Characteristics of Exemplary Science, Technology, Engineering, and Math (STEM)-Related Experiential Learning Opportunities

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ABSTRACT

Experiential opportunities at the secondary level give students the "intimate and necessary relation between the processes of actual experience and education" (Dewey, 1938, p. 19-20). Career and Technical Education classes (CTE) and co-curricular experiences, one type of experiential learning, underpin and cultivate student curiosity and often channel interests into STEM-related post-secondary disciplines and career choices. There is little existent research on the characteristics of exemplary experiential learning opportunities and the impact on stakeholders. This study is intended to identify the qualities and characteristics of an exemplary secondary experience through the lived experiences of the stakeholders; students, STEM-related teachers, and CTE/STEM Administrators.

A qualitative research design was used to examine characteristics and implications for students of four STEM-related programs throughout Virginia. Conclusions from the study include fundamental principles for providing exemplary experiential STEM-related learning opportunities. These principles include: providing hands-on, real world learning opportunities for students, providing learning opportunities that will enhance student ownership in their learning, providing unique and comprehensive career exploration opportunities for students, providing a schedule for teachers that will give them time to plan, deliver, and manage *exemplary experiential* learning opportunities, providing continual teacher and administrator in-service training relative to planning and implementing *exemplary experiential* learning opportunities, investing appropriate funds for providing *exemplary experiential* learning opportunities. Establishing and

maintaining active partnerships with business/industry and colleges/universities, and maintaining active advisory communities, providing appropriate staff to support the provision of *exemplary experiential* learning opportunities is needed. The need for adequate funding, improving perception of CTE and STEM programs, and small class sizes was also recommended.

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GENERAL AUDIENCE ABSTRACT

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DEDICATION

I dedicate this study first and foremost to my family. My parents, Betty and Harold Munn, who are constantly with me in spirit and instilled in me a deep love for learning; my brothers, David and Paul, who have provided love, support, and encouragement, as well as more than a few dinners and words of wisdom along the way. My children, Hilary, Matthew, Alicia, and Jackson and their spouses, whom I love like my own; and my grandchildren, all of whom have allowed me to take this journey with love and encouragement, while often stepping to the background so I could fulfill my goal! I owe my friends my eternal love and gratitude for enduring my self-doubt, moaning, groaning, and for stepping up to the plate to help me when I couldn't do it all. Last, and also first, my special friend Dan for making me believe this was within my reach. It takes a village to complete this task and I am blessed to be part of a very loving village

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Abbreviations and Acronyms

AAAS   The American Association for the Advancement of Science

ACTE   Association for Career and Technical Education

CTE   Career and Technical Education

CTSO   Career and Technical Service Organization

DECA   Distributive Education Clubs of America (formerly)

FBLA   Future Business Leaders of America

FCCLA   Family, Career, and Community Leaders of America

FEA   Future Educators Association

FFA   Future Farmers of America (formerly)

HOSA   Health Occupations Student Association (formerly)

ISTEM   Integrative Science, Technology, Engineering, and Mathematics

ITEA   International Technology Education Association

NAP   National Associated Press

NAEP   National Assessment of Educational Progress

NASDCTEc   National Association of State Directors of Career and Technical Education Consortium

NBPTS   National Board for Professional Teaching Standards

NCEE   National Commission on Excellence in Education

NSF   National Science Foundation

OECD   Organization for Economic Cooperation and Development

PISA   Program for International Student Assessment

SEAD   Science, Engineering, the Arts, and Design

STEM   Science, Technology, Engineering, and Mathematics

STEAM   Science, Technology, Engineering, the Arts, and Mathematics

TEL   Technology and Engineering Literacy

TSA   Technology Student Association

CHAPTER 1 INTRODUCTION

The National Economic Council, Council of Economic Advisers, and Office of Science and Technology Policy Executive Summary of 2011, *A Strategy for American Innovation,* highlights the need for

> … doing what America does best - investing in the creativity and the imagination
>
> of our people. To win the future, we must out-innovate, out-educate, and out-build
>
> the rest of the world. We also must take responsibility for our deficit, by investing
>
> in what makes America stronger, cutting what doesn't, and reforming how our
>
> government operates so it focuses on promoting our economic growth and preparing for the challenges of a new century (National Economic Council, 2011, p. 1).

The investment in experiential learning in our education system is requisite in order to "win the future", as stated above. McKeough, Lupart, & Marini state that learning transfer is "the ultimate aim of teaching"(1995, p. vii); however, attaining this goal has been problematic in educational settings. Experiential learning involves project-based, reflective, and cooperative learning opportunities, which provide rich opportunities for fostering depth and the ultimate transfer of knowledge (Furman & Sibthorp, 2013, p. 17). Co-curricular opportunities are those experiences that supplement the curriculum alongside the regular classroom activities, often after school hours. The movement toward science, technology, engineering and math (STEM) education forges on towards creating a system of tapping into naturally overlapping disciplines in meaningful ways for students. Co-curricular opportunities offer experiential learning while honing skills. Many of these co-curricular opportunities are implemented through Career and Technical Education (CTE) courses.

The National Science Foundation (NSF) began the push for excellence in STEM fields after the warning from the National Commission on Excellence in Education to the United States that "the well-being of its people, the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people" (1983). The STEM movement was born from the need to more clearly identify the integrative nature of approaches to educating, which "cannot be separated from social and aesthetic contexts, neither should the study of technology be disconnected from the study of the social studies, arts, and humanities" (Sanders, 2009, p. 21). The STEM movement has, therefore, adopted experiential learning as a key tenet for delivering instruction. Experiential education constructs knowledge and skill acquisition through problem-based, project-based, and collaborative experiences where there is natural overlap between subject areas. A key player in advancing the STEM movement is Career and Technical Education (James & Marrett, 2011, p. 60). Through experiential learning, CTE has offered students programs and instructional approaches to strengthen "students' understanding of STEM content and … attract more individuals into STEM career pathways" (STEM Brief, 2009, p. 1). CTE has a rich history of integrating into its curriculum academic and workplace skills. In addition, one of CTE's major instructional delivery strategies is that of combining curricular and co-curricular opportunities (experiential learning) that combine classroom instruction with environments where hands-on, real world problems are tackled. Therefore, for those teachers who are teaching STEM-related courses, organized co-curricular opportunities are available for their classes within the framework of CTE. In addition, because co-curricular learning opportunities have always been an integral part of the CTE curriculum, CTE teachers are in an excellent po-

sition to provide assistance to teachers who have not had this experience.

Career and Technical Education is gaining attention as an avenue to give students in public secondary classrooms an experiential learning experience for practicing a mixture of academic and workplace skills. Context is emphasized and tied directly to real life situations, within a community of peers. Learning is acquired through participation and social interaction, where there is a shared collective identity, with a shared purpose in promoting the interests of the group, as learners advance through a progression of experience from novice to expert (Jordan, et al. 2008, p. 71). In CTE classes, advancement through the stages in skill acquisition is paramount.

The lack of skills in science, technology, engineering and math necessary to keep up with the demand for innovative, competitive industries is proving problematic, driving the need to improve our educational system in order to create a world-class workforce (National Economic Council, 2011, p.3.) Educational reforms are taking root as the underpinnings of a nation of qualified workers in STEM careers are shaped. The Obama Administration "pledged to prepare an additional 100,000 STEM teachers by the end of the decade, with strong teaching skills and deep content knowledge (National Economic Council, 2011, p. 32). With the Trump administration, the support of education and specifically STEM education remains to be seen.

The CTE experience includes a mandated co-curricular piece, which broadens students' ability to apply the skills obtained in real world situations. As we look to teachers to give students opportunities to engage in creative and critical thinking, the divide between teachers of academic disciplines and career and technical education (CTE), or vocational education as it is also known, has been wide since the inception of vocational education. As students fall further behind their global counterparts in academic performance, the gulf between academics and CTE

must be bridged in order to provide students the support needed for making natural connections between theory and application. CTE courses can and should offer the practical application of academic abstracts and theories in STEM areas. Encouraging teachers to work together, collaborating across disciplines, and giving students the "time, place, and permission to think and do" (Baum-Combs, Cennamo, Newbill, 2009) should be a priority in CTE and STEM classrooms. The movement towards integrating curriculum, creating engaging formal and informal learning environments, and preparing students for further education and/or occupations could require a change in the way teachers think about their practice, and the way they are educated (Dortch, 2012, p. 7).

As teachers are trained to fulfill the role of collaborators across disciplines, care must be taken to instill awareness, between both academic and career tracks. In doing so, students will have a better ability to transfer knowledge and skills to life after school if theories and skills are applied in a meaningful way. Giving students robust and varied opportunities to use newly obtained skills is imperative. One method of providing meaningful practice is through co-curricular opportunities, which affords students the chance to learn deeply and think critically on their feet through experiential learning.

The trend towards interdisciplinary, or transdisciplinary teaching points to a positive effect on student learning. The National Association of State Directors of Career and Technical Education Consortium (NASDCTEc) outlines in their call to action the understanding that our nation's economic future depends on our ability to prepare students to be effective, innovative, productive members of society (2010, p. 8). In order to fulfill this commitment, educators are faced with creating programs that break down the barriers between CTE and academic disciplines in order to design a system that recognizes the supportive nature of CTE (2010, p. 8).

Background of the Problem

"Co-curricular refers to activities, programs, and learning experiences that complement what students are learning in school—i.e., experiences that are connected to or mirror the academic curriculum. Co-curricular activities are typically, but not always, defined by their separation from academic courses", according to the Glossary for Educational Reform, a website dedicated to defining educational terms for interested parties (http://edglossary.org/co-curricular/, 2015). The Carl D. Perkins Act of 2006 spells out the expectation for Career and Technical Education teachers to provide co-curricular experiences, or experiential learning opportunities, for their students and there are organizations within program areas that offer a variety of these opportunities, usually in the form of competitions or performances that demonstrate skills. Co-curricular opportunities vary in rigor within school districts and across program areas.

Understanding what an exemplary experiential learning experience for students encompasses would necessitate a study to evaluate value added to STEM-related courses. Experiential learning and co-curricular programs in a public school setting are intended to impact student learning and career projection. The extent of the impact on students, teachers, and the formal classroom environment should also be studied.

Statement of the Problem

Experiential learning and co-curricular opportunities as provided in Virginia Public Schools' STEM-related courses are hit or miss. The problem addressed in this study is related to identifying and analyzing experiential learning opportunities provided in selected Virginia Public Schools' STEM-related courses. It was conducted to define characteristics and cite examples of what exemplary opportunities look like, and to analyze the impact of experiential learning opportunities on students and career projection. Examining how the facilitation of an experiential

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learning experience impacts teachers, formal teaching, and the classroom environment was also a goal.

Purpose of the Study

The purpose of this study was to identify characteristics and examples of exemplary STEM experiential learning opportunities as lived by STEM stakeholders; including school administrators, teachers, and students involved in STEM opportunities and to better understand the impact on students and career trajectory. It was conducted to provide examples of exemplary experiential learning opportunities that enhance STEM-related courses, illustrate the significance these opportunities add to classroom instruction, and show how both students and teachers are positively affected.

Research Questions

The main question to be answered in this study was: What constitutes an exemplary experiential learning experience for STEM-related courses and what challenges exist that make implementation of exemplary opportunities in Virginia schools difficult? The study was guided by the following questions:

1. What are the characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived opportunities of administrators, teachers, and students?

2. What are examples of exemplary STEM-related experiential learning opportunities?

3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived opportunities of students, teachers, and administrators?

4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

Significance of the Study

The challenges of educating and creating life-long learners, which is highlighted by the critical shortage of an adequate pool of employees for businesses and employers, leave researchers examining approaches to developing successful traditional and non-traditional, formal and informal, methods of teaching (National Academy of Sciences; National Academy of Engineering, Institute of Medicine, 2010; Prinsley & Baranyai, 2015). Experiential and co-curricular learning opportunities are significant because students are engaged in meaningful experiences where skills are practiced and they are immersed in real world problem-solving events. Transfer of knowledge from the classroom to the work world is imperative. Studies show an increase in retention in college when graduates follow a CTE pathway over a traditional academic path (www.teacherlearning.com, p. 34). Although not all CTE and STEM programs are exemplary, defined criteria could assist in a holistic move towards outstanding programs statewide.

Defining characteristics and finding examples of exemplary experiential learning opportunities will help educators create valuable experiences for students. Analyzing the impact of experiential learning opportunities on student learning and career projection are important in determining the value added by these opportunities. Examining how the facilitation of an experiential learning experience impacts teachers, formal teaching, and the classroom environment can provide important information that can be used when preparing quality teachers and was also a valuable aspect of this study.

Researcher's Relationship to the Study

The researcher has worked in public schools in Virginia for over 20 years, and has integrated co-curricular opportunities into her classroom curriculum and has served as an advisor for a co-curricular student organization. It is clear to the researcher that when co-curricular oppor-

tunities are provided there is a positive impact on students' academic achievement, their evolving identity, and their future career paths were clear in some cases. The desire to create exemplary experiential learning opportunities for students is the driving force for conducting this study.

Overview of Research Design

The study used a qualitative design to answer the research questions. Understanding and interpreting lived experiences are significant for researchers in order to assist those in decision-making positions. Interpretevism, or constructivism, maintains that there is no single, observable reality, but rather multiple realities or interpretations of events (Merriam, 2009). Individuals seek to understand the world they live in by creating meaning from their experiences and interactions with others. Researchers using qualitative research methods seek out a variety of views in order to have rich data to substantiate their findings. This study focused on the lived experiences of administrators, teachers, and students and their views on exemplary experiential learning opportunities in STEM-related courses. Extreme group sampling and convenience sampling were both used for choosing study participants (Lard, 2012; Patton, 2002). Constant comparative and content analysis were used to identify common themes from data collected from semi-structured interviews (Creswell, 2013; Merriam, 2009; Patton, 2002).

Theoretical Framework

The theoretical framework for this study was based on *experiential learning theory*, which emerges from the construction of knowledge from real-life experience (Yardley, Teunissen, & Dornan, 2012, p. 161). David Kolb, one of the forefathers of experiential learning theory, credits the views of Dewey, Lewin, and Piaget as the "foremost intellectual ancestors of experiential learning theory" (Kolb, 1984, p. 15).

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Based on Kolb's conceptualization of the importance of experiences in educational settings, the following topics were explored: (a) characteristics of experiential and co-curricular opportunities in STEM classes - based on the elements identified by the experiential learning theory for an exemplary educational experience, (b) lived experiences of administrators, teachers, and students concerning STEM experiential opportunities - stemming from the lived experiences of those active stakeholders and the perceived educational and personal impact on career trajectory for students, (c) strategies used to implement exemplary experiential learning opportunities - based on those generally excepted programs qualifying as 'successful', and (d) challenges and barriers that make the implementation of these opportunities difficult or impossible to implement - arising from the struggling, ineffective, or non-existent experiential learning opportunities offered throughout the state of Virginia. A more in-depth discussion of the theoretical framework for this study is presented in Chapter 2.

Delimitations

Co-curricular and extra-curricular opportunities are often used interchangeably to describe any activity that takes place outside of the normal school day. For the purposes of this study, the term co-curricular as a form of experiential learning is the focus because it refers to an extension of the curriculum and complements what students are learning in the classroom. Secondly, school systems in the State of Virginia are varied in their experiential learning and co-curricular offerings, so programs were chosen for this study based on the perceptions of quality programs in existence across the state as viewed by university CTE and STEM faculty, and K-12 CTE and STEM stakeholders in close proximity to the researcher, the Virginia Department of Education Governor's STEM Academies, as well as other key players involved in implementing

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these perceived exemplary opportunities. There are other quality programs but due to time and other constraints, this study was restricted to four school systems.

Limitations

The main limitation for this study was the inability to research exemplary school systems outside Virginia and across the nation. For example, a neighboring state, North Carolina, has several programs in place that are worthy of examination. The findings in this study may not be generalized by the researcher to other geographic locations. However, a given reader can determine whether it can be generalized to their particular setting.

Definition of Terms

A definitions of terms is offered in order to ensure a common understanding of terms used throughout the study. A citation follows the terms not defined by the researcher.

Career and Technical Education (CTE): The National Board for Professional Teaching Standards describes CTE as secondary school courses intended to assist students in developing their interests and aptitudes while stimulating their intellectual, social, and emotional growth. "CTE provides students with opportunities to acquire skills, master concepts, and develop strategies for personal and professional success. Applied instruction within work-based learning integrating practical and theoretical knowledge across projects, as they prepare for higher education and future careers" (NBPTS, 2014).

Credentials: verification of an individual's qualifications or competence issued by a third party with the relevant authority to issue such credentials (ACTE, 2016).

Certification: "the process of giving official or legal approval to a person, company, product, etc. that has reached a particular standard" (Cambridge Dictionaries Online, 2016).

Co-curricular Experience: refers to opportunities, programs, and learning experiences that complement, in some way, what students are learning in school—i.e., opportunities that are connected to or mirror the academic curriculum. Co-curricular opportunities are typically, but not always, defined by their separation from academic courses. For example, they are ungraded, they do not allow students to earn academic credit, they may take place outside of school or after regular school hours, and they may be operated by outside organizations." (The Glossary of Education Reform, 2013).

Extra-curricular Experience: Not falling within the scope of a regular curriculum; of or relating to officially or semiofficially approved and usually organized student experiences connected with school and usually carrying no academic credit *(extracurricular sports)* (Miriam-Webster, 2015).

Integrative Science, Technology, Engineering, and Mathematics Education (ISTEM): "the application of technological/engineering design based pedagogical approaches to *intentionally* teach content and practices of science and mathematics education through the content and practices of technology/engineering education. Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels" (Wells & Ernst, 2012/2015).

Science, Technology, Engineering, and Mathematics (STEM): "an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy" (Tsupros et al., 2009).

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Organization of Dissertation

Chapter 2 consists of a presentation of the literature review including a detailed discourse of the theoretical framework. A thorough discussion of the history of STEM, CTE, and co-curricular opportunities follows. Chapter 3 outlines the research process, with headings for research design, selection and number of participants, procedures for data gathering and analysis, the pilot study, and statements regarding study rigor and quality. A presentation of the results of the study is found in Chapter 4. A synthesis of the study, lessons learned from the literature review and data analysis, conclusions reached by the researcher, recommendations for practice, and recommendations for further research are found in Chapter 5.

Summary

The search for characteristics and criteria to design exemplary experiential learning opportunities for students in STEM programs will benefit school systems in Virginia, as educators strive to create opportunities that will enable students to transfer knowledge and skills from the classroom to life. As the push to encourage students to enter STEM-related careers intensifies, providing rigorous, energizing, and meaningful opportunities alongside the regular school day curriculum becomes increasingly important. Experiential and co-curricular opportunities are so varied it is difficult to ascertain what constitutes a quality experience for students; however the importance cannot be underscored enough. These are the opportunities that can make or break a student's desire to pursue a particular career interest. Bringing together stakeholders to identify characteristics of exemplary opportunities, from the perspective of the students, teachers, and CTE & STEM Directors will help schools solidify the necessary components of a quality experiential learning activity.

CHAPTER 2 LITERATURE REVIEW

The History of Science, Technology, Engineering, Math (STEM)

In 1983, the National Commission on Excellence in Education issued a report warning that our "once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world" (p.1). The Science, Technology, Engineering and Math (STEM) movement was born partially in response to national concerns identifying the need to more adequately prepare our citizenry to be literate in the areas of science, technology, engineering, and mathematics (STEM) (NCEE, 1983; ITEA, 2000; AAAS, 1989). The American Association for the Advancement of Science (1989) noted that literacy for all Americans should

> …include being familiar with the natural world and respecting its unity;
> being aware of some of the important ways in which mathematics, tech-
> nology, and the sciences depend upon one another; understanding some of
> the concepts and principles of science; having a capacity for scientific
> ways of thinking; knowing that science mathematics, and technology are
> human enterprises, and know what that implies about their strengths and
> limitations; and being able to use scientific knowledge and ways of think-
> ing for personal and social purposes (p. xvii).

Over the past 100 years, the change in technological innovations and the impact on all sectors of our lives makes it imperative for STEM literacy to serve as a means to meaningful employment (Asunda, 2011). The push for programs that educate students in STEM areas has become a priority (NCEE, 1983; ITEA, 2000; AAAS, 1989).. Progress, however, has been slow. The Program for International Student Assessment (PISA) publishes results from assessments

given to 15 year olds globally in reading, mathematics, and science literacy every three years. For the past 15 years, scores from the US lagged behind other developed countries in the Organization for Economic Cooperation and Development (OECD). In 2009, the U.S. was the "only OECD country with a younger generation that had a lower level of high school or equivalent achievement than the older generation" (Gordon, 2014, p. 347). Countries such as China, Finland, Singapore, Japan, South Korea, Australia, and Canada have outperformed the US in all three areas. The US performed below the OECD average in all areas except reading. These results have not changed substantially since the assessments began 15 years ago (Buckley, 2013).

One area assessed by PISA is applied knowledge/literacy, or "[h]ow well can students nearing the end of compulsory schooling apply their knowledge in life situations" (Buckley, 2013, p. 4). In mathematics, there are four literacy content categories: *Quantity, Uncertainty* and *Data, Space and Shape*, and *Change and Relationships*, with the approximate percentage of scale points 25% for each category. Literacy process categories are also defined as *Formulate* (25%) - recognizing and identifying opportunities to use mathematics; *Interpret* (25%) - which is interpreting, applying and evaluating mathematical outcomes in order to determine whether results are reasonable and make sense; and the *Employ* (50%) category which carries the most weight in the percentage of score points. In this category, students are to employ "mathematical concepts, facts, procedures, and reasoning to solve mathematically-formulated problems and obtain mathematical conclusions" (Buckley, 2014, p. 9). There are six literacy proficiency levels, which assess problem-solving skills and the ability to apply subject matter knowledge. A brief description of each mathematical proficiency level is shown in Table 1.

Table 1. *Mathematical Literacy Proficiency Levels*

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Identify information and carry out routine procedures according to direct instructions in explicit situations.	Employ basic algorithms, formulae, procedures, or level conventions. Capable of direct reasoning and making literal interpretations of the results.	Execute clearly described procedures, including those that require sequential decisions. Select and apply simple problem-solving strategies.	Work effectively with explicit models that may involve constraints or making assumptions. Capable of reasoning with some night, in straightforward contexts.	Work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterizations and insight pertaining to these situations.	Apply insight along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for attacking novel situations.

(Buckley, 2013, p.11)

In 2012, only nine percent of U.S. 15 year-olds scored at a proficiency level of 5 or higher in mathematics literacy. The number scoring below level 2 in mathematics proficiency was 26% (Buckley, 2013, p. 20-21). This is lower than 36 countries and the OECD average, lagging behind countries such as Shanghai-China, Korea, Japan, Switzerland, Canada, Australia, France, and the United Kingdom (Buckley, 2013, p. 16).

As with mathematics literacy, PISA also assesses science literacy using six levels of proficiency. In science literacy, the percentage scoring at or above proficiency level 5 was 7%, with 18% scoring at level 2 or below. This performance was also below the OECD average and behind 26 other countries. As with the mathematics scores, the science scores rank behind countries such as Shanghai-China, Singapore, Japan, Finland, Australia, the United Kingdom, and

Canada. The U. S. was below the average in both the number of students who performed below

Level 2 and above Level 5. Table 2 shows the literacy levels of proficiency in science.

Table 2. *Science Literacy Proficiency Levels*

Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Present scientific explanations that are obvious and follow explicitly from given evidence.	Use direct reasoning and make literal interpretations of the results of scientific inquiry or technological problem-solving.	Identify clearly described scientific issues in a range of contexts. Select facts and knowledge to explain phenomena and apply simple models or inquiry strategies.	Select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations.	Use well-developed inquiry abilities, link knowledge appropriately, and bring critical insights to situations. Construct explanations based on evidence and arguments based on critical analysis.	Link different information sources and explanations and use evidence from those sources to justify decisions. Demonstrate advanced scientific thinking and reasoning, and use scientific understanding in support of solutions to unfamiliar scientific situations.

(Buckley, 2013, p.26)

      In keeping with the PISA assessments of mathematics and science, the National Assess-

ment of Educational Progress (NAEP) administered an assessment of technology and engineer-

ing literacy for the first time in 2014. This assessment only examines student performance in the

United States, however, so it does not show how students perform in relation to other countries.

The National Center for Educational Statistics 2014 Technology and Engineering (TEL) Grade 8

Assessment Report Card summarizes data for national average scores and percentage of students

who completely/correctly finished the steps in sample tasks. The average scores of eighth grade

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students tested in the NAEP assessments is the "largest nationally representative and continuing assessment of what America's students know and can do in various subject areas" (NCES, https://nces.ed.gov/nationsreportcard/about/) and highlights the performance of these students. The TEL assessment content areas included Technology and Society, design and systems, and information and communications technology.

The TEL report is broken down by race/ethnicity, gender, and eligibility for the national school lunch program, parent education level, type of school, location, students with disabilities, and English language learners. The statistics show that the majority of students are performing below proficiency standards. Non-white students, those of lower socio-economic status, and those with disabilities, and English language learners performed the worst. Table 3 displays the data.

Table 3. *Achievement level results of eighth-grade students assessed in NAEP technology and engineering literacy (TEL), by various student groups: 2014*

Characteristics	Below Basic	At or above Basic	At or above Proficient	At Advanced
All students	17	83	43	3
Race/ethnicity				
White	9	91	56	5
Black	35	65	18	#
Hispanic	24	76	28	1
Asian	11	89	56	7
Native Hawaiian/Other Pacific Islander	18	82	30	#
American Indian/Alaska Native	20	80	42	2
Two or more races	12	88	45	5
Gender				
Male	18	82	42	3
Female	15	85	45	3
Eligibility for National School Lunch Program				
Eligible	27	73	25	1
Not eligible	7	93	59	6
Information not available	8	92	60	7
Highest level of parental education				

Table 3. *Achievement level results of eighth-grade students assessed in NAEP technology and engineering literacy (TEL), by various student groups: 2014*

Did not finish high school	28	72	20	#
Graduated from high school	26	74	27	1
Some education after high school	11	89	44	2
Graduated from college	11	89	55	5
Unknown	33	67	20	#
Type of school				
Public	17	83	42	3
Private	7	93	60	6
School location				
City	22	78	37	3
Suburb	15	85	48	5
Town	16	84	42	2
Rural	14	86	45	3
Status as students with disabilities (SD)				
SD	51	49	13	1
Not SD	12	88	47	4
Status as English language learners (ELL)				
ELL	59	41	5	#
Not ELL	14	86	45	4

NOTE: Black includes African American and Hispanic includes Latino. Race categories exclude Hispanic origin. Private schools include Catholic, other religious, and nonsectarian private schools. SD includes students identified as having either an Individualized Education Program or protection under Section 504 of the Rehabilitation Act of 1973. The results for students with disabilities and English language learners are based on students who were assessed and cannot be generalized to the total population of such students. Detail may not sum to totals because of rounding.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2014 Technology and Engineering Literacy (TEL) Assessment.

     Clearly problems still exist but as more STEM subjects are supported in experiential learning environments and as more attention is given to transdisciplinary teaching and learning, there is hope for improvement. There are components of middle and secondary education in the U. S. that provide a model for using experiential learning and transdisciplinary learning. Career and technical education *intentionally* integrates the natural overlap between disciplines in formal and informal learning environments.

Historically all disciplines have been taught in isolation, with the exception of CTE courses. The use of integrated curriculum is found to be more student centered, more relevant, more stimulating, improves problem-solving skills and retention, while encouraging higher order thinking skills (Furner & Kumar, 2007; Fllis & Fouts, 2001; King & Wiseman, 2001; Smith & Karr-Kidwell, 2000). *Integrative* STEM (iSTEM) education, as distinguished from integrated STEM, carries integration a step further by using the "application of technological/engineering design-based pedagogical approaches to *intentionally* teach content and practices of science and mathematics education through the content and practices of technology/engineering education" (Wells & Ernst, 2012). Extending the reach of transdisciplinary teaching and learning even further, Wells & Ernst state "[i]ntegrative STEM Education is equally applicable at the natural intersections of learning within the continuum of [all] content areas, educational environments, and academic levels" (2012).

The History of Career and Technical Education

Career and Technical Education in the U.S. has evolved over decades. Formalized vocational education began in colonial times, often for indigent, orphaned, or delinquent children who were indentured to serve apprenticeships. Industrial education eventually became the institutional program developed for these students by the mid 1880's. The Old Deluder Satan Act of The Massachusetts Bay was the first education law in the U.S., which outlined requirements for academics as well as vocational skills to be taught. The Morrill Act of 1862 provided for the first time, federal funds to establish land-grant colleges. This act articulated distribution of funds to all states with the expectation of offering educational opportunities to all students. (Gordon, 2014, p. 56). For the first time, academics and vocational curricula were integrated through weaving language, mathematics, and science into agricultural, home economics, and mechanical

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arts courses (Gordon, 2014, p.58). The limited number of students prepared for higher education was immediately evident and therefore impacted secondary school curriculum (Gordon, 2014, p. 60).

The second Morrill Act of 1890 was intended to establish equal educational opportunities for black students. Southern states, many of which maintained separate colleges for African Americans, were mandated to build facilities that were equal to white schools (Gordon, 2014, p. 60). However, land grant colleges found it difficult to find a large enough number of students who had the necessary training and background to attend college. The next step was to look at secondary schools to feed colleges.

In 1917-1918, the passage of the Smith-Hughes Act provided federal aid for vocational education at the secondary level, according to Barlow's article entitled, *Coming of Age 1926-1976,* published in *American Vocational Journal* in 1976. Barlow reports that, in an effort to rescue a nation "[a]shamedly … caught by World War I with our skills down" (Barlow, 1976, p. 63), the need for vocational education for the masses came to the forefront. The Germans' were deemed better vocationally prepared than the U.S. and the Commission on National Aid to Vocational Education was formed by Congress to research this plight (Gordon, 2014). As with the Morrill Act of 1862, the Smith-Hughes Act initially provided funding for agricultural, home economics, and mechanical arts courses.

As support for vocational education continued; Walter F. George, co-author of the George-Reed, George-Ellzey, George-Deen, and George-Barden Acts, secured additional funding for secondary vocational programs (Gordon, 2014, p. 103-104). Senator George contended that well-rounded academics and vocational courses of study should not interfere with each other, but "the two could well be brought together, beginning at the secondary level…" (Gordon,

2014, p. 104). The attention on funding for strengthening instruction in science, mathematics,

foreign languages, technical programs, vocational guidance, and training was supported by the

National Defense Education Act of 1958 (Scott & Sarkees-Wircenski, 2004).

It became increasingly evident that technological changes were rapidly occurring and

therefore demanded new ways of thinking about teaching, education as a whole, and the increas-

ingly technological world of work. Funding for additional courses related to other occupational

areas such as health, marketing, business, and technology were added to the list of federally-

funded vocational programs. Table 4 shows the progression of funding for these programs.

Table 4. *Major Legislative Acts Impacting CTE*

Act	Mission/Intentions	Area of Impact	Academic Level
First Morrill Act 1862	Cornerstone for Land Grant institutions. Promoted service to the people, "liberal and practical education of the industrial classes in pursuits and professions of living" (Gordon, 2014, p. 57). The first national legislation to support vocational education. Changed the direction of higher education. Opened doors of post-secondary education to wider public audience.	Primarily formed to educate farmers, agricultural technicians; educate housewives in home economics, nutrition, and child-rearing; prepare engineers and technicians for an industrialized society.	Post-secondary colleges and universities.
Second Morrill Act 1890 (Maintenance Act)	Provide educational opportunities for African American students. Mandated that land-grant institutions be open to both white and black students, and separate but equal facilities established.	Teacher education became one of the main functions of Black Land Grant institutions; auto mechanics and woodworking were most frequently offered; engineering wasn't offered.	Post-secondary colleges and universities

Table 4. *Major Legislative Acts Impacting CTE*

Act	Mission/Intentions	Area of Impact	Academic Level
Smith-Lever Agricultural Extension Act of 1914	Provide programs of cooperative extension in agriculture and home economics; offered programs in teaching and research. Formalized the principle that states were responsible for elementary and secondary education while higher education was a national responsibility	Teacher education, agriculture, home economics.	Elementary and Secondary education.
Smith-Hughes Act of 1917	Established federal funding for secondary and postsecondary vocational training after recognizing the need for having a pool of students qualified for post-secondary education.	Agriculture, home economics, trades and industry.	Secondary and post-secondary education.
George-Deen Act of 1936	Established funding for distributive occupations and teacher education	Vocational education	Secondary education.
George-Barden Act of 1946	Increased appropriations from $14 million to $29 million. Authorized funds to support youth organizations in agriculture; Future Farmers of America and New Farmers of America. Authorized funding for Home Economics ,Trade and Industrial Education.	Agriculture, Home Economics, Trade and Industrial education.	Secondary education
George-Barden Amendments of 1956	Added practical nursing and fishery occupations. Vocational programs were provided for annually until 1962.	Vocational education	Secondary education
National Defense Education Act of 1958	Funded state and local school systems for strengthening instruction.	Science, mathematics, foreign languages, technical programs, vocational guidance, training programs.	Secondary education.

Table 4. *Major Legislative Acts Impacting CTE*

Act	Mission/Intentions	Area of Impact	Academic Level
The Vocational Education Act of 1963, 1972, 1978	Provided federal funding for residential vocational schools, work-study programs, research, and training.	Added business education and cooperative education; introduced special programs for disadvantaged, aimed to improve student achievement in reading, mathematics, written, and oral communication.	Secondary and post-secondary education.
The Carl D. Perkins Vocational Education Act of 1984 (Perkins I); Vocational and Applied Technology Education Act (Perkins II) 1990; Vocational and Technical Education Act (Perkins III) 1998; Career and Technical Education Act (Perkins IV) 2006	Perkins I promoted improved, modernized, quality vocational education programs to meet the needs of a diverse workforce, including special populations, and spur economic growth. Perkins II provided funds for the integration of academic and vocational disciplines and provided funding to states and localities to provide greater opportunities for disadvantaged populations. Perkins III called for greater accountability for student performance. Perkins IV focused on academic achievement of CTE students and strengthening the connections between secondary and post-secondary schools.	All vocational areas.	Secondary and post-secondary education.

(Gordon, 2014; Scott & Sarkees-Wircenski, 2004)

In the late 70's, the term career education was being used, somewhat broadening the outlook of vocational education. With this change came the evolution of CTE today, which transformed from "a limited number of vocational programs available at the turn of the 20th century into a broad system that encompasses a variety of challenging fields in diverse subject areas which are constantly evolving due to the changing global economy" (Association for Career and

Technical Education, 2011b, p. 1). All program areas have the stated goals of providing profes-

sional development, program recognition, and program-improvement opportunities; advocating

for the profession in both technical and academic sectors while promoting a unified direction;

increasing new members to the profession and encouraging continued involvement as active par-

ticipants (Gordon, 2009, p. 232). The diverse fields can be seen in Table 5, which shows the

eight major areas of study and sample courses offered.

Table 5. *Major Areas of Study within CTE*

Area	Sample courses offered
Agricultural Education	Horticulture, agriculture mechanics, agribusiness
Business Education	Accounting, office occupations, business management, and Information systems
Marketing Education	General merchandising, apparel and accessories marketing, real estate, financial services and marketing business and personal services marketing
Family and Consumer Science Education	Consumer and family living education as well as occupational fields such as food services, interior design, and childcare
Trade and Industrial Education	A wide range of trades such as auto mechanics, carpentry, metalworking, graphic arts, and cosmetology
Health Science Education	Practical nursing, registered nursing, medical and dental assistants, and radiologic technicians
Engineering and Technical Education	Materials, processes, and technologies that are used in manufacturing, construction, transportation, communication, and other components of industries
Technical Education	A variety of technical occupational fields such as communications, engineering-related technologies, and computer sciences

(Gordon, H., 2014, p. 235)

Vocational education, at its inception, was promoted as a way for teaching students how

to work (Barlow, 1976, p. 64). As the authors describe the viewpoint of Franklin J. Keller, prin-

cipal of Metropolitan Vocational High School in New York City on vocational education, they

paint a picture of learning by accident, trial and error, or in the case of slaves, "under the whip-lash" (Barlow, 1976, p. 64). Keller wrote,

> Duller folk often learn best when they are 'yelled at'. Average people learn by
>
> being told how and by being shown. Bright boys and girls need only watch the
>
> expert and then imitate. They learn by observation. (Barlow, 1976, p. 65).

Fortunately, others had a more enlightened view of vocational education. Grayson N. Kefauver, who was the dean of the School of Education at Stanford University, recognized the importance of vocational education when the demand for workers during war time brought an awareness of a lack of skilled workers. He wrote,

> The urgent demand for the war industries has made everyone conscious of the
>
> importance of vocational education. New Schools have been developed and the
>
> programs of existing schools have been expanded to meet this demand. Youth
>
> surveys have shown that many young people who are unable to secure employ-
>
> ment have not been trained for useful work. Hence, there has come the demand
>
> that the schools give more attention to vocational education and vocational guid-
>
> ance. We have never before witnessed as great an effort to strengthen and to ex-
>
> tend the program of vocational education in the schools of this country. (Barlow,
>
> 1976, p. 65).

This narrow focus on vocation and work led to two different tracks of education in our schools, the academic path versus the vocational path. In 1967, fifty years after President Wood-row Wilson signed the Smith-Hughes Act, an issue of the American Vocational Journal was ded-icated to reviewing the progress made (Barlow, 1976, p. 82). In reviewing agricultural education

at his university, Professor of Vocational Education at the University of Arkansas, Roy W. Roberts, remarked,

> It has been suggested that the technological changes in agriculture are not a result of happenstance but of a century of study and experimentation in agriculture. The changes have resulted in a division of labor in agriculture that has made farming and agriculture no longer synonymous … [a]gricultural educators must take cognizance of these facts and make adjustments in courses, curriculums and methods of instruction in agriculture in the secondary and post-secondary schools. (Barlow, 1976, p.83).

Initially, traditional vocational education courses were known for preparing students for jobs based on non-academic, manual labor, and related to specific trades. Procedural knowledge, rather than conceptual knowledge, was the focus. One result of dividing education into two tracks was the creation of blue collar vs. white collar workers and the stigma attached. Blue collar workers have typically been seen as not being as intelligent as white collar workers. In a study of local high school graduates in San Diego, 85 percent went on to a college or university. The study showed "a higher rate of retention in college for students from CTE than for those from traditional college prep programs" (Tech and Learning, 2009. pg. 35), calling the assumption of lesser intelligence into question.

The steer away from the strictly vocational track was formalized in the late 1990's by two historical events, a name change and a substantial overhaul in the curriculum. In 1998 the American Vocational Association (AVA) changed its name to the Association for Career and Technical Education (ACTE). Although the term "vocational" hasn't been completely eradicated, the name change was important in order to "mold its image around the portrait of modern workforce

education" (Gordon, 2014, p. 93). According to an assessment of stakeholder views in 1995, the term "vocational" conjured visions of "non-college bound training meant for someone else's children" (Gordon, 2014, p. 93). The term was a major reason people did not join the organization, and it was associated with lower-level skills and outdated programs. Today, on the ACTE website, career and technical education is described as "cutting edge, rigorous and relevant", preparing youth for "a wide range of high-wage, high-skill, high-demand careers" (ACTE, 2016b).

On the ACTE website, 16 career clusters are identified and CTE is credited with preparing students to be "college and career-ready by providing core academic skills and technical, job-specific skills" and integrating "academics in a rigorous and relevant curriculum" (ACTE, 2016b). This integration of academic skills has long been a part of career and technical education, however, academic educators have been slower to understand and/or accept the part CTE plays in honing academic skills in students. A study of administrators, math and science teachers, CTE teachers, and guidance counselors on the perceptions of CTE and the impact on students' life after graduation in the state of Nebraska found that math and science teachers, and guidance counselors were the most ambivalent. They didn't recognize the impact, however, CTE teachers and administrators were more likely to have a positive view of CTE and the academic impact on students (Herian, 2010). This lack of recognition in academic educators isn't unusual, but hopefully it is changing with the STEM movement. The positive impact of CTE on students' lives is cited by ACTE with the following statistics:

- Four out of five secondary CTE graduates who pursued postsecondary education after high school had earned a credential or were still enrolled two years later.

- A person with a CTE-related associate degree or credential will earn on average between $4000 and $19,000 more a year than a person with a humanities associate degree.

- 27 percent of people with less than an associate degree, including licenses and certificates, earn more than the average bachelor degree recipient.

There are several types of credentials available for CTE students. A credential is defined on the ACTE website as a verification of an individual's qualifications or competence issued by a third party with the relevant authority to issue such credentials. There are four types of credentials recognized: certificates, certifications, licenses, and degrees. Certifications are the most widely used by high school CTE programs. Table 6 exhibits the different credentials from the ACTE website.

Table 6. *Recognized Types of Credentials*

	Certificate	**Certification**	**Degree**	**License**
Awarded by …	Education Institution	Business, trade associations, industry	Education Institution	Government Agency
Results from …	Course of Study	Assessment	Course of Study	Meeting Requirements
Indicates …	Education	Skill Mastery	Education	Legal Permission
Completed in …	>2 years	Variable	2+ Years	Variable
Maintained by …	N/A	Skill practice, re-assessment	N/A	Re-application, continuing education

Table 6. *Recognized Types of Credentials*

Example …	ServSafe Food Handler, Green Manufacturing Specialist, Certificate in Business Administration	Certified Welder (CW), Certified Logistics Technician (CLT), Certified International Information Systems Security Professional (CISSP)	Bachelor of Science, Master of Science, Doctor of Engineering	Registered Nurse (RN), Cosmetologist, Master Plumber

(ACTE, 2016, Retrieved from https://www.acteonline.org/cte/#.VpJ-X5MrIdU)

Today, decreasing federal and state budgets, and President Obama's *Race to the Top by 2014* effort, along with the accountability measures outlined in the *No Child Left Behind Act*, makes it crucial for CTE to authenticate why providing a better Career and Technical Education program at the high school level is important (Hersperger, Slate, & Edmondson, 2013, p. 157). The Office of the Press Secretary of the White House published a Fact Sheet in 2009 on the *Race to the Top* initiative. The emphasis is on reform in the following areas:

- Designing and implementing rigorous standards and high quality assessments by encouraging states to work jointly toward a system of common academic standards that builds toward college and career readiness, and that includes improved assessments designed to measure critical knowledge and high-order thinking skills.

- Attracting and keeping great teachers and leaders in America's classrooms by expanding effective support to teachers and principals; reforming and improving teacher preparation; revising teacher evaluation, compensation, and retention policies to encourage and reward effectiveness; and working to ensure that our most

talented teachers are placed in the schools and subjects where they are needed the most.

- Supporting data systems that inform decisions and improve instruction by implementing a statewide longitudinal data system, assessing and using data to drive instruction, and making data more accessible to key stakeholders.

- Using innovation and effective approaches to turn-around struggling schools by asking states to prioritize and transform persistently low-performing schools.

- Demonstrating and sustaining education reform by promoting collaborations between business leaders, educators, and other stakeholders to raise student achievement and close achievement gaps, and by expanding support for high-performing public charter schools, reinvigorating math and science education, and promoting other conditions favorable to innovation and reform (Office of the Press Secretary, 2009).

CTE & STEM

The journey from land grant institutions with programs in agriculture, home economics, and mechanics to secondary and post-secondary programs focusing on transdisciplinary programs stressing innovation and entrepreneurship has been a long one. Virginia Tech, a land-grant college established in 1872, began as Virginia Agricultural and Mechanical College. A bachelor of science degree was begun in the early 1900's in the areas of agriculture, horticulture, applied chemistry, general science, civil engineering, mechanical engineering, and electrical engineering. During the administration of Marshall Hahn, whose first day as president fell on July 2, 1962, the 100th anniversary of the signing of the first Morrill Land-Grant Act, the institution expanded programs more than any other time in the history of the school, and began attaching

"university", rather than institution to its name. In October of 1964, a public commitment was made to offer a "quality university education" and in 1970 there was an official name change to Virginia Polytechnic Institute and State University. Under Hahn's guidance, women were allowed to enroll in all courses in 1964 for the first time, and enrollment grew from 5,500 students in 1963 to over 13,000 in 1971, including almost 3,500 women (Robertson, 1972).

In his November 2015 letter to the Virginia Tech community, current president Timothy Sands speaks of preparing students well for the future, promoting "guided and experiential learning and mentorship, as these elements associate strongly with well-being and engagement" (Sands, 2015, para. 7). He speaks of staying true to the land-grant mission of restoring affordability for all students and providing academically prepared individuals "to serve humanity at the highest levels of their ability" (Sands, 2015, para. 9).

Career and technical education programs & STEM have a natural association. As CTE becomes recognized as more of a major player in cultivating students with academic and technical skills, the partnership could evolve into the schools envisioned by early proponents of vocational education. The current "maker movement … is the umbrella term for independent innovators, designers and tinkerers … a convergence of computer hackers and traditional artisans" (Voight, 2014, para. 2). This is important because according to *USA Today*, makers pump $29 billion into the world economy each year (Stewart, 2013). As the cost for technology such as 3D printers, Arduinos, and Raspberry PI computers decline, consumers are becoming innovators and many companies are interested in supporting this movement (Bajarin, 2014). As educators and industry officials embrace the practice of interdisciplinary collaboration (e.g. STEM, STEAM, SEAD), CTE & STEM classrooms provide the playground to manifest making and innovation in our schools.

Transdisciplinary learning environments where creative, critical thinking skills are developed in opportunities designed for problem-solving are necessary components of exemplary CTE & STEM programs. The maker movement, endorsed by the Obama Administration, is an example of the push towards innovative thinking, and applied STEM skills (Obama, Presidential Proclamation, 2014). The National Day of Making 2014, also known as the White House Maker Faire, was a celebration of generations of American innovators, intent on highlighting current entrepreneurs, educators, and innovators who are "sparking creativity and encouraging invention in … communities" (Obama, 2014). According to the proclamation,

> I am committed to helping Americans of all ages bring their ideas to life. Alongside our partners, my Administration is getting tens of thousands of young people involved in making. We are supporting an apprenticeship program for modern manufacturing and encouraging startups to build their products here at home. Because science, technology, engineering, and mathematics (STEM) are essential to invention… "(Obama, 2014).

Since its inception, CTE has been the training ground of "makers". The national awareness of the maker movement is now bringing CTE into the limelight. With funding through the Perkins Act, CTE is better situated than most disciplines to house STEM initiatives.

The Carl D. Perkins Act

In 1984, the federal government enacted one of five acts authorizing federal funding of career and technical education, the Carl D. Perkins Vocational and Technical Education Act of 1984 (Perkins III). Perkins money is the primary source of funding for the improvement of career and technical education programs. The most recent reauthorization occurred in 2006, which changed the name to the Carl D. Perkins Career and Technical Education Act of 2006 (Perkins

IV) (Dortch, 2012, p. 1). The reauthorization of the Perkins Act of 2006 moved to "increase the focus on the academic achievement of career and technical education students, strengthen the connections between secondary and postsecondary education, and improve state and local accountability" (U. S. Department of Education, 2007). Increased emphasis on the academic, career, and technical skills of students enrolled in CTE programs now makes accountability mandatory. On the Perkins Collaborative Resource Network website Commonly Asked Questions section, career and technical education is defined as "organized educational activities that offer a sequence of courses that provides the individual with the academic and technical knowledge and skills the individuals need to prepare for further education and for careers in current or emerging employment sectors" (U. S. Department of Education, 2011). Perkins IV requires increased opportunities for developing rigorous and challenging CTE programs, integrating academic and technical standards in order to prepare students as competitive, high skilled workers ready for the global workforce and a changing global economy The need for education that advances technology, computer science, math, and science, or STEM fields, is paramount (Hersperger, Slate, & Edmonson, 2013; NCEE, 1983).

The push for accountability for educators heading into the 21st century affected academic teachers and CTE teachers alike. The US Department of Education states the reauthorization of Perkins IV set state and local program requirements in place "to assess the effectiveness of the state in achieving statewide progress in career and technical education, and to optimize the return of investment of Federal funds in career and technical education activities" (as cited in Hersperger et al., 2013. p. 158). Perkins IV was funded at $1.1 billion in 2012 (Dortch, 2013, pg. 1).

Perkins IV outlines accountability from state CTE opportunities through establishing the Perkins Core Indicators of Performance requirements.   These indicators consist of gathering data on performance levels in STEM disciplines and other academic areas, such as language arts, technical skills, graduation rates, non-traditional participation and completion, certification, and degree completion. Performance data is collected on the 13 indicators for all students and also on special populations. A program improvement plan must be put into place if acceptable levels are not maintained (U. S. Dept. of Education, 2011).

In 2012, a blueprint for reauthorization of the Perkins Act was created by the Obama Administration in an effort to create CTE programs which prepare students for post-secondary education or the job force (Dortch, 2012, p. 1). The blueprint is intended to "usher in a new era of rigorous, relevant, and results-driven CTE shaped by four core principles" (Dortch, 2012, p. 1, U. S. Department of Education, 2012). These core principles spell out more effective CTE programs that are aligned with the needs of the labor market and industry; the principles require stronger collaboration between all stakeholders to improve CTE programs; a clear, meaningful accountability system for performance; and a systemic reform of policies to support increased innovation (Dortch, 2012, p. 2, U. S. Department of Education, 2012).

Learning Theories

The purpose of this study was to identify characteristics and examples of exemplary integrative STEM co-curricular opportunities, using Kolb's experiential learning theory as the basis for creating exemplary opportunities. Examining the roots of learning theory is needed to better follow the evolution of the experiential learning theory. Outside of educational research, experiential learning has underpinnings in the works of therapeutic psychology researchers Carl Jung, Erik Erikson, and Abraham Maslow, to name a few (Jordan, et al., 2008). There are subtle differ-

ences in the definition of experience in learning situations between researchers. Kolb defines experiential learning as the process by which knowledge is transformed though experience (Kolb, 1984, p. 38). Mezirow views the process by interpreting prior knowledge to revise the meaning of an individual's experience and use it as a guide for actions in the future (Mezirow, 2000, p. 5). Wilson believes an informal experience can permanently change knowledge or behavior as a result of a formal educational experience or training (Wilson, 2005, p. 7). Beard and Wilson argue that the process of bringing together the person's inner world with the environment in active engagement helps them make sense of the process (Beard and Wilson, 2006, p. 19). Experiential learning theory stems from the basic learning philosophies as viewed by Plato, Socrates, and Aristotle.

In western educational thought, there are three basic philosophies of learning; ideas, experience, and development (Jordan, A., Carlile, O., & Stack, A., 2008, p. 10). Idealism stemmed from Plato, Socrates, and Descartes', and is based on the belief that ideas come before experience, experience being "misleading, transient, and personal" (Jordan, et al., 2008, p. 22). Idealism emphasizes theory before practice, logical thinking, and a liberal education (p. 11).

Experience is the second basic western philosophy of education. Learning comes from doing and is more important than theory (Jordan, et al., 2008, p. 11). Within the category of experience are two distinct philosophical stances: empiricists, who believe that learners are passive receivers, with teachers organizing experiences for students, and romanticists, who assert that formal educational experiences are restrictive and unnecessary (p. 12). Empiricism is best understood as the 'filling of empty vessels' or giving knowledge to a passive learner, and requires nothing more than willingness on the part of the learner (p. 13). Learning is predictable, and best used in training skills, where competencies can be scrutinized (p. 14).

In the 18th century, Jean-Jacques Rousseau claimed that children learned through natural consequences, and although he felt humans were naturally good, civilization was corrupting and children shouldn't be exposed to society until their moral compass had been established. Romanticism considered emotions and the education of the individual, with importance given to feelings and the senses. This was the beginning of child-centered education, with teachers as facilitators who provide a rich educational environment (p. 14-15).

The third western educational philosophical category is development, which stems from Aristotle and his view of humans as growing, feeling, thinking beings, with a natural desire to know things (p. 16). Jean Piaget and Jerome Bruner are often associated with constructivism, which posits that learning comes from actively engaging in an environment that explores the world, and due to the interactions between existing knowledge and new knowledge, conceptual changes occur and new meaning is formed. Exploration and discovery are valued over teachers imposing their authority and solutions to problems (p. 57).

Constructivist thinking embeds prior knowledge within new, broadening context and giving children a framework for predicting the future, according to Bruner in *Toward a Theory of Instruction* (1996). Social constructivism maintains that there is also a social aspect to learning, which shapes how individuals think and attach meaning to experiences (Jordan, et al., 2008, p. 59). Unlike Piaget, Lev Vygotsky held that teachers were important in guiding and passing on theoretical knowledge in the Zone of Proximal Development (ZPD), where teachers and learners interact (p. 59-60). Albert Bandura, a Canadian psychologist, suggested in the 1960's that modeling, giving students examples of good work, allows them to learn by observation (p. 60).

Constructivism, as a learning theory, impacts modern education by acknowledging individual learning styles, examining individual strengths and multiple intelligences, exploring inno-

vation, and implementing community-based, and problem-based learning. Peer interaction and discussion is an important aspect, while nurturing curiosity, using interactive materials, and creating opportunities for students to engage in opportunities that encourage autonomy, and socio-cognitive conflict (Jordan, et al., 2008, p. 62-63). Building on Piaget's constructivist theory, Seymour Papert and his theory of *constructionism* contends that "learning is situated and is best approached by 'diving into' situations" while showing their understanding through demonstration and artifacts (Becker, Hodge, & Sepelyak, 2010, p. 9). Fry, Ketteridge, and Marshall posit a constructivist perspective, "experience gained through life, education and work should play a central role in learning … called experiential learning" (Fry, et al., 2009).

Theoretical Framework

John Dewey stated, "…there is an intimate and necessary relation between the processes of actual experience and education" (Dewey, 1938, p. 19-20). John Dewey described the behavior of young children and the natural curiosity they exhibit. As stated by the "wisest of the Greeks … wonder is the mother of all science" (1910, p. 31). Dewey uses the words of Wordsworth to further exemplify curiosity and wonder,

> The eye it cannot choose but see;
>
> We cannot bid the ear be still;
>
> Our bodies feel, where're they be,
>
> Against or with our will (1910, p. 31)

He goes on to describe the curious mind, alert, exploring, and constantly seeking material for thought, and "the only sure guarantee of the acquisition of the primary facts upon which inference must base itself" (1910, p. 31). Dewey further posits that social stimuli develops a higher stage of curiosity, constantly questioning but without any motive other than an eagerness to un-

derstand the world. The feeling that "the facts that directly meet the senses are not the whole story, that there is more behind them and more to come from them, lies the germ of intellectual curiosity" (1910, p. 32). Unfortunately he also describes how many people lose their sense of curiosity if it isn't challenged. He quotes Francis Bacon, who said, "we must become as little children in order to enter the kingdom of science" (1910, p. 33). According to Dewey, it is the teacher's job to

> … keep alive the sacred spark of wonder and to fan the flame that already glows. His problem is to protect the spirit of inquiry, to keep it from becoming blasé from overexcitement, wooden from routine, fossilized through dogmatic instruction, or dissipated by random exercise upon trivial things (1910, p. 34).

Although many educators embrace the teachings of Dewey, the challenges associated with implementing experiential learning in traditional classrooms are formidable. David Kolb, in *Experiential learning: Experience as the source of learning and development,* spells out a framework for learning where the connections between education, work, and personal development are forged to supplement formal education and generate an environment where each individual can reach their full potential (1984, p. 4). Learning occurs differently for individuals as they react to their perceptions of their individual experiences. The social interaction exhibited in experiential learning along with situated context is fundamental to learning (Yardly, et al., 2012, p. 161).

Experiential learning theory differs from the traditional view of learning in the viewpoint that ideas are formed through experience, and continually modified through a process that is emergent, not indicative of a particular outcome, because knowledge is constantly changing as experiences impact knowing (Kolb, 1984, p. 26). Therefore, basing learning on outcomes rather

than process doesn't allow for the changing, modification, and reshaping of ideas as learners have more experiences (Bruner, 1966, p. 2).

In experiential learning, teachers provide opportunities and then help students process the experience. Social and problem-based experiences with a work or community service component improve perceptual skills, problem-recognition, and provide students with an opportunity to react to the experience. Intentional reflection is a key element to allow examination and organization of thoughts about the experience, suggesting that experiential learning in and of itself is not sufficient (Boud, Keogh, & Walker, 2013; Jordan, et al., 2008). Active engagement within context, linking new knowledge to prior knowledge, gives students a better ability to transfer knowledge from the abstract to future practice (Yardley et al., 2012).

Experiential learning is a central component of constructionist learning theory and paramount to exemplary CTE and STEM programs. Kolb's experiential learning model consists of four stages of the learning process; (1) concrete experience as the basis for observation, (2) reflection and theories formed from observations, (3) new concepts and hypothesis are formed in new experiences, and finally (4) active experimentation, where one tries out what was learned (Boud, Keogh, & Walker, 2013, p. 12). Figure 1 depicts Kolb's Experiential Learning Model.

The four cycles of the model actually spiral, through many iterations of doing, reflection, creating meaning and transforming by the action, transference to other contexts where the cycle begins again (Kolb & Kolb, 2010, p. 3). The relationship between play, imagination, creativity, cognitive and emotional growth is supported by years of empirical evidence (Callois, 2001; Dewey, 1990; Erikson 1950; Freud, 1965; Gadamer, 1992; Kolb & Kolb, 2010; Mainemelis & Ronson, 2006; Miller, 1974; Piaget, 1962; Sutton-Smith, 1997; Turner, 1974; Vygotsky, 1966; Winnicott, 1971). Play, as a precursor to problem solving, spurs children to ask questions, to ask

why and develop their knowledge through social constructions such as talking and interacting (Morrison, 2006).
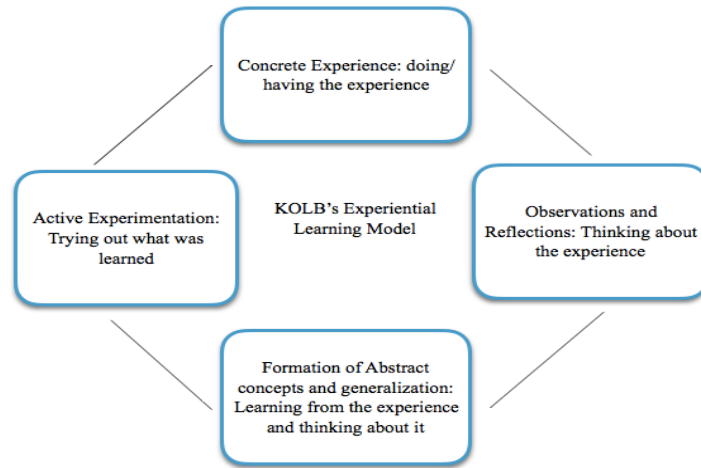
There are many differing views on what constitutes 'play'. Kolb & Kolb outline a framework for understanding play in learning and development in their study of a ludic learning space (2010). Two contrasting poles exist within the term play: "irrational and rational, playful and serious, imaginary and real, arbitrary and rule bound" (Huizinga, 1950; Hutt, 1981; Kolb & Kolb, 2010; Spariosu, 1989; Sutton-Smith, 1997; Turner, 1974). In some forms of play, there is a competitive relationship that is the primary goal such as in group games, theater, or music (Huizinga, 1950; Kolb & Kolb, 2010). Epistemic play, or serious, focused play generally leads to intense investigation which then transitions into a more relaxed mode, or ludic play, where the knowledge gained through epistemic play is applied (Hutt, 1981; Kolb & Kolb, 2010).

Kolb & Kolb contend that play allows people to establish their own criteria for excellence and achieve higher order learning through creating their own rules, allowing them to take control of their own learning. Also, placing equal value on process and outcomes. Only through paying attention to both process and outcome can meaning be acquired. Lastly, the recursive nature of

play gives individuals the time to "mature and deepen, moment to moment, stage by stage" (Kolb & Kolb, 2010, p. 23). These three principles of creating a space conducive to deep learning underpin experiential learning.

Creating an experiential environment within formal educational systems is not easy due to the seemingly contradictory goals of passing standardized tests while stressing creativity. Kolb and Kolb describe the ludic learning space as stemming from a safe, consistent, self-organized place that allows practice in stepping outside the norms and constraints that usually confine us (2010). Learning in the ludic learning space provides students a safe environment where they can practice and discover free from extrinsic pressure (Kolb & Kolb, 2010). Co-curricular opportunities at the secondary level provide high school students with a place to practice skills learned in the classroom. An environment offered in classrooms, in the workplace, or in co-curricular experiences, where students 'play' with actual tools, methods, and processes used in the real world supports exemplary experiential learning opportunities.

Co-curricular Opportunities

There is uncertainty as to what constitutes a co-curricular experience. Some confuse co-curricular experiences with extracurricular. Extracurricular experiences are defined as "academic or non-academic experiences that are conducted under the auspices of the school but occur outside of normal classroom time and are not part of the curriculum. Additionally extracurricular experiences do not involve a grade or academic credit and participation is optional on the part of the student" (Bartkus et al., 2012, p. 698). Bartkus et al. go on to define co-curricular activity as "one that requires a student's participation outside of normal classroom time as a condition for meeting a curricular requirement" (2012, p. 699). They further argue that experiences that are voluntary and align with a specific curriculum should be defined as *direct extracurricular activi-*

ties. These are definitions more appropriate for post-secondary and higher education experiences. Co-curricular opportunities at the secondary level for this study will be defined as,

> "… activities, programs, and learning experiences that complement, in some way, what students are learning in school—i.e., experiences that are connected to or mirror the academic curriculum. Co-curricular activities are typically, but not always, defined by their separation from academic courses. For example, they are ungraded, they do not allow students to earn academic credit, they may take place outside of school or after regular school hours, and they may be operated by outside organizations." (The Glossary of Education Reform, 2013).

Career and technical education program areas each have a co-curricular student organization that is an integral part of the curriculum. Co-curricular opportunities give students a safe environment to practice technical and academic skills. Kolb and Kolb (2010) argue that the goals of productivity, creativity, and learning can be complementary rather than contradictory if learning environments are designed where students are allowed to "play" and intrinsic, rather than extrinsic, interests and self-exploration is encouraged. Their case study on ludic learning spaces within a softball league suggests that

> …most organizations tend to over emphasize control and demand for accountability through an excessive use of extrinsic rewards and ignore the detrimental effects this has on member's creativity and productivity. The case study suggests that deep learning can be promoted within the formal organizational settings if the organizational space allows participants to self-organize, creating boundaries for recursive, timeless play and allows their intrinsic interests and authenticity to come alive. (Kolb and Kolb, 2010, p. 24).

A natural setting to allow students to play and examine genuine real world problems while practicing creativity, problem-solving, and trade skills is provided through co-curricular opportunities. Co-curricular opportunities are intended to go hand in hand with specific curricula and give students the time and space to practice real world skills, sometimes in a simulated environment and sometimes in a real life environment, within the school day and outside, with competitions and without. Experiential learning opportunities are wide and can encompass most, if not all, disciplines. However, most school districts do not offer experiential learning opportunities in all areas. For the purposes of this study, the areas examined will be limited to CTE and STEM related exemplary experiential learning opportunities.

Co-curricular opportunities within secondary CTE programs traditionally come in the form of Career and Technical Student Organizations (CTSOs). Each program area has an associated CTSO. CTSOs are generally formed within a program area as a local chapter, sponsored by an instructor who serves as the advisor. Each CTSO has a state and national office and assist with assistance to instructors on policies, guidelines, and curricula (Gordon, 2014, p. 274). These organizations operate on the belief that "the total development of individuals is essential to the preparation of competent workers" (Gordon, 2014, p. 273). Research shows that participation in student organizational opportunities is the most effective action in helping students reach their full potential (Gordon, 2014; Threeton, 2005, Reese, 2003; Zirkle & Connors, 2003; Harris & Sweet, 1981). Students interested in specific vocational fields can participate in events that are designed to increase their leadership, technical, and job-related skills through individual, cooperative, and competitive opportunities. CTSO opportunities occur within and outside the normal school day. Although competitions can vary, often students compete in industry-developed, job-related skills tests (Gordon, 2014). Table 7 shows CTSOs and a few of the STEM-related com-

petitions offered. DECA, FCCLA, and FFA have relatively few, or none related to STEM.

TSA, on the other hand, has too many to completely list.

Table 7. *Career and Technical Service Organizations (CTSOs)*

Organizations	Programs	Competitions
National FFA (formerly Future Farmers of America)	Agriculture Education: making a positive difference in the lives of students by developing their potential for premier leadership, personal growth and career success through agriculture education	Agricultural Technology and Mechanical Systems, Environmental and Natural Resources, Food Science and Technology, Veterinary Science
Future Business Leaders of America (FBLA) and Phi Beta Lambda (PBL)	Business Education: Bringing business and education together in a positive working relationship through innovative leadership and career development programs	3-D Animation, Computer Applications, Computer Game & Simulation Programming, Computer Problem Solving, Cyber Security, Desktop Applications, Digital Video Production, Electronic Career Portfolio, Graphic Design, Database Design & Applications
DECA (formerly Distributive Education Clubs of America)	Marketing Education: prepares emerging leaders and entrepreneurs in marketing, finance, hospitality and management in high schools and colleges around the globe	Business Management & Administration, Entrepreneurship, Finance, Hospitality & Tourism, Marketing
Family, Career and Community Leaders of America (FCCLA)	Family and Consumer Science Education: to promote personal growth and leadership development through Family and Consumer Sciences education. Focusing on the multiple roles of family member, wage earner and community leader, members develop skills for life through character development, creative and critical thinking, interpersonal communication, practical knowledge, and career preparation.	Skill Demonstration Events: Culinary Chicken Testing, Culinary Chicken Fabrication, Culinary Food Art, Culinary Knife Skills, Fashion Sketch, Technology in Teaching, Toys that Teach

Table 7. *Career and Technical Service Organizations (CTSOs)*

SkillsUSA	Trade & Industrial Education: a partnership of students, teachers and industry working together to ensure America has a skilled workforce. SkillsUSA helps each student excel.	3-D Visualization and Animation, Additive Manufacturing, Architectural Drafting, Audio/Radio Production, Automated Manufacturing Technology, Automotive Refinishing Technology, Aviation Maintenance Technology, Broadcasting News Production, Cabinetmaking, Technical Computer Applications, Welding, Welding Art/Sculpture
Business Professionals of America	Business and Office Education: to contribute to the preparation of a world-class workforce through advancement of leadership, citizenship, academic and technological skills.	Database Applications, Computer Network Technology, PC Servicing & Troubleshooting, Network Administration Using Microsoft, System Administration Using Cisco, Network Design Team, Computer Security, Visual Basic/C# Programming, C++ Programming, Java Programming, SQL Database Fundamentals, Computer Programming Concepts, Digital Media Production, Computer Modeling, Computer Animation Team, Broadcast News Production Team
HOSA: Future Health Professionals	Health Occupations Education: to enhance the delivery of compassionate, quality health care by providing opportunities for knowledge, skill and leadership development of all health science education students, therefore, helping the student meet the needs of the health care community.	Human Growth and Development; Pharmacology, Transcultural Health Care, Biomedical Laboratory Science, Dental Science, Physical Therapy, Sports Medicine, Veterinary Science, Creative Problem Solving; Biomedical Debate, Forensic Medicine, Medical Innovation

Table 7. *Career and Technical Service Organizations (CTSOs)*

Technology Student Association (TSA)	Technology Education and STEM-based co-curricular programs: fosters personal growth, leadership, and opportunities in technology, innovation, design, and engineering. Members apply and integrate science, technology, engineering and mathematics concepts through co-curricular activities, competitive events and related programs.	Animatronics, Architectural Renovation, Biotechnology Design, Computer Aided Design (CAD), Digital Production, Engineering Design, Flight Endurance, Manufacturing Prototype, Photographic Technology, Structural Design and Engineering, SciVis (STEM focused), System Control Technology, Technology Bowl, Transportation Modeling, Video Game Design,
Future Educators Association (FEA)	Education and Training career cluster programs: provides students interested in education-related careers with activities and materials that help them explore the teaching profession in a variety of ways.	Lesson Planning & Delivery-Career Tech; Research Learning Challenges; Technology Video

(Gordon, 2014; ACTE, 2016; Business Professionals of America, Retrieved from http://www.bpa.org/comete/eventlist)

STEM-related experiential learning opportunities help students become tinkerers, more sophisticated problem-solvers, and construct knowledge through social interaction and talking (Morrison, 2006). Morrison describes the attributes of STEM educated students in Table 8.

Table 8. *Attributes of STEM Educated Students*

Problem-solvers	Able to frame problems as puzzles and then able to apply understanding and learning to these novel situations (argument and evidence)
Innovators	Independent and original investigators using the design process
Inventors	Recognize the needs of the world and creatively design and implement solutions
Self-reliant	Able to set own agendas, develop and gain self-confidence and work within time specified time frames

Logical thinkers	Using the logic offered by calculus and found in 60% of all professions world-wide; able to make the kinds of connections to affect an understanding of natural phenomena
Technologically literate	Understand the nature of the technology, master the skills needed and apply it appropriately (Knowledge, Ways of Thinking and Acting, and Capabilities as specified by ITEA in Technically Speaking)

(Morrison, 2006, pp. 2-3)

STEM students are also described as those students bridging the space between STEM disciplines as taught in schools and as used in the workplace, and "able to relate their own culture and history to their education" (Morrison, 2006, p. 2).

Experiential learning in STEM disciplines is presumed to be valuable, however well-designed research studies are sparse showing the value of course-based lab work vs. more in-depth experiential opportunities for undergraduate students (Thiry, Laursen, & Hunter, 2011; Holstein & Lunetta, 2004; Nakhleh, Polles, & Malina, 2003). Research for secondary school students is even sparser. Thiry et al. (2011) contend from their study of undergraduate students' professional and personal gains in STEM disciplines as determined by their participation in "legitimate, professional communities of practice" (Thiry et al., 2011, p. 383) that quality co-curricular experiences were significant contributors to enhancing students' learning in a myriad of ways. Quality experiences were critical to maintaining student interest in the field, while poor experiences contributed to a loss of interest and at times abandoning career goals for some (Thiry et al., 2011, p. 383). Thirty et al. describes a quality experience as providing authentic projects, delivering adequate training and supervision, frequent discussions of the progress of the work being done, encouragement, and challenges that "extend their intellectual capabilities and are not relegated to non-educational, routine tasks…[or] left alone to grapple with tasks far beyond their intellectual capabilities" (Thiry et al., 2011, p. 384).

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Table 9 shows an example of the rich variety of co-curricular opportunities offered in Anne Arundel County Public Schools, Maryland in STEM disciplines. This example shows opportunities available to students who participate in co-curricular opportunities across the nation.

Table 9. *Co-curricular Opportunities in Anne Arundel County Public Schools, Maryland*

Co-curricular Activity	Competition Associated	Academic Level
Bio-Medical Allied Health Club	No Competition	Middle
Continental Math League, Inc.	Competition	Elementary - High
Destination ImagiNation	Competition	Elementary – High
First in Math On-line Competition	Competition	
Integrated Fine Arts Club	No Competition	Elementary - High
MESA - Mathematics, Engineering, and Science Achievement	Competition	Middle - High
NASA Best Club - Aerospace Engineering	Competition	Elementary - High
SEAPerch	Competition	Elementary – High

(Retrieved from http://www.aacpsadvancedstudies.org/aacps/Co-Curricular/Co-Curricular%20Resources/Co-Curricular%20Clubs%20Competitions.pdf)

Co-curricular Impact on Career Pathways

Studies show that lack of social and academic engagement in school and the absence of strong relationships with adults are major indicators of soaring high school dropout rates within certain minority groups (Anderman & Freeman, 2004: Arroyo, Rhoad, & Drew, 1999; Eccles &

Gootman, 2002; National Research Council, 2004; Alfeld et al., 2007; Somers & Piliawsky, 2004). Participation in extra-curricular and co-curricular opportunities is shown to play a role in engaging students and keeping them in school (Alfeld, et al., 2007). Although studies on benefit added from CTSO affiliation is scarce, one study found a "positive association between amount of CTSO participation and academic motivation, academic engagement, grades, career self-efficacy, college aspirations, and employability skills" (Alfeld et al., 2007, p. iii). Another study showed a positive effect on 10th grade members' grades (Camp, Navaratnum, & Jeffreys, 1987). A more recent study of the impact of time spent doing Technology Student Association (TSA) activities showed a contribution to skills development and an awareness of what is required for a career in a technical field (Taylor, 2006). Thousands of students participate in CTSOs yearly and their involvement is thought to be beneficial to them, however, there is untapped potential if co-curricular opportunities were better implemented in all CTE programs and included more of a variety of students (Alfeld et al., 2007).

Enticing students to pursue STEM fields is difficult given that only one in seven students in the U. S. now chooses a STEM-related career (Soldner et al., 2012). Students may enter post-secondary institutions with the intent to graduate with a STEM degree, but the rates of attrition are high in areas where there aren't many students to begin with. The problem is compounded in under-represented minorities. There are many barriers to earning bachelor's degrees but the K-12 experiences of less challenging courses, unqualified teachers, and unavailability of education-al technology are cited as a few reasons (Soldner et al., 2012). In post-secondary environments, "academic conversations with peers are related to more positive outcome expectations, [and] greater interest in STEM pursuits …" (Soldner et al,. 2012, p. 330). The general position was taken by the researchers that "socially-supportive environments … are good for all students, irre-

spective of demography" (Soldner et al., 2012, p. 330). It stands to reason that if the aim of our educational system is to produce more STEM-savvy workers, exemplary experiential learning opportunities must be offered to secondary students, engaging them, providing them with opportunities to try new experiences, and encouraging academic discussions. Supporting students in STEM curricular and experiential learning or co-curricular opportunities will hopefully bolster confidence and boost the numbers of those who choose a STEM career pathway.

Summary

This literature review lays out the CTE and academic pathways, from stratified educational trajectories to interwoven and co-dependent partners with an emphasis on STEM and why it matters. Experiential learning is explored as the avenue for giving students experiences and opportunities to extend their learning in co-curricular opportunities. These opportunities underpin and cultivate student curiosity and often channel interests into STEM-related post-secondary disciplines and career choices. There is little existent research on the impact of exemplary co-curricular opportunities on secondary school students, although there are studies on the impact of post-secondary opportunities. There is also limited research on what constitutes quality experiential learning or co-curricular opportunities. This study is intended to identify the qualities and characteristics of an exemplary secondary experience through the lived experiences of the stakeholders.

CHAPTER 3 METHODOLOGY

A detailed overview of the qualitative research design is presented in Chapter 3, including the purpose of the study, the statement of the problem, and the research questions guiding the study. Participant selection, data collection and analysis procedures, indicators of quality, rigor, and the chapter summary are also presented.

Statement of the Problem

Experiential learning and co-curricular opportunities as provided in Virginia Public Schools' STEM-related courses are hit or miss. The problem addressed in this study is related to identifying and analyzing experiential learning opportunities provided in selected Virginia Public Schools' STEM-related courses. It was conducted to define characteristics and cite examples of what exemplary opportunities look like, and to analyze the impact of experiential learning opportunities on students and career projection. Examining how the facilitation of experiential learning opportunities impact teachers, formal teaching, and the classroom environment was also a goal.

Purpose of the Study

The purpose of this study was to identify characteristics and examples of exemplary STEM experiential learning opportunities as lived by STEM stakeholders; including school administrators, teachers, and students involved in STEM opportunities and to better understand the impact on students and career trajectory. It was conducted to provide examples of exemplary experiential learning opportunities that enhance STEM-related courses, illustrate the significance these opportunities add to classroom instruction, and show how both students and teachers are positively affected.

Research Questions

The main question to be answered in this study was: What constitutes an exemplary an experiential learning experience for STEM-related courses and what challenges exist that make implementation of exemplary opportunities in Virginia schools difficult? The study was guided by the following questions:

1. What are the characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students?

2. What are examples of exemplary STEM-related experiential learning opportunities?

3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, and administrators?

4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

Research Design

The study used a qualitative design to answer the research questions. Understanding and interpreting lived experiences are significant for researchers in order to assist those in decision-making positions. Interpretevism, or constructivism, maintains that there is no single, observable reality, but rather multiple realities or interpretations of events (Merriam, 2009). Individuals seek to understand the world they live in by creating meaning from their experiences and interactions with others. Researchers using qualitative research methods seek out a variety of views in order to have rich data to substantiate their findings. This study focused on the lived experiences of administrators, teachers, and students and their views on exemplary experiential learning opportunities in STEM-related courses. Extreme group sampling and convenience sampling were both used for choosing study participants (Lard, 2012; Patton, 2002). To collect data, one-on-

one interviews with the research participants were conducted. Constant comparative and content analysis were used to identify common themes from data collected from semi-structured interviews (Creswell, 2013; Merriam, 2009; Patton, 2002).

Selection of Participants

Participants in the study were chosen based on the perceived relevance of information they could provide on the research topic (Lincoln & Guba, 1985; Merriam, 2009). The term 'participant' was used to imply a more inclusive and representative process (Rossman & Rallis, 2012, Nkhata, 2013). Purposefully selected samples, although small, focused on depth and richness of information. The participants were chosen precisely because of their knowledge and expertise of the subject being studied. The view of an average experience was not what was being sought, but rather exemplary opportunities. A range of opportunities was sought, looking for variance in geographic location, programs offered, and the types of students served (i.e. those in CTE focused programs or those in purely academic programs with a STEM focus). There are different strategies for obtaining purposeful sampling which are shown in Table 10.

Table 10. *Purposeful Sampling*

Extreme Deviant Sampling	Cases are chosen by being unusual or special in some way, either outstanding successes or dismal failures. The richness of information comes from the cases being outliers.
Intensity Sampling	The cases manifest the phenomenon being studied, providing the richness of information.
Homogeneous Sampling	The focus is on a subgroup, which provides richness.
Typical Case Sampling	Highlighting a case that would be considered average.
Stratified Purposeful Sampling	Focuses on subgroups that can then be compared.

Table 10. *Purposeful Sampling*

Convenience Sampling	The main advantage is the ease of access to participants, although there is the risk of losing richness of information.

(Patton, 2002)

For the purposes of this study, a combination of extreme deviant sampling and convenience sampling were used to purposefully select participants. First, through discussions with university CTE/STEM faculty and local CTE directors and considering their views on reputations of school programs, STEM-related programs were identified by examining the list of Governor's STEM Academies found on the Virginia Department of Education website. From this list, sites were considered due to the conversations with those listed, but also considered was the importance to the researcher of using sites that varied in discipline focus (i.e. agriculture, business and information technology, health care, cyber security, automotive technology). The next consideration was the ability to get permission to interview participants. Several school systems required permission from a school board administrator. Obtaining permission was sometimes problematic so programs were chosen from the six who granted permission. The first person contacted at each site was the administrator in charge of the STEM program, seeking their approval for conducting the study at their respective site. These contacts were made by telephone. The administrator giving approval at each site served as the administrator participant and was requested to obtain the teacher and student participants. Four schools were chosen due to availability and scheduling issues with the other two. It was felt that only four were needed, but the other two were ready to participate if additional information was needed. Once all participants were identified and agreed to participate in the study, they were contacted by telephone to set up appointments to conduct the interviews. A follow-up email was then sent to confirm each ap-

pointment. After the interviews were transcribed, it was determined by the researcher that no new information would be forthcoming in additional interviews.

Number of Participants

The number of participants was determined subject to the information being gathered (Merriam, 2009; Patton, 2002). When no new information emerged, it was decided there were enough participants. The number of participants was sufficient to allow those outside the study sample to identify with the experiences of those within the study (Seidman, 2013). For the purposes of this study four exemplary programs in the state of Virginia were chosen. Three participants were chosen from each program; an administrator, teacher, and student. In one program, a second teacher wanted to participate, so there was a total of 13 participants.

Data Gathering Procedures

Qualitative data consists of words, direct quotations, opinions, feelings, descriptions of experiences and behaviors (Merriam, 2009; Patton, 2002). The researcher was the primary tool for gathering data, in a face-to-face setting. The potential for researcher bias required constant reflection to avoid influencing interpretations and understandings. Interviews were the primary means used to gather data for this study. Field notes were taken in order to describe the situation and all things that help to set the context.

Interviews

Rossman & Rallis write of the necessity for "talk" to understand how participants view their world (2012). Dialogue in these interviews allowed the researcher and participant to co-construct meaning. The researcher asked for concrete examples and elaboration to solidify understanding of the experiences being described. Patton (2002) posits that the reason we interview is simply because we cannot observe everything; we have to ask people questions in order

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to find out "feelings, thoughts, and intentions" (p. 341). Several participants were used because the goal was to compare responses and identify similarities and differences. There are several tools available to collect data from individuals. In this study, face-to-face semi-structured interviews were used and recorded to assess lived experiences of the participants relative to STEM-related exemplary experiential opportunities. Students, teachers, and CTE/STEM administrators from four programs were asked to participate. Table 11 organizes the available tools and describes uses.

Table 11. *Data Collection Tools From Individuals*

In-depth interviews	Used on a small number of people; *life-history interviews* are usually very long (up to 15 hours of interview time); *narrative interviews* which focus on sensitive issues deal with a specific topic and require one to two hour interviews.
Semi-structured interviews	Used to collect similar information from individuals in a larger sample ranging from 12 - 90. Questions are used flexibly but usually specific information is required from all individuals interviewed.
Qualitatively based surveys	Based on prior qualitative data in a study population. Often they emerge from in-depth or semi-structured interviews.
Individual- level network data	Personal networks or relationship of individual respondents; often used to show an individual's network members involvement in risky behavior and measures of positive or negative social support.

(Lapan et al., 2012; Merriam, 2010, Seidman, 2006)

Interview Questions

There are six types of interview questions used in qualitative research that help get to the heart of the research topic (Merriam, 2010; Patton, 2002). The kinds of questions asked of people are a) *experience and behavior questions* - to elicit information about actions, opportunities, and activities; b) f*eeling questions* - tapping into one's emotional response to something (happy, sad, afraid); c) *opinion and values questions* - allowing interpretation of opinions, beliefs, or what he or she thinks about something, not to be confused with what someone *feels* about something; d) *knowledge questions* - what factual information does a participant have about the issue; e) *sensory questions* - questions about tactile experiences, such as what was seen, heard, touched; and f) *background/demographic questions* - questions that pertain to demographics such as age, education, and used to identify characteristics of the participants (Merriam, 2010; Patton, 2002). In this study a semi-structured interview protocol was developed and used to collect the data. The protocol used a variety of types of questions that were previously described and follow-up questions were used for clarifications and elaborations in order to collect the richest data possible. All interviews were digitally recorded with the permission of the participant. The interview protocol of questions used for teachers and administrators in this study may be found in Appendix E.

Questionnaire

Setting the context of the study was important in order to properly analyze the data obtained from the interviews. Knowing participant's demographic information such as their background, years of experience, their relationship to STEM and CTE, and selected information about their program provided this context. Participants provided this information by completing a paper survey. The questionnaire used in the survey may be seen in the Appendices F and G.

Appendix F contains the teacher and administrator questionnaire and Appendix G the student questionnaire.

Field Notes

During interviews, field notes were written to provide descriptions of what was observed but not necessarily captured any other way. Observations of what transpired during the interview, the researcher's feelings and reactions, and reflections that cannot necessarily be conjured up later were important to interpreting data. Taking field notes was a critical part of the interview process. The physical setting of the interview, the connotation and symbolic meaning of words, nonverbal communication and physical clues or body language were all important data noted. The researcher's observations were a major part of the research data collected.

<div align="center">

Data Analysis Procedures

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A qualitative research design is emergent and data was analyzed as it was collected. Ensuring the accuracy of the interview transcriptions, writing memos about what was learned, and using a careful system for organizing and managing data early on were rudimentary steps taken in this study. Audio recordings were made to capture the participants' spoken words during interviews. As data were collected a careful process was used to analyze it. Each recorded interview was first transcribed. The transcriptions and field notes were carefully examined to identify common codes and patterns throughout the transcripts and notes. Themes and attributes for each theme were identified and analyzed by identifying patterns and grouping common codes. Sample interview transcripts are provided in Appendix H.

Transcribing Interviews

Analyzing the qualitative data was an on-going process of being immersed in the data while bringing meaning through categorizing, coding, finding patterns, and themes. Interviews

were transcribed by the researcher in a Microsoft Office Word table for ease in maintaining all transcripts within a single table, using different documents for each transcription. Columns were added for notes as needed. The researcher made careful judgments concerning how to edit words.

Repeatedly playing short segments of the interview recordings allowed the researcher to ensure enhanced transcription accuracy. Listening to the audio recordings while re-reading the transcription allowed for the researcher to become very familiar with the data.

To determine when the analysis of data was complete, the researcher used four questions developed by Hatch (2012). These questions were: a) are deviant cases and contradictory data explained, and in this case, there were none, b) can the analysis be justified, c) is a complete story told, and d) can the analysis be written into a coherent findings (Hatch, 2012).

Codes

Coding was the first step in managing and classifying raw field notes and verbatim transcripts, picking out the significant content and bringing order to the data (Patton, 2002). As data was scrutinized, the researcher identified codes and assigned and labeled appropriate meaning and tried to capture the essence of the data.

In this study, two phases were used to generate codes: initial coding and focused coding (Charmaz, 2006, Lapan et al., 2012). During the first reading, all field notes and transcripts were analyzed and comments were made about what to do with different pieces of data, organizing data into topics using a Google Extension called *Read and Write*. This app allowed the researcher to highlight sections of the transcripts and organize them according to highlight color. Also during the initial coding, the researcher analyzed what was happening in the data. What did it suggest and from whose perspective? In focused coding, line-by-line and incident-by-incident

coding, using gerunds or noun forms of verbs, helped the researcher make connections between codes. The issue being discussed was noted in a separate column for ease in sorting. A sample transcript with codes and themes are shown in Appendix I.

Attributes

Attributes were the concepts or abstractions that were derived from the coding. The bigger attributes were the major sections of the final story. When analyzing data collected in this study, codes were assigned on a line-by-line basis in the interview transcripts. Identifying patterns and regularities in codes and analyzing the codes using Hatch's outline of finding patterns and regularities, the researcher then gleaned the attributes from the codes (Hatch, 2002).

Themes

Themes are statements of meaning that weave through most of the pertinent data and integrate concepts (Ely et al., 1991). Themes emerged when thinking about how the attributes were related to each other. Content analysis and the constant comparative methods of data analysis were used in this study. Segments of data, or codes, were compared with one another to find similarities, differences, and then grouped into attributes, and finally themes. The resulting themes underpin the findings for the research questions.

Organizing Matrices

Displaying data and putting it into visual formats that present information in an organized, systematic way is a recommended strategy for getting an overall view of the information (Miles & Huberman, 1994). One form of visual display is the use of matrices. Matrices were defined as rows and columns and forced the researcher to "see relationships between the parts and the entirety" (Hatch, 2002, p. 175). Matrices were developed in this study to assist the researcher in analyzing the data as thoroughly as possible.

Memo Writing

In this study, memos were the notes written about the researcher's thoughts and under-standing of the data (Graue & Walsh, 1998). Memos were used to articulate the impressions made on the researcher when visiting different participants. A sample memo is show in Appendix J.

Pilot Study

Testing the data collection process and data analysis procedures was imperative before actually conducting a study. Sharing the interview instrument with potential participants ensured that questions were interpreted as intended and the information being sought was obtained through the questions as worded. Weaknesses or flaws were weeded out before conducting the main study by using all interview instruments and questionnaires intended for use in the real study. A pilot study was conducted involving three participants involved in STEM-related experiential learning opportunities; one student, one teacher, and one CTE administrator. The pilot study participants were chosen based on convenience sampling (Merriam, 2009). Participants in the pilot study were also chosen based on the perceived relevance of information they could provide (Lincoln & Guba, 1985; Merriam, 2009). Geographic location and proximity to the researcher was an important criterion for the pilot study. The research instrument was developed through discussion with a cohort of CTE teachers and doctoral students in a university CTE program.

The teacher chosen for the pilot study was a teacher in an STEM-related program in the county where the researcher resides. The student participant was a current student of a CTE program and was recommended by the CTE teacher. The CTE Director for the same school system

also participated. The pilot study was intended to mirror the participants in other programs across the state of Virginia.

Participants were contacted via personal phone calls and then followed up with an email. Interviews were recorded and held to 45 minutes per interview in order to recognize and respect the participants' time commitment. Once the pilot study interviews were conducted, the data analysis procedures were tested, and the interviews were transcribed and coded. The pilot study revealed minor changes in the questions asked of participants in order to better examine the re-search questions. Minor changes were made to the interview questions of students through recognition that the student participant was not getting to the heart of the issues being examined and per recommendations by the pilot study participants and professional seminar cohorts who examined the data.

Quality and Rigor

Ensuring the quality and rigor in this qualitative research study was determined by sever-al factors. Quotes that take readers inside the experience and let them hear the participants' voices were included. Using quotations that clearly conveyed the message of the study is a sign that the findings are well supported (Hatch, 2002). The use of quotes was used extensively in Chapter 4.

Additional factors to ensure quality and rigor of the study were establishing trust, gaining credibility, addressing transferability, establishing dependability, establishing confirmability, es-tablishing authenticity and paying close attention to research ethics. A brief description of each of these factors and how they were addressed in the study are as follows.

Trustworthiness

Validity in quantitative research is the twin to trustworthiness in qualitative research (Savage, 2005). Ensuring rigor in data collection and analysis verifies trustworthiness. Having multiple data sources to maximize contributions to the researcher's understanding and comparing data is a strategy to ensure rigor (Yin, 2003). This study gathered data from 13 participants across 4 different STEM-related programs. Belonging to a peer researcher support group is another strategy for ensuring quality research (Ely et al., 1991). The researcher obtained feedback on transcripts and memos from a professional seminar cohort throughout the data analysis. As recommended by Mariano (1995), a database was kept to assist in understanding linkages between raw data and findings including rich descriptions to ensure confirmability.

Credibility

Patton (1999) posits three distinct but related elements of inquiry for determining credibility:

- Rigorous techniques and methods for gathering high-quality data that are carefully analyzed, with attention issues of validity, reliability, and triangulation;
- Credibility of the researcher, which is dependent on training, experience, track record, status, and presentation of self; and
- A philosophical belief in the value of qualitative inquiry that is the fundamental appreciation of naturalistic inquiry, qualitative methods, inductive analysis, purposeful sampling, and holistic thinking (p. 1190).

Qualitative analysis, unlike the statistical analysis of quantitative data, is a creative process and depends on the ability of the researcher to conceptualize and possess astute pattern recognition skills (Patton, 1999). Credibility in this study was established through purposeful

sampling, use of a pilot study, and triangulation. The researcher had a personal connection to the topic of research as a veteran CTE teacher and co-curricular advisor. Researcher bias was a concern, however, training and mentally preparing for the interviews and observations helped create distance and objectivity, and improved the accuracy, validity, and reliability of the data as required.

Triangulation. Triangulation is a term taken from land surveying, where knowing a single landmark doesn't help much, but knowing two landmarks allows you to locate yourself at the intersection of those points (Patton, 1999). The logic of triangulation claims that more than one method is necessary to solve a problem. Different types of data are thought to limit errors caused by a single method. Triangulation can also be achieved through interviews with purposeful participants and collecting multiple perspectives, rather than using multiple methods (Patton, 1999). In this study, triangulation was achieved through examining the lived experiences of STEM/CTE stakeholders; triangulating student experiences, teachers' experiences, and STEM/CTE Directors' experiences and thoughts on characteristics of exemplary experiential learning opportunities.

Transferability

Over-generalization of results is a common problem with qualitative research. Patton (1999) writes of three sampling limitations that often surface due to the highly contextual and case dependent findings:

- Limitations arise in the situations that are sampled because it is almost impossible to observe all situations,
- Limitations will result from the time periods during which observations took place, or problems of temporal sampling,

- The findings will be limited based on selectivity in the people sampled either for observations or interviews, or on selective document sampling. This is inherent with purposeful sampling (p. 1197).

The purpose and the limitations of the sample in this study were carefully outlined to discourage over-generalization and assist with keeping the results in context (Patton, 1999). Although the results of this study cannot be generalized to other STEM-related programs, readers of the results can determine whether or not the findings can be transferable to their own settings.

Thick Description

Thick description allows the reader to get a clear picture of how the researcher interpreted the interview. The term was originally meant to imply an insider's version of events and was later used to enhance the possibility of transferability of the study's results, setting the context so that others may determine the similarity between themselves and the study (Lincoln & Guba, 1985; Merriam, 2009). In this study, rich description of the context including the description of physical surroundings of STEM programs and narratives about each participant and their backgrounds where provided, which underpin the research results.

Dependability

Devon Jensen states in *The Sage Encyclopedia of Qualitative Research Methods* that in qualitative research, familiarity with the experience in context through literature reviews allow researchers to have a fair understanding of what to expect in the field when designing appropriate methods for the study. Due to the variability of the environment, however, the field experience may be very different from what was expected (Jensen, 2008). This often affects research procedures, interview questions asked, and number of interviews. Dependability recognizes that the research environment cannot be fully understood in advance, it is evolving and there are

methodologies to account for these issues (Jensen, 2008). One example of dependability would be replication of a study that could result in similar findings. The researcher was open to the variations and changes that occurred and was careful to track all research design alterations that were necessary due to these changes. When the study was first designed, interviewing business partners was included. However, finding business partners who were willing to participate became problematic. It was determined that their participation was not integral to the heart of the study so they were dropped. Dependability of this study was also determined by using an audit trail, confirmability, and reflexivity.

Audit Trail. An audit trail is a systematically maintained system of documenting all materials and data generated in a study for the purpose of a third party being able to judge the dependability of the study (Schwandt, 2007; Lincoln & Guba, 1985). It includes the theoretical framework that shaped the study, the memos generated, a statement of findings and conclusions, reflexivity about procedures, and a general confirmability of the findings (Schwandt, 2007). An audit trail was used in this study. Participant recruitment and consent materials, the interview protocol, a sample transcript, data analysis matrices, and memo samples are included in Appendices A, B, C, D, E, I, and J.

Confirmability. Confirmability allows the research to expand on, or confirm current knowledge about the issue under study (Jensen, 2008). It measures the accuracy or the meaning behind the data. Jensen states that "truth and meaning are reliable only to the point where they can be verified as more than just a singular event peculiar to that specific research endeavor and researcher" (p. 113). It is essential to the research because it moves the study "beyond a one-time event into a framework where meaning and truth can be used to build on, expand, or create theory" (p. 113). Although the researcher brought her own perspective to the study, the findings

were based on the data rather than the bias of the researcher. Being open and upfront about biases and maintaining an appropriate qualitative process to respond to those biases was crucial. Reflexivity is a means of attaining confirmability (Erlandson et al., 1993). Confirmability in this study is shown through the careful attention to data analysis, being transparent about researcher bias, and reliance on theory, rather than the perspective of the researcher, to underpin the findings.

 Reflexivity. The awareness on the part of the researcher of her effect on the research was important because in the end, there was only the interpretation of the data to present in the findings. The researcher's very presence would have had some kind of effect on the study because it is impossible to remain outside the subject matter (Anderson, 2008). This concept of reflexivity was another layer of analysis, where the researcher thought deeply about the effects of her presence and thoughts on the lives and perspectives of the participants.

Authenticity

 The set of criteria used to judge the kind of qualitative inquiry determines authenticity (Schwandt, 2007). Guba and Lincoln (1985) argue that validity is defined by authenticity. In determining authenticity, Guba and Lincoln identified the following criteria:

- Fairness - the necessity of a balance of voices such that all participants are heard and represented in a balanced way.

- Ontological authenticity - the necessity of raising awareness and understanding among participants in the research.

- Educative authenticity - participants develop an understanding and appreciation of the constructions of others.

• Catalytic authenticity - the prompting of interest-based action among participants and the involvement of the researcher in educating them.

Establishing authenticity reassures that "both the conduct and evaluation of research are genuine and credible not only in terms of participants' lived experiences but also with respect to the wider political and social implications of research … shifting away from concerns about the reliability and validity of research to concerns about research that is worthwhile and thinking about its impact on members of the culture or community being researched" (James, 2008, p. 45). In this study fairness was ensured through the representation of each voice of each participant, no one voice favored over the others. Reflection on the characteristics of their STEM-related experiential learning opportunities potentially raised awareness of positive characteristics and perhaps highlighted aspects that needed improvement. Educative and catalytic authenticity was ensured as examination and thought were given by participants to exemplary experiential learning opportunities.

Ethics

Caroline McAuley introduces ethics as "creating a mutually respectful, win-win relationship in which participants are pleased to respond candidly, valid results are obtained, and the community considers the conclusions constructive" (2003, p. 96). Establishing a successful relationship between researcher and participant was integral to the responsibility of the researcher in designing a study that was the least intrusive possible. A set of ethical rules or prescriptions was not available, due to the relatively ambiguity of what constitutes an ethical issue (Bell, 2008; McAuley, 2003). Ethical responsibility and behavior was essential through all stages of the research, from the design, recruitment, treatment throughout the process, and the consequences of

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participation. A number of consistent considerations outlined in the literature that researchers should follow to ensure an ethical, robust study are as follows:

- Voluntary consent - one tenant of social research is that each individual voluntarily participates of his or her own free will and can withdraw at any time. Consent forms are used to clarify procedures and ensure understanding before interviewing takes place.

- Informed consent - encouraging people to participates necessitates that they have a clear and accurate understanding about the research being conducted, methods used to gather data, the intended outcomes of the results.

- Anonymity and confidentiality - Protection of the participants' identity is one of the most important aspects of the ethical treatment of participants. Anonymity and confidentiality are not the same thing. Anonymity relates to the inability of anyone, including the researcher, to determine the source of the data. Confidentiality means the researcher knows the identities of the respondents and the individual responses, but no one else has access to the data. Telling the participants the data will be confidential isn't enough; researchers must take steps to ensure the information is confidential.

- No harm to participants - research should never cause harm, either physical or psychological, to participants, even if unintended. Interviewing often asks participants to reveal unpopular attitudes or force people to feel uncomfortable when examining aspects of themselves they don't usually consider. If there is the possibility of latent adverse effects, the researcher should follow up with them later (Homan, 1991; Kimmel, A. J., 1988; May, T., 2001; McAuley, 2008).

There was an ethical responsibility in this study, to the researcher, to colleagues, and to the research participants. The norms and expectations outlined helped establish a protocol that

constituted ethical behavior. In this study, consent forms ensured voluntary participation, paren-

tal permission if a participant was under the age of 18, and clarified expectations, intent, and

procedures were given to participants in advance. In addition, participants were informed that

they could withdraw from the study at their own free will at any time. Institutional Review

Board (IRB) permission was also obtained before engaging with participants. The IRB permis-

sion form is in Appendix K.

Summary

The qualitative methods used in this study have been outlined in detail in Chapter 3. The

purpose of the study, the statement of the problem, and the research questions guiding the study

were discussed. Participant selection using extreme deviant sampling, data collection and analy-

sis procedures using constant comparative methods were explained. The pilot study was dis-

cussed, as well as indicators of quality and rigor.

CHAPTER 4 FINDINGS

Chapter 4 begins with an overview of the purpose of the study, followed by the research questions and a description of the participants. The main purpose of Chapter 4 is to present the findings of the study. These findings are presented the order in which the research questions are listed.

The purpose of this study was to identify characteristics and examples of exemplary STEM experiential learning opportunities as lived by STEM stakeholders; including school administrators, teachers, and students involved in STEM opportunities and better understand the impact on students and career trajectory. It was conducted to provide examples of exemplary experiential learning opportunities that enhance STEM-related courses, illustrate the significance these opportunities add to classroom instruction, and show how both students and teachers are positively affected. The characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students, what constitutes an exemplary experiential learning experience for STEM-related courses, and what challenges exist that make implementation of exemplary opportunities in Virginia schools difficult were determined through the following questions:

1. What are the *characteristics* of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students?

2. What are *examples* of exemplary STEM-related experiential learning opportunities?

3. What is the *impact* of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, and administrators?

4. What *challenges* exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

Semi-structured interviews were conducted and recorded to answer the research questions. A questionnaire was also used to collect demographic data to add context to the narratives of the participants. All the participants were currently from the state of Virginia and came from four different school systems; one in the southwest portion of the state and three from northern Virginia.

Demographic Profile of Participants and Program Description

Demographic information was obtained for each of the participants on gender, race, age range, education level, type of school participating (public high school, STEM Academy, Magnet School, CTE Technical School), and locality of school (city, suburban, town, and rural - as classified by the National Center for Education Statistics). The demographic information is shown in Table 12. A summary and description of the participating program areas and individual participants is also provided.

Summary of Participants

Six of the participants were female and 7 were male. The majority of the participants were white, with one Hispanic/Latino and two of Asian descent. All STEM Administrators had an education level of a master's degree. Teachers' education levels included one doctorate, two masters plus 30 hours, and one bachelor's degree. Student participants were in the 10th, 11th, and 12th grades, with one a college freshman. One school system was in a rural area with the other three located in suburban areas.

Table 12. *Demographic Profile of Participants*

Part. No.	Pseudonym	Gen- der	Race	Age	Highest Educa- tion Lev- el	School Dis- trict Type	Position

Table 12. *Demographic Profile of Participants*

Part. No.	Pseudonym	Gen- der	Race	Age	Highest Educa- tion Lev- el	School Dis- trict Type	Position
1	Renee	F	White	40-50	Masters	Rural Governor's STEM Acad- emy	STEM Administra- tor
2	Ricky	M	White	41-50	Masters +	Rural Governor's STEM Acad- emy	Teacher
3	Jimmy	M	White	15-20	12th grade (currently enrolled)	Rural Governor's STEM Acad- emy	Student
4	Veronica	F	White	50+	Masters	Suburban Governor's STEM Acad- emy	STEM Administra- tor
5	Michael	M	White	50+	Bachelors	Suburban Governor's STEM Acad- emy	Teacher
6	Patty	F	His- pan- ic/Lat ino	15-20	10th (cur- rently enrolled)	Suburban Governor's STEM Acad- emy	Student
7	Greg	M	White	50+	Masters	Suburban Governor's STEM Acad- emy Magnet School	STEM Administra- tor

Table 12. *Demographic Profile of Participants*

Part. No.	Pseudonym	Gender	Race	Age	Highest Education Level	School District Type	Position
8	Gretchen	F	White	41-50	Masters +	Suburban Governor's STEM Academy Magnet School	Teacher
9	Lori	F	White	41-50	PhD	Suburban Governor's STEM Academy Magnet School	Teacher
10	Ian	M	Asian	21 - 25	College Freshman (currently enrolled)	Suburban Governor's STEM Academy Magnet School	Former Student
11	Jack	M	White	41-50	Masters	Suburban Governor's STEM Academy	STEM Administrator
12	Ethan	M	White	30-40	Bachelors	Suburban Governor's STEM Academy	Teacher
13	Regina	F	Asian	15-20	11th grade (currently enrolled)'	Suburban Governor's STEM Academy	Student

Note: All participants' names are pseudonyms.

Description of Participants and Programs

The following is a description of each program and participant. Programs are identified by number and participants are identified by pseudonym in order to protect program and participant identity and to conform to the confidentiality agreement.

Program 1. This program is housed in a traditional high school with a school-within-a-school Governor's STEM Academy in a very rural location. The STEM Academy is centered on CTE and Agriculture. There is only one high school in the county, the community is largely agricultural, and there is little diversity. There is a 92% graduation rate at this school with a high percentage of students on free or reduced lunch. There are only 9 schools division wide, serving Pre-K to 12th. It is one of the poorest counties in Virginia. Approximately 62% of graduating seniors go on to post-secondary education of some kind. Participants from this program are described in subsequent sections.

Participant 1 – Renee (Administrator). Renee is a female in the 41-50 year old range. She has her Master's in Education and her undergraduate major was Biology. She taught high school for 13 years and has been a STEM Lab Administrator for the past 4 years. Her primary focus is on creating and setting up opportunities for classroom teachers in the STEM Lab and obtaining business and university partnerships. She has been instrumental in encouraging and helping create transdisciplinary, experiential learning activities across curriculums within her school. Some of the experiences Renee helps with are electrophoresis, pig dissections, cosmetology and hair investigation under a microscope, infectious diseases and child care, water and soil testing, exploring GMOs (genetically modified organisms), and DNA testing. Over $700,000 was brought into the system through these collaborative opportunities and relationships with the community and area businesses.

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Participant 2 – Ricky (Teacher). Ricky is a male in the 41-50 year old range. He has a

Master's Degree in Agricultural Leadership and is working on a PhD in Agricultural Education.

He has been teaching Agriculture and other STEM courses for the past 9 years. He teaches

courses in agriculture production, veterinary science, metal fabrication/welding, and biotechnol-

ogy. Students in his classes grow and sell crops, raise livestock, study and then plant GMO

crops, pull the DNA out of crops and look for genetic markers, study the chemistry and physics

of metals, do an ELISA (enzyme-linked immunosorbent assay) test which measures antibodies in

blood and help determine how diseases spread, and teach nursing students about the human heart

through pig dissection. He was instrumental in starting the STEM program as it now exists at his

school. Ricky's work in the STEM Academy has brought in over $750,000 to his school over

the past 9 years with their farm operation.

Participant 3 – Jimmy (Student). Jimmy is a senior at this rural high school and takes

STEM classes in agriculture. His future plans are to go to community college and then a univer-

sity to study horticulture. He would like to open his own greenhouse someday.

Program 2. Program Area two is a Governor's STEM Academy housed within a tradi-

tional high school. It has a CTE focus and pulls from 19 high schools and has an enrollment of

approximately 1,300 students. It is located in a suburban location with a high density, diverse,

highly transient population. Eighty percent of the graduates go on to post-secondary education.

They have many partnerships with businesses and universities. They offer industry certifications

and licensure along with club opportunities such as Aerospace, First Robotics, IEEE, Skills

USA, FCCLA, and DECA. They have a career experience specialist dedicated to creating op-

portunities for students inside and outside the classroom. Field trips are highly encouraged and

frequent. They have several key business partners that work closely with the school, offering

internships and field trip opportunities as well as other key resources. Participants from program two are described in subsequent sections.

Participant 4 – Veronica (Administrator). Veronica is in the 50+ age bracket and her education level is a master's degree with her undergraduate degree in Business Education. She taught for 25 years prior to becoming an administrator and has been an administrator at the STEM Academy for 8 years.

Participant 5 – Michael (Teacher). Michael is a teacher at the STEM Academy. He is in the 50+ age bracket. He is also an adjunct professor at a university near the school. Michael has been teaching at the STEM Academy for the past 9 years. His high school students often work together with his college students on engineering projects. His students participate in a Robotics program as well as other engineering projects. He has also been involved in a *Girls in Engineering* program.

Participant 6 – Patty (Student). Patty is a sophomore at the STEM Academy. She is very interested in computers and the *Girls in Engineering* program at her school. She will be the in the first generation of her family to go to college. She wants to eventually get a PhD and be an educational researcher like her mentor at an area university.

Program 3. This program area is a suburban magnet school and is located in a high density, affluent area and has a predominantly math and science focus. It is a school-within-a-school situation presently, but a new facility is being built and the STEM focus will expand to include CTE courses and enrollment is expected to increase. This school was the smallest of all visited programs, with a total enrollment of 267 students pulling from 16 county high schools. The program is very competitive and only accepts 67 freshman (from over 900 applicants) each year and students continue the program throughout their high school career. The school focuses

on an inquiry-based, interdisciplinary science and math model. The students participate in expe-

riential learning through a 3-year research project they design themselves. Students graduate

having completed their graduate level research projects. There are only 11 faculty members, five

of which hold PhDs and another with 30 hours towards a doctorate degree. One strength of this

program is the partnerships with area businesses and universities which provide mentorships,

financial help, and other key resources. Ninety-nine percent of graduates attend a 4-year college

or university. The Mean SAT scores of the class of 2015 graduates are; Math - 750, CR - 702,

Writing - 703. In the graduating class of 2014, which consisted of 62 students, almost $4 million

in merit-based scholarships were awarded.   Participants from program three are described in

subsequent sections.

Participant 7 – Greg (Administrator). Greg is the administrator for this math and sci-

ence magnet school-within-a-school and is in the 50+ age bracket. Greg has a master's

degree in Biology and taught high school biology and physics for 41 years. He has been an ad-

ministrator with this STEM school for over 10 years. He started the program from scratch after

being recruited from a classroom teaching assignment in another state.

Participant 8 – Gretchen (Teacher). Gretchen is in the 41-50 age bracket and a science

teacher at this program three school. She has 30 hours towards a doctorate degree and her un-

dergraduate degree was in Animal Science with a minor in Communications. She teaches biolo-

gy and has been at this school between 4-9 years, with a total of 16 years teaching experience.

Participant 9 – Lori (Teacher). Lori is a mathematics teacher at this magnet school. She

is in the 41-50 age bracket and has her doctorate degree in Mathematics. She is integral in plan-

ning and implementing the annual sophomore class trip to the Bahamas where students study en-

vironmental issues.

Participant 10 – Ian (Student). Ian is a graduate of the magnet school in the 20 - 25 age bracket. He is a junior at a well-respected university studying Mining Engineering. As a graduate and college student, Ian provides a slightly different perspective than those students interviewed that are still n high school. Ian's view of his experiences come from a basis of a graduate of the STEM program, who sees the impact of his high school experience and how it has helped him as a college student.

Program 4. Program four is a recently designated Governor's STEM Academy and a school-within-a-school environment. It is located in a suburban location in a very affluent area. This school pulls from 7 area high schools and has an enrollment of almost 900 with a diverse student body with representation from over 60 countries. There are 11 different course areas that students can participate in. Students are offered industry certifications in over 50 areas. There are several key business and university partners that work closely with the school. There is also a career specialist that helps with administration of the program. Participants from program four are described in subsequent sections.

Participant 11 – Jack (Administrator). Jack is the principal at the STEM Academy. He is in the 41-50 age bracket and has his Master's degree. Jack has been the administrator since the Academy's inception. A recent accomplishment, which came from collaborating with a parent, is an added course in Cyber Security. It is offered as a zero period with a volunteer business partner teaching the class. Students were lined up out the door to enroll when first offered and they now have 80 students enrolled in several sections of the course.

Participant 12 – Ethan (Teacher). Ethan is a teacher in the Automotive Department. He is also an adjunct instructor at a local community college, teaching automotive repair classes to area practicing technicians.   He is in the 31-40 age bracket.

Participant 13 – Regina (Student). Regina is a junior at the STEM Academy and enrolled in Cyber and IT courses. She is also taking International Baccalaureate courses in Design and Technology. She plans to attend a college or university after graduation.

The interviews conducted with the participants culminated in an overarching feeling of pride, accomplishment, and dedication to their programs. Each participant was eager to share the different aspects of their programs, outlining the characteristics and qualities that, in their views, make these opportunities great for students and teachers alike.

Characteristics of Exemplary STEM-related Experiential Learning Opportunities

R1: What are the characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students?

A better understanding of the components of an exemplary STEM-related experiential learning experience was gained through visiting different schools and discussing lived experiences within their programs with various stakeholders to obtain different perspectives. Participants were asked to explain their experiences and outline the characteristics they felt contributed to making learning opportunities exemplary. Two main themes developed through these conversations: (1) Program Qualities and (2) Curriculum Development and Instructional Delivery Strategies. A number of codes emerged from the data analysis leading to attributes supporting each theme. Table 13 provides the themes and each of their attributes and codes.

Program Qualities

The first theme to emerge regarding characteristics of exemplary STEM-related experiential learning opportunities was program qualities. A brief narrative for each attribute and examples of participant comments are presented in the subsections that follow.

Table 13. *Characteristics of Exemplary STEM-related Experiential Learning Opportunities Themes, Attributes, and Codes*

Theme	Attribute	Code
Program Qualiuties	• Opportunities for real-world experiences and career exploration	• Specialized equipment needed • Students responsible for learning • Having high expectations • Offering realistic, relevant curriculum • Introducing engineering • Exploring employer expectations • Choosing career paths • Helping students make decisions • Making career connections
	• Students given choices and ownership of their learning	• Students figuring it out themselves • Getting hands dirty • Creating passion keeps work ethic alive • Exploring based on interest • Students choose own research
	• Support from university and business partners	• Business and university mentors provide needed expertise • Business partnerships donation made school possible • Without business support, couldn't do things • Grants and businesses needed to provide funding
	• Teacher characteristics	• Hiring best teachers • Teachers want to be the best they can be • Teachers guiding, not instructing • Recruit teachers not technicians • Mixture of teacher strengths • Teachers as lifelong learners • Confident teachers • Teachers love kids and teaching • Teacher-centered schools with Student-centered Pedagogy • Maintaining vision in teaching
	• Professional support positions within the school	• Making partnerships • Solidifying partnerships • Managing things • Getting teachers involved • Making contacts
Curricululm Delivery and Instructional Delivery Strategies	• Provision of transdisciplinary learning across curriculums	• Seeing how it all fits together • Progressing science concepts so it's easier to grasp • Collaborating important aspect • Integrated inquiry based curriculum • Courses segue into other courses • Understanding is fundamental • Blurring physics, math and art

Table 13. *Characteristics of Exemplary STEM-related Experiential Learning Opportunities Themes, Attributes, and Codes*

Theme	Attribute	Code
	• Provision of hands-on learning opportunities	• Teaching in Socratic style • Doing it makes them know it • Offering curriculum that stresses critical thinking • Hands-on experience is good for them, don't get experience anywhere else

Opportunities for real world experiences and career exploration. Often mentioned by participants were the opportunities for real-world application given to students. A common sentiment was exemplified by Jack, a STEM program administrator, when he said, "… our goal here, I think it's to expose them to a variety of opportunities … to make them current, global, something that is going on right now, something that is in demand ... that we're tied in to the economic development of the region, or the country, or the world. (Jack Ln# 172 - 174)". The opportunity to explore careers was also a characteristic of exemplary opportunities. Students also recognized the importance of relevance of the curriculum to their world and lives after graduation. Jimmy, a senior in an agriculture program shared the importance of his experience, "… before I thought that stuff was cool … I really enjoy plants so … while I'm here getting a lot of knowledge from it and I'm going to transfer it over to college because I have a feeling I'm going to actually go into something in plants in college, so it's helped me a lot." (Jimmy Ln# 40-42). Selected comments associated with these attributes from other participants included:

• "I need them to know what the employer would expect a good entry-level employee to enter the workforce with." (Ethan Ln# 42 - 43).

• "I think our courses are geared towards giving the students a really good exposure to that industry or that career and we'll find out if they flourish or not." (Jack Ln# 170 - 171).

- "[O]ne project that we run through the STEM lab is this well water testing … it's sort of …associated with [university name] too, so kids can bring in their well water samples and they can learn about water testing in the lab but then they can go to [university name] and see how it's tested in their lab, which is really good because it connects them to possible careers that they might not know existed." (Renee Ln# 33 - 37).

- "[W]e had a student today in the vet science class and we did this ELISA lab and we talked about epidemiology and she went home and told her parents she was completely changing what she was going to enter college for … [big smile] and the reason was she didn't realize it was out there and she didn't realize how fascinating and interesting it was to her. " (Renee Ln# 54 - 55).

- "I think it just helps kids decide what they really want to do. If they don't know about it … and how are they going to know?" (Veronica Ln# 145 - 146).

- "The purpose of the class is to introduce engineering to students. It also is designed to help students understand what engineers do in general and then hopefully help the figure out would I like to be an engineer myself." (Michael Ln# 5 - 8).

- "I think … it's cool to see … that you can take so many different directions into your career path. Or you can even change them if you need to somehow to modify your best interests" (Patty Ln# 58 - 60).

Participant responses indicated the importance of giving students a taste of career paths and exposure to different fields. Students don't always know what careers are available or what goes into a typical day in a chosen path until it's too late. Time and money are often wasted on pursuing fields that don't really suit them. Experiential opportunities allow students to try different things and in a sense, play - using equipment and practicing skills in a safe environment.

Student choice and ownership of learning. Students were given choices and encouraged to make discoveries through inquiry, design, iteration, problem-solving, and critical thinking opportunities. Ian explained the exemplary nature of his high school experience, when stating "… we were given free rein to choose something that interests you and do a research project about it and make it better." (Ian Ln# 43 - 44). As their understanding grew, they often became the teachers in their areas of interest. Ricky spoke of his students and their ability to share their learning when he said, "My kids were able to teach what they learned! Oh… it was a beautiful thing!" (Ricky Ln# 174 - 175).

Comments from other participants supporting the student choice and ownership of their learning attribute were:

- "One where the kids definitely would be in charge of their learning or their communicating with each other ... where they're held responsible." (Lori Ln# 67 - 68).

- "What makes this school exemplary is our curriculum. I think … I think that you need to stress critical thinking and that's what we do." (Greg Ln# 141 - 143).

- "… rather than walking us through it step by step he just has us go and do it by ourselves so we can try and figure it out the way that we want to … well we do have some guidelines but I think the freedom that we have to experience it … what makes hands-on learning probably the best way to learn." (Regina Ln# 19 - 22).

- "They really need to be a self-directed learner and need to apply additional time beyond the classroom." (Jack Ln# 28 - 29).

- "Two or three years later we have the seniors now teaching the freshman and sophomores." (Jack Ln# 454 - 455).

- "We co-enroll with the University of X. All of our math courses are taught using inquiry style. It's extremely Socratic." (Greg Ln# 57 - 59).

- "I've been active going back and visiting the [school name] pretty regularly and it honestly blows me away just how cutting edge the things these 16 - 17 yr olds are doing. It's really cool just … the tools the [school name] gives students in the sciences." (Ian Ln# 44 - 46).

- "That was just really cool. Just … from coming from 'raise your hand to go to the bathroom' and middle school in general, to 'hey, here's a bunch of rocks … hit them together to make smaller rocks, and oh, here's some hydrochloric acid if you think that will help." (Ian Ln# 76 - 80).

- "A high school experience where I was given a lot of freedom, I was given a lot of choices, um, especially academic choices on my own, for myself, and that much more closely mirrored college rather than the more prescriptivist approach that was the norm in my county." (Ian Ln# 82 - 84).

- "They were very good at treating us like adults and I know … 15 I'm not a child anymore but at the same time … 14 year olds can think for themselves and [school name] was very good at acknowledging that and letting us do that." (Ian Ln# 86 - 88).

- "I think they are also very good at giving that agency, having the understanding-based segway through the sciences was very good at not killing people's interests and as we got into junior and senior year it meant a lot more." (Ian Ln# 104 - 105).

- "We had a lot of choice of which of the AB Sciences we could go into … let us really … no really pushing … pushing the boundaries of our understanding of the science we were most interested in." (Ian Ln# 104 - 107).

- "Each student gets a computer about a month and a half in and um, we have to take it apart ourselves." (Patty Ln# 15).

- "For example before I came into Computer Systems class I had some engineering and from there I … uh little pieces from my computer that I didn't know were in the computer actually but when I saw them I thought … oh, I'm familiar with this so I think you always get to build on your learning." (Patty Ln# 55 - 57).

- "I've seen this in a lot of my classes … specifically engineering ... STEM Advanced Engineering … and Computer Systems A+ but I think it's letting the students have multiple mediums of them discovering how they like to learn best." (Patty Ln# 42 - 44).

- "In my sophomore year in Cisco my teacher brought out a bunch of switches and hubs one day? And he let us hook them up to our computers and play around with them kind so we could figure out how to configure them by ourselves, because up to then we'd been using um, simulation software instead of the real thing." (Regina Ln# 12 - 15).

- "If we take concepts that we learn in the classroom and apply it to hands-on activities, kids make the learning their own instead of something that they've gained through rote learning or something we're trying to get back out of them during a test." (Ricky Ln# 40 - 42).

- "They start to take ownership and responsibility for their own learning and their classmates' learning and not always look to someone else to be the yes/no guy. In life YOU have to be the yes/no people." (Lori Ln# 33 - 35).

Support from business and university partners. The next theme that stood out in all conversations was the crucial role played by businesses and university partnerships. Most of the participants admitted they could not provide the caliber of programs offered without the resources provided by industry and post-secondary institutions, with both monetary and expertise

support. Greg, the administrator who created the magnet school where he works leans heavily on business partners for financial support,

> "So when we started the [school name] … I give them so much credit … the leadership at that time … because basically we have a very interesting partnership. We have a partnership with the [business name]. [Business name] built [business name], which is right down the road from us, it's a half million dollar research facility. And they cut a deal …with the county … and the deal was this. We will pay no taxes and we will donate a million dollars a year for science education in the school district." (Greg Ln# 82 - 88).

Jack, administrator of a STEM Academy, also depends on business partners for expertise, as he explained when he said "…you may not have that expertise on your staff but that's where you reach out to your business partners." (Jack Ln# 177 - 178).

> Other comments citing the support of industries and universities were:

- "Individuals from IT companies … they are willing to come here and talk to the kids because now we're on the same page. They aren't coming to here to say well yes, Algebra II is important … or Trig … or Pre-calc … I got it, I'm an engineering … you need to know that. But they are actually coming in here and saying wow, you guys and girls want to do this … OK this was my career path just as an example but now in the industry this is where you can go and what you can do and stay in touch with me." (Jack Ln# 60 -65).
- "I have no staff that knows anything about Cyber Security. He said, I will come to your school and teach it during your Learn … which is our remediation time … to any kid who wants to learn it … I said you'll do that on your own time? He said, yah, I'll bring a buddy over. So they did." (Jack Ln# 441 - 444).

- "This is where the one good partnership I have is with [X] Community College … they have a post-secondary associate's degree program so we feed a lot of kids who are interested in expanding their knowledge there then I go to his meetings and he goes to mine." (Ethan Ln# 121 - 124).

- "The first place for approval is with their mentor who is the person they are assigned to for research. And I assign them to a research section with someone with expertise in that field." (Greg Ln# 264 - 266).

- "A lot of money comes through this place and it is … it is … being financially supported by our partners." (Veronica Ln# 159 - 160).

- "If a business comes to me and just wants to do man hours … hey, we just want to reach out to our schools … parents want to be able on a Saturday to help out with the Robots … we'll set up lunch! We'll cut up a salad for robotics kids … we welcome that too. However they can support us I try to find a way!" (Veronica Ln# 172 - 175).

- "We get together with them they tell us what kind of toys handicapped children would to have so we have our students design and build those toys and they have to come up to the standards of the physical therapist. Sometimes we've had our toys rejected [laughter] but that's good because then the students know … you have to deliver to a certain level of quality so that's a learning thing for them as well." (Michael Ln# 31 - 35).

- "We have a huge robotics program and if we didn't have parents out there supporting and businesses supporting we couldn't do it. So [teachers] welcome the extra set of hands. We have an ER doctor up here at X Hospital that comes here in his scrubs to help our robotics team … Dr. F … and I'm like … did you sleep today? You're still in your scrubs … and now

he wants to help these kids, so it wouldn't be possible if people weren't willing to help out."

(Veronica Ln# 202 - 207).

Partnerships with businesses and colleges and universities play a crucial role. Expertise and funds not always available to public schools are often provided as these partners help mold workers and learners of the future.

Teacher characteristics. Certain teacher characteristics were cited as necessary attributes to quality STEM-related experiential learning opportunities. It is critical for program success to have teachers who are willing to do something out of the box, out of their comfort zone, and often times more difficult than standard teaching practices. Several participants mentioned that teaching in the traditional manner or status quo would not be enough to plan and provide exemplary opportunities. Also, getting teacher input and having confidence in their abilities to facilitate learning and face the fear of doing things differently was mentioned. Ian commented about his teachers being on the same page in their outlook, when he said, "… the teachers who were all on board with that understanding-oriented vision." (Ian Ln# 65 – 66).

Comments from other participants supporting the teacher characteristics attribute were:

- "[I]t's not like you can teach the same things over and over and over again, so just when you think you've got it down you've got to jump to the next page." (Renee Ln# 134 -135).

- "I think in any class you can make engaging … if you have the personality to do it." (Jack Ln# 351).

- "When we are talking about our engineering classes and working with … our teachers are really in sync with innovate, innovate, innovate." (Veronica Ln# 71 – 72).

- "I think it's a matter of your philosophy too, don't be afraid to try something, have confidence in your teachers." (Jack Ln# 376 – 377).

- "You know, one of these days I want to write a book, and the title of this book is going to be Teacher-Centered Schools with Student-Centered Pedagogy. Because I think that's the way it needs to be." (Greg Ln# 112 – 114).

- "[I]t's also a fear on the part of the teachers, I mean I taught in a regular classroom for 15 years before I came here and I had to be willing to stretch and to be challenged and to be open to teaching a different way. And I am that way and that's why I wanted to teach here." (Gretchen Ln# 66 – 69).

- "It blows me away. It really is a collection of some of the best high school teachers in the country." (Ian Ln# 64).

- "[I]t's kind of like a classroom where the students will do work, they will put the work up on the board and during class they are having discussions and arguing and defending their answers and the teachers are trying to be Socratic and not tell them, yah, that's right or wrong, but say, do you agree with that?" (Lori Ln# 29 – 32).

Individual teacher characteristics were commonly stated as important aspects of an exemplary experiential learning program. The need for including teachers in designing curriculum and creating a common vision, hiring teachers who want to constantly learn and grow, who aren't afraid of a challenge, and aren't intimidated by not being the expert are important attributes of the type of teacher in an exemplary experiential learning environment.

Professional support positions within the school. Another important aspect of all highly successful exemplary experiential STEM-related opportunities, as discussed by the participants, was the importance of a designated position to manage the expertise, funding, and opportunities offered by industries and universities, and nurturing these connections. The lack of time for teachers was pointed out in almost every interview. Building solid relationships was crucial

to each of the opportunities; however, this would be problematic if left solely to teachers. Greg's program was the only program that did not have a designated person to provide this service. However, the small size of the school, with only 11 faculty members and approximately 260 students allowed him to forge these partnerships. Other supporting remarks were:

• "We have … a position called Career Experience Specialist, and … it's more an HR position? Her job solely for me is to make partnerships, solidify partnerships, arrange things, without that position in this academy, it would be very hard because as a staff, I have my AA here, I have finance person, I have two counselors, but I mean, I couldn't manage these things!" (Veronica Ln# 223 – 229).

• "She gets all the teachers involved and works with "[business name] … OK they're coming at 2:00 and the [business name] is coming at 12:30 like … the rest of us have our own jobs too … we don't have the time …" (Veronica Ln# 235 – 238).

• "[Jack] has a Career Experience Specialist too … and she does similar stuff so I think he would say that he relies on that Careers Experience Specialist too to keep those partnerships up and going … if I didn't have that position … and I know Jack will say the same thing." (Veronica Ln# 243 – 251).

• "As a lab manager, I bring teachers in to do these activities and they wish there was more time they could be in here and they wish there were more activities that they could do and unfortunately there's only one lab and one of me so they can't." (Renee Ln# 93 – 95).

• "Their everyday teacher schedules prevent you from having the time to set up all of these labs or make all of these contacts or things like that." (Renee Ln# 97 – 99).

• "I kind of got put into the role … but I don't think they realized how valuable that role has been for making all of this happen and the fact that, you know, I just set up a lab, like the ELI-

SA lab, it was very labor intensive and I actually needed time where nobody was interrupting me to make all these solutions and you know, in a teachers' world, there isn't that window …" (Renee Ln# 101 – 105).

Reflection on the comments point out the need for a specific staff member responsible for coordinating and nurturing partnerships and assisting with learning opportunities. There isn't sufficient time given for teachers to effectively manage these kinds of on a regular basis. On-going field trips, mentorships, classroom visits by partners, equipment and material acquisition, these are all very time consuming but necessary tasks involved with creating exemplary experiential learning opportunities.

Curriculum Development and Instructional Delivery Strategies

Another theme to emerge regarding characteristics of exemplary STEM-related experiential learning opportunities was curriculum development and instructional delivery strategies. Attributes ensuring solid curriculum development and instructional delivery strategies included: provision of transdisciplinary learning across curriculums and provision of hands-on learning opportunities. The following subsections explore these attributes.

Provision of transdisciplinary learning. The transdisciplinary nature of their offerings was a big influence on exemplary opportunities. The natural overlap and connections students were able to make in experiences that removed the traditional disciplinary boundaries found so often in our high schools was an important component. Ian, a graduate of the Program 3 magnet school, explained the science curriculum offered at the STEM school as compared to his home high school,

> … [O]ne thing I've noticed about the way the sciences were taught in my county
>
> where I went to high school … it started with Earth Science, and then Chemistry,

and then if you really wanted to do more science you could do Physics and one of

the AP Sciences that were available. … that was mostly because, that was sort of

the progression of what's easiest to grasp. It's a lot easier to understand why rocks

are hitting each other than sort of the calculus that goes with physics and that

makes a lot of sense, but also it really doesn't because biology is applied chemis-

try is applied physics and you really have to start with the fundamentals of phys-

ics to really understand what's going on in a lot of processes in chemistry and

earth science." (Ian Ln# 5 – 13).

The connections between Veterinary Science and Nursing, Automotive and Technology

Education, and Medicine and Engineering are just a few of the other connections mentioned by

participants. The following statements provide additional examples of why the participants felt

transdisciplinary learning is such an important attribute for highly successful STEM-related op-

portunities:

- "It's integrated and the kids don't even know they are learning those subjects." (Ricky Ln#
  95).

- "So for example, we start out the year with our freshman … in classical mechanics … basically
  an honors level physics course … and that segways into dynamics, which is typical, um which
  segways into erosion, which is not typical. Which segways into … of course you can't under-
  stand erosion unless you understand weathering. And of course you can't understand weather-
  ing unless you understand acid based chemistry. Um, so … and I could keep going." (Greg
  Ln# 27 - 32).

- "It's very interesting because a lot of people say to me … so what courses do you offer there?
  And I'm kind of torn between, well, math and science and research …. Everything because

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when the students choose their own research, they are basically choosing an elective of their choice." (Greg Ln# 63 – 66).

- "So one of the things recommended to me and I rejected it early on was, well … have the physics teacher come in when you're doing physics and have the earth science teacher come in when you're doing earth science and I said no, this is supposed to be integrated! What message am I sending to the kids if I say Ms. X doesn't know enough about physical science to teach you about F=MA. Let's bring Dr. Y in … NO, what are we trying to say here?" (Greg Ln# 162 – 168).

- "[W]e just always had that …'OH' moment … we didn't necessarily see how it all fit together and then it just does." (Ian Ln# 72).

- "I'm so fascinated by that! I like to mix …. Her [mentor] purpose is to reach out to the parents and to reach out to minorities and that's really what I want to intersect … I want to meet … I want to go into that intersection of activism and what I like to do with computers." (Patty Ln # 83 – 85).

- "So some of the labs that I help them with I'm not really the expert in and some labs I am the expert in so we can bounce off of each other and really blend the class together so … when Mr. H and I last year were teaching together we sort of did this watershed thing and we were talking about water tests and water shed and … him being an Ag teacher … we pulled out the soil profiles and topographic maps and put it all together to make the big picture." (Renee Ln#117 – 123).

- "We bring … things back from the farm back to class … and that gets back to the biotechnology class, to where we can use GMO foods … actually plant GMO crops at the farm … we bring them back to the STEM Lab and then in biotechnology we can pull the DNA out of the

crops and look for the genetic markers to identify what GMO traits are found in its DNA."
(Ricky Ln# 18 – 21).

- "… metal fabrication class we get into … talking about the metals and we get into the chemistry and physics of it and they learn how chemical changes occurs in metal whenever metals heated up and cooled down." (Ricky Ln# 23 – 25).

- "I make them do soil tests and what they'll do is analyze the soil and see what kind of nutrients the soil needs … we don't want to just go out and throw down a bunch of fertilizer … and hope that it makes the crops grow, we want an analysis to see how much to put down and they'll have to come under the budget." (Ricky Ln# 63 – 66).

- "… our math courses are all integrated so for example our freshman course is called … analytical geometry functions and trigonometry through transformations. So we do everything kind of through a transformations platform so the kids understand how to use transformations and how things are interrelated through geometry and you know, algebra and trigonometry, you know, how there's a relationship between everything …" (Lori Ln# 6 – 11).

- "We were looking to create an integrated inquiry based curriculum. OK, so we threw out the book and started fresh." (Greg Ln# 6 – 7).

- "Here's anecdotally something that's very, very interesting … you know one of the things that was looked at with dubiousness over was that we do not offer computer science. Well my answer is of course we do for anyone who wants it, they can do a research project in computer science … but how could you be a science magnet school and not offer computer science? And … that was a conscious decision we made when we set the curriculum. We thought math skills were more important than programming because if you think mathematically, you got it." (Greg Ln# 213 – 219).

- "… Animal Sciences … we like to include them in our STEM as well because they are so much about the world of biology … anatomy of the animals … not just the … we call it Veterinary Tech … those kinds of things but all of the math and science behind those kinds of courses as well." (Veronica Ln# 31 – 35).

The natural blending of content was repeatedly eluded to and evident throughout most of the opportunities. In many of the opportunities studied, stratifying the content was impossible. Intertwining the disciplines reflected the natural way things work. Students were perceived to have gained knowledge without direct instruction from a textbook in a specific discipline.

Provision of hands-on learning opportunities. Learning opportunities that are hands-on and allow students to actually "do" rather than read about it were one of the most often described characteristics of exemplary learning opportunities. Hands-on opportunities that students thought were fun, cool, or enjoyable were described when Ricky talked about his classes, "… basically I try each week in my class to have some type of hands-on experiences that goes along with what I'm teaching." (Ricky Ln# 45 - 46). Additionally participant remarks illustrating the importance of hands-on learning are as follows:

- "It's like getting hands on … whatever you're working on … right now we're working on getting out DNA and stuff like that. If you're going to go into that field you have a step up if you're going on to college for that. So doing that here you have a general idea of what you're gonna do later on in life." (Jimmy – lines 6-8).
- "Well experiential learning is anything that is hands-on. Uh, the big concept is they actually learn by doing." (Ricky Ln# 34 – 35).

- "… for a lot of them it's good for them to get a hands-on experience … they live fairly pam-pered lifestyles in this area so they've never touched a tool or taken apart anything so it's a great experience." (Ethan Ln# 82 – 84).

- "… seeing it is experiential but I think that when you integrate something that you saw or you're hands-on doing it is what is really exemplary in my mind." (Veronica Ln# 43 – 47).

Offering students the chance to explore, create, produce, manufacture, or fix something was portrayed as a powerful experience, helping students gain a greater understanding of how things work and fit together.

Examples of Exemplary Experiential STEM-related Opportunities

R2. What are examples of exemplary STEM-related experiential learning opportunities?

Three themes relating to examples of exemplary experiential STEM-related opportunities evolved as participants gave example after example of opportunities offered in their experiences. These themes included: (1) In-class opportunities, (2) business and industry opportunities, and (3) co-curricular opportunities, industry credentials and certifications, and competitions were revealed as the kinds of exemplary opportunities offered. There were common threads throughout the opportunities discussed. Jack talked about what his program needs to provide for students, when he said, "… we need to give them the industry experience, the certifications, provide them with the internships, provide them with a high quality curriculum, provide them with amazing classroom experiences, something they are interested and engaged with, something they are learning and they aren't wasting their time." (Jack Ln# 188 - 191). Table 14 presents the themes, attributes, and codes that were revealed by participants.

Table 14. *Examples of Exemplary STEM-related Experiential Learning Opportunities Themes, Attributes, and Codes*

Theme	Attribute	Code
In Class Opportunities	• Designing classrooms to mimic real world environments	• Designing like a shop Environment • Working in the kitchen in culinary arts • Using real world curriculum and equipment in classrooms • Having cutting edge equipment • Failure good because then students know you need quality controls
Business/University Opportunities	• Businesses offering expertise and equipment	• Need expertise and equipment from businesses • Provide equipment • Provide expertise
Business/University Opportunities	• Universities offering expertise and opportunities	• Co-enroll with university • Teachers can't be experts in everything • Mutually beneficial to partnerships • Intermingling, working together with university students
Co-curricular/Industry Certifications, and Competitions	• Access to industry certification, credentials, and co-curricular opportunities and competitions	• Giving access to industry certifications • Students building for competitions • Giving students opportunities to go from design to build
Co-curricular/Industry Certifications, and Competitions	• Increased time spent	• Spending time beyond classroom preparing engages students • Helping obtain practical skills engages students • Incorporating competitions, certifications, problem-based learning
Co-curricular/Industry Certifications, and Competitions	• Increased student engagement	• Going beyond tools to clubs • Preparing for competition engages students • Helping obtain practical skills engages students

In-Class Opportunities

Exemplary opportunities given to students during class time were explained as mimicking real world work places, using up to date equipment and the methods used in industry. A brief narrative for the attribute supporting this theme and examples of participant comments are presented in the subsection that follows.

Designing classrooms to mimic real world environments. Classrooms were often set up to simulate real world environments in the exemplary opportunities discussed. Michael described a local organization that came into his classroom and set up equipment to help monitor satellites. He said, "… [business name] has the satellite and we're gathering data … we've made a little ground station in our classrooms to capture the data and send it to [business name]." (Michael Ln# 28 - 30). Each example given by a participant contained most of the characteristics outlined as necessary for exemplary experiential learning opportunities. Additional participant remarks illustrating the importance of designing classroom opportunities to look and feel like real world environments are as follows.

- "… [business name] has the satellite and we're gathering data … we've made a little ground station in our classrooms to capture the data and send it to [business name]." (Michael Ln# 28 - 30).

- "We use real equipment, sort of like the German … you know you don't teach auto tech on a board or with like models, or you need to bring in the same equipment that they use in industry. You need to use the same curriculum … the NATEF … you need to use the same standards that they have in industry." (Jack Ln# 159 - 162).

- "It's designed almost like a shop environment where each day I give them a task to try and get done and try to figure out how many hours they turned and so forth, but instill so forth all the areas of the field." (Ethan Ln# 21 - 22).

- "… it's real … we're watching … we're looking at the same things those workers are looking at their satellite … they let us control one of their satellites … so they gave us the operation here in our classroom where our students … they'll tell us … when the satellite is at this trajectory … turn it so it's you know … 90 degrees … or whatever they tell us but we actually move

the wings on the satellite … they sent us a commendation that our students did it so our students were actually doing work … they let us do that. … the idea that we were given that responsibility and experience was phenomenal! You know, that's real." (Veronica Ln# 61 - 70).

- "We're using algae to get lead out of water, so doing like … living things to better our lives.… I like the labs we do. I enjoy getting all the DNA and then we got the DCR machine where we can copy the DNA so if you want to put it in something else." (Jimmy Ln# 19).

- "I'll use Culinary Arts as an example. As you know, when the chef is working with the students and the students don't have a clue or have never been exposed to working in a kitchen … and then all of a sudden he tells them well these are the ingredients, this is what you need to weigh and measure … this is the process and when they go through these steps … and create an entree and then they are able to serve that and then the customer is like, oh my goodness … it's like they've created this, they've made this … they did it themselves. A lot of satisfaction … so I see a lot of that." (Jack Ln# 100 - 107).

These types of in-class opportunities were perceived as valuable to students in deepening their understanding of the curriculum.

Business/Industry and University Opportunities

Relying on business/industry and university opportunities through field trips, internships, mentorships, and collaborations were brought out by the participants as another theme associated with exemplary learning opportunities. A brief narrative for the attributes of (1) business and industry opportunities, and (2) university opportunities and examples of comments from participants follows.

Business/Industry Opportunities. Working alongside experts in the field gave students a more realistic view of what to expect in careers. Ethan spoke of his former students now in

business who are willing to return and help his present students when he said " … it was tough at first but now my former students that get out of the program say whenever you need me I'll come." (Ethan Ln# 133 - 134). Additional participant comments supporting this theme are as follows:

 "… all of the Cyber programs we have Oracle, Cisco, … Network Administration, and we also have A+ Computer Technologies course … all of those programs … as far as experiential learning have their own avenues to do different programs whether it's hands-on here in the building or going out to different facilities and sites." (Veronica Ln# 17 - 21).

- "… our programs like Entrepreneurship or Teachers for Tomorrow … or Dental programs … those kids go out into the field. So our Dental kids go into a dental office and have to spend … I think it's 25 hours in a dental office assisting … not just watching … our Animal Science kids go to the veterinary programs around and do things in the clinics." (Veronica Ln# 100 – 104).

- "So some of the projects the students do are … to create something that helps somebody who's disabled and we do a lot with disabled children's toys. And … our teacher … along with the students … made a walker that helps … for blind toddlers so it's just trying to make our community and our world better." (Veronica Ln# 73 - 78).

      University Opportunities. Encouraging students to collaborate with college students and faculty gave high school students a deeper understanding of curriculum. Patty spoke of her relationship with her mentor at a partner university and the experience she gained tutoring other students when she said, "I have … I don't know [what] to call her but she's sort of like a mentor because I tutor kids in Java at [university] in Thompson Hall." (Patty Ln# 77 - 78). She further explained that she now intends to become an educational researcher, which directly stemmed

from this relationship. Other beneficial opportunities were revealed by the participant comments that follow:

- "… one project that we run through the STEM lab is this well water testing, um, it's sort …associated with [university name] too, so kids can bring in their well water samples and they can learn about water testing in the lab but then they can go to [university name] and see how it's tested in their lab, which is really good because it connects them to possible careers that they might not know existed …… and then they come back and learn what their results mean … and then what makes it exemplary …(Renee Ln# 33 - 40)."

- "[teacher name] goes up to [university name] and teaches it there. Some of the same projects they are doing at [university name] are here. Some of his students come and mentor and he'll probably tell you when you interview him that … our students mentor the college students because there are things that we've taught that they haven't learned in the Engineering classroom at [university name] so they're helping each other … which is phenomenal ... that's amazing." (Veronica Ln# 26 - 31).

- "We're fortunate to have Cisco supporting us, Oracle supporting us, [university name], University of [X] … we use some of their curriculum in our Engineering program … they come up once a year and evaluate our program." (Veronica Ln# 52 - 54).

- "The one good partnership I have is with [X] Community College … they have a post-secondary associates degree program so we feed a lot of kids who are interested in expanding their knowledge there then I go to his meetings and he goes to mine (Ethan Ln# 144 - 148).

Co-curricular Activities, Industry Certifications, and Competitive Opportunities

Co-curricular opportunities, industry certifications, and competitive opportunities, which were most often offered in CTE STEM Academies, were discussed as being valuable to the stu-

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dents' engagement in the opportunities. Attributes participants included were (1) access to in-

dustry certifications, credentials, and co-curricular opportunities, (2) increasing time spent be-

yond normal classroom hours in order to accomplish certification and compete, and (3) increas-

ing student engagement added value to students' experiences. Sample participant comments sup-

porting these themes follow.

Access to industry certifications, credentials, and co-curricular opportunities and

competitions. Giving students access to industry certifications, credentials, and co-curricular

opportunities and competitions was an attribute mentioned by participants in exemplary opportu-

nities. Regina mentioned the importance to her of doing well on her International Baccalaureate

(IB) test when she said, "… well in our Design and Tech class we do a lot of hands on, like way

much more than I expected… because it's not an industry certification class … but it's like an IB

test … more focused around info again … so I'd really like for their to be a way to have concepts

and hands-on so we can get both and still do well on the test …" (Regina Ln# 70 – 73). She at-

tributed the availability and access of these opportunities to her increased knowledge. Other

comments by participants supporting this attribute follow:

- "Yes, I do have one of the best facilities in the county and I work hard to get us the best tools

  so the students have a wide range of experience learning how to use CNC, plasma cutters, laser

  cutters, all the different shop metal tools, but then it goes beyond that it goes into building ro-

  bots by the robotics club … learning about aerospace through the Aerospace Club." (Michael

  Ln# 21 - 25).

- "[S]ort of our capstone course is Cyber Security. And that's where we're using CompTIA

  Security Plus certification. All certifications are really valuable in the industry. I know the

  Department of Defense and some others … they really want the minimum of A+ and if you

have Security + that is additional … a bonus I guess … but they are sought after. Students can actually sit for them here free and they can graduate with one, two, maybe three or four industry certifications." (Jack Ln# 20 - 24).

Increased time spent. The increased time students spent on earning industry certifications and participating in competitions was mentioned by participants. Jack commented on the necessity for students to spend time outside normal classroom hours when he said, **"**We also have a number of competitions the IT students participate in. One is the Cyber Patriot. And that is I guess … when you look at these certifications, there really isn't enough time during the day to teach all the material and go over it so a kid has to … can pass it … they really need to be a self-directed learner and need to apply additional time beyond the classroom to their work … ." (Jack Ln# 25 - 29). Other comments supporting this attribute follow.

- "… the Ag production classes deal with actual farm production, whether it's growing crops for commercial use to enter the food chain, livestock production, for…large animals to be produced to satisfy the meat market, or uh, consumer needs … we actually have a farm where we use 65 acres which gives the kids the opportunity to learn about things in class but then we take them out to the research farm and get to do hands-on management practices not only harvesting the crops but they play a big role in what we grow, how we grow it, what types of animals we have on the farm, so we actually have kids who give up their summer, and work with us during the summer to manage the farm." (Ricky Ln#12 - 16).

- "They come after school and sit around and it's all group … it's really a collaboration of students at each table and they are all … communicating, working together, cooperative learning, answering each other's questions and it's sort of a … it's a learning … uh learning is going on." (Jack Ln# 47 - 49).

Increased student engagement. Co-curricular opportunities and competitions were mentioned as experiences that increased student engagement. Jack spoke to this when he said, "… we have students earning their Network + and Server + [certification] in addition. But if we take what … companies want or colleges want, they want these students that are so motivated and a lot of times their energy is captured with the computer competitions, so we offer Cyber Security Club, which meets after school, so we extend the school day. We have probably 70 - 80 students signed up from freshman to seniors in the Cyber Security Club." (Jack Ln# 34 - 38). Other comments from participants supporting increased student engagement due to co-curricular opportunities and competition in exemplary experiential learning opportunities follow.

- "… what they are doing is prepping for the next round of Cyber Patriot or they are just in general talking about competition that's coming up or maybe forensics, they may be talking about a subject we may not cover in class and that's a lot of fun … and it just shows you how engaged and interested these students are!" (Jack Ln# 45 - 47).

- "... we did a lab where, we were broken into groups, it was competitive and we all started with some mass of rock and we just learned about all the different processes of weathering and so whoever finished the hour and a half time period with the least amount of rock after running it through a sieve won. It was just this is how weathering works. It was just constantly all kinds of fun things like that." (Ian Ln# 37 - 40).

Impact of Exemplary STEM-related Experiential Learning Opportunities

R3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, and administrators?

Another aspect of this study was to determine how exemplary experiential learning opportunities impact students and teachers. Participants gave evidence that both students and

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teachers were positively impacted through participation in exemplary experiential learning op-

portunities and there were similarities in how they were affected. In order to have an informed

citizenry and productive graduates, it is imperative to keep students engaged and interested

throughout their education and allow them to take ownership of their learning. Jimmy stated, "I

just feel kind of grateful that we have the opportunity to actually learn all this because not many

people get to learn it until they get to college so I just enjoy it while I've have it" (Jimmy Ln#

32). In a time when teachers are leaving the profession in droves, keeping teachers satisfied and

engaged is as important as keeping students satisfied and engaged. Both students and teachers

found the relationships formed as one of the most important impacts. Table 15 shows the themes

that emerged regarding the impact of exemplary experiential learning on students and teachers

and the codes and attributes supporting each theme.

Impact on Students

A consensus among participants was that exemplary experiential learning opportunities

impact students in many positive ways. There were four attributes supporting this consensus, in-

cluding: (1) Student engagement, (2) relationships, (3) life after graduation, and (3) student per-

sonal growth. A brief narrative for each attribute supporting this theme and examples of partici-

pant comments are presented in the subsections that follow.

Table 15. *Impact of Experiential Learning on Students and Teachers:*
Themes. Attributes, and Codes

Theme	Attribute	Code
Impact on Students	• Student engagement	• Engaging students • Keeping some students in high school • Student satisfaction when they make something or fix something • Positive feedback from kids returning from college/careers • Developing student passion and interests • Students as teachers
	• Relationships formed	• Thinking of kids personally and then academically • Developing personal relationships with staff

Table 15. *Impact of Experiential Learning on Students and Teachers:*
Themes. Attributes, and Codes

Theme	Attribute	Code
		• Being part of Nerd school good for them • Students thinking and collaborating together
	• Life after grad-uation	• Helping college feel like a breeze • College is almost boring • Head and shoulders above everyone else in college • Well prepared for engineering college • Performing better on standardized tests • Students accelerating in math skills • Students get better jobs • Didn't need Computer Science because math skills gave them skills to figure it out • Giving students game-changer programs • Adding value to students' lives and educational experiences
	• Student person-al growth	• Empowering to students • Talking at college graduate level by graduation • Building confidence in female students • Creating thinkers, collaborators • Creating analytical, logical, progressive thinkers • Treating like adults helped personal development • Solving problems • Increasing sense of pride
Impact on Teachers	• Teacher job sat-isfaction	• It's more exciting • Validating teacher • Constantly refreshing and keeping fire burning about the teaching profession • Different everyday • Giving agency to teachers • Freeing for teachers • Teachers are happier • Positively impacts teachers
	• Relationships formed	• Making personal connections to students • Building rapport with students • Students coming back and keeping in touch • Being personally invested in student growth
	• Teacher growth	• Giving staff opportunities to grow • Teachers as learners • Teachers committed to inquiry learning • It's more difficult • Informing teacher practice • Teachers challenging themselves

Student engagement. Participants claimed these classes were sometimes credited with keeping students in high school at best, and keeping them interested in subject areas at least. Ian spoke of traditional programs that sometimes kills students' enthusiasm when he said, "I think that the way science is taught … and math more so … very much turns a lot of people off towards the STEM fields … science and math. Just very bright kids either get burned out or turned away from science and math the way they are taught." (Ian Ln# 91-93). Further comments to support the importance of student engagement follow:

• "I'd say I'm a better student because before I never really tried in school, I never really put myself out there, but up there I just put myself forward. I wanna participate in things." (Jimmy Ln# 49-50).

• "[T]he kids in their sophomore year are planning their research projects and not someone handing them a handout of what's step 1, what's step 2, what's step 3 … they gotta figure out what your own steps are and some kids really struggle with that but for some of them … you'll see some students who were not the strongest students in the classroom all of sudden they find a research topic that they love and they all of a sudden …it's like … [excited voice] can I contact this person??" (Lori Ln# 69 - 74).

• "… its engaging, it's applicable … it's kind of like you hook them." (Renee Ln# 64).

• "I've actually heard teachers throughout the school say, you know this kid was totally disengaged in my class but he comes to my class and he tells me about all the exciting things we've been doing on this end of the school so they come down to investigate. I hope it's going to spread throughout the school, that this type of experiential learning is really taking hold, especially if we can get away from this SOL testing." (Ricky Ln# 83 - 87).

- "This is the first time that maybe they get a little soil underneath their fingernails and they think it's exciting!" (Ricky Ln# 104 - 105).

- "For some of my students it's the only thing that keeps them in high school … I sometimes get those anomalies where that could be the thing with some kids that gets them through high school." (Ethan Ln# 85 - 90).

The comments reflect the importance of having engaged students for a program to be successful. In the opportunities studied, the students were interested and excited, which resulted in increased participation, fewer discipline issues, even keeping some kids from dropping out of school. Students were perceived to be more motivated and inclined to examine career interests not considered before.

Relationships formed. The relationships built between school staff and students and student-to-student was evident. The STEM schools generally seemed to create an atmosphere of inclusivity and individual safety, safety to step outside the box and be different, safety to try and fail and be allowed to try again. An element of trust was formed which is sometimes lacking in traditional classrooms. Evidence of these relationships was cited in the following comments:

- **"**[If you asked the] question … what are some of the things that make this special to you I would say 9 out of 10 kids would say … if you picked one that went to the Bahamas, which is most of them … they'd say the Bahamas trip. And one of the things they'd say is we formed as a family." (Lori Ln# 141 - 145).

- "It's just a great opportunity to really see just the group and seeing them start to bond with each other. And still be kids because they are still going to be silly and goofy and you can see that but you can also see kind of the way they work together." (Lori Ln# 165 - 168).

- "… our official t-shirt says Nerd School … the kids designed it … being part of a nerd school is really a good thing for them." (Greg Ln# 205 - 209).

- "...the teacher will be able to interact well with the student and the student will be more attentive and have a higher success rate in terms of testing and any other type of project." (Regina Ln# 49 - 51).

- "… when their seniors [university students] are doing a senior design project they are coming here to actually do the fabrication so [university name] seniors as well as my students are intermingling and working together so all of that mix is what I think… the experience … not any one class … not any one thing but the environment is what makes it good." (Michael Ln# 36 - 42).

Rapport and trust was perceived as important aspects of these opportunities, which emerged from the comments. Students felt a personal connection to teachers which is often lacking in traditional classrooms. Also, the relationships built between students and mentors seemed to have a positive impact on students. Students helped each other and became a cohesive group or cohort, which positively impacted them.

Life after graduation. Students, teachers and administrators commented on the impact on students' lives after they graduate. Opportunities for real world experience was given to students while allowing them to explore career choices. Although not explicitly stated, active involvement with businesses and/or university partners served to underpin these opportunities. Many cited successful college preparation, career and job skills preparation, and a better ability to transfer knowledge to life skills as advantages gained in participating in these opportunities. Examples of quotes are noted below:

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- " I have kids who are coming back now that are very successful in college and even successful in their careers and will say to me that the classes they took under me have greatly prepared them for college because they knew what to expect … no one else had ever told them." (Ricky Ln# 11 - 113).

- "… as far as those that are entering careers, they say the same thing … they come back and say I was able to use a lot of what I learned in your class in my job today … … even though it's not Ag-related, some of the thought processes and being able to solve problems and apply it to their jobs has helped them out a lot." (Ricky Ln# 113 - 116).

- "I might look for a part time job, for when I'm in college, centered around what I'm studying … because the experience is an important part of getting a job and since I need to support my-self as well, I can't exactly get a full on job but I can get a better job than most jobs because I can prove I've got the experience." (Regina Ln# 33 - 36).

- "I actually just found out what I want to do when I'm older, which is actually a researcher." (Patty Ln# 75).

- "I think I want to run my own greenhouse … you know I really love plants ... and I also want to grow my own food and stuff that I like, you know, corn, beans, you know stuff like that." (Jimmy Ln# -lines 81-83).

- "Well when I get hands-on experience … I learn more about what I'm going to do in a job … an actual physical job than just concept based learning and taking notes. So for those who don't have that opportunity I think they are basically at a disadvantage because they won't know what they are going to face when they go into the industry whereas people like me who have taken these hands-on classes already know and they're prepared and so they'll probably do much better." (Regina Ln# 25 - 30).

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- "I think we're actually giving them game-changer type programs." (Jack Ln# 155).

- "[Students] are satisfied or feel that they've added value to their lives or their educational experience." (Jack Ln# 192 - 193).

- "I think it better prepares them for life after school. It gives them … some of the things we're doing gives them a work ethic … and I think a lot of young people today have been lacking in work ethic." (Ricky Ln# 98 - 97).

- "[I]t gives them a good leg-up on you know, getting a job, and then once they're in the job already having the basic skills and not having to cover that kind of stuff." (Ethan Ln# 95 - 96).

Pointing kids on a career path and providing them with transferable skills was evident in the comments of the participants. They were able to take the opportunities offered them and apply the knowledge later in life. Students coming back to their high school programs was common, sharing the ways they were impacted. Teachers were then often allowed to modify and make changes to their courses to improve the experiences.

Student personal growth. The opportunity for personal growth was also often cited. Also, creating an informed citizenry was also touched on. Instilling a sense of pride, honing work ethics, facing fears and overcoming obstacles, and building students' confidence were mentioned in the following:

- "… what I really like about what these kids do is … like [Jimmy] who was in here before, you know here's somebody you would never have put into that field … he said he didn't even like science but now he's proud of his project … he goes to his other classes and he talks all about it." (Renee Ln# 69 - 71).

- " … getting our kids to be creative because … it's so much … STEM is so much about making our world better and innovating what's already there and understanding it better and being creative." (Veronica Ln# 73 - 74).

- "I think there's a lot of individual satisfaction … in just CTE … you're just not doing a test or a quiz … that you're actually trying to create a solution or build something or create something that you are proud of." (Jack Ln# 121 - 123)

- "it helps them mature and develop and learn to face fears and not be afraid of obstacles but look at them as challenges they can figure out on their own." (Lori Ln# 206 - 207).

- "You never stop learning … learning just keeps on." (Patty Ln# 65).

- "For biotechnology when we talk about GMO's … even if they don't go to [university name] … to study biochemistry or biotechnology … they are eating GMO's and … the famous Jimmy Kimmel interview where he went around to people and said, so would you eat a GMO and they said, Oh NO! NO … how come? It's terrible for you! So… what is GMO? What does that stand for? ummm …. I don't know …. G… ummm… and they couldn't answer him … [Laughter] so it had no basis. So even if it's making citizens that are well-informed … because who's going to make our policies in the future? They are!" (Renee Ln# 82 - 88).

- "You need to be an informed citizen to make those policy decisions even if you don't foresee that as a career field." (Renee Ln# 90 - 91).

- "I think it's hard to beat the satisfaction or the smile on a student's face when someone may hit it out of the ballpark when making something in culinary arts or … in other cases maybe fixing or solving a problem with someone's car." (Jack Ln# 115 - 117).

- "I'd say it will give them some sense of pride and accomplishment and stuff." (Ethan Ln# 93 - 94).

Some of the biggest perceived impacts for students were the areas of personal growth they experienced by participating in these opportunities. A sense of pride, increased self-confidence, the ability to define problems, design a solution, and then apply their skills to develop and improve on a solution were large factors in increasing students' feelings of self-worth and giving them a perceived step up in comparison with students in traditional programs. The participants seemed to feel that these students could "figure it out" when they needed to.

Impact on Teachers

Teachers were impacted in similar ways to students. The three main themes that emerged from discussions were (1) increased teacher satisfaction, (2) relationships formed with students, and (3) teacher growth. A brief narrative for each attribute supporting this theme and examples of participant comments are presented in the subsections that follow.

Teacher job satisfaction. Increased **t**eacher satisfaction was noted as a positive impact on teachers by most participants. This was perceived by students and administrators, and mentioned by teachers. Greg stated that, "I think the teachers are very happy … compared to how they were in their last school." (Greg Ln# 249 - 250). Offering teachers the freedom to teach in an innovative, unique atmosphere appears to keep them engaged, as is represented in the following statements:

- "It makes me feel like the job that I'm doing is worthwhile." (Ricky Ln# 124).
- "… as you know last year the No Child Left Behind bill was done away with, the Every Child Succeeds Act was approved and when that act was approved, this was the highlight of my career. Senator Kaine stood on the senate floor during the passing of that bill and specifically named my program as the role model for all future education programs in America. THAT was the highlight of my career." (Ricky Ln# 212 - 216).

- "I think it's constantly refreshing for the teacher. I would think that that sort of engages them too to keep that fire burning or the excitement about the profession going." (Jack Ln# 341 - 342).

- "I definitely think our curricular areas lead to … teachers wanting to be the best they can be." (Jack Ln# 352).

- "[I]t is exciting and everyday … almost every day I go home and have a story to tell my wife about … you won't believe what this one kid did … [laughter] … oh it was awesome cuz one kid actually remembered this!" (Ethan Ln# 113 - 115).

- "You need to center your program around the strengths of your faculty. And don't try to fit these square pegs into these round holes … they're not going to fit so you look at the strength of your faculty and guess what? You are playing to their strengths, they are happy! You need happy faculty." (Greg Ln# 116 - 119).

- "I think it's impacted teachers in a very positive way. I think there's not a soul on this faculty … there's only 12 … only 11 teachers … there's not a soul on this faculty who is not com-pletely committed to inquiry learning." (Greg Ln# 240 - 242).

- "It gave the teachers a lot of … they had a lot of agency in how exactly they were going to shape the labs." (Ian Ln# 138).

- "I'm sure that was good for them. I guess that's sort of a symptom of both the very freeing …empowering." (Ian Ln# 146).

- "I think in the academy they are happy coming to work because for the most part they have kids who want to be in the classes … especially when I draw from 25 schools … those kids made the choice to get on a bus and come here for our class so we have very little disciplinary issues. I think if you asked my teachers they'd say it's a great place to be. I think more so than

a typical English teacher or a geometry teacher that has a set 30 kids who could care less about geometry." (Veronica Ln# 213 - 215).

• "[I]t makes me feel you know, validated in what I'm doing … that this is a good thing." (Michael Ln# 97).

Analyzing the comments made, it appears that being part of an environment that was freeing and empowering to teachers was perceived as increasing teacher satisfaction. Teachers were often given the freedom to innovate and create learning opportunities that made students want to come to class, and gave them a willingness to work hard towards a shared goal. Fewer disciplinary issues were noted due to increased student engagement, which makes teaching much more enjoyable.

Relationships formed. The importance of creating relationships between students and teachers was mentioned many times throughout our conversations. Students recognized it and so did teachers and administrators. In all the opportunities, students chose whether or not to enroll in the programs. Often the personality of the teacher or the quality of the relationships made were key considerations. According to Jack, "… you get that right teacher in a classroom and amazing things can happen." (Jack Ln# 213). Other supporting comments included the following:

• "I think there's something about seeing a kid not in a classroom. For me, like seeing who are the adventurous ones? Who is the helpful one when they see someone struggling? Who are the ones who are just so excited and like, not rushing to see the biggest thing, who can take time and stare … who are the ones that notice everything. Who are the ones … you know you start to see this … kind of this side of kids that you don't normally see." (Lori Ln# 156 - 161).

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- "So partnerships help some but I'd say the main thing is, especially in high school is building rapport with the kids." (Ethan Ln# 36 - 37).

- "I think there's a really good relationship between the students and the teacher." (Patty Ln# 99).

- "I think that it really grows a bond between teachers and students, more in hands-on experiences because I feel like a teacher becomes a colleague or coworker with us so we're all working towards this one goal, so I feel like the chemistry between the teachers and the students is a lot better than in the rest of the classroom environment type stuff." (Regina Ln# 46 - 49).

- "I think also to connect with people our age on a much more personal level than I feel like … not quite any of the teachers at my home high school did ... the vast majority of the teachers at my home school … just got a much more personal connection to us, and … it really felt like they were personally invested in our growth." (Ian Ln# 142 - 146).

- "So it's just 16 kids and a teacher for 3 hours and I can't really quite speak to how it was for the teachers but I can imagine how that might have been. It was just a lot better experience for them than trying to wrangle 35 students which was large but a pretty standard class size at my home high school." (Ian Ln# 146 - 150).

Increased rapport with students was perceived as a natural outgrowth of experiential opportunities. Some of the reasons for this were smaller class sizes, more time spent with individual students, and students and teachers working together towards a common goal. Having a shared vision with other teachers was also perceived as a beneficial component of these types of opportunities. Being members of a learning community seemed to enhance the experience for all involved.

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Teacher growth. Teacher growth and personal characteristics emerged as an important theme. Teachers as learners and facilitators was important. Ricky stated, "I think it's a bar you have to set for yourself as an educator … that you know, hey I want to be the best at what I'm doing and I want to share the experiences with my students. You know, I'm not happy with the status quo. I want my kids coming out of here doing great things. I think, you know, that's my motivation." (Ricky Ln# 140 - 143). Other supporting comments made were:

- "… we started teaching Cyber Security from our business partners during our Learn and kids just came in and then our IT teachers sort of knew A+ back then and network administration and they started sitting in and they started picking it up." (Jack Ln# 448 - 450).

- "They're not here for the money but … if I can sort of cut through the red tape or tell them what's a priority or what to focus on and hopefully also to encourage them to challenge them-selves and become like a top program." (Jack Ln# 256 - 258).

- "… for me, it's hard … it's always a challenge." (Lori Ln# 241).

- "I definitely love what I do." (Lori Ln# 272).

- "I think it does impact her because it strengthens her knowledge which makes the students bet-ter." (Patty Ln# 99).

- "It makes me want to discover new things that I can share with my students. Maybe there's something I'm missing that they really need, and if I stay on top of things and watch …. you know we're in a evolving society … everything is evolving and changing, we have to evolve and change with it as a teacher and if we don't make those changes then really we're nothing but a glorified daycare for our children. But if we can bring them things that can prepare them to step outside of the school system and be productive members of society then that motivates

me when they are doing well, that maybe I'm doing the right thing and I want to continue doing those things." (Ricky Ln# 124 - 132).

- "[I]t's just comfortable to be a sage on the stage blah blah blah blah blah. Inquiry teaching is very hard! It's very hard to surrender your classroom to learning. You know [laughter] you know, everybody has a hard time with that." (Greg Ln# 245 - 247).

- "I got my … AP biology teacher, Dr. [X], was a working biophysicist in a past life … well that's great but she doesn't know ecology to save her life! [laughter] She had to learn ecology to teach AP Bio! It was hysterical! She was like … what is this? So she's got a … lab and a C. elegans lab, a worm lab, you know. Well she's never grown a C elegans in her life but you know, she's learning." (Greg Ln# 298 - 302).

- "So, setting up a great STEM Academy … what you need to do … first of all you need to make sure you recruit teachers not technicians." (Greg Ln# 99 - 101).

- "Now half my staff have PhD's but that's not because I recruited PhD's, it's because I recruited pedagogues and lifelong learners." (Greg Ln# 102 - 103).

- "My best introductory physical science teacher is a biologist. She won the presidential award for a physics lesson. She hadn't taken physics in 14 years before she started teaching here, but guess what, she's a great teacher and learner. And does she know as much physics as the guy who teaches AP Physics, absolutely not! I wouldn't put her near an AP Physics class. BUT, I was looking for people who were confident in themselves, who were lifelong learners, and love kids and love teaching. And if you get that, you've got it." (Greg Ln# 103 - 108).

Reflecting on the comments of the participants and how teaching in an experiential learning environment impacts them, it was clear that teachers were perceived as more satisfied in their careers, even though the job was often more challenging than teaching in a traditional manner.

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The relationships formed with students, and the encouragement to grow and not accept mediocrity seemed to make their experiences richer and more rewarding. Teachers were often pushed beyond their comfort zone, but administrators, business and university partners, and the community, which created a safe environment for them to grow, also offered them support.

Challenges to Exemplary STEM-related Experiential Learning Opportunities

R4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

Participants were asked what they perceived as challenges to providing exemplary experiential learning opportunities within STEM programs. Four themes emerged: (1) funding, (2) time, as in (a) lack of time for teachers, (b) lack of time for students, and (c) lack of time for business and university partners, (3) perception for (a) minorities and nontraditional students, and (b) parent and communities, and finally (4) class size were mentioned as potential barriers to exemplary experiential learning opportunities. Table 16 presents the themes, attributes, and codes that emerged from the discussions. A brief narrative for each theme, their supporting attributes and examples of participant comments are presented in the subsections that follow.

Table 16. *Challenges to exemplary STEM-related experiential learning opportunities: Themes, Attributes, and Codes*

Theme	Attribute	Codes
Funding	• Lack of funding	• Initial startup costs • Money problematic • High cost from breakage • Can't pay teachers enough • Getting teachers to come to STEM programs instead of industry
Time	• Lack of time for teachers	• Time consuming for teachers • Not enough time for staff development • Not enough time to teach material • Developing assessments in teachers' spare time
	• Lack of time for stu-	• Traveling to academies takes time out

Table 16. *Challenges to exemplary STEM-related experiential learning opportunities:*
Themes, Attributes, and Codes

Theme	Attribute	Codes
	dents	• of schedules • Students have limited time in their schedules for electives
	• Lack of time for business/university partners	• Businesses don't have time to visit classes • Difficult to get advisory board to meet due to time constraints
Perception	• Perception of minorities and non-traditional students	• Public perception a problem • Low minority enrollment • Minority students won't apply • Societal issues • Public perception that minorities aren't as smart • Perception as elitist schools • Filling classes with females until Federal bureaucracy shut it down
	• Parent and community perception	• Community and administrators recognizing value of program • Parents do not want students in CTE courses • CTE courses not rigorous • Vocation is a dirty word • Changing parent perception
Class Size	• Necessity for small class sizes	• Needing small class sizes • Inaccessible to students • Doubling class size affects experience • class size problematic • Competitive, hard to get in • Hard to give quality feedback to students if class sizes too large • Small sizes limits access • Needing small class sizes • Inaccessible to students • Doubling class size affects experience • class size problematic • Competitive, hard to get in • Hard to give quality feedback to students if class sizes too large • Small sizes limits access

Funding

Lack of appropriate funding was a barrier alluded to by every participant. Experiential learning is expensive and most school systems do not have the funds to sustain these opportunities. Most overcame this obstacle with resources supplied by businesses and university partners, or running a business through their programs, which covered the extra costs involved in having these opportunities. Ethan commented on funding of his program, "We have an awesome program where people can donate a car to us .… we sell a good amount of cars … so we're fairly self-sufficient, we don't need a lot of funding." (Ethan Ln# 60 - 68).

Comments made supporting the attribute of funding as a barrier follow:

- "… since I've been here I've brought in a little over $700,000 into our program, to our department … a lot of it has been in corporate sponsorship … grant funding." (Ricky Ln# 189 - 191).

- "[T]he student auto sales program and donated cars really helps because it gives us a lot of additional funding where we don't have to go to the school and say hey, I need $10,000 in tools this year …." (Ethan Ln# 99 - 101).

- "… then students and me will evaluate it and determine if it makes sense to fix it up and then we can sell them. The money comes back into the school to pay for the tools and we have a scholarship program and stuff like that." (Ethan Ln# 62 - 64).

- "A lot of it is because money … you know a school if they don't have the money to do it they're not really going to push for it … so I think financial reasons are a big part." (Jimmy Ln# 76 - 77).

- "When it comes down to it money is always going to be a problem. Even at the [school name] money was a problem. There was only so much that we could do … the students could do with their research … that we could get funded." (Ian Ln# 177 - 179)

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- "[T]he kids are new to it so they break stuff every now and then so the cost involved with a technical program." (Ethan Ln# 69 - 70).

- "[I]f we didn't have this $100,000 a year that we get from [company name] for research I couldn't do some of the international trips that we do." (Greg Ln# 256 - 257).

Funding has always been an issue for public school programs. The need for funding is even greater in experiential learning opportunities. Providing equipment and supplies is often prohibitively expensive. Technology is constantly changing and therefore, the needs are continuously changing in order to provide real world opportunities for students.

Time

Lack of time and limited access was a barrier all participants mentioned. Teaching in experiential ways is often more difficult, and more time consuming. Gathering resources, the logistics of coordinating experiences, and the time to give adequate feedback to students on projects appeared to be problematic. Time was an issue for teachers, students, and business partners.

Lack of time for teachers. Teachers have limited time in their schedule to plan, implement, and then provide meaningful feedback to students. Lack of time has always been a concern for educators but in an experiential learning program it takes on even more importance. Collaboration and planning across curriculums, integrating hands-on learning opportunities, supplying the necessary equipment, supplies, and sometimes expertise, coordinating the logistical issues of providing field trips, guest speakers, and extensive labs were mentioned as being problematic.

- "I bring teachers in to do these activities and they wish there was more time they could be in here and they wish there were more activities that they could do and unfortunately there's only one lab and one of me so they can't." (Renee Ln# 93 - 95).

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- "Some of them are you know, super experienced and just didn't have a way to tap into it because their everyday teacher schedules prevent you from having the time to set up all of these labs or make all of these contacts or things like that." (Renee Ln# 97 - 99).

- "… you are always interrupted [laughter] and you've always got something else to do, … as far as the STEM education I think that piece of it has been unique to what we have here and I think it's been a really valuable component to what we have here because … for teachers to implement some of these things it's hard to do at that level … because of time." (Renee Ln# 107 - 110).

- "We can only reach so far, there's only so much we can do because if you're in research 3rd block … and I might know your topic … but I'm teaching 3rd block so I can't help you. So those are kind of our big limitations you know, sometimes the kids need more than we are able to give. That's why being able to reach out to outside mentors is great because they are the ones who are really going to know the topic anyway." (Lori Ln# 86 - 91).

- "They grade for hours and hours and hours. You know … I'm a classroom teacher at heart. I remember how impossible it was for me to do a conscientious job grading. It was not practical and I never was good at it. And one of the reasons I was not good at it was me, but the other reason was there were just too many papers. So here I am demanding high quality work from my kids but I can't react to it." (Greg Ln# 224 - 228).

Lack of time for students. Students only have a specified amount of time in their schedules and with graduation credit requirements, and there often isn't time in their schedules to travel to STEM Academies to participate in time-consuming electives. Jimmy spoke of the accessibility problems for students that don't live close to his STEM Academy when he said, "… just not having access to it … I mean other schools like X,Y,Z, in this [geographic] region, we're

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the only one. So if there's no access to it how are they really going to know?" (Jimmy Ln# 73-74).

- "They [students] can't afford to come in first period and second period because they really want to take another course and they can't spend the time on the bus between their base school and the academy." (Patty Ln# 107 - 111).

   Lack of time for businesses and university partners. Business partners are running businesses as their first priority, which limits the amount of time they can delegate to supporting schools. Comments made by participants supporting the attribute of time as a barrier follow:

- "… the rest of us have our own jobs too … like we support that but we don't have the time …" (Veronica Ln# 235 - 238).

- "They're [business partners] so busy and most of the technicians and managers say they don't have time to come over here and talk about stuff." (Ethan Ln# 124 - 125).

- "It's hard to get the managers and the higher ups to come to anything." (Ethan Ln# 135).

Perception

   Perception was also mentioned as a theme and possible barrier to offering exemplary experiential learning opportunities to more students. Fighting parent and community perceptions was mentioned as perceived barriers to offering good opportunities. Career and Technical Education programs have a long history of being considered programs for inferior students. Crossing traditional gender lines has also been a constant battle. The problem of convincing minorities to consider themselves as viable members of these learning communities was also mentioned. The perception of inaccessibility to minorities and non-traditional students, and the continued stigma attached to CTE programs keep some students from participating. These emerging attributes are discussed further in the sections below.

Perception of minorities and non-traditional students. Gender and cultural stereotyping and federal regulations initially enacted to protect non-traditional students and the unintended consequences of that legislation also was mentioned as playing a part in keeping students from participating in some programs. Michael spoke of the problem with legislation intended to help with this issue but actually hurt when he said, "We used to have a *Girls in Engineering* program which was great and then the federal bureaucracy squashed it. You know … how stupid. It was … like right now I might have 3 or 4 girls in any class. When I had the girls only I had 30 to 50 … I had to have two sections of girls only classes. So the need is there, I mean, all I had to do is give an opening … boom, there it was." (Michael Ln# 127 - 131). Comments supporting this attribute follow:

- "I think … a lot of students are deterred because … maybe it's their gender because maybe they don't feel comfortable being … it's happened to me too because I admit it … ." (Patty Ln# 102 - 103).

- "[My mom] ... didn't grow up in the United States so I … did understand that it's culturally very different …it got me a little bit annoyed because she knows I'm really into these courses … to say that to my sister was like really offensive." (Patty Ln# 116 - 118).

- "The barriers can be public perception. That can be a real problem. For example one of the issues we have here is minority enrollment. And that's something that you probably should touch on in your dissertation. And TJ has the same problem. Um, my problem is they won't apply. It's not that we aren't taking them … they won't apply. Um, let's see, if you think about it, it's a societal issue. Why are these kids … a) either not getting prepared, or b) being convinced that they can't apply here! So so, 21% of our school district. Maybe even a little

bit higher, are black and Hispanic, and 6% of my applicants are. You think of 3% … and 3%

of 68 kids is one kid!” (Greg Ln# 305 - 312).

- “We had someone recently suggest to us that the way to get more black kids to apply to us was

  to … these are my words, they did not use these words … to dumb down your math program.

  They said, why do you need to offer multivariable calculus? Why … and to me that’s the ul-

  timate WRONG thing to do! You know … to, to dumb down your program so more black

  kids can get in … what are you SAYING with that?” (Greg Ln# 317 - 321).

       Perception of parents and community. Most of the programs visited were housed

within CTE programs and there has often been negative reactions to CTE programs and long-

held beliefs that CTE is less rigorous than traditional academic experiences. STEM Academies

were also mentioned as appearing elitist and therefore out of reach for some students. These

perceptions were mentioned as problematic in the following participant comments:

- “The other thing with public perception is elitist schools. You know I only accept 68 kids and

  there were 1000 applicants. Um, we’re elitist … and we are! But is that so bad? And the key

  is you just, you just have to keep the public perception that you are doing good for the country,

  for the county. For the kids … so those are difficulties that … I think any STEM school is go-

  ing to run into.” (Greg Ln# 325 - 329).

- “I still think there are stigmas out there that it’s a CTE class … and those are maybe for ‘those’

  children but not “these” children … from a counselor … human barriers who might say, you

  don’t want that class.” (Jack Ln# 476 - 478).

- “It's always about getting the word out [about CTE]. In my entire career, I started teaching in

  ’84, it’s always about letting kids know … and even in those years it's changed so dramatically

  … vocation is a dirty word … we don’t say that anymore … so getting the word out to parents

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… the parents are our age so it's not like it was when we went to high school … this is in fact our tag line is college and career readiness because it's not about going to the work place … I mean you could … but most of them don't! We are giving them a boost in college and that is how they need to see us. That's my only thing … getting the word out about what really goes on here." (Veronica Ln# 305 - 311).

Class Size

Large class sizes have also been a constant problem in public schools. Managing experiential learning opportunities is not perceived as possible with large class sizes. The need for small class sizes was supported by the following statements:

- "Class size is one [problem]." (Ethan Ln# 145).

- "Size … I mean for us its [class] size." (Lori Ln# 296).

- "You have a lot of kids fighting for those few spots." (Ethan Ln# 32).

- "… the goal of doing this was that … we'll have more space … we can increase our size. I … people are excited because they're like, OH, they'll be more space for my kid to go to [school name] and I'm like yah, but know what? Just like anything … when you bulk size things you lose something … sometimes you lose quality when you bulk." (Lori Ln# 301 - 305).

- "The sad part is, we don't want to make our class sizes too much bigger. Because the whole idea is that we're discussion … and if you get too many in the room and there will be some people who aren't there actively participating. So I think there's a kind of magic number somewhere … I don't know exactly what it is but I know it's not 25. That's just too many." (Lori Ln# 312 - 316.

- "Money and class size. How could we do research with 20 kids in a class?" (Greg Ln# 279).

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- "If you were from another building and you didn't know what we did here, you'd really be not very happy with what you see here. My class sizes are 16 to 18." (Greg Ln# 222 - 224).

Summary

Chapter 4 shows the findings of the study of exemplary STEM-related experiential learning opportunities across Virginia. The characteristics of exemplary opportunities that emerged were divided into two themes: (1) program qualities and (2) curriculum development and instructional delivery strategies. For the theme 'program qualities, five attributes were identified that support this theme. They include: (1) Opportunities for real world experiences and opportunities for career exploration, (2) students given choices and ownership of their learning, (3) support from university and business partnerships, (4) teacher characteristics, and finally (5) professional support positions within the school.

The data also revealed two common attributes for the theme of curriculum development and instructional delivery strategies. They include: (1) provision of transdisciplinary learning, and (2) provision of hands-on learning opportunities.

Examples were given of opportunities offered in each program studied and the data fell into three different themes; (1) in-class opportunities, (2) business/industry and university opportunities, and (3) co-curricular opportunities, industry certifications, and competitions. Supporting the theme of 'in-class opportunities' was one attribute: (1) designing classes to mimic real world environments. Supporting the theme of business/industry and university opportunities two attributes emerged: (2) businesses offering expertise and opportunities, and (3) universities offering expertise and opportunities. Supporting the theme of 'co-curricular opportunities, industry certifications, and competitions' three attributes were revealed: (1) access to industry certifica-

tion, credentials, and co-curricular opportunities and competitions, (2) increased time spent, and (3) increased student engagement.

Another aspect of the study looked at the impact of experiential learning on students and teachers. Supporting the theme of 'student impact' were four attributes including: (1) engagement, (2) relationships formed, (3) life after graduation, and (4) student personal growth. Supporting the theme 'teacher impact' were three attributes including: (1) teacher satisfaction, (2) relationships, and (3) teacher growth.

Finally, challenges to offering exemplary experiential learning opportunities were revealed. Four prevalent themes emerged; (1) funding, (2) time constraints, (3) perceptions, and (4) class sizes. Supporting the theme of 'funding' was one attribute: (1) lack of funding. Supporting the theme of 'time constraints' were three attributes: (1) lack of time for teachers, (2) lack of time for students, and (3) lack of time for business and university partners. Supporting the theme of 'perception' were two attributes: (1) perceptions of minorities and non-traditional students, and (2) perceptions of parents and the community. Supporting the theme of 'class size' was one attribute: (1) necessity for small class sizes.

Chapter 5 will provide a summary of the research project, conclusions reached, discussion on the findings, recommendations on ways to extend opportunities, and recommendations for areas of further research.

CHAPTER 5 DISCUSSION OF RESULTS AND CONCLUSIONS

Chapter 5 begins with an overview of the study; followed by conclusions made based on the findings of the study, a discussion of the findings and conclusions, recommendations for practice, recommendations for further research, and final thoughts of the researcher.

Overview of Study

The overview of the study includes the statement of the problem, a brief description of the purpose of the study, the research questions, a brief description of the research methodology used, and a list of key findings.

Statement of the Problem

Experiential learning and co-curricular opportunities as provided in Virginia Public Schools' STEM-related courses are hit or miss. The problem addressed in this study was related to identifying and analyzing exemplary experiential learning opportunities provided in selected Virginia Public Schools' STEM-related courses. It was conducted to define characteristics and cite examples of what exemplary opportunities look like, and to analyze the impact of exemplary experiential learning opportunities on students and career projection. Examining how the facilitation of an exemplary experiential learning experience impacts teachers, formal teaching, and the classroom environment was also a goal. Finally, challenges for offering exemplary experiential learning opportunities were examined.

Purpose of the Study

The purpose of this study was to identify characteristics and examples of exemplary STEM experiential learning opportunities as lived by STEM stakeholders; including school administrators, teachers, and students involved in STEM opportunities and to better understand the impact on students and career trajectory. It was conducted to provide examples of exemplary

experiential learning opportunities that enhance STEM-related courses, illustrate the significance these opportunities add to classroom instruction, and show how both students and teachers are positively affected. Finally, it was conducted to identify challenges for offering exemplary experiential learning opportunities in STEM-related courses.

Research Questions

The main question to be answered in this study was: What constitutes an exemplary an experiential learning experience for STEM-related courses and what challenges exist that make implementation of exemplary opportunities in Virginia schools difficult? The study was guided by the following questions:

1. What are the characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students?

2. What are examples of exemplary STEM-related experiential learning opportunities?

3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, and administrators?

4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

Methodology

This study used a qualitative design to answer the research questions. Research focused on the lived opportunities of administrators, teachers, and students and their views on exemplary experiential learning opportunities in STEM-related courses. Participants were included from four STEM programs across Virginia. A total of 13 stakeholders were interviewed and audio-recorded to collect data. Constant comparative and content analysis were used to code and identify attributes. Themes then emerged from the data collected from the semi-structured interviews.

Also, field notes were taken and hard copies of a demographic questionnaire were filled out by participants to add context to the study.

Key Findings

The key findings of the study are restated below:

- Two overarching themes describing characteristics existent in exemplary STEM-related experiential learning opportunities emerged among participant interviews: (1) program qualities, where six attributes were revealed: (a) Opportunities for real world, opportunities, (b) opportunities for career exploration, (c) students given choices and ownership of their learning, (b) support from business and university partnerships, (d) teacher characteristics, and (e) a professional support positions within the school. Under the theme of (2) curriculum development and instructional delivery strategies, two attributes were identified: (a) provision of transdisciplinary learning across curriculums, and (b) provision of hands-on learning opportunities. All opportunities studied mentioned each of these areas as important components of their experiences.

- Examples of experiential learning opportunities offered in each of the experiences that participants felt were exemplary were given. Examples include (1) in-class opportunities, (2) business and industry opportunities, and (3) co-curricular opportunities, industry credentials and certifications, and competitions.

- The impact of exemplary STEM-related experiential learning opportunities on students and teachers were identified. (1) Students were identified as being impacted in four ways: (a) student engagement, (b) relationships formed, (c) life after graduation, and (d) student personal growth. (2) Teachers were seen as impacted in three common ways: (a) teacher satisfaction, (b) relationships formed, and (c) teacher growth.

- Challenges and barriers to schools wanting to offer exemplary experiential learning opportunities in STEM-related courses to students were identified in four main areas of concern: (1) funding, (2) time constraints for (a) teachers, (b) students, and (c) business/university partners , (3) perceptions of (a) minorities and non-traditional students and (b) parents, and finally (4) class sizes.

Conclusions

Based on the findings of the study, as related to the lived experiences of school administrators, teachers, and students, the following conclusions were made:

1. Fundamental principles for providing exemplary experiential STEM-related learning opportunities exist. Without these fundamental principles it is impossible to provide *exemplary* opportunities. These principles include:

   A. Providing hands-on, real world learning opportunities for students that require them to develop deep thinking and problem-solving skills and get into higher levels of learning.

   B. Providing learning opportunities that will enhance student ownership in their learning.

   C. Providing unique and comprehensive career exploration opportunities for students.

   D. Providing a schedule for teachers that will give them time to plan, deliver, and manage *exemplary experiential* learning opportunities.

   E. Providing continual teacher and administrator in-service training relative to planning and implementing *exemplary experiential* learning opportunities.

F. Investing appropriate funds for providing *exemplary experiential* learning opportunities.

G. Establishing and maintaining active partnerships with business/industry and colleges/universities.

H. Establishing and maintaining active advisory communities.

I. Providing appropriate staff to support the provision of *exemplary experiential* learning opportunities.

J. Utilizing existing CTE co-curricular student organization activities (i.e. competitions, community-based projects, hands-on classroom learning opportunities, etc.) in all STEM-related courses.

K. Establishing and utilizing appropriate enrollment policies for courses that provide *exemplary experiential* learning opportunities.

L. Establishing and utilizing a strategic continual five-year marketing plan for courses that provide *exemplary experiential* learning opportunities.

2. The impact of participation in exemplary STEM-related experiential learning opportunities on students include:

A. Increased engagement in class participation.

B. A positive effect on students from the personal relationships formed with their teachers and other students.

C. Increased job skills after high school and higher rates of meaningful employment.

D. A more meaningful academic experience in college.

E. Personal growth that gave confidence, a better work ethic, and often passion for an area of interest.

3. The impact of providing exemplary STEM-related experiential learning opportunities on teachers include:

   A. Increasing job satisfaction.

   B. Establishing positive professional relationships with other teachers and students.

   C. Lessened disciplinary issues due to increased student engagement.

   D. Enhancing growth in teaching abilities.

4. The challenges that make it difficult to provide exemplary STEM-related experiential learning opportunities include:

   A. Inadequate funding,

   B. Time constraints for teachers, students, and business/university partners,

   C. Inaccurate perceptions of the parents, students, guidance counselors, and the general community,

   D. The need for small class sizes.

Discussion of Findings

Characteristics of Exemplary STEM-related Experiential Learning Opportunities

The results of this study pointed out several characteristics of exemplary experiential learning in STEM-related opportunities. The characteristics were divided as follows: (1) Program attributes and (2) curriculum and strategies.

Program Qualities. Respondents across the board defined similar program qualities that were essential for quality exemplary experiential learning opportunities. (a) Opportunities for

real world opportunities, (b) opportunities for career exploration, (c) support from business and university partners, (c) students given choices and ownership of their learning, (b) support from business and university partnerships, (d) teacher characteristics, and (e) a professional support positions within the school.

   Opportunities for real world opportunities. Quality learning opportunities involve providing students with real world projects that offer challenges, encouragement, and discussions (Thiry et al., 2011). Students practice real world skills, in a simulated or real life environment, while practicing the arts of creativity and problem-solving. Classroom instruction coupled with real world problems allow students to broaden their ability to transfer and apply these skills. Veronica described an experience of visiting a cardiac operating room given to all her academy students, "… we do it [visit an operating room] about once every 3 weeks so all the kids can get through it … we kind of have different teachers go along with the kids so we can learn about this too, and one got queasy yesterday so it's the real thing [laughter], … the kids handle it really well and who can say they've seen open heart surgery when they're 17 years old!" (Veronica Ln# 88 - 92). Regina, one of the students interviewed, described her experiences taking computers apart, this way, "So it was like really nice to get down and actually work with a physical thing like we actually would with an actual career or industry job." (Regina Ln# 15 - 16). The importance of offering students a realistic experience is paramount to finding out how things work.

   Opportunities for career exploration. The value added to students' lives through career exploration provided by exemplary experiential learning opportunities and the chance to pinpoint career interests was evident in the results. Renee discussed how her students learned from visiting different businesses because, "[I]t exposes them to what is out there … if you like science

then you say, well I'll be a vet or a doctor, because you really don't have any idea what all the other fields that are out there. I think the more that we expose them to in high school they can make those choices, they can figure out what they like or they don't like." (Renee Ln# 47 - 50). Often students think they like something but they do not really know what is involved in the career. Letting students experience careers through mentorships and visits gives them a close up look and gives them a feel for what is really involved in the career day-to-day. Jimmy described the effect of his STEM Academy courses on his career path when he said, "Yah, it's made me pretty much choose what I want to be when I'm older. And pretty much biotechnology in particular has done that because … when … you know before now … before I'd taken the class … I had no idea what I wanted to do. I had no idea what I was going to try to do." (Jimmy - Ln# 44-46). If students aren't given a realistic glimpse of careers available to them, there is no way for them to find their career interest until much later in life, perhaps after missing opportunities. Many college students switch majors several times before deciding on a program to complete. These opportunities will assist students in making a wise choice for a major when they enter college. Also it can assist a student in identifying what post-secondary education is needed to pursue a given career. If a student doesn't understand what training is required to go into a career, time and money can be wasted following the wrong path.

   Student choice and ownership of their learning. Students overwhelmingly described choice and freedom as being important aspects of their experiences. Teachers and administrators also spoke of students as self-directed learners and the necessity of sometimes struggling with the content rather than being handed information and answers. This seems to support Kolb and Kolb's (2010) argument that learning environments designed where student interests and self-exploration is encouraged and where students play and mimic real life, are much more engaging.

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Students at one program took a trip to the Bahamas in their sophomore year. In order for the trip to be successful, students had to step up and take control of what they were learning. When describing this event, Lori spoke of the qualities of the experience that made it so valuable. She spoke of the students' ability to overcome fears and obstacles when she said, "…freedom, in some sense. Independence. Um, battling fears? Kids are battling fears like … I'm afraid to go out in the water and then they get over it … some of them are afraid that first day putting the mask on and it doesn't feel comfortable." (Lori Ln# 175 - 177). Further, Lori described a student who was diabetic and used an insulin pump to control her blood sugar. She wanted to go on the trip so badly that she decided to learn to give herself injections and train some of her friends to help her so she could go, because she could participate if she had to rely on her insulin pump due to problems with the pump and inaccessibility of an adequate health care facility.

Greg described his program's use of the Socratic system where students are totally responsible for their learning and have choice in their research projects. He said, **"**[I]t's all inquiry based. They have no lab book, they design all their own labs." (Greg Ln# 35 - 36). He went on to say, **"**[Name] County has a gigantic science fair culture … ok … I can do that. Our kids do great at science fairs because we give them two years and they are passionate you know, they are just passionate. And you know why? Because they chose it themselves and they are interested in it." (Greg Ln# 129 - 132).

Taking ownership of their learning can show itself in different forms. Several participants mentioned students actually becoming the teachers in exemplary opportunities. Renee described a class at her school where students "… come back and learn what their [water testing lab] results mean … and then what makes it exemplary … then they teach it to their parents! And I've even had a student that then go in and help with the community activity." (Renee Ln#

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40 - 41). Jack also spoke about his students as teachers when he said, "[I]f they've performed

that standard at a high level … they become proficient and now they become the teacher

…[student name]… he's now the teacher … he's proven to his colleagues that he's learned the

material and then he's going to turn around and teach it to the other students." (Jack Ln# 133 -

136).

     Support from business and university partners. As stated in Chapter 4, business and

university support is crucial to being able to provide exemplary experiential learning opportuni-

ties. Businesses can not only provide equipment, supplies and other types of funding, they can

also provide expertise. Veronica eludes to the importance of partnerships when she said, "So in

our Engineering and our IT … first of all … all of this hinges around the type of businesses and

companies and universities that work with you." (Veronica Ln# 50 - 51). Greg spoke at length

about his business partnerships. He described their importance when he said,

    …the business partners are hopefully the ones who will give you the money. You

    know, do we have people we are in touch with that will help us out? Yah, but it's

    hard and quite often people walk in here and say, we want to help you out and …

    I'm not going to say I need money …. Although I do have a business partner who

    helps with our robotics team and we flat out ask them for money. But what I real-

    ly need is expertise! Or equipment" (Greg Ln# 288 - 292).

Schools are often understandably reluctant to offer courses where teachers are not considered

discipline experts or 'highly qualified'. The focus on teacher credentials and subject area

knowledge is important, but if that is the sole consideration, it is also very limiting in the courses

that can be offered. Obtaining help from the real experts, those who live the discipline every day

and have continual up-to-date training, is likely more important. It is not feasible for teachers to

maintain expert status when the majority of their time is spent in a classroom, especially in areas that are changing rapidly. A limited number of professional development training days does not make one an expert. Extending teacher contracts to include mentorships with businesses and/or universities for teachers during summers when they aren't in class might be a way of contributing towards teacher expertise and creating partnerships between business and universities.

Teacher characteristics. Participants discussed the characteristics and personality traits of teachers as being impactful on exemplary experiential learning opportunities. Jack mentioned a collaboration between teachers in his school and the type of teachers necessary to make it work when he said, "You may have Tech Ed and Automotive working together to work on a different kind of hybrid vehicle. … so it's about I think, experimenting and really sort of challenging yourself and you want to find teachers that want to challenge themselves. Not just do their routine." (Jack Ln# 199 – 202). Renee discussed the necessity for teachers to be willing to deal with frequent change and constantly changing technology, "While I was comfortable with some of the technology in this biotechnology, I've been a teacher now for how many years and these fields change quickly." (Renee Ln# 132 – 129). Not all teachers are comfortable or willing to accept change.

Fear of change and stepping out of the box was mentioned by several participants. Also, pointed out was the inadequacy of traditional teachers who are comfortable and use only direct instructional strategies. Students have also gotten comfortable with this instructional strategy. These two issues were discussed in detail by Gretchen, when she said,

> … Fear … from the teacher perspective as well as the student perspective. I think
>
> a lot of times the student will come to us and they will get upset and they'll say
>
> well you're not teaching me anything. And … that's what it's supposed to feel

like. It's supposed to feel like I'm not teaching them anything. And some stu-

dents are very uncomfortable with that because they've come from traditional

classrooms with a teacher standing up in front of the class. (Gretchen Ln# 62 –

66).

The importance of informed teacher input was also pointed out. Jack implied the the suc-

cess of his program relied greatly on involving and supporting his teachers. He said, "… contin-

ually solicit input from staff on what they saw … and find the resources for them to do it." (Jack

Ln# 381).

Professional support positions within the school. Each program participant revealed the

significance of a designated support position within a school for assisting teachers in a variety of

ways. This person must be dedicated to making these opportunities possible. The discussions

pointed out the difficulties with logistics in experiential learning opportunities. This attribute

was mentioned because providing exemplary experiential learning experience is very time con-

suming and teachers need assistance in organizing these opportunities. Veronica explained the

impact in her school system, when she said, "… we're lucky to have that position. In [X] Coun-

ty each academy has a position like that because they support experiential learning and it's a job

in itself." (Veronica Ln# 230 – 231). Every STEM Academy in her school district employs a

person who's responsibilities include creating and nurturing partnerships, arranging field trips

and school visits, as well as managing grants and gifts from partners. The position in the rural

school district, with only one high school, depended on this position to do all of the above and

also help teachers set up labs, collaborate, co-teach, and carry out learning experiences in the

STEM Lab at her school.

Curriculum development and instructional delivery. The way curriculum has been developed in the studied STEM Academies, and the instructional delivery strategies used were described as paramount characteristics of providing exemplary experiential learning opportunities in STEM-related courses. Providing transdisciplinary learning opportunities which crossed traditional boundaries along with hands-on, real world teaching strategies were also essential characteristics revealed.

Provision of transdisciplinary learning across curriculums. Learning in a real world environment allowed disciplines to follow the natural overlap and provide students with their learning with their peers, as was revealed by Rick when he explained what happened in his Veterinary Science class,

> The Nursing Department is coming in … a good example was my Vet Science
>
> class. We did a two week pig dissection … that means a group of two kids had a
>
> fetal pig and they spent two weeks with that thing. And that's a long time …and
>
> they began with the skin … then they identified the superficial muscles and how
>
> all those worked, then went into the deep muscles, then they went into the lower
>
> abdominal cavity and the chest cavity and we really took our time.   But the key to
>
> that was, at the end of every day … the last 20 minutes of every class … the nurs-
>
> ing students came in and my kids had to teach them the anatomy and physiology
>
> of all the parts that they learned that day. So, with a pig's anatomy, it's so similar
>
> to the human anatomy that the nursing students actually got to see firsthand these
>
> organs. (Ricky Ln# 164 – 174).

Showing students how subjects are related underpins all the opportunities studied. Whether it was the sciences, math, agriculture, or business, there was overlap and integration within all op-

portunities. Greg's magnet school doesn't offer computer programming as a specific course because the math skills acquired, the research projects chosen by students, and the freedom to explore areas of their interest naturally enhanced their skills in gaining the knowledge needed for computer science fields. Intentionally stressing the math and science behind different disciplines gave students a better understanding of why they needed the knowledge.

Provision of hands-on learning opportunities. Exemplary opportunities provided kids with the opportunity to, figuratively and literally, get their hands dirty and really interact with supplies, equipment, and the ability to fail in a safe environment. Kolb's experiential learning model outlines the steps necessary for experiential learning. First, doing or having the experience, next thinking or reflecting on the experience, then learning from the experience, and then trying out what was learned (Kolb, 2003). In keeping with this theory, Ricky posited that, "… we're no longer training kids to go into the industrial revolution … but we need to still teach these kids to be able to think for themselves and solve problems and the easiest way to do that is to be able to allow this through hands-on learning." (Ricky Ln# 36 – 38). Veronica further explained that, "… seeing it is experiential but I think that when you integrate something that you saw or you're hands-on doing it is what is really exemplary in my mind." (Veronica Ln# 43 – 47). The hands-on opportunities created memories for the students and showed them the application side of the knowledge they were gaining.   These opportunities made the understanding more concrete and the experiences more meaningful. Ian explained the hands-on approach in his integrated science class as a freshman, "… we did a lot of mechanics … we did labs with friction with a plane that we could incline just so we could see when something would start slipping on it on different surfaces or how surface area affected friction." (Ian Ln# 36 - 37). From all perspectives, the hands-on aspect of exemplary opportunities was identified.

Examples of Exemplary STEM-related Opportunities

Specific examples given in Chapter 4 of the opportunities provided in the STEM Acade-
mies studied revealed rich, varied, integrated curricula across disciplines, and engaging learning
opportunities for students. There were three distinct types of opportunities revealed, the in-class
opportunities, those opportunities provided at business/industry and university locations, and co-
curricular opportunities, including industry certifications and credentials, and competitions.

In-class opportunities. The tendency of public high schools to concentrate on standard-
ize testing is in contradiction to the exemplary experiential learning opportunities offered at the
STEM Academies. The time spent on planning and preparing for course units and activities in
preparation for SOL testing eats into time that should be used focusing on creating more mean-
ingful opportunities for students. In the exemplary experiential learning opportunities studied,
the experiences offered in class were varied. Jimmy commented on his biotechnology class and
what he was able to do when he said, "I enjoy getting all the DNA and then we got the DCR ma-
chine where we can copy the DNA so if you want to put it in something else … it's just cool to
me…." (Jimmy Ln# 31-34). For students like Jimmy, getting to study DNA under real condi-
tions enabled him to really understand DNA and give relevance to a topic that would most likely
be considered boring if read from a textbook. Regina enjoyed getting to work with 'an actual
thing' in class, like she would in a job setting. For her, it meant having an advantage over others
when looking for a job, which she knew she would need to support herself through college. All
schools should offer classroom opportunities that students know are relevant and will help them
in the future.

Business/Industry and University opportunities. One of the four core principles
spelled out by the U S. Department of Education (2012) is the necessity for stronger collabora-

tion between all stakeholders in education. Businesses and post-secondary institutions offer increased collaboration in exemplary experiential STEM-related opportunities by allowing high school students to collaborate and participate in mentorships, internships, field trips, and discussions introducing students to real world occupations and areas of future involvement. Ethan spoke of his former students now in business who are willing to return and help his present students when he said, " … it was tough at first but now my former students that get out of the program say whenever you need me I'll come." (Ethan Ln# 133 - 134). The importance of placing equal worth on process and outcomes, as posited by Kolb & Kolb (2010) is validated by Michael when he stated,

> We have to define what the problem is, then we have to set a solution and to set a
>
> criteria for success. So this is where I keep talking about the requirements … like
>
> they have to say in order for this thing to be considered successful it has to do …
>
> and then they lay out quantitatively what functions it will have to do and how well
>
> it will have to do it so they have something to shoot for … and this is how it func-
>
> tions in the real world so it's not like I'm just building any old thing and what
>
> happens … no it has to meet these standards. (Michael Ln# 48 - 53).

Michael stressed that not only are the skills and processes important for students to know, but also there is a quality control component in order to live up to standards demanded by industry to produce quality products. Knowing how to do something is important but if it is not done well, no one wants the end product. Both elements are crucial and business and university partners help students understand this. Businesses and universities have the cutting edge equipment and expertise that is not possible for teachers to have due to teachers being in classrooms all day while the real world is constantly changing needs, wants, and technologies. The way for second-

ary schools to have cutting edge programs is for businesses and universities to get deeply involved in school programs, training students and teachers.

Co-curricular, industry credentials and certifications, and competitions. Credentials, industry certifications, and competitions which are often offered in co-curricular opportunities are verifications that students know what they are supposed to know (ACTE, 2016). They offer an accountability system for student performance as outlined as necessary by the U. S. Department of Education (2012). Co-curricular activities and competitions provide real-world opportunities for students and have the capacity already built in to CTSOs to offer credentials and industry certifications. Jack explained his program's use of certifications and competitions this way, when he said, "I think when you can incorporate competitions, industry certification … internships … problem-based learning through projects … how well you performed on this, you know I think we're doing the right stuff. (Jack Ln# 90 - 93). The competitive relationship as a primary goal in some forms of play is defined by Kolb & Kolb and mentioned several times as a student engagement tool (Huizinga, 1950; Kolb & Kolb, 2010). Allowing students to help create the rules, making students responsible for their learning and the outcomes achieved, and giving students the time to hone skills, and providing opportunities with an iterative nature until they achieve success are meaningful ways of conducting co-curricular opportunities.

Impact of Exemplary STEM-related Experiential Learning Opportunities

Studies have shown that students are positively impacted by involvement in co-curricular opportunities by keeping them in school, increasing grades, and developing job skills (Alfeld et al, 2007, Camp et al., 1987, Taylor, 2006). However, this study revealed impacts in other experiential learning environments as well and the impact on career projection. Impacts on teachers and their teaching practice, and classroom environment was also revealed.

Impact on Students. The impact on student engagement, relationships with fellow students and faculty, their lives after graduation and career trajectory, and enhanced personal growth was attributed to membership in an experiential learning environment by the participants.

Student engagement. Increased student engagement was one of the main impacts for students. Ian spoke of traditional programs and how they squelch student interest when he said, "… someone that absolutely loves science because of the time they went to the zoo and spent 6 hours watching the otters play around and they thought science was going to be awesome and then they spend their first year of high school learning about earthquakes and erosion … it kills a lot of enthusiasm" (Ian Ln# 97 - 100). In contrast, when speaking of exemplary experiential environments, Ricky explained the impact on his students when speaking of his Agriculture program, "… we've done this for the last couple of years you know they really enjoy it, they really enjoy it." (Ricky Ln# 177). Happy, motivated kids were mentioned many times throughout discussions. Increased academic motivation from participation in CTSOs has been documented through previous research (Alfeld et al., 2007) but the study presented here points towards experiential learning environments in general, including those within classrooms, on location during field trips and internships, as well as in co-curricular experiences as making the studied opportunities exemplary.

Relationships formed. Strong relationships with adults and other students were mentioned as important impacts on students in experiential learning environments. Studies show that the lack of secure relationships are indicators of increased dropout rates within certain minority groups (Anderman & Freeman, 2004: Arroyo, Rhoad, & Drew, 1999; Eccles & Gootman, 2002; National Research Council, 2004; Alfeld et al., 2007; Somers & Piliawsky, 2004). This study revealed a connection between relationships and a feeling of belonging to a learning community.

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These relationships were credited with establishing a positive environment and an emotionally safe learning environment for students. Students often form bonds with their teachers, other students, and sometimes mentors and community partners as they collaborate on projects. Lori reveals the impact of forming relationships and creating a safe environment when she says, "I think this gives a safe haven for people that were otherwise seen as nerdy. You know, everybody's a nerd here. We wear shirts that say Nerd School and we're OK with it. So for us … I think for a lot of kids, it 's a place they can be themselves and not be judged." (Lori Ln# 197 - 200). It is also a safe environment for kids who have not tried doing things before. Students who trust their teachers are more willing to try things they would not ordinarily try. In some instances, students and teachers learned together and were collaborators rather than the typical student and teacher relationship.

   Life After graduation. The impact of college and career trajectory is also important attributes brought up by participants. Jimmy spoke of the impact of his biotechnology course when he said, "I think right now I want to go to [school name] and get my associates and then transfer that over to [university name] and to support myself financially I'm going to have a job for a little bit and then I'm going to open my greenhouse or whatever I'm going to do when I get older." (Jimmy Ln# 88-90). Before becoming involved in the Agriculture program, he was a self-proclaimed lackluster student. His goals changed and he was motivated to move along a path towards his dream of owning his own greenhouse. Jimmy wasn't alone, all the students told how their paths were made clear after being in exemplary experiential learning environments. Regina felt better prepared for a job, Patty revealed her desire to become an educational researcher, and Ian spoke of his love of rocks piqued by his experiences in his integrated science classes. He is now studying Mining Engineering. Greg reported that his graduates spoke on a

graduate level after completing his program, which impacted them favorably when they attended college. They were above their peers from the beginning. Ian confirmed this viewpoint when he spoke of his feeling of preparedness when attending college. All participants spoke of how students were either positively impacted, or expected to be positively impacted, by their experiential learning opportunities after they graduated.

  Student personal growth. Morrison's description of STEM educated students listed in Table 8 in Chapter 3 appears to be spot on (2006). The characteristics described by participants pinpointed problem-solvers, innovators, heightened self-confidence, an enhanced work ethic, and logical thinkers who are able to apply skills and knowledge appropriately while making connections in order to have a better understanding of natural phenomenon (Morrison, 2006). Renee supported this notion when she spoke of, "… making our kids more literate, making applications across subject areas, exposing them to other careers and jobs and interests … making some of these kids more college ready and confident." (Renee Ln# 148 - 150). All student participants related their sense of accomplishment and pride and their increased feelings of confidence. The teacher and administrator participants noted the students' heightened ability to problem-solve and figure things out for themselves.

  Impact on Teachers. The impact of experiential learning environments on teachers was also revealed in this study. Although most participants recognized a heavier workload and increased difficulties in offering these opportunities to students, students, teacher, and administrators all recognized the increased job satisfaction, the professional relationships formed between students and staff, and the encouragement to grow as educators. Teachers that were involved in these opportunities often claimed to be happier and more engaged in their schools, more personally connected with their students, and given many opportunities for growth as educators.

Teacher job satisfaction. Job satisfaction was mentioned repeatedly as an outcome of experiential learning environments. Research shows that approximately 46% of teachers quit teaching with five years (National Commission on Teaching and America's Future, 2003). One of the reasons given for dissatisfaction was low student motivation. Increased student motivation is apparent in these learning exemplary experiential learning environments, as discussed above, which then positively impacts teachers and their feelings about coming to work in the morning. Discipline issues are another issue which increases dissatisfaction and pushes teachers out the door. Teachers and administrators interviewed commented on the fact that their programs had few to no discipline issues. Giving students choice in their learning was mentioned as one reason discipline was not a problem.

Teachers involved in these experiential learning opportunities, like students, do not seem to enjoy the status quo or stale attitudes that often become entrenched after teaching for a few years. These teachers made it known that they enjoyed their jobs, even if it was harder, they felt better about what they were doing and wanted to continue doing it. Ricky reinforced this finding when he said, "… it makes me feel good that my kids are actually getting something out of it ." (Ricky Ln# 178). Greg also supported the view of the importance of teacher satisfaction when he said, "So finances are really key things. I can't pay my teachers more but I can give them fringe benefits. You know, like encouraging them to go to conferences. I feed them twice a year at my house … you just want them to look at this place and say, I can't imagine teaching anywhere else and being happier." (Greg Ln# 274 - 279). Having teachers who are leaders and collaborators, not merely employees, who are allowed to take chances and explore new areas for professional growth made a big difference in overall teacher morale, which ultimately impacts school culture.

Relationships formed. Positive and supportive professional relationships between teachers and students emerged as an important part of how students view school. Teachers who have positive interactions with students, who show they care and have interpersonal knowledge of their students, and are enthusiastic and encouraging are seen as exemplary (Gentry, et al., 2011, pg. 111). These relationships helped the students and the teachers. Both mentioned it as an important component of exemplary experiential learning opportunities. Jimmy commented on the relationships he saw his teacher make and the impact he thought it made when he said, "Well … Mr. X, he worked really hard to get that STEM Lab put up here. And I can tell it's had an effect on him. He really does enjoy … he does … and you can tell by the way that he teaches and gets along with his students. He has a connection with everyone, so yah, I can see where it does [impact him]." (Jimmy Ln# 67-69). Positive professional relationships between administrators and teachers was also evident, although not directly addressed. Administrators spoke of their teachers with pride, and expressed confidence in their abilities even if they were not considered experts in the discipline. Teachers spoke of the importance of administrative support, or at the very least, lack of administrative hindrance to offering experiential learning to students.

Teacher growth. Communities of practice are identified by Lave and Wenger as being members of a social community where connections between learning and the social world drive the projects they engage in (1991, pg. 157). As noted in the *Race to the Top* initiative, attracting and keeping effective teachers is an integral part of quality opportunities and sometimes problematic. Allowing teachers the freedom to use innovative and effective approaches to instruction and supporting and encouraging their willingness to step outside their comfort zone is evident in the classrooms visited. Teachers in experiential learning environments seem to support this line of thought when the participants spoke of their experiences. "… they [teachers] do see the value.

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Sometimes it's just a matter of … they wanted to do some of these things with their kids but it's a little bit out of their comfort zone themselves." (Renee Ln# 95 - 97).

Overall, the perceived impact on teachers from all participants appears positive, offering teachers increased job satisfaction, the chance to really get to know and connect with their students, and encouraging them to step out of the box, think creatively and become more knowledgeable educators through professional development opportunities, relationships with business partners, and university contacts.

Challenges to Exemplary STEM-related Experiential Learning Opportunities

Challenges exist that make offering exemplary STEM opportunities problematic for several reasons. The barriers revealed most are funding, time constraints for students and teachers, and community perception of STEM opportunities.

Funding. Funding has always been an issue for public schools and STEM programs are no exception. Cuts to funding in CTE, where three of the studied STEM programs are housed, would take its toll if not for businesses and industries, who have stepped up to fill the gap. For schools not having close business relationships, it would be very difficult to implement opportunities that have a strong experiential component. Greg summed it up with his comment, "You know funding is I think one of the big problems for STEM schools." (Greg Ln# 254). Grants were mentioned as a way to obtain funding for STEM programs. There is an increased push for workers in STEM fields which has resulted in many grants offered in STEM areas. The U.S Department of Education describes the need for "innovators, educators, researchers, and leaders who can solve the most pressing challenges facing our nation and our world" (USDOE, 2017, retrieved from https://www.ed.gov/stem), The barrier with grant funding is the time it takes to write a grant and then the necessary paperwork involved in keeping track of what has been spent,

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reports, and other requirements. In Greg's program, parents were expected to pay for some of the students' experiences. His students took overseas field trips to the Bahamas and South Korea and parents paid for these trips. While parent funding is an option, it does restrict participation to those who can afford it.

Time. Time constraints were also clearly identified as a barrier to offering exemplary STEM-related experiential opportunities. Extra time is something that can't be bought or created, although smaller class sizes and a smaller teaching load can only be provided through adequate funding.   Time was also a factor mentioned by several participants for business and university partners. Schools have a choice in how to provide what is needed to insure quality learning opportunities vs. not providing what is necessary to prevent watering down the quality of the offering. Adequate time is a critical component of exemplary learning opportunities. If sufficient time is not given to teachers as providers of the opportunities, the consequences will be the same and there will be lower quality programs, regardless of the reason given for not providing it. Looking at scheduling alternatives, team teaching, fewer duties, and extended contracts are options for creating more time.

Lack of time for teachers. All participants recognized the limitations due to sufficient time to provide exemplary opportunities for students. Renee states the obvious with, "… that really can be a barrier …scheduling and time … obviously in schools that's always … that's always a barrier." (Renee Ln# 137 - 138). Drake and Burns describe the process of designing integrated curriculum and the need for reviewing curriculum to identify natural areas of overlap (2004), however, in reality little planning time is given to teachers to do this planning. Teachers often take on this task during their own time. All teachers and administrators mentioned teachers spending time after contract hours working to create meaningful opportunities for students. Stu-

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dents did not seem to recognize this, however, it was not part of an interview question. Until teachers are given adequate time to focus on innovative lessons and experiences for students, it is unlikely that exemplary experiential learning opportunities will be offered broadly throughout Virginia school systems.

Lack of time for students. Inadequate time was problematic for not only teachers, but also students who only have so much time in their schedules for electives and extra courses. It is even worse for students who have more credit requirements for an advance diploma. Taking time to travel from home schools to STEM academies were mentioned as difficulties. Leading back to funding, the possibility of having STEM academies at all schools, eliminating this hurdle, is impractical due to the increased expense. However, transdisciplinary teaching and learning does not need to be housed in STEM Academies. Virginia high schools could be redesigned to incorporate transdisciplinary opportunities across disciplines where natural overlap occurs, but especially in CTE classes. Designing courses that allow students to learn academic concepts along with real job skills and meaningful projects seems to be a logical next step in providing exemplary high school opportunities and a new way to provide curriculum at every school. This could be a new model for high schools of the future.

Lack of time for business and university partners. Time was also a problem for business and university partners. Sufficient time for day-to-day activities required with the additional strain of assisting schools by providing expertise in the form of guest speakers or field visits was mentioned by administrators and teachers as problematic. Providing paid mentorships for teachers on site during non-school times could be a more meaningful alternative to spending an hour or two occasionally in classrooms. Immersing teachers in real world environments for a prolonged period would add to their knowledge of current business practice. Providing students

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with these same opportunities through internships would also go a long way towards giving them

a glimpse inside the everyday practices of businesses. Some universities are offering extended

programs to teachers during the summer when they are not in classrooms to provide training.

Offering more of these types of opportunities and stipends to teachers would likely increase the

level of participation in the programs already offered.

Perception. Public and community perception was also identified as a barrier to offering

exemplary experiential learning opportunities. The belief that minorities and non-traditional stu-

dents do not belong in certain disciplines continues to be a problem with parents. Also, an out-

dated view on CTE courses adds to the negative connotation associated with these opportunities.

Perception of minorities and non-traditional students. Studies show that the lack of

strong relationships with adults contribute to high school dropout rates within certain minority

groups (Anderman & Freeman, 2004: Arroyo, Rhoad, & Drew, 1999; Eccles & Gootman, 2002;

National Research Council, 2004; Alfeld et al., 2007; Somers & Piliawsky, 2004). As stated

above in the impact on students, one of the most important accomplishments of exemplary

STEM opportunities is heighten relationships between students and adults. Perception by minor-

ities and non-traditional students of their ability and suitability of belonging to STEM opportuni-

ties is a hindrance. Greg identifies this problem when he said, "I'm very proud of the fact that

we are meeting … that we have at least the number of applicants percentage wise that we accept,

but I'm grossly disappointed in the fact that we do not have the applicant pool. So yah, that's a

community perception problem." (Greg Ln# 314 - 316). Michael spoke of the consequences of

the Title IX Amendment, which "protects people from discrimination based on sex in education

programs or activities that receive Federal financial assistance (USDOE, 2015). He said, "… 30

to 50 girls would fill those [Engineering] classes and it would be the exact same curriculum as

the coed and we were again, doing great. Federal bureaucracy said, oh, you can't have single sex

classes. There you go, shut it down." (Michael Ln# 133 - 135). The unintended consequence of

the amendment actually shut down access to females in some instances.

 Perception of parents and community. Patty's experience with her mother not wanting

her to take automotive classes is another prime example of perception problems keeping students

from entering STEM fields. She says, "… their parents might not let kids take it. For example,

it's very weird to admit but my mom didn't want me to take auto collision which is another

course offered in the academy … she told my sister … that's not for girls … take cosmetology

because my sister … all my siblings and I were just like … so shocked!" (Patty Ln# 112 - 114).

This perception of gender stereotypes has long plagued CTE programs and math and science

courses. Also, the perception that CTE courses only being for students that are not bound for

college is still hindering participation. As noted by Herian's (2010) study of the state of Nebras-

ka and the lack of recognition by specifically school guidance counselors, science and math

teachers, of the positive impact of CTE on students. Students are often counseled not to take

these classes by guidance counselors unaware of the content of CTE programs and the prepara-

tion for college and/or careers.

 Discussions about how to change misguided perceptions of parents, counselors, students

and the general public are needed. One place to begin is with educators themselves. Many

teachers of academic disciplines, guidance counselors, and school administrators do not know or

understand the contributions that could be made to creating exemplary experiential learning op-

portunities for all students, not just those in STEM Academies. In some instances, CTE teachers

do not fully understand their role in providing opportunities that intentionally teach students the

math, the science, the artistry, or the engineering involved in a project. Teacher preparation

courses would be the place to cultivate this change in mindset. Pre-service teachers in CTE and academic discipline should be required to incorporate experiential learning across disciplines, working with other pre-service teachers. Counselor, leadership, and administrator education programs should also require a course educating them on CTE curriculum and the value of experiential learning across disciplines.

Class Size. Class size was the last barrier mentioned as a hindrance to offering exemplary experiential STEM-related learning opportunities. Again, with decreased funding, class sizes are often too large to effectively offer experiential learning opportunities. With larger class sizes comes increased difficulties with student engagement, having meaningful discussions, creating relationships, providing students with necessary supplies and equipment, and giving them the time to practice skills. Ian pinpoints the importance of smaller class sizes when he says, "Another issue with [school name] is because of the small class sizes and the limited faculty, it's not very accessible to … And even the students in X County … I want to say the hard cap of 70 … when 7000 kids are applying is not a lot and that really is a shame. And it's definitely a balancing act between making it a program that can put all the kids that want to go there through it and still maintaining it as a program that has the same experience, the very small class sizes, and the very personal experience that it's supposed to be." (Ian Ln# 187 - 191). Having smaller communities of learning, allowing teachers to team teach and provide more meaningful feedback to student work, and changing the model of all high school courses to transdisciplinary, experiential learning models would reach all students. This should be every day practice in all schools.

Recommendations

Based and the findings of and conclusions made in this study, the following recommendations for practice and further research are presented.

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Recommendations for Practice

In order to enhance the provision of exemplary experiential STEM-related learning opportunities, the following recommendations for practice are made.

1. The fundamental principles provided in the conclusions of this study, must be followed for schools to provide these *exemplary experiential* learning opportunities for STEM-related experiences.

2. The provision of cross-curricular transdisciplinary curriculum must be the every-day practice in all schools in order to provide *exemplary experiential* STEM-related learning opportunities.

3. Creative class schedules for students and teaching loads for teachers need to be established and implemented in order to provide *exemplary experiential* STEM-related learning opportunities.

4. A strategic continual five-year marketing plan should be developed and implemented for courses providing *exemplary experiential* STEM-related learning opportunities.

5. Real-world opportunities in the forms of hands-on classroom learning activities, work-based learning (i.e. cooperative method of instruction, internships, clinical experiences, etc.) should be provided for students.

6. A permanent, active school-wide planning committee with administrator, teacher, student, business, university, and parent representatives should be established, implemented, and maintained in order to recommend policies for providing *exemplary experiential* STEM-related learning opportunities.

Recommendations for Further Research

In order to expand knowledge related to select findings of this study, the following recommendations for further research are made.

1. Identify and analyze how cross-curricular transdisciplinary curriculum development can be standard practice in all schools.

2. Identify and analyze types of meaningful real world experiences/career exploration and how these opportunities can be provided for students.

3. Identify and analyze how to gain ownership in business/industry and university for partnering with local school systems to provide exemplary experiential STEM-related learning opportunities.

4. Investigate types of international exemplary experiential STEM-related learning opportunities and how to provide them.

5. Investigate creative funding models for providing exemplary experiential STEM-related learning opportunities.

6. Identify and analyze various creative student schedules and teacher teaching schedules that best supports the provision of exemplary experiential STEM-related opportunities.

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Final Thoughts

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It was an honor and a privilege to meet and have candid conversations with educators and students with respect to their views concerning exemplary experiential STEM-related learning opportunities and programs. They all exhibited great passion when describing what they thought made their opportunities and programs exemplary and the constraints they faced when planning and executing them. The variety between the programs, the richness of the diverse curricula of-

fered, and the level of thought put into these programs was inspiring. All participants seemed to

respect the study and the information being sought, and were eager to help despite their very

busy schedules. It was a pleasure to spend time with each of them and hear their stories.

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Appendix A: Email to Program CTE/STEM Administrators

Request for information on STEM-related experiential learning opportunities

Dear (STEM/CTE Administrators)

A focus on integrative STEM, or STEM, has become a critical part of education around the world. One of the tenants of STEM is to integrate experiential learning opportunities into the STEM curriculum. Currently I am a graduate student at Virginia Tech conducting a research project entitled "Characteristics of Exemplary Science, Technology, Engineering, and Math (STEM)-Related Experiential Learning Opportunities". The research project is in partial fulfillment of my doctor of philosophy degree in Career and Technical Education.

You have been identified as a critical stakeholder in providing STEM education and I am writing to seek your input on characteristics of exemplary experiential learning opportunities in your program, as well as the impact on students and teachers. Data will be collected from STEM-related stakeholders; including administrators, teachers, and students using semi-structured interviews. Results of the study may provide insight into exemplary program characteristics and formulation. Please note that this research study has been approved by the Virginia Tech Institutional Review Board. Parental permission would be obtained if students are interviewed. I therefore request an interview with you to seek your input about the topic. This interview should last approximately 30 minutes and can be conducted in your locality at a time and place of your convenience. I would also like to interview an STEM-related teacher who you feel uses exemplary experiential learning opportunities in his/her classroom, one of his/her students who is involved in the STEM-related course so that I can contact them to request an interview as well. I would be grateful if you have suggestions of three teachers, and students in your area so that I may choose one of each to contact. I respectfully request three in case someone chooses not to participate.

Questions will be on the following issues:

1. What are the characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students?

2. What are examples of exemplary STEM-related experiential learning opportunities?

3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, and administrators?

4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

If you have any questions regarding this research, please contact Jamie Simmons, the researcher, at (540-320-3036; email jamiesim@vt.edu) or Faculty Advisor, Dr. Bill Price (540-231-7390; email wprice@vt.edu).

Thank you in advance for any assistance.

Best Regards,

Jamie Simmons
Principal Researcher

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Consent for Participants in Research Projects Involving Human Subjects
PARENT CONSENT AND PERMISSION FORM

Title of Study: Lived Opportunities of Stakeholders Regarding Exemplary STEM-related Experiential Learning Activities

Principal Investigator:
Jamie Simmons   jamiesim@vt.edu

Purpose of this Research/Project

The purpose of the research is to learn more about how administrators, teachers, students, and business leaders view and/or experience the integrative STEM-related experiential learning opportunities provided by your school system. I hope to gain insight into the characteristics of exemplary opportunities that develop critical and creative thinking skills for students.

Procedures

During the research process you may be recorded. The researcher may ask you and/or your child about the experience and take notes or record the response. You will be asked to evaluate your opportunities with experiential learning programs using either an interview, a paper, or online questionnaire. Responses to these interviews and questionnaires will be analyzed for this research. You are not required to participate in this research and if consent is given, you may quit at any time. I ask for your consent to participate in this research.

Risks

There are minimal risks to participation in this study. Risks to participants are no greater than the risks associated with attending a public program. In addition, your child has the right to withdraw from participation at any time by notifying the researcher in writing or in person of the desire to withdraw.

Benefits

STEM and CTE programs are designed to build leadership, gain competence in academic and career-building skills, develop critical and creative thinking skills. Through real world, integrative, informal learning environments and experiential learning opportunities, students are intended to gain skills which will prepare them for, and promote STEM careers. Your child's STEM skills may improve. The results of this research will inform future experiential learning offerings, as well as contribute to our understanding of what constitutes an exemplary experiential learning experience for students. No promise or guarantee of benefits has been made to encourage you to participate.

Extent of Anonymity and Confidentiality

Information gathered from the study may be used in research reports, presentations, and articles in professional journals. Real names will not be used. Rather, pseudonyms will be used. With your permission, an audio or video recording of participant interviews may be used to gather data. The researcher will analyze the audio recordings to answer research questions. All study materials will be retained for an indefinite period in a secure location. When all project research is

complete, the data will be destroyed. The Institutional Review Board (IRB) may view this study's collected data for auditing purposes.

Compensation
Taking part in this study is voluntary; you will not be compensated for participating in this study.

Freedom to Withdraw
You and your child are free to withdraw from this study at any time without penalty. You and your child may choose to not respond to any research questions that you choose. There may be circumstances under which the investigators may determine that you should not continue to be involved in the study.

Questions about the Research
Should you have any questions about this research or its conduct, contact:
Jamie Simmons   jamiesim@vt.edu

If you have questions about your *rights as a participant*, please contact:
Dr. David Moore, moored@vt.edu
Chair Virginia Tech Institutional Review Board for the Protection of Human Subjects

_____   _____
Name of child with permission to participate   Date

Subject's Responsibilities
I voluntarily agree to my child's participation in this study. My child and I have the following responsibilities:
   •   Participate in interviews about your experiences in experiential learning programs.

Subject's Permission
I have read the Consent and Permission Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my consent for my child to participate in the study:

_____   _____
Signature of parent/guardian   Date

_____
Printed Name of parent/guardian

This form was adapted from a parent permission slip used by the Institute for Creativity, Arts, and Technology (ICAT) at Virginia Tech

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Consent for Participants in Research Projects Involving Human Subjects
STUDENT ASSENT Form

Title of Study: Lived Opportunities of Stakeholders Regarding Exemplary STEM-related Experiential Learning Activities
Principal Investigator: Jamie Simmons jamiesim@vt.edu

Purpose of this Research/Project
The purpose of the research is to learn more about how administrators, teachers, students, and business leaders view and/or experience the STEM (science, technology, engineering, and math) -related learning opportunities provided by your school system. You have been identified as a studentwho participated in an outstanding STEM program. I hope to gain insight into the characteristicsof programs like yours that develop critical and creative thinking skills for students. If characteristics can be identified through the experiences of actual participants, the opportunity to develop other outstanding programs can be created throughout the State of Virginia.

Procedures
You will be interviewed face-to-face for about 45 minutes about your experiences with the STEM-related experiential learning opportunities. The interview will be audio and video recorded and notes will be made about the interview. The interview will take place and venue convenient to you.

Questions will be on the following issues:
1. What are the characteristics of exemplary STEM-related experiential learning opportunities a determined by the lived experiences of administrators, teachers, students, and business partners?
2. What are examples of exemplary STEM-related experiential learning opportunities?
3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, administrators, and business partners?
4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

You will also be asked to complete a brief questionnaire for demographic information. The information will be used to provide context to the research results.

Risks
There are minimal risks to participation in this study. Risks to participants are no greater than the risks associated with attending a public program. In addition, you have the right to withdraw from participation at any time by notifying the researcher in writing or in person of the desire to withdraw. Participation in this study will not affect your grades, whether you agree to participate or not. Participation is strictly voluntary.

Benefits
The results will of this study might, (a) inform policy formulation with regards to curriculum integration in general, but more specifically, an integrative approach to CTE and STEM education, and (b) inform the development of implementation guidelines for the mutual leveraging of CTE and STEM education.

Extent of Anonymity and Confidentiality
Every effort will be made to protect your identity in any written work resulting from this study. Where need arises to use a name, pseudonym will be used to identify you in any written materials. The researcher will make every effort to mask identifiers. For example, your school district will not be identified by name or other identifying characteristics.

The researcher is the only individual who will have access to the recordings of the interviews. Transcripts may be viewed only by the researcher and members of the dissertation committee. It is possible that the Institutional Review Board (IRB) may view this study collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

Compensation
There will be no compensation given to you for participating in this study.

Freedom to Withdraw
You are free stop participating in this study at any time. You may feel free to decline to answer any questions during the interview or in the questionnaire.

Subject's Responsibilities
I voluntarily agree to participation in this study. I have the following responsibilities:
• Participate in interviews about your experiences in experiential learning programs.

Subject's Permission
I have read the Consent and Permission Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my consent to participate in the study:
_____ Date_____
Subject signature

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject, I may contact:

Jamie Simmons, Researcher jamiesim@vt.edu 540-320-3036
Dr. Bill Price, Faculty Advisor wprice@vt.edu 540-231-7390
If you have questions about your rights as a participant, please contact:

Dr. David Moore, moored@vt.edu 540-231-4991
Chair Virginia Tech Institutional Review Board for the Protection of Human Subjects

_____   _____

Name of child with permission to participate   Date

<div align="center">**Appendix D: Informed Consent for Participants**</div>

Title of Study: Lived Opportunities of Stakeholders Regarding Exemplary STEM-related Experiential Learning Activities

Principal Investigator:

Jamie Simmons   jamiesim@vt.edu

Purpose of this Research/Project

The purpose of the research is to learn more about how administrators, teachers, students, and business leaders view and/or experience the integrative STEM-related experiential learning opportunities provided by your school system. I hope to gain insight into the characteristics of exemplary experiential learning opportunities that develop critical and creative thinking skills for students.

Procedures

You will be interviewed face-to-face for about 30 minutes about your experiences with the STEM-related experiential learning opportunities. The interview will be audio recorded and notes will be made about the interview. The interview will take place and venue convenient to you.

Questions will be on the following issues:

1. What are the characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students?
2. What are examples of exemplary STEM-related experiential learning opportunities?
3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, and administrators?
4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

You will also be asked to complete a brief questionnaire for demographic information. The information will be used to provide context to the research results.

Risks

No more than minimal risk.

Benefits

The results will of this study might, (a) inform policy formulation with regards to curriculum integration in general, but more specifically, an integrative approach to CTE and STEM education, and (b) inform the development of implementation guidelines for the mutual leveraging of CTE and STEM education.

Extent of Anonymity and Confidentiality

Every effort will be made to protect your identity in any written work resulting from this study. Where need arises to use a name, pseudonym will be used to identify you in any written materials. The researcher will make every effort to mask identifiers. For example, your school district will not be identified by name or other identifying characteristics.

The researcher is the only individual who will have access to the recordings of the interviews. Transcripts may be viewed only by the researcher and members of the dissertation committee.

It is possible that the Institutional Review Board (IRB) may view this study collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

Compensation
There will be no compensation given to you for participating in this study.

Freedom to Withdraw
You are free stop participating in this study at any time. You may feel free to decline to answer any questions during the interview or in the questionnaire.

Respondent's Responsibilities
I voluntarily agree to participate in this study. I have the following responsibility: I agree to participate in a face-to-face audio-recorded interview and to answer questions honestly.

Initial _____ Date _____

Subject's Permission
I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent:

_____ Date_____

Subject signature

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject, I may contact:

Jamie Simmons, Researcher

Dr. Bill Price, Faculty Advisor

David M. Moore
Chair, Virginia Tech Institutional Review Board for the Protection of Human Subjects Office of Research Compliance

540-320-3036/jamiesim@vt.edu Telephone/e-mail

540-231-7390/wprice@vt.edu Telephone/e-mail

540-231-4991/moored@vt.edu Telephone/e-mail

Appendix E: Interview Protocol

The main question to be answered in this study was: What constitutes an exemplary an experiential learning experience for STEM-related courses and what challenges exist that make implementation of exemplary opportunities in Virginia schools difficult? The study was guided by the following questions:

1. What are the characteristics of exemplary STEM-related experiential learning opportunities as determined by the lived experiences of administrators, teachers, and students?

2. What are examples of exemplary STEM-related experiential learning opportunities?

3. What is the impact of participation in exemplary STEM-related experiential learning opportunities as determined by the lived experiences of students, teachers, and administrators?

4. What challenges exist that may prevent or make difficult the implementation of exemplary STEM experiential learning opportunities in STEM-related courses?

Below is a list of interview prompts that will be used to gather information necessary to answer the research questions. The interview will be of a semi- structured nature, so the participants are expected to speak about many aspects of the topics as the interview evolves. The interview will be guided by the following questions:

1. Tell me your name and your job title.

2. What department or curriculum areas are involved in providing your STEM-related courses? Can you tell me a little about these courses?

3. I am here today to determine the characteristics of exemplary experiential learning opportunities in STEM-related courses for students. From your experience, can you describe your definition of an experiential learning experience in STEM related courses?

4. Can you give me examples of STEM-related experiential learning opportunities?

5. What are characteristics of exemplary opportunities?

6. Why do you think these characteristics make the experience exemplary?

7. What positive contributions do you feel these experiential learning opportunities make to the students' lives?

8. Can you please describe examples and how you feel it impacts students?

9. Do you feel these opportunities have impacted students after graduation? If so, how?

10. In your view, are the teachers that provide experiential learning opportunities impacted in any way?

11. What supports are in place to encourage and help teachers provide exemplary opportunities?

12. Do all STEM-related courses in this school division offer experiential learning opportunities to students?

13. Do some offer more exemplary opportunities than others? Can you speculate on why that is?

14. Do you have an advisory board?

15. What would you consider to be barriers to offering exemplary experiential learning opportunities?

16. Is there anything that you would like to add?

At the conclusion of the interviews, each participant will be thanked for participating in the study. The interviews will be transcribed as soon as is possible after each is completed.

Appendix F: Teacher and Administrator Questionnaire

Characteristics of Exemplary STEM Experiential Learning Opportunities Questionnaire

Thank you for participating in the research study, "**Lived Opportunities of Stakeholders Regarding Exemplary STEM-related Experiential Learning Activities**". The information gathered will assist in putting the study in context.

Demographics

Name: _____

1. What is your gender?

Male _____   Female _____   Other _____

2. What is your age bracket?

Under 30 _____   31-40 _____   41-50 _____   over 50 _____

3. What is your race?

   o   American Indian or Alaska Native

   o   Asian

   o   Black or African American

   o   Hispanic or Latino

   o   Native Hawaiian or other Pacific Islander

   o   White

   o   Other (specify) _____

4. What is your highest academic degree?

   o   Associate

   o   Bachelor'

   o   Master's

   o   Doctorate

o   Other (please specify) _____

5. What was your college major?

6. How many years have taught at the K-12 level?

7. What is your major curriculum area (one in which most of your teaching occurs)?

8. What is your current job title?

9. Including this school year, how many years have you been in your current job?

   o   Less than 4 years

   o   4 to 9 years

   o   10 to 14 years

   o   15 years or more

10. Years in this school district

   o   Less than 4 years

   o   4 to 9 years

   o   10 to 14 years

   o   15 years or more

11. Prior to this district

   o   Less than 4 years

   o   4 to 9 years

   o   10 to 14 years

   o   15 years or more

12. What is the locale categorization of your school district?

   o   City

   o   Suburban

   o   Town

   o   Rural

13. Please provide the type of secondary (high) school where you currently teach?

School type

- o CTE Center
- o Career Academy
- o STEM Academy
- o Alternative school
- o Regular secondary school
- o Regional Technical Center
- o Other type of school (please specify) _____

Adapted from Questionnaire from the dissertation of Bentry Nkhata

**Characteristics of Exemplary STEM Experiential Learning Opportunities Student
Questionnaire**

Thank you for participating in the research study, "**Lived Opportunities of Stakeholders Re-
garding Exemplary STEM-related Experiential Learning Activities**". The information gath-
ered will assist in putting the study in context.

Demographics

1. Tell me your name and the name of your school.

2. What STEM-related courses are you taking? Can you tell me a little about these courses?

3. I am here today to determine the characteristics of top notch learning opportunities in
    STEM-related courses for students. From your experience, can you describe your defini-
    tion of a hands-on learning experience in your STEM related courses?

4. Can you give me examples of STEM-related hands-on learning opportunities?

5. What are characteristics of the best opportunities?

6. Why do you think these characteristics make the experience excellent?

7. What positive contributions do you feel these opportunities make to your life?

8. Can you please describe examples and how you feel it impacts you now?

9. Do you feel these opportunities will impact you after graduation? If so, how?

10. In your view, are the teachers that provide experiential learning opportunities impacted in
    any way?

15. Is there anything that makes it more difficult, or gets in the way of taking these courses?

16. Is there anything that you would like to add?

At the conclusion of the interviews, each participant will be thanked for participating in the
study. The interviews will be transcribed as soon as is possible after each is completed.

Appendix H: Sample Interview Transcript

I   Can you tell me your name and your job title please?

P4 Um my name is "Veronica" and I'm the administrator for the "Program 2" Governor's

STEM Academy.

I   OK, and what department or curriculum areas are involved in providing your STEM related

courses?

P4 Uh, here our Health and Medical Sciences, our IT, Engineering, um, and our Trade and

Industrial are all considered um, part of our STEM program.

I   OK, can you tell me a little bit about those courses?

P4 Um … yes … uh … Health and Medical .. we have … the titles of the courses or … credits or

I   Just any information you'd like to share …

P4 Uh, Health and Medical we have everything from Exploring Health Sciences, Language and

Medicine, Medical Systems … where they sit for the medical assistant certification in the spring

… we also have Pharmacy and those students sit for the pharmacy certification so they can be a

pharmacy tech … um … we just started Fire Fighting this year, which falls under Health and

Medical … works with EMS and Fire … but the students sit for the Firefighting 1 and 2 to be a

real fireman … that …I supervise that program but its actually run at the Fairfax County facility

a couple of miles from here … at the training facility. Um, in our IT program and Cyber … all

of the Cyber programs we have Oracle, Cisco, um, Network Administration, and we also have

A+ Computer Technologies course … all of those programs … as far as experiential learning

um, have their own avenues to do different programs whether its hands on here in the building or

going out to different facilities and sights. Um … in our Engineering program we have STEM

Engineering as the first level course basically for 10th graders but after that they can take STEM

Robotics 1 or 2 … we're the only school in X County that has that … and then we also

have Engineering Physics and Engineering Math … both of which count as a science and a math

credit, not a CTE credit. So kids can get engineering credits that are core as well. Um, our

engineering teacher is a [university] professor. So after he teaches engineering here he goes

up to [the university] and teaches it there. Some of the same projects they are doing at [the university] are

here. Some of his students come and mentor and he'll probably tell you when you interview him

that um, our students mentor the college students because there are things that we've taught that

they haven't learned in the Engineering classroom at [the university] so they're helping each other …

which is phenomenal ... that's amazing.   Um … and then our courses like Animal Sciences …

we like to include them in our STEM as well because they are so much about the world of

biology … anatomy of the animals … not just the vet care, tech care … we call it Veterinary

Tech … uh … those kinds of things but all of the math and science behind those kinds of courses

as well.

I   Awesome … you've got a lot of cool stuff going on …

P4   Yah … I know, there are a lot of amazing opportunities here …

I   It is amazing … so I'm here today to determine the characteristics of exemplary pro-
grams in

STEM related courses so from your experience can you give me your definition of an

experiential learning experience? Of an exemplary …

P4   An exemplary experience … I know this is question 1 and when I was reading it I was
kind of

seeing question 1 and 2 as very similar. Question 2 was asking about … like I see
characteristics

and examples as kind of the same thing … it's kind of hard to … so characteristics to
me means

the students are doing it .. that the students are actually taking part in a project of
some sort as

opposed to visiting on a field trip and just walking through a plant and seeing it …
yah, seeing it

is experiential but I think that when you integrate something that you saw or you're
hands on

doing it is what is really exemplary in my mind. So I have a lot of different examples
of quality

experiences that our students do.

I   OK, we'll go right into …

P4   So in our Engineering and our IT … first of all … all of this hinges around the type of

businesses and companies and universities that work with you. So for our Engineer-
ing and IT

we're fortunate to have Cisco supporting us, Oracle supporting us, [the university],
University of

X … we use some of their curriculum in our Engineering program … they come up
once a

year and evaluate our program … but the business side of it … for example the [business name] …

[business name]… is located near by … and its also the area we live in … [business name] is right

down the road and they are a big sponsor for us and they provide field trips um, and when the

students go over there … one of the things … we go in their actual room where they monitor

every satellite that travels the Earth and there are a lot of satellites up there. Every country is

labeled … Google … they can tell us there is Google satellite right now … to our Russian … this

is China's … they're on a different path … this is trash … we're worried about the trash hitting

our satellites … it's real … we're watching … we're looking at the same things those workers

are looking at. And then on top of that is the [business name], they are located in this area

… right on the other side of the River … on the [state name] side … their satellite … they

let us control one of their satellites … so they gave us the operation here in our classroom where

our students … they'll tell us … when the satellite is at this trajectory … turn it so its you know

… 90 degrees … or whatever they tell us but we actually move the wings on the satellite to

change the direction for the [business name]. And they sent us a commendation that our

students did it so our students were actually doing work … they let us do that … now you know,

the truth is, we're not going to crash the satellite but the idea that we were given that

responsibility and experience was phenomenal! You know, that's real … um, like I said

[the university] and the University of X, um, when we are talking about our engineering classes and

working with … our teachers are really in sync with innovate, innovate, innovate … you know

getting our kids to be creative because … its so much … STEM is so much about making our

world better and innovating what's already there and understanding it better and being creative.

So some of the projects the students do are … um, try to create something that helps somebody

who's disabled and we do a lot with disabled children's toys. And um, one of … our teacher …

along with the students … made a walker that helps … for blind toddlers so its just trying to

make our community and our world better. So our Girls in Engineering … we let them go out

into a public park and we say how would you make this better? What would you engineer to

make this park better? So that was a project they worked on last year so I think experiential

learning is doing something real. Not reading about it, not watching a movie, but doing it …

I   Make it meaningful …

P4   Now at the same time, a lot of our experiential learning is going out … like our medical

students we go to the cardiac dome … we watch open heart surgery … we go every 3 weeks and

we can only take 10 kids at a time because in the learning lab they can watch the surgery and

then the doctors come up and say, now, what I had to do today was that … so that's at X

Hospital which is renown for its cardiac center … you know, on the east coast … and these

doctors are willing to spend their time and tell the kids … so that was yesterday … we do it

about once every 3 weeks so all the kids can get through it … so some of our teachers … we

kind of have different teachers go along with the kids so we can learn about this too and one got

queasy yesterday so its the real thing [laughter] … but uh, the kids handle it really well and who

can say they've seen open heart surgery when they're 17 years old! You know …

I   So, its sounds like its really important to have those experts that are in the field intimately

involved and willing to support your programs …

P4   Yah … for us [business name] is a huge partner … as far as our Cyber program and our

Cyber Patriot competition, um … in our Computer Systems Tech we're part of VA Stars

(Virginia Student Training and Refurbishment) program we get donated computers and we

rebuild or build from scratch and then send those computers to someone that can use them …

now granted they are older … but to somebody that doesn't have one, you still can get Internet

access and do basic word processing and what you need to do for that … um, even in our

programs like Entrepreneurship or Teachers for Tomorrow … or Dental programs … those kids

go out into the field. So our Dental kids go into a dental office and have to spend … um … I

think its 25 hours in a dental office assisting … not just watching … our Animal Science kids go

to the veterinary programs around and do things in the clinics. We have to buy insurance for that

so we have to buy insurance for our dental students to go out because frankly, you know,

something could happen … but you know, that's what I mean by experiencing … actually doing

it, not hearing about it or watching a movie … or even watching a video or whatever …

I   … and internships or mentorships are a valuable part of that?

P4   … uh huh … we have another program, Girls in Engineering, where um, we try to get … we

have a lot of women engineers who volunteer their time once a month or once every other month

we have a dinner … we provide dinner so once the women get off work they can come here and

meet with our girls and we may have a project that they do, they may support them in solving a

problem, or we may say … what's your journey? How they got where they are and they'll talk

about being at Virginia Tech and being the only girl in a class … or being at the rocket launch at

Wallops Island and being the only woman in the group of men that watch this take off … so

hearing it so that the girls can kind of anticipate what's still to come and give them confidence …

like there's no reason you can't do it … you know, that kind of … so that to me is a real

experience … um, somebody telling them that you can do it because I did it and I didn't think I

could.

I   That's great … um, so what positive contributions do you think these kinds of experiences

make to a students' life?

P4　Well … I mean, they're teenagers and they get a lot of pressure … what are you going to with

your life?　You know … where are you going to go to school?　Are you going to go to school

are you not going to school … what are you going to study … duh duh duh … and frankly they

don't know!　So I think these experiences help them understand what they'd like to do … you

know kids will say I'd like to be an engineer … what does that mean?　Civil engineer? Uh,

there's .. you know … I don't know … there's so many … biology … there's biomedical

engineering … there's so many in engineering … what does that mean?　My dad's an engineer

… well what does he do?　What does his day look like?　What does he physically do when he

goes to work and what does his day look like but these kids don't know.　So through these

experiences um, they can see …. oh … I can work with this satellite and make sure that this

satellite is on its trajectory … well how do I do that?　Well, I have this program … this is what

the program looks like … so you know … it helps them figure out well, there's no way I could

look at a computer screen all day and figure out this satellite … I don't care … that's not me … I

need to do something more physically demanding!　Maybe I'm an engineer out on the field at

VDOT helping design roads, you know what I mean?　So its … do I want to … figuring it out

by seeing people doing it … um, and hearing peoples stories.　When we go we always … in fact

the CIA group that's coming today … we have a panel … all of those folks in the [business name] are going

to talk about their journey … how they got to work in the [business name]. And the [business name]… the reason

they're so interested is they want people to know they are a city within themselves. You don't

have to be a spy … you can be an engineer, an accountant ... they have health and medical fields

you know, things for bioterrorism, they have Cyber things at the [business name] … not just a spy … so they

want people to see their community as more and they have such a wonderful outreach for us …

and we were one of the first school that they picked. They just picked us last year, it's kind of a

new outreach for them. So, I think it just helps kids decide what they really want to do. If they

don't know about it … and how are they going to know?

I   That's exactly right … and sometimes they might think they might want to do something and

then find out … no I don't want to do that …

P4   Yah, they might look at a restaurant and they might think you have to be a waitress or a cook

… well no, there's so much behind a restaurant or a store … inventory … they just don't

understand every aspect of … just like… in Animal Science … all the things that you could do in

Animal Science.   In carpentry … our teacher … he is STEM related too … in that you've got to

know math, you've got to know geometry and angles to build something. You've got to know

engineering to make sure it's a solid structure but he also wants them to know, you know what?

You could work in resource management and work in the parks and understand wood and trees

and keeping a sustainable forest. That's also within the realm of carpentry and construction. So

that's what I hope that our teachers do for our students.

I   Um, I'm hearing you say "we go … we take … " [laugher]

P4   Yes … so how? Um, a lot of money comes through this place and it is … it is … being

financially supported by our partners. Um … some of our partners will be specific on how the

money is spent and some will not. I got a check today and I always get happy about getting that

check because it doesn't have strict parameters so I'm free to use it how I see fit. But its made

possible because of our partners. I can move around some of my funding … so my funding is

separate from my school's … I have my own finance tech so I have to be really careful with

grant money that its spent correctly. If [business name] gave me money and I have to show

folks what I did spend it on and … I can understand that … reporting back to how their funds

were spent … I totally understand that … but a lot of these things are made possible through our

partners most definitely … and yesterday was Giving Tuesday so we did things to thank our

partners … we did several tweets with some of our partners names and we put some of our

partners names on our website under each course so people can see oh, Exxon Mobile is

supporting engineering so um, we can get out there as much as they do for us. In the same token,

if a business comes to me and just wants to do man hours … hey, we just want to reach out to

our schools … parents want to be able on a Saturday to help out with the Robots … we'll set up

lunch! We'll cut up a salad for robotics kids … we welcome that too. However they can support

us I try to find a way.

I   Very cool, very very cool … so um, how do you think these experiences impact students after

they graduate?

P4   After they graduate … um … after they graduate from high school? Um ….I hope that they

didn't just learn about the satellite at the research lab but they remember the people that worked

with them? Those people were willing to donate their time and excited to tell them about it …

and about giving back … I think this world is about giving back so I hope our kids … we do

have a lot of returning graduates? So you know, um, we had several last week because of

Thanksgiving and whether they're in their first year of school or … um, we just had two enter

Dental school through our dental program and they want to come back and tell the teacher I got

accepted to med school … they already went through college … they are at VCU in Richmond

and they're going to be dentists and they started in our dental program so I hope that they want to

come back and either talk to students or in some capacity somewhere give back. Um, we have

some graduates that I actually give them mentor badges … they do background checks through

the county if they are going to work with kids more than a day they have to be badged and

background checked … so I have a student who comes here all the time in our technology lab

and he's almost an assistant teacher … I mean he's only 21 years old but he wants to be a

teachers someday so we welcome his help because he's a good guy, we trust him and he's a good

teacher! So I hope these experiences of course help them decide what they want to do in their

life but more so they see … it opens up their eyes to opportunities in the world and giving back.

I   I'm sure they network and they've probably got job opportunities if they want them. Do most

of your students go on to 4 year schools or …

P4   Yah, I'd say 85% go onto further education and about 15 to community college or working.

I   Ok, ok … so in your view are the teachers that provide these experiential learning activities

impacted in any way?

P4   Um … impacted … yah I mean they are always looking for outside resources and um, just for

example today has been a really busy day here in the academy um, and tomorrow, so we … are

the teachers impacted … yah, I think the more the better … we have a huge robotics program if

we didn't have parents out there supporting and businesses supporting we couldn't do it. So they

welcome the extra set of hands. We have an ER doctor up here at X Hospital that comes

here in his scrubs to help our robotics team … Dr. X … um, and I'm like … did you sleep

today? You're still in your scrubs … and now he wants to help these kids so it wouldn't be

possible if people weren't willing to help out. So definitely they're impacted in a positive way.

I   Do you think they are happier coming to work? I know we have a problem wth teachers and

moral and …

P4   I think in the academy they are happy coming to work because for the most part they have

kids who want to be in the classes … especially when I draw from 25 schools … those kids made

the choice to get on a bus and come here for our class so we have very little disciplinary issues

… not to say we don't have any because we do … um, but yah I think if you asked my teachers

they'd say its a great place to be. I think more so than a typical English teacher or a geometry

teacher that has a set 30 kids who could care less about geometry.

I   Right …

P4   These kids signed up for an elective course … now having said that they can certainly get in

the class and say, oh, heck no … this is not for me … this is not what I thought it was … I can't

do this, I don't want to do this … whatever! But they're teenagers so that's going to happen if

they sign up for Creative Writing … they gotta know I'm not a creative writer … I can't write

creatively … so um, you know …

I   Um … what supports are in place to encourage teachers to provide these kinds of activities?

P4   We have uh, a position called Career Experience Specialist, and um, she's not a teacher … it

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doesn't require a teaching degree … its more of a … its not a counseling position either … its

more a an HR position? Her job solely for me is to make partnerships, solidify partnerships,

arrange things, she just had a baby Nov. 11 and we miss her dearly right now so there's four of

us picking up the pieces but without that position in this academy, it would be very hard because

as a staff, I have my AA here, I have finance person, I have two counselors, but I mean, I

couldn't manage these things! So right now there are three of us who are divvying up what

Bonnie did, we're lucky to have that position. In X County each academy has a position

like that because they support experiential learning and its a job in itself.

I   Yah, yah …

P4   It's a full time teaching job.

I   Yah, I've heard that before …

P4   [laughter] She runs our camp, she runs our events … it's engineering week so she puts on

… you know like Code Day is coming up … she gets all the teachers involved and works with

[business name] … OK they're coming at 2:00 and the [business name] is coming at 12:30 like … the

rest of us have our own jobs too … like we support that but we don't have the time …

I   …and teachers don't have the time …

P4   … and teachers don't have the time … no, no …

I   So do all the programs in this school division … in X County … offer experiential

learning?

P4   Um … we're encouraged to do it so to what extent we do it … like when you go to

… Jeff is the administrator there … Jeff does very similar things … he has a Career Experience

Specialist too … um and she does similar stuff so I think he would say that he relies on that

Careers Experience Specialist too to keep those partnerships up and going. They go out to

businesses … you know they'll go to Goodyear … they'll go places … Hank is a big supporter

… Hank over here … a car dealership, um … and then I kind of come in and stand for pictures

and stuff … and I meet with them too but like she does the MOU … making sure the grants right

… you know … doing our publicity and our Twitter and I retweet but like together … if I didn't

have that position … and I know Jeff will say the same thing.

I Do you have an advisory board?

P4 I do have an advisory board but its very difficult. We haven't met this year … I'll be frank

about that … uh … it ebbs and flows. I do have people on the books who are my advisors … i

have constant contact with some of my businesses but as you can imagine when you have a

meeting and you have somebody from [business name] and you have somebody from [business name]

and you have somebody from [business name] and you have somebody from a dental office we have to

focus our meetings and have a focus for them. It's not just about are we teaching what's

important. They come from such different areas of industry … its difficult …So, there is … Jeff

has one … I have one … but we're moving to a formula that … a STEM Advisory counsel for

the county because what we're finding is that … like my [business name] person also serves

on the X County Advisory Board … well there's a lot more power [laughter] in that one

than I have here. Like I can run ideas up the chain but that advisory board is more … 'get things

done' … mine is kind of like … oh we can talk about it and we can do some things but … you

know what I'm saying? So we're really moving toward a way that… we don't want to waste

their time, you know? And we want them …. they have more clout frankly. And we don't want

them going to all these meetings where like what advisory board's today? [laughter]

I Right …

P4 They are busy …

I Yah, they're busy people … so what would you describe as barriers to experiential learning

opportunities?

P4 Um … uh, transportation … you know, you take 30 kids somewhere or you take 10 kids

somewhere … do you get a whole school bus? Sometimes you need a charter bus and they're

expensive um, so transportation … how and when … scheduling … um, its all well and good

when a business says, oh I have 10 people who want to help you … and sometimes its like …

ahhh … how and when are they going to help, you know? [laughter] … you know you want

their time … their outreach … you want to celebrate their outreach to our school community but

sometimes I'm like … uhhhhhhh … I don't know if I should put that on tape [laughter] … just

the scheduling is hard. Field trips are sometimes hard because kids are pulled in so many

directions and uh, they can't miss their chemistry class or their calculus class to go to the [company name],

frankly. Um, they have to juggle their schedules and figure that out … oh I can't leave that day

so … its both ways … encouraging kids to go but we can't require them. For a trip tomorrow

we're going to [business name], which is a cybersecurity firm and we had more kids sign up than we can

take … um … so another challenge on the business side … our folks need clearances … our kids

need social security numbers and that might be a barrier. We also have OSHA re-quirements, so

some of our places a student has to be 18. Well … few of our students are 18 yet so if they're 17

they can do a few things here or they can observe, but that's another barrier. The pharmacy is a

big thing for that … to work at the pharmacy you have to be 18, uh, in our some for our

engineering place … I think more of the security up in this area is more the screening. Anytime

[business name], [business name], we need to turn in who is going on the field trip 3 weeks before so they can be

cleared to come … and that's hard on the school system to do when parents don't want to share

social security numbers and uh, we can't ask for that so we have to kind of political correct get

through that. Um, and some business … in fact, when I asked the [business name] to help today they said

they couldn't. [laughter] That's a perfect example because they said … I can give you the

paragraph that they gave me but its all about their being taped, their information being used

somewhere so we do our best to follow the rules for [business name] but still get our kids a kind of

experience so they work with us thankfully but that's a barrier because um, its just a barrier.

And if I'm taking 10 kids somewhere as opposed to 20 … how do I take 10 kids? I can rent two

vans … I do that from the X Co. government ... then I need two drivers but I only need one

chaperon for 10 kids … then so … those kinds of challenges are more logistics as opposed to

opportunities ... its more logistics …

I   Is there anything else you'd like to add?

P4   No, no … we have a great place here

I   Sounds like it …

P4   Its always about getting the word out. In my entire career, I started teaching in '84, its always

about letting kids know … and even in those years its changed so dramatically … vocation is a

dirty word … we don't say that anymore … so getting the word out to parents … the parents are

our age so its not like it was when we went to high school … this is in fact our tag line is college

and career readiness because its not about going to the work place … I mean you could … but

most of them don't! And we are giving them a boost in college and that is how they need to see

us. That's my only thing … getting the word out about what really goes on here.

I   Maybe our day is coming [laughter]

P4   Well I think with the new graduation requirements coming around … when is that … 2018?

And there's more opportunities for kids to take like … creative writing as one of their English

requirements rather than English 11 and I think when you have more opportunities like that for

kids and I don't see it as tracking, I see it as very positive.

I   Yah we have to be careful about how we do it

P   Yah

I   OK, thank you very much!

Appendix I: Sample Transcript with Codes and Themes

Line #	P	Text	Code	Themes
	I	Can you tell me your name and your job title?	None	Preliminaries
	P8	My name is X and I'm a teacher.	None	Preliminaries
	I	And you teach science?	None	Preliminaries
	P8	I teach Science, Introduction to Research, and Biology	None	Preliminaries
	I	OK, so can you tell me a little bit about the courses you teach?	None	Preliminaries
	P8	OK, so for tenth grade we have an integrated science program which basically continues	Integrating science program	TransdisciplinaryCurriculum
		from ninth grade so its earth science, chemistry, and physics all integrated together. So since	Integrating earth science, chemistry, and physics	TransdisciplinaryCurriculum
		its a continuation of ninth grade at the end of the student's 10th grade year they take a	None	
		chemistry and earth science SOL. Uh, then my 10th grade introduction to research course it's	None	
		basically the same students I have in science but its consider to be a different class and we	None	
		essentially do some research projects together to prepare them to do independent research	Preparing students to do independent research	Student Ownership
		their junior and senior year so we do … we start with literary reviews, we actually do research,	Students conduct literary reviews and do research	Student Ownership
		we collect a lot of data and then they actually do the stats and then they do a final research	Collecting data, do stats, compile research	Student Ownership
		paper which would be similar to something that would be published in a peer reviewed journal	Write publishable research paper	Student Ownership
		article. And then, biology … I teach that to juniors and its called AoS Biology and its taught	None	

		probably at the AP level but we don't get through quite as much content as you would in an AP	None	
		class or like a freshman biology course in college. Um, but we do a lot of unique labs … that are	Conduct unique labs	Hands on Strategy
		unique to us … and its a flipped classroom. So the students watch videos at night to learn the	Using flipped classroom strategy	
		content and we go over it a little bit during class or I might give them a quiz on the content, but	Using flipped classroom strategy	
		then we generally apply the content in the labs during the school day.	Application of content	Hands on Strategy
	I	Uh, can you describe one of the activities that you might do?	None	
	P8	Sure, probably one of the favorites that we might do is on the genetics unit. And so we	None	
		would start the activity … we give the students a problem … and we haven't covered anything in	Giving problems without explanation	Personal Growth
		genetics yet so we give them a page of a problem and we talk about Nasonia wasps and how	Discussion about problem	Personal Growth
		there's like a red eyed female and a black eyed male and we kind of explain the scenario and	Explain scenario using vocabulary	Personal Growth
		we put a lot of key terms in there that you would not usually know .. that the students wouldn't	Explain scenario using vocabulary	Personal Growth
		know … and then we … again we don't teach the students genetics we actually get Nasonia	Don't actually teach content	Student Ownership
		which are little wasps, and we do a cross in class and we look at their behavior … their mating	Observe and predict outcomes	
		behavior … and then while the wasps mature, the babies mature … the female will lay her eggs	Observe and predict outcomes	
		and while the babies mature in about two weeks time in the midst of that we teach the genetics	Teach in context to problem	In-class experiences

		unit. So simple Mendelian genetics, Subian genetics, other days I do some simple genetics that	Teach simple types of genetics	In-class experiences
		you might see in another classroom, um, and then at the end of the two weeks they basically	None	
		look at the offspring and count the eye color and sex and then basically what they figure out …	Students observe and problem solve without teacher input	In-class experiences
		and then we do a chai square analysis and they will want to say that its a sex link trait based on	Students do analysis without teacher input	In-class experiences
		what they had learned and then they find its not a sex link trait because the chai square analysis	Students discovery without teacher input	In-class experiences
		does not match up with that and then we basically in that sense teach them a third type of … or	Teach alternate type of genetics	In-class experiences
		a different type of inheritance pattern, uh … its haploid diploid inheritance meaning unfertilized	Teach alternate type of genetics	In-class experiences
		organisms are always males and fertilized organisms are always females. And they don't know	None	In-class experiences
		anything about that … we don't teach that, and then they find out about that through their	Students aren't taught content	Student Ownership
		statistical analysis.	Students discover through their analysis	Student Ownership
	I	OK, that's very cool. So what do you think the characteristics of a really exemplary	None	
		experience is?	None	
	P8	You mean for the students?	None	
	I	For the students	None	
	P8	Basically when they go in and um, they don't know anything that's going to happen … we	Students aren't told what's going to happen	Student Ownership

		don't give them forewarning, they have to put their computers away, they have to put their cell	Students aren't allowed to use outside resources	Student Ownership
		phones away, cuz one of the first things they always want to do … they always want to look	Students aren't allowed to use outside resources	Student Ownership
		something up. Uh, so we make them put everything away and they just have no idea what the	Students aren't allowed to use outside resources	Student Ownership
		outcome is going to be, we don't tell them how to do the lab, they have to figure it out	Students problem solve without teacher input	Student Ownership
		themselves, they have to do the experimental design. Of course we know where we want them	Students discover using experimental design	Student Ownership
		to go and we guide them a little bit and by the time they are juniors they will say, oh, this is an	Teacher facilitates and guides	Teacher Characteristics
		[school name] lie or this is an [school name] story because they've finally gotten the deal by that point. So that's	Students realize school ethos	Student Ownership
		pretty much an exemplary …. They have no idea and they have to figure it out themselves.	Students problem solve without teacher input	Student Ownership
	I	Figure it out … yah … how do you think this impacts your students?	None	
	P8	It makes them think. Um it makes them collaborate. It makes them realize that you can get	Students think and collaborate	Relationships Formed
		… you get more and more from experience than by looking something up on Google. It makes	Get more from experiencing	Hands-On Experiences

		them be analytical, logical, progressive type of thinkers. Like if I do this what's going to happen	Students become analytical, logical, progressive thinkers	Personal Growth
		here, or maybe I shouldn't do that. Um and it empowers them I think, I think it empowers them	Students empowered	Personal Growth
		to be the bearer of information and experience than again, looking at someplace else.	Students bring information through experience	Hands-On Experiences
	I	Uh hmmm, what do you think some of the barriers of offering these kinds of activities in more	None	
		schools?	None	
	P8	Fear. Um, from the teacher perspective as well as the student perspective I think a lot of	None	
		times the student will come to us and they will get upset and they'll say well you're not teaching	Students upset that teachers aren't teaching	Personal Growth
		me anything. And um, and that's what its supposed to feel like. It's supposed to feel like I'm not	Intentionally not teaching	Personal Growth
		teaching them anything. And some students are very uncomfortable with that because they've	Causing discomfort	Personal Growth
		come from traditional classrooms with a teacher standing up in front of the class. And its also a	Different than other classrooms	Teacher Growth
		fear on the part of the teachers, I mean I taught in a regular classroom for 15 years before I	Causes teachers fear also	Teacher Growth
		came here and I had to be willing to stretch and to be challenged and to be open to teaching a	Willing to stretch and be challenged	Teacher Growth
		different way. And I am that way and that's why I wanted to teach here, but I know a lot of my	Wanting to teach in a different way	Teacher Growth
		colleagues who teach in regular schools they have been teaching for 15 to 20 years and they	Different ways of teaching than other schools	Teacher Growth

		see retirement right down the road and they don't want to change anything and they walk in at 9	None	
		and leave at 4 and whatever they get done during that school day is what they get done. Um,	None	
		but you, you know, I'll call them stale teachers, you know, I just don't think that, you know …	None	
	I	OK, that's really all I have to ask unless you have something else you want to add.	None	

Appendix J: Sample Memo

School visit experiences

October 11, 2016 1:00 pm

The drive to the school today for my first interview was down very rural roads. When I came to the school, it was obviously an older building that had been renovated. It was a very large high school, and the STEM Academy was housed in the CTE section of the building. The STEM lab was fairly small, but very well equipped. It looked more like a science lab that the STEM/building/engineering space I was expecting. It makes sense that there is more of a heavy science focus to their Agriculture program. Several students came in and out during the interviews, showing a great rapport between students and the teachers. I saw the behaviors exhibited, so I wasn't surprised when the mutual respect and camaraderie was mentioned by both students and teachers in the interviews.

November 30, 2016 9:00 am

I'd been to this high school before, several years ago on a field trip for pre-service teachers. It was bustling with activity today. I really noticed the administrator's main focus was on business partners and university partners, and what they add to her program. The opportunities offered to these kids are incredible. All kids should have these kinds of programs.

The administrator stayed in the room while I interviewed the student. I cringed when the student remarked at one point about one of her teachers not be a very good teacher. I wondered what the administrator thought about that or would do with that information, if anything. Hopefully she took it with a grain of salt coming from a 16 yr. old.

The teacher I interviewed seemed reluctant to talk about how he was impacted in any personal way. It brought home to me the selflessness of many teachers, who never consider how it impact them, to them it's not important. Impact to the student is what matters.

November 30, 2016 1:00 pm

This STEM Academy was housed in a high school in a suburban area outside a large urban area. It seemed smaller than the other two schools I'd visited. I felt like the teacher I interviewed wasn't expecting my visit and I felt like I was intruding, but he was very gracious and put his other work on hold to talk to me. He showed me all around his shop area, which looked like a real auto mechanic shop. The equipment there was impressive. I almost didn't get to talk to the student, she was going to miss the bus so we talked quickly but I still got a good interview with her.

December 1, 2016 10:00 am

This STEM Academy was housed in a traditional high school too. The volunteer at the front of the school where I had to check in, didn't know where it was within the school. I had to ask sev-

eral students, who also didn't know for sure, but knew the general direction. I finally had to stop in a classroom and ask a teacher. It was a very small program housed in a very large high school at the back of the school. There were no students in the halls, only the sophomores were there that day and they were all taking a test. They were very busy because they were getting ready to go on a field trip out of the country. The principal was very gracious, although he forgot our appointment and wasn't there when I got there. His administrative assistant was able to get him on the phone and he got a teacher to talk to me until he got back. That's why I have 13 participants and 2 teachers from one school. When the principal got there, I felt like we were kindred spirits in our views of education and could have talked for hours. It was well worth the visit, I got more out of it than I expected. This school was different than the others.

Issues with setting up interviews

After problems getting responses from initial emails sent to administrators to set up interviews, Dr. Price initiated introductions through emails. This made a huge difference. I was then able to call and talk to the administrators and follow up with my email. Cold calling and emailing did not work. Arranging contact through Dr. Price gave me access to more participants than I could use.

Appendix K: IRB Approval Letter
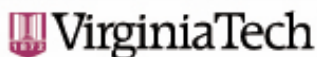
Virginia Tech

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website http://www.irb.vt.edu

MEMORANDUM

DATE: August 22, 2016

TO: Bill Price Jr, Jamie Munn Simmons

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)

PROTOCOL TITLE: Lived Experiences of Stakeholders Regarding Exemplary STEM-related Experiential Learning Activities

IRB NUMBER: 16-477

Effective August 9, 2016, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 5,6,7**
Protocol Approval Date: **August 9, 2016**
Protocol Expiration Date: **August 8, 2017**
Continuing Review Due Date*: **July 25, 2017**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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