing the situation that you have and how you can innovate and improve it."
Theme 2: Learning Environment		
	Safety	"Don't expect to get in the lab immediately, just because you have to go through safety checks first."
	Teacher as Facilitator	"The teacher is there, but they're not literally doing it for us."

	Construct ideas and designs	"And who's to say maybe I'll want to make something; I'll be able to because I know how to design and use the machines to create it.
	Controlled environment	"It's more of a controlled environment where we have access, but our teacher supervises us."
	Fun	"We didn't get upset about it, we just had fun with it."

Research Question 2: How do students describe their personal development as a result of participating in an ILC?

Theme 3: Personal Development		
	Desire for improvement	"I felt very accomplished, but there's always that room and desire I have to like push for more."
	Character	"It's just a very good step towards just overall character building."
	Increased confidence	I'd like to say, I was confident in my measuring ability, but I learned the correct way to read at absolute zero."
	Satisfaction	"I was just filled with excitement that it worked."
	Patience	"I would say teamwork and patience because you can't just start off with one thing, you have to build on it and improve it.
Theme 4: ILC Benefits		
	Exposure	"I'm getting more exposure to engineering disciplines."
	Challenges students	"At time we didn't get directions. Our teacher wanted to challenge us to see what we had."
	Translation to other fields	"You have to do the projects, present your information, your constraints, and overall, I feel like aspects that are applied to engineering can be used through other fields in life."

Research Question 3: How do students describe their professional skills development as a result of participating in an ILC?

Theme 5: Skill Development		
	Critical thinking	"Not saying that I'll never use engineering; I definitely will – like that critical thinking, those skills will follow me forever."
	Problem-solving	"Because I mean at its core, engineering is problem-solving."
	Leadership	"Very much people skills, cooperation, and leadership because having to take charge in a group of peers, you learn who isn't really going to be focused on the task."
	Teamwork	"It's helped me work together with people."
	Communication	"So I've been able to learn how to communicate effectively with almost everyone in the workshop."
	Creativity	It's helped my creativity. I used to think of myself as not a creative person, but with engineering all solutions are possible."

Knowledge Construction

Many ILCs focus on building a product, as indicated through hearing directly from students about their current projects and lab experience. When the student produces something in the ILC, he or she puts into action many ideas that the student possesses from prior knowledge. Technical skills may be involved; however, through trial and error, a product can be successfully constructed without the learner necessarily being able to understand all the concepts involved in the process (Valente & Blikstein, 2019). Additionally, Martinez and Stager (2019) pointed out Piagetian constructivism, "Is a well-established theory of learning indicating that people who actively construct new knowledge by combining their experiences with what they already know" (p. 35). Additionally, Morado et. al (2021) points out in their study how learning is developed by

making things, interacting with the learning environment, the available materials, and others; how learning is makerspaces is provoked and learners are inspired (pp. 1097-1098). Sometimes learning is on-the-go. Seven of the eight participants were enlightened by the process of their current project and were able to share their takeaways and learned experiences. For example, two participants mentioned the productive struggle of learning. They recalled working on a project. Although most of the groups indicated that they had some struggles in completing the project, with their development of problem-solving and teamwork skills, they were able to attain the finished product.

Students utilized prior knowledge to recall what they had learned to apply to their project development and construction processes. One participant mentioned that he was able to recall a certain step from another hands-on experience, which allowed him to find solutions to the problem. He also mentioned that it was more like finding solutions to problems that one normally would not think of because it is easy to Google an answer, but actually having to think it through to reach the ultimate goal was a way that students were able to construct knowledge. Valente and Blikstein (2019) have asked how we can understand how the learners' production process has helped them construct knowledge. In general, the evaluation of teaching and learning processes is still based on the idea that the student has learned a concept if he or she is able to successfully apply it or is able to talk about the acquired information (Valente & Blikstein, 2019, p. 256). When participants were asked to discuss their projects, any challenges, and their arrival at a solution, they were able to discuss the acquired information. They described some of their experimentation through trial and error. Nicole mentioned that she had had to just keep going even though she made mistakes, because she could always come back to it and try it a different way.

Learning Environment

Learning is a continual process of construction in which we connect to concepts through our experiences (Morado et al., 2021, p. 1096). When describing a day in the ILC, safety was the number one factor that was prevalent for seven of the eight participants. They emphasized the importance of safety when working in a space such as theirs with its heavy machinery. Amos was the most concerned with the safety aspect. He mentioned that while the tools were useful, they were also very dangerous. When asked if he had anything to add to his experience, Amos wanted to make sure that students were aware that they would not be in the lab space immediately because it takes a while to learn the processes and procedures of lab safety. He mentioned that there were numerous important safety checks that needed to be completed before students can start working in the lab. Other participants mentioned other specifics, such as the need for safety goggles and that no other items such as cell phones or headphones could be brought in.

Amos also mentioned that while many may view the ILC as a free space, students worked in a controlled environment. They had access to use the equipment at any time; however, the teacher did have to know what they were doing, and she supervised whenever a student made wood cuts or uses the heavy-duty machinery. Four of the eight participants mentioned the teacher as a facilitator or "guide" within the ILC who explained what the project is and any foundational knowledge that needed to be understood prior to starting the project. The participants explained that they were mostly on their own but were able to ask for guidance when they needed it. They were allowed to operate the machinery on their own while the teacher was present due to the trust they had built with their teacher.

Additionally, many students were enthused to answer questions about their experience within the ILC. Five of the eight participants mentioned that their experience was fun. Deon and Yasir mentioned that the ILC was a very fun experience and that they felt like all people could benefit from knowing how to build things in general. Paige explained that many times, students did not get too frustrated, and that they mostly had fun with their projects. She felt that in the end, they had really tried their best. Amos pointed out that there was a lot to learn and do sometimes, but that the ILC could be very fun most of the time. Randall mentioned that he felt really relieved when some projects were complete, but overall, he had fun working with his group to accomplish the task.

Personal Development

Six of the eight participants mentioned a desire for improvement. They all reflected on their learning and how it could have been improved once they reached their end result. Paige mentioned how much of engineering is problem solving, critical thinking, and analyzing the existing situation and ways that it could be improved and innovated. She described some challenges that she had experienced while working on her project, concluding that she felt like the project could have been enhanced but that her group had tried their hardest. Marcus described some of the challenges with digital learning, particularly in building a bridge from home during COVID-19. He explained the challenge of trying to get the metal bar to hold for support and the glue to make it stick. He ended up feeling frustrated with the project and realized there was room for improvement.

When explaining the skills gained from being in this program, one that Marcus mentioned was patience. He stated that normally he likes to finish tasks quickly; however, it takes patience to build things. He has found that this understanding has helped him in his

personal life as well. William mentioned that his confidence has increased significantly in this program. Prior to the program, he felt that he was confident in his measuring ability, but he found out that he needed additional practice. Through the proper teachings and practice, William has improved his measuring ability. He learned about using absolute zero on a ruler to verify his measurements. After William finished his projects, he was satisfied and felt very accomplished, but he stated, “There’s still always that room and desire I have to push for more.” Many of the participants also mentioned their relief and satisfaction once their projects were complete. Amos mentioned that he felt a lot of satisfaction that he was actually able to get the project done. Although he felt that his project was not perfect, it was something he had managed to finish and felt mostly very proud of.

ILC Benefits

Participants mentioned a range of benefits of an ILC, with the most common themes being exposure, challenge, and translation to other fields. Nicole mentioned that she was a student who liked everything to be handed out and given to her, but being in this program was opposite of that, challenging her to figure it out. She also mentioned that, at times, students did not receive directions as their teacher wanted to challenge them. The teacher essentially wanted to see what they were made of. Nicole really appreciated that she could get a glimpse into the engineering world and have an entire workspace dedicated to it. She stated that the ILC was not just for engineers but for anyone who wants to know how to design and fix things: “I really feel like in school. I really do feel there are some classes that aren’t necessarily preparing you for what you need, but this is definitely a class that does.” Amos pointed out that he has received more exposure to engineering disciplines overall because, “for whatever reason chemical

engineering doesn't work out for me, I can always see what other disciplines are available because engineering is just that much of a vast career path, with a lot of options."

William explained how engineering is applicable in various fields:

> "I'd say even if you didn't have an interest in the field, it's a very good step towards overall building character. You do have to do projects, present your information, present your constraints and overall, I feel like aspects that are applied to engineering can be used through other fields in life."

Yasir emphasized that his experience within the ILC gave him an idea of what he would have to go through in real life as an engineer. He found this pathway to be a "creative pathway" that allowed him to pursue anything he could think of. Marcus felt that he was able to learn the basics of the machines and that, in college, he would be ahead of those students who might not have had this opportunity in their high school. Deon was considering several career pathways, including psychology, computer science, or even joining the military. Deon felt that the skills he had developed in the ILC would translate into any career that he chose and would also help him in college. Lastly, Randall also mentioned the exposure that he had gained. He stated that what he had been learning was closely aligned to the demands of the real world and that "by this time you have had it in school, and you have a teacher who is there to guide you through."

Skill Development

ILCs can create conditions for students to be creative and critical and to solve problems (Valente & Blikstein, 2019). The first four participants all mentioned critical thinking and problem solving as skills that they continuously developed while in this program. Others offered examples of how they had utilized these skills. The primary skills mentioned during interviews were critical thinking, problem solving, leadership, teamwork, and communication. Nicole

mentioned critical thinking and problem solving several times to emphasize how "those skills…will follow me forever." Many of the participants saw problem solving as the core of engineering.

Yasir and Nicole connected the dots of math and problem solving within engineering and specifically mentioned finding their own solutions to problems. Paige provided feedback on what she had learned and gained from being in this program, including

> "the perspective of what an engineer is. A lot of people think engineers just build things, but it is really problem solving; it's critical thinking; it's analyzing the situation that you have and how you can improve and how you can innovate it."

She also noted that this pathway had helped her learn to work better with other people: "It's helped me to be open-minded to different possibilities and situations and just be a leader." Deon further emphasized that his program had taught him how to think critically and work with others, when previously he had been mostly familiar with working alone. Randall mirrored other participants' statements regarding being able to communicate better. He stated, "I've been able to learn how to communicate effectively with almost everyone in the lab because it requires you to know everyone in the workshop so that you can get along with them and do you work efficiently."

Amos focused on leadership skills, which were prevalent in participants' acknowledgements of this program's benefits. When asked about the skills that he had acquired while in this program, he stated that,

> "I would say I can get with the leadership skills as well. When you're managing a project, you have to know what you're doing, but you also have to know what everybody else is doing too. So there has to be a consensus."

Teamwork was an important factor that tied into leadership as well. William reflected on many technical skills he had acquired, but when he reflected on professional skills, he mentioned that he had also developed

> "very much people skills, cooperation, and leadership skills because having to take charge in a group of peers, adolescents, teens, you aren't really going to be focused on the task most of the time. I've learned to kind of drawback the attention to focus but still give us enough time where we can have those moments of joy to ourselves so that way it doesn't become overbearing or too much for my teammates to handle."

Connection to Conceptual Framework

The conceptual framework that guided this study included Rojewski and Hill's (2017) framework for developing and implementing workforce education, student voice theory, and constructivism.

Rojewski and Hill (2017) Framework

Rojewski and Hill's (2017) framework focused on three pillars: career navigation, work ethic, and innovation. Forming the core of the study, these concepts were brought to life through the lens of the participants.

Career Navigation

These participants participated in career navigation through career awareness and exploration. Many of them understood the vast majority of disciplines that were available in engineering, so they were aware of career opportunities available to them. The participants knew what type of engineering field they wanted to pursue in the future. While the interviews were limited as they did not directly ask how students had decided on which discipline of engineering

they wanted to pursue, they were confident in their responses, as if their own personal research was previously conducted on various disciplines.

Work Ethic

Work ethic was highlighted in Rojewski and Hill's (2017) framework as an interpersonal skill. This framework specifically emphasized communication. Many of the participants mentioned how they had to communicate while working in groups to complete their projects. As noted in Chapter 1, Jacobson-Lundeberg (2016) found communication to be foundational to other 21st century skills, such as critical thinking, problem solving, stress management, and risk taking. Their study also emphasized that communication formed the basis for collaboration. As noted in this research, participants' responses evidenced that significant collaboration was needed to complete their projects within the ILC. Participants' responses demonstrated that participation in an ILC was directly related to fostering the interpersonal skills described in Rojewski and Hill's (2017) model, including critical thinking, problem-solving, leadership, teamwork, communication and creativity. This framework offered an explicit call to action to emphasize problem-solving strategies in education, the need for which was illustrated by the participants' responses.

Within this model, work ethic also included dependability and initiative. Through participants' day-to-day tasks, students had to take initiative to work on their projects. Although they were not asked directly how they might demonstrate dependability and initiative, through their collaboration and group efforts, students remarked that they were dependent on their teammates to accomplish their goal. Understanding the extent to which each teammate was dependable is a limitation of this study, as that aspect was not explicitly stated or explored. Nevertheless, students taking the initiative to ideate, create, and bring their designs to life

demonstrated the enthusiastic and personal initiative that they displayed, as did their frequent expression of desire to improve their projects.

Innovation

Innovation was a key factor in students ideating and seeing their projects through the engineering process in the ILC. Rojewski and Hill (2017) have suggested that workforce education programs must increase efforts to allow for innovation and creativity. As noted in the findings, creativity was a subtheme of research question 3 concerning how students describe their professional skill development. Participants' responses illustrated how their ILC provided a space for them to innovate and use these specific skills. The opportunity for participants to engage in "making" in their ILC created the necessary environmental conditions for them to be creative and critical, solve problems, and work collaboratively in groups to determine one or more solutions.

Student Voice Theory

Secondly, student voice theory was directly utilized to provide direct quotes from students. As explained in Chapters 1 and 2, student voice theory seeks to understand the voice of the student and offers the opportunity to provide direct feedback and potentially inform education reform. Allowing space for student voice considers students as co-participants rather than as merely a data source. As expressed, when information is provided to students, they are allowed the right to influence their educational journey and its outcome. Their recommendations have the potential to guide future research and initiate transformation in our education system. This study explicitly allowed students an avenue to share feedback. All participants were eager to provide details of their experience. Randall even mentioned that he had never considered providing feedback about his experience and that he was happy to have the opportunity to do so.

Constructivism

Constructivism directly relates to how knowledge is constructed from a personal point of view (Merriam & Tisdell, 2016). Participant findings also addressed research question 1 concerning how students construct knowledge through ILC participation. Themes and subcategories demonstrated that participants constructed knowledge through productive struggles, recalling prior knowledge, experimenting in the lab, and analyzing their results. As explained in Chapter 2, Sharkins et al. (2017) have argued that constructivist classrooms empower students to find their own solutions, at their own pace, rather than focusing on getting answers "right" or "wrong." This ILC exemplifies a constructivist-based classroom in which students are designing and constructing their own artifacts. Martinez and Stager (2019) celebrate the fact that, "In the truest sense, children are natural engineers, and we can create classrooms that celebrate this fact" (p. 43).

CHAPTER 6

DISCUSSION

The preceding chapter presented the study findings, along with common and identified themes, and connected them to the study's underlying conceptual framework. Chapter 6 summarizes the study and offers an interpretation of the findings, implications for practice, and future research recommendations. This research aimed to record and amplify the students' voice knowledge about innovation learning centers (ILCs), their experience, and the skills they had gained through participating.

I conducted this general qualitative interview study to allow students to provide their direct feedback in an effort to fully understand their experiences within an ILC. Fourteen students explicitly expressed interest in participating, and all fourteen were given consent forms to return. Eight students returned the form and were ultimately interviewed for this study. Data saturation (Creswell and Guetterman, 2019) was met, so there was no need to follow up with the remaining six. The data was collected through semistructured interviews using the interview guide located in Appendix A. All interviews were conducted in a school setting, whether a classroom or the school's media center collaborative room. Interviews were audio-recorded and transcribed using the Temi software application. For this study, I utilized hand coding and Microsoft Excel to keep the data organized. Additionally, I conducted a two-pass process using open and axial coding. Codes were placed into themes.

Interpretation of Findings

Research question 1 asked how students constructed knowledge through participation in an ILC. Participants described their experiences during a day in the makerspace or lab, thereby highlighting their views and perspectives obtained through their project completions. Valente and Blikstein (2019) have pointed out that research has often emphasized that students use different concepts throughout their activities and projects developed in these spaces. The concepts that the participants have developed while making in such spaces have assisted them in producing their final artifacts. They have utilized background knowledge and strategy to devise with their solutions. One participant specifically mentioned strategy to explain their best method of approaching their project. Knowledge construction is happening while participants are building and innovating their ideas. Additionally, Valente and Blikstein (2019) have noted that merely producing an artifact is insufficient to demonstrate that knowledge has been constructed. Reflection also plays a part in developing awareness. Each participant mentioned how they could have improved upon their project, so it was clear that their ILC allows space for reflection.

Rojewski and Hill (2017) asked how K-12 schools can best prepare young people for the world of work. This research demonstrates how a transferable skillset is applicable across various careers. Many participants explained how being involved in the ILC was not only for students aspiring to be engineers but that all students can benefit, as they were developing skills that would assist them in any career. These participants were constructing knowledge through their projects: They start with a problem to which they find solutions through background knowledge, critical thinking, analyzing, and problem solving.

The ILC is an innovative environment in which learners can explore, create, and reflect on their learning. The participants working in this space were able to learn from one another and

build on their ideas. The teacher acted as a facilitator, guiding them along the way and evaluating the knowledge that was constructed through students' production and creating the necessary conditions to promote students' understanding of various concepts and strategies. Many participants reflected on their learning when they mentioned challenges and aspects of their projects that could be improved. As Valente and Blikstein (2019) have asserted, "learners must be able to conceptualize what was produced, which allows for the transformations of their mental schemas" (p. 260). These participants were able to conceptualize their learning and how the various skills and knowledge were connected.

Research question 2 asked how students described their personal development as a result of participating in an ILC. Many of the participants expressed increased confidence, satisfaction, patience, and a desire for improvement as result of participating in the ILC. Their confidence increased in areas such as their math ability, precision when working with certain cuts, and operating various machinery, which many did not know how to do prior to participating in the ILC. Moreover, participants who mentioned that they were used to working solo ended up feeling more confident in their skills to communicate effectively with others in the class. Satisfaction was ultimately the result of their personal and technical development while completing their projects. Participants noted their increase in patience, as often they would become frustrated while building their artifacts, yet quitting was not an option for them. Therefore, they developed the capacity for patience and regrouping. Their desire for improvement was an interesting theme amongst the participants. Organically, participants mentioned ways in which they could have improved their final product, suggesting that they were not content to stop at "good enough."

Clapp et al. (2017) identified the importance of developing students' agency and character building after speaking with educators. The connection between the conceptualization of agency and maker-centered learning reflects the need, identified by their interviewees, to help students develop an I-can-do-it orientation toward making tangible objects (Clapp et al., 2017). Participants' satisfaction was a direct reflection of realizing that they, too, could do it. One particular participant built his confidence on his accomplishment. When asked if he could elaborate on how this program pathway was "providing him a pretty good boost," William specifically stated,

> "I'm not going to lie and it seems a little childish, but when I successfully cut a piece of wood, it was just like that satisfying feeling of I just cut that wood. I was telling everybody I cut wood."

It was at that moment that William felt capable of achieving what he had put his mind to in the ILC.

Many participants mentioned the personal development of building character as a result of participating in the makerspace.

> Clapp et al. (2017) additionally pointed out that students develop certain aspects of character that are deeply linked and inform the way they think and feel about themselves: building confidence, competence, and forming identities. The building of confidence is closely related to developing a sense of identity in relationship to one's work in maker-centered classroom. What may start out as simple skill building may soon turn into important identity building based on the confidence developed through one's maker abilities (p. 26).

Research question 3 asked how students described their professional skills

development as a result of participating in an ILC. Many participants described the core of engineering as rooted in problem solving. When asked what skills had have acquired from participating in the program, participants either directly mentioned skills in their interview or offered examples of them. The most commonly cited skills are noted in Table 2 in Chapter 5: critical thinking, problem solving, leadership, teamwork, communication, and creativity.

One example of critical thinking in the findings was shared by Nicole, who stated that her teacher wanted to challenge students to think through the creative process: "I've just learned that you have to critically think, regardless of the mistakes." She stated that she would definitely use critical thinking and that it would follow her forever. Yasir stated, "I've always been into solving problems and I've always had the idea of thinking outside the box and finding my own solutions for different things." Paige mentioned that in her future career, clients would want to build trust in her, "so this pathway has helped me with my leadership skills." When asked if there was anything that she would want to convey to future students who take this pathway, she mentioned that if they wanted to improve their critical thinking, this was the pathway for them. Deon mentioned that, in this pathway, "you have to think for yourself." When asked about any other skills obtained besides critical thinking, he immediately mentioned "working with others." Randall specifically mentioned an increase in his communication skills, as all students had to learn to work with other students in the workspace. Yasir emphasized how this pathway was considered a creative pathway that provided space to tap into those creativity skills. Along similar lines, Paige stated that "I always used to think of myself as like not a creative person, but with engineering all solutions are possible, so I've just opened up my mind a lot."

Implications for Practice

This study has formally presented students' voice and their active participation in their learning, which is supported by the findings. Additionally, more research is needed around the teacher's viewpoint and documentation of knowledge construction. Many of the students interviewed have increased their skill set levels, as documented through feedback from participant interviews. They were able to share how they constructed knowledge within the projects and artifacts they were challenged to make. Yet without interviewing the teacher, it remains difficult to measure the knowledge that was constructed throughout the process. Furthermore, as a teacher, this is encouraging to know that students are seeing their participation in an ILC beneficial to their future world of work. It provides a layer of confirmation that the teacher that is facilitating instruction in this space is on the right track, per the participants' responses. While a cause and effect cannot be proven with this study, various participants referenced many beneficial factors of an ILC.

The findings were consistent with previous research. For example, Boettcher's (2017) research demonstrated how CTE programs are expanding to assist in 21st century skill development through the use of ILCs. This reflects how students are utilizing these spaces to enhance their 21st century skill set. Some of those skills evidenced in this research include critical thinking, problem solving, creativity, teamwork, and others. Van Holm (2015) pointed out that makerspaces are the latest expansion of access and opportunity to help push society over the tipping point of engagement with design. However, the need for continuous expansion and the evolution of CTE has been demonstrated as an implication of this study.

This study focused particularly on an ILC that is embedded within an engineering pathway. As identified through this research, participants stated how this pathway has allowed

them to enhance their skillset, which they view as transferable to various career pathways. This research has demonstrated a need to potentially consider incorporating ILCs that are embedded in other CTE pathways. For instance, in Gwinnett County Public Schools (GCPS), there are 17 career clusters. Within those career clusters, there are 79 pathways available. Since ILCs have been a proven way to develop skillsets needed for the future, there is a need to include ILCs in more pathways.

Lastly, during this study I was reminded that students had a year in which, although they were participating in the ILC, it was entirely online due to the COVID-19 pandemic. The framework used for this study did not allow for online learning or an alternative learning environment. However, two of the participants mentioned how they were participating at home during online learning. Nonetheless, gathering feedback from students on the effect of digitally participating in an ILC presented a need for further research. The participants mentioned how their teacher would introduce the machinery and how to use it. Additionally, the teacher was able to occasionally mail home materials for students to be active participants while at home. However, the student collaboration piece, a crucial part of student learning, was missing.

Recommendations for Future Research

This study aimed to add knowledge about students and their perspectives on participating in an ILC. Ultimately, I sought to formally document the students' voice to gain a deeper understanding of what knowledge construction, personal and professional development occurred from their participation within this space. Further research is still needed as a result of the findings in this study. Recommendations for future research would include the study of documenting knowledge construction from the teacher's point of view and how that occurs in ILCs.

Including the study of knowledge construction from the teacher's perspective would attribute to knowing whether student knowledge has been gained. The student simply completing a product is only the first step; it remains to be evaluated how the teacher would determine what that student has actually learned. Diving deeper into the evaluation of learning, examining what reflection activities are taking place, and considering how students recall knowledge would provide a foundation to formally examining knowledge construction.

Another recommendation would be to study the incorporation of ILCs that may be based in other pathways. This approach could compare personal and professional development within another pathway setting. For example, if there is an ILC embedded in a construction or agriculture pathway, research could consider what skills students are developing through their participation. This would illustrate whether students were developing technical skills and/or professional skills that would also translate within other career choices.

As we know, the impact of COVID-19 limited the uses of ILCs, as students in some regions were fully digital. Understanding the student experience in a digital ILC would provide insight into whether a digital space would be beneficial for students that may participate in an alternative secondary educational setting. Discovering if students are able to develop personal and professional skills in such settings would allow us insight into the benefits of various available instruction delivery options.

Lastly, some makerspaces are community workshops where members can access whereby a paid or public membership (Van Holm, 2017). Boettcher (2017) stated that, "Today's CTE courses enable students to develop the problem-solving, communication, and critical thinking that employers across industries report as some of the most important and the source of one of the biggest gaps in today's workforce" (p. 43). However, Van Holm (2017) notated that,

"Makerspaces have yet to produce substantial or tangible outputs that researchers can use to measure their contributions, such as number of jobs produced or patents filed" (p.165). For ILCs that are situated in a secondary setting, further research is needed to measure the outputs of student participation. At the end of the pathway, students take an end-of-pathway assessment which gives them a certification. Further research can potentially measure how those certifications are transferring to job opportunities, and/or increasing workforce retention.

Limitations

In qualitative research, how many participants to interview and how many sites to visit, haunts the novice qualitative researcher (Merriam & Tisdell, 2016). In this study, I used purposeful sampling to select students who were qualified to complete the study. Selecting those individuals who can provide the researcher with the information that she needs to answer her research questions is the most important consideration in qualitative selection (Maxwell, 2013). These were students who had taken the two prerequisite classes and returned the consent form to participate. Of the fourteen who explicitly expressed interest, only eight returned their consent forms, allowing them to move forward with an interview; thus, the size of the sample was a limitation in this study. Their responses do not represent all participants involved in an ILC, as qualitative research is not generalizable to broader populations. Therefore, these findings highlight opportunities to further investigate using a larger sample size and data collection from multiple ILCs.

Conclusion

The participants' views presented in this study have contributed to the optimistic understanding of the student experience of ILCs. The insightful findings of this smaller-scale study must now be extended through work with a larger sample, with specific attention to ILCs

that may be embedded in other pathways outside of engineering to investigate knowledge construction, personal and professional skill development. Evaluating student experiences in other ILCs would serve as a valuable contribution to CTE and offer new ways to ensure students leaving high school are equipped with the skills needed to cultivate workforce readiness. Finally, as notated in Van Holm (2017), “Makerspaces may serve to help educate a region’s workforce, particularly in mechanical arts” (p. 166). As previously stated, about a potential shortage of skilled workers, there is still a growing concern regarding in the world of manufacturing (Van Holm, 2017). As most shop classes have become obsolete, this is the closest opportunity for students to learn trade skills and engage with machinery and tools. There is great potential to incorporating ILCs inside of schools.

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APPENDIX A

LOCAL SCHOOL RESEARCH APPROVAL

(Revised 4/12/2022)

LOCAL SCHOOL RESEARCH REQUEST FORM

Name of School: South Gwinnett High School

Name of Researcher: Kandra Malone

Position or Grade: Teacher

A. Research Project

a. **Title:** Fostering 21st Century Skill Development by Engaging Secondary Students in Innovation Learning Centers

b. **Statement of Problem and research question:** This study seeks to understand and examine experiences of students within innovation learning centers. Student feedback on their experiences will impact and guide the future use of these unique spaces. The following research questions will be used to anchor this study: 1) How do students construct knowledge through participation in an ILC? How do students describe their personal development as a result of participating in an ILC? 3) How do students describe their professional skills development as a result of ILC participation?

c. **Subjects or population for the study:** Students enrolled in the engineering pathway at South Gwinnett High School.

d. **Reason for doing this research:**

x	Graduate Study at University of Georgia University/College
	Publication/Presentation
	Other (please specify)

e. **Dates research will be conducted:** 9/14/2022 to 12/16/2022

B. **All research and researchers must** a) Protect the rights and welfare of all human subjects, b) Inform students and/or parents that they have the right not to participate in the study, c) Adhere to board policies and applicable laws which govern the privacy and confidentiality of students records. Researchers requesting to conduct research across our school district must complete a GCPS Research Proposal to be reviewed by the Gwinnett IRB. Please visit our GCPS Research & Evaluation website for details and instructions.

C. This form must be completed by school employees requesting to conduct research only at the school where they work. Co-researchers participating in this request must also be employed at the same school as the researcher. **Principals ONLY need to approve/sign Local School Research Requests from their school employees.**

D. This form may also be completed by principals requesting to conduct research only at the school where they work. The assistant superintendent assigned to the principal must approve/sign the request form.

E. A copy of all Local School Research Requests must be forwarded to the Research & Evaluation Office - ISC for our files. Please send via the information below.

Via Email:
Dr. Sheril Bryan, Sheril.Bryan@gcpsk12.org & Mrs. Jennifer Rogers, Jennifer.Rogers@gcpsk12.org

[signature] 9-14-22

Principal's Signature **Date of Approval**

Assistant Supt. Signature (only if principal is the researcher) **Date of Approval**

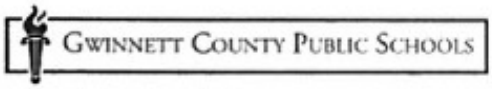
RE: Local school research request

Jennifer Rogers <Jennifer.Rogers@gcpsk12.org>
Thu 9/15/2022 12:42 PM
To: Kandra Malone <Kandra.Malone@gcpsk12.org>
Cc: Sheril Bryan <Sheril.Bryan@gcpsk12.org>;Dorothy Jarrett <Dorothy.Jarrett@gcpsk12.org>

Ms. Malone,

We've received your Local School Research Request and will place a copy in our files. Please make sure you keep a copy for your own records.

Thank you,



Jennifer Rogers
Administrative Assistant to Natalie Gore
Chief Strategy, Performance, and Accountability Officer
678.301.7090 (direct)
Website

From: Kandra Malone <Kandra.Malone@gcpsk12.org>
Sent: Thursday, September 15, 2022 11:09 AM
To: Sheril Bryan <Sheril.Bryan@gcpsk12.org>; Jennifer Rogers <Jennifer.Rogers@gcpsk12.org>
Subject: Local school research request

Good morning,

Attached is my local school research request form signed by my principal.

Thanks!

Kandra Malone

Career and Technical Education

FBLA Region 13 Adviser

School Store Sponsor

South Gwinnett High School

APPENDIX B

UGA IRB APPROVAL LETTER

UNIVERSITY OF GEORGIA

Tucker Hall, Room 212
310 E. Campus Rd.
Athens, Georgia 30602
TEL 706-542-3199 | FAX 706-542-5638
IRB@uga.edu
http://research.uga.edu/hso/irb/

Human Research Protection Program

EXEMPT DETERMINATION

October 21, 2022

Dear Roger Hill:

On 10/21/2022, the Human Subjects Office reviewed the following submission:

Title of Study:	Fostering 21st Century Skill Development by Engaging Secondary Students in Innovation Learning Centers
Investigator:	Roger Hill
Co-Investigator:	Kandra Malone
IRB ID:	PROJECT00006260
Funding:	None
Review Category:	Exempt Flex 7

We have determined that the proposed research is Exempt. The research activities may begin 10/21/2022.

Since this study was determined to be exempt, please be aware that not all future modifications will require review by the IRB. For more information please see Appendix C of the Exempt Research Policy (https://research.uga.edu/docs/policies/compliance/hso/IRB-Exempt-Review.pdf). As noted in Section C.2., you can simply notify us of modifications that will not require review via the "Add Public Comment" activity.

A progress report will be requested prior to 10/21/2027. Before or within 30 days of the progress report due date, please submit a progress report or study closure request. Submit a progress report by navigating to the active study and selecting Progress Report. The study may be closed by selecting Create Version and choosing Close Study as the submission purpose.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).

Sincerely,

Kimberly Fowler, Director
Human Subjects Office, University of Georgia

APPENDIX C

PARENTAL CONSENT FORM

Parental Consent Form

We invite your child to take part in a research study being conducted by Kandra Malone, who is a teacher at South Gwinnett High School, as part of a doctoral study titled, "Fostering 21st Century Skill Development by Engaging Secondary Students in Innovation Learning Centers." This study, as well as your rights as a parent, are described below.

Description: This study will examine the experiences of students within innovation learning centers. We are asking your student to be in the study because he/she is involved in an innovation learning center, such as the engineering lab. Your child will be asked to answer interview questions that will help guide this study. Your child will talk about their experience within the innovation learning center and specific skills that they've obtained while participating. Being in the study will guide the direction of teaching and learning as it relates to career and technical education.

Confidentiality: Your child's answers will not be associated with their name. Rather, your student will be given a pseudonym, or fictitious name, to protect their personal information. This interview audio will only be used for the purposes of research (e.g., analysis of responses, transcription of responses, etc.) and will not be available to anyone aside from the researcher. The decision to take part or not take part in this study will not affect your child's grades in school.

If your student agrees to participate in this study:

- We will collect information about the skills that your student has acquired in the innovation learning center.
- We will ask that your student meet with Kandra Malone during Thursday's advisement class that lasts from 8:48-10:27 or after school. For both options, we will meet in the media center.
- The interviews should not take more than 30 minutes to complete.
- Interviews will be audio-recorded and will be kept on my UGA secure OneDrive until the study is complete.

This study could prompt future research without additional consent. After your student's real name and identifiable information has been removed for privacy, this study could be used to help researchers, administrators, teachers, understand students' experiences, like your student who are involved in innovation learning centers.

Freedom to Withdraw or Refuse Participation: Participation is voluntary. Your child has the right to refuse to answer any of the interview questions.

Questions? Please feel free to ask the investigator/researcher any questions before signing the consent form or at any time during or after the study. If you would like to review the interview questions beforehand, then they will be provided to you.

Principal Investigator: This study is under the direction of Dr. Roger Hill; University of Georgia, College of Education, Aderhold Hall – 104C, 706-542-4100.

If you have any questions about this study, contact Kandra Malone at 931-801-8972 or via email at Kandra.Malone@gcpsk12.org. If you have any complaints or questions about your rights as a research volunteer, contact the Institutional Review Board (IRB) at IRB@uga.edu or 706-542-3199.

Informed Consent Statement

I, _____, give permission for my child, _____ to participate in the research project entitled, "Fostering 21st Century Skill Development by Engaging Secondary Students in Innovation Learning Centers." The study has been explained to me and my questions answered to my satisfaction. I understand that my child's right to withdraw from participating or refuse to participate will be respected and that his/her responses and identity will be kept confidential. I give this consent voluntarily.

_____ _____

Signature *Date*

Name of Researcher: _____

_____ _____

Signature *Date*

APPENDIX D

MINOR CONSENT FORM

Assent Script/Form for Participation in Research

Fostering 21st Century Skill Development by Engaging Secondary Students in Innovation Learning Centers."

We are doing a research study to understand your experience within an innovation learning center. We are asking you to be in the study because you are involved in the engineering lab. If you agree to be in the study, you will be asked to answer interview questions that will discuss what you do in the lab and the skills you have gained.

You do not have to say "yes" if you don't want to. No one, including your parents, will be mad at you if you say "no" now or if you change your mind later. We have also asked your parent's permission to do this. Even if your parent says "yes," you can still say "no." Remember, you can ask us to stop at any time. Your grades in school will not be affected whether you say "yes" or "no."

You can ask any questions that you have about this study. If you have a question later that you didn't think of now, you can email me at kandra.malone@gcpsk12.org.

Name of Child: _____ **Parental Permission on File:** ☐ Yes ☐ No

(For Written Assent) **Signing here means that you have read this paper or had it read to you and that you are willing to be in this study. If you don't want to be in the study, please don't sign.**

Signature of Child: _____ **Date:** _____

(For Verbal Assent) **Indicate Child's Voluntary Response to Participation:** ☐ Yes ☐ No

Signature of Researcher: _____ **Date:** _____

APPENDIX E

18+ CONSENT FORM

UNIVERSITY OF GEORGIA
CONSENT FORM

"Fostering 21st Century Skill Development by Engaging Secondary Students in Innovation Learning Centers."

You are being asked to take part in a research study. The information in this form will help you decide if you want to be in the study. Please ask the researcher(s) below if there is anything that is not clear or if you need more information.

Principal Investigator:	Dr. Roger Hill College of Education 706-542-4100	**Co-Investigator:**	Kandra Malone College of Education 931-801-8972

We are doing this research study to learn more about your participation in the engineering innovation learning center that you are a part of. We are wanting to know the skills that you have developed during your time in this space. Your answers to our research questions will help us determine what students gain from participation and future uses of these spaces.

You are being invited to be in this research study because you have been a participant in this pathway and currently enrolled in the 3rd level engineering class.

If you agree to participate in this study:

- We will collect information about the skills that you've acquired in the innovation learning center.
- We will ask you to meet with Kandra Malone during Thursday's advisement or after school in the media center. The interview should not take more than 30 minutes to complete.
- Interviews will be audio-recorded if you agree below.
- We will follow up within a month to verify what I transcribed in our interview is correctly stated.

Participation is voluntary. You can refuse to take part or stop at any time without penalty. Your grades will not be affected by refusing to participate or withdrawing from this study. If you withdraw from this study, you will still receive the Comet Cash as an incentive. Your decision to participate will have no impact in your participation in your engineering class.

Questions will only be geared toward your participation in the innovation learning center. However, if any question makes you uncomfortable, you can skip these questions if you do not wish to answer them.

Your responses may help us understand the skills you've gained from participation and guide the direction of curriculum instruction as it relates to career and technical education.

We will take steps to protect your privacy, but there is a small risk that your information could be accidentally disclosed to people not connected to the research. To reduce this risk, we will use a fake name, so your information is not identifiable. I will keep a code key in a locked cabinet and it will be destroyed after the research is complete. We will only keep information that could identify you in a locked cabinet and it will be destroyed after the research is completed.

This study could prompt future research. After your real name has been removed for privacy, this study could be used to help researchers, administrators, teachers, understand students' experience like yourself that are involved in innovation learning centers.

Incentives/compensation for participation
You will receive $5 in Comet Cash that can be used at The South Exchange (school store) or South Perk (the coffee shop). If you decide to withdraw from this study, you will still receive the Comet Cash.

Audio/Video Recording/Photographs
Audio recordings will be used for this study to properly transcribe your responses and assist in writing my data analysis. The recordings will be archived after transcription to my secure UGA OneDrive that Dr. Hill and Kandra Malone will only have access to.

Please provide initials below if you agree to have this interview audio recorded or not. You may still participate in this study even if you are not willing to have the interview recorded.

_____I do not want to have this interview recorded.
_____I am willing to have this interview recorded.

Please feel free to ask questions about this research at any time. You can contact the Principal Investigator, Dr. Hill at 706-542-4100, rbhill@uga.edu. If you have any complaints or questions about your rights as a research volunteer, contact the IRB at 706-542-3199 or by email at IRB@uga.edu.

If you agree to participate in this research study, please sign below:

_____	_____	_____
Name of Researcher	Signature	Date
_____	_____	_____
Name of Participant	Signature	Date

Please keep one copy and return the signed copy to the researcher.

APPENDIX F

INTERVIEW PROTOCOL

DEMOGRAPHIC INFORMATION

Pseudonym:

Grade level:

Date:

Location:

Start Time:

QUESTIONS

1. What is your role in the makerspace program?
    a. How long have you been in this pathway?
2. What does a day in the makerspace look like? Could you go through what your routine looks like?
3. What have you gained from being in this program so far?
4. What skills have you acquired while participating in this program?
5. What do you plan to pursue after high school?
6. Would you say being in this program is helping you work towards that goal? If so, explain.
7. What convinced you to choose this academic pathway within this school?
8. Can you explain the last project that you worked on while in this makerspace?
9. What were some of the challenges that you experienced?
10. How did you work through those challenges?
11. When you arrived at a solution, what were your thoughts about solving the problem?
12. Please provide details about whether you would promote this program to other students. If you were to promote this program to other students in your school, what would you convey to them as reasons they should apply? If you would not promote this program, what is missing?

HELPFUL STEMS

What have I omitted in my questions that you would like to add?

Possible probes:

You mentioned …, can you elaborate more on that?

You mentioned …, can you explain what that experience was like for you?

APPENDIX G

CLASSROOM AND LAB SPACE PHOTOS