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The CybHER Program supported by CISSE Framework to Engage and Anchor Middle-school Girls in Cybersecurity

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The CybHER Program supported by CISSE Framework to Engage and Anchor Middle-school Girls in Cybersecurity

A dissertation submitted to Dakota State University in partial fulfillment of the requirements for the degree of

Doctor of Science

in

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By
Pamela Rowland

Dissertation Committee:
Dr. Ashley Podhradsky - Chair
Dr. Gabe Mydland
Dr. Jennifer Nash
Dr. Cherie Noteboom

Dissertation Approval Form

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This dissertation is approved as a credible and independent investigation by a candidate for the Doctor of Science in Information Systems degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this dissertation does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department or university.

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Dissertation Title: CybHER – A Framework to Engage and form Anchors for Girls in Cybersecurity

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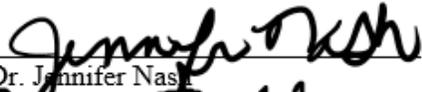
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It will be difficult to express my gratitude in a short amount of text, so please realize my gratitude goes beyond what you read on this page.

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I dedicate this dissertation to my dad and mom who taught me to never stop learning, to be kind, and that love always wins.

Abstract

There is a piercing shortage of personnel in the cybersecurity field that will take several decades to accommodate. Despite being 50 percent of the workforce, females only account for 11 percent of the cybersecurity personnel. While efforts have been made to encourage more females into the field, more needs to be done. Reality shows that a change in the statistics is not taking place. Women remain seriously under-represented in cybersecurity degree programs and the workforce.

Prior research shows that elementary girls are equally as interested in the cyber path as boys. It is in middle school that this interest shifts, which raises interesting questions about middle-school girls' perceptions of cyber-related studies. This study focuses on middle-school girls' perceptions of cybersecurity and what promising practices can be discovered to engage middle school girls in cybersecurity. These promising practices are then applied to the CybHER program.

Drawing on literature from gender gap and STEM research, prior interventions, and anchoring girls to the field, this study looks specifically at adolescent females in middle school. Through open-ended interviews, rich data was collected to form the CISSE framework of promising practices. The CISSE framework shows that community, influence, social media connection, education, increase in self-efficacy, and education are important factors to anchor girls in a cybersecurity career path.

The CISSE framework assisted in developing and enhancing the comprehensive program called CybHER. CybHER started as simply a name with a dream. By incorporating the CISSE framework, paying attention to prior successes and prior research, the CybHER program developed into a comprehensive program that includes intervention methods to educate and motivate girls to pursue cybersecurity. Five CybHER themes make up the program. These themes recognize time and relationships as important elements to girls.

CybHER provides community, influence, social media connection, increased self-efficacy and education while also producing anchors for girls in cybersecurity. Evaluation from experts in the field suggest that the program will make a significant difference in recruitment and retention of girls.

Declaration

I hereby certify that this dissertation constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions or writings of another.

I declare that the dissertation describes original work that has not previously been presented for the award of any other degree of any institution.

Signed,

Pamela Rowland

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Chapter 1: Introduction

Background of the Problem

A fresh approach is needed to combat the underrepresentation of women within the cybersecurity workforce. This phenomenon is typically termed the gender gap. The need for cybersecurity workers is increasing, and the gender gap is not improving. There is a clear disconnect between the cybersecurity industry and the message adolescent girls receive about the field; indicating that this industry is not for them. We need to act now, starting with girls in middle school to help them sustain interest throughout their education. I believe that with innovative teaching materials and pedagogical approaches, female students could be motivated to choose a cybersecurity degree.

By the year 2020, there is expected to be a deficit of 1.5 million professionals in the cybersecurity field (Nolte, 2015). The cybersecurity market grew from $3.5 billion in 2004 to $75 billion in 2015, with a forecast of reaching $170 billion by 2020 (Morgan, 2016). The human capital crisis is one of the most significant obstacles we face in an effort to meet the growing demand in the market.

The Bureau of Labor Statistics states "employment of computer and information technology occupations is projected to grow 12 percent [annually] from 2014 to 2024, faster than the average for all occupations. These occupations are expected to add about 488,500 new jobs, from about 3.9 million jobs to about 4.4 million jobs from 2014 to 2024" (*Occupational Outlook Handbook*, 2016).
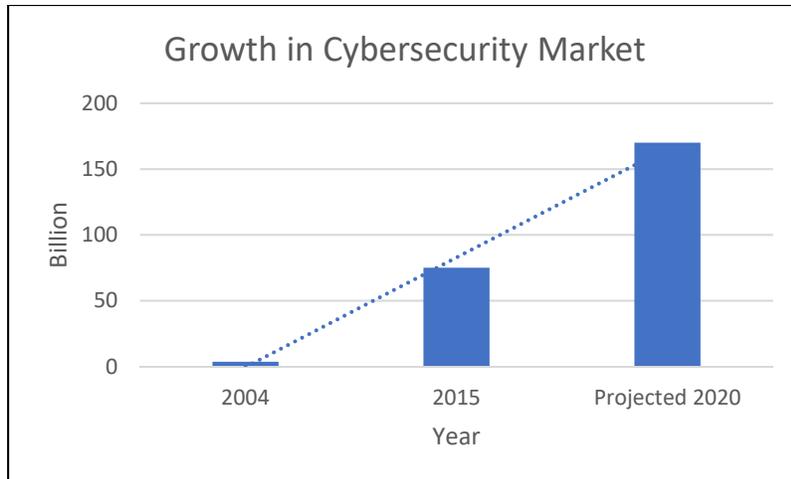
Figure 1: Chart of expected growth in Cybersecurity market

Nationally, the gender gap has been well recognized and documented (Foundation, 2017). A theme has emerged showing women are not entering the computing field in large numbers, and most notably this is seen in cybersecurity (*Securing Our Future: Closing the Cybersecurity Talent Gap*, 2016). Currently, only 11% of computer security professionals are women, therefore, retaining and growing the number of women in cybersecurity is key to addressing the shortfall of trained professionals while improving the diversity of thought that experts state will strengthen our national security (Davidson, 2017).

There is a growing interest and focus on diversity in the global IT economy. A diverse workforce is a reflection of the world and marketplace. There are several benefits to a diverse workforce. First, it contributes to increased levels of innovation and creativity (Florida, 2005; Green, López, Wysocki, & Kepner, 2002). Second, it increases employee recruitment and retention (Kossek & Pichler, 2007). Third, diversity lends itself to the creation of more diverse products and services (Joshi & Kuhn, 2001). Including more women in cybersecurity will not only increase the number of workers, but will also increase the quality, creativity, innovation, and group problem solving (Jayne & Dipboye, 2004; Konrad, 2003).

Awareness programs of cyber careers have grown in the recent years. These activities include career exploration incentive programs, clubs, job fairs, competitions, scholarships, mentoring programs, and camps. A recent report indicated that 26% of the young people surveyed were more aware of these opportunities from the previous years, however the gender

gap maintains with nearly twice as many men as there are women knowing about these activities (*Securing Our Future: Closing the Cybersecurity Talent Gap*, 2016).

Adolescents lack awareness of the wide range of opportunities in cybersecurity. Perceptions of computer science careers are frequently limited to gaming or programing (Grover, Pea, & Cooper, 2014; Shumba et al., 2013), and cybersecurity is not seen as different from computer science. Social activities often draw girls into STEM activities, but girls do not realize that cybersecurity has a high social component.   Girls perceptions of cybersecurity are important to examine as this field differs from computer science. Cybersecurity requires a unique set of skills including crisis management, forensics, and the ability to work on a collaborative team (Bagchi-Sen, Rao, Upadhyaya, & Chai, 2010; Tims, Turner, Corbett, Deemer, & Mhire, 2014).

We have many challenging problems in the field of cybersecurity and for that reason alone we must engage women as an untapped resource in our national effort to protect our citizens and infrastructure. Globally there is a growing focus on cybersecurity leading to demands for a larger and more diverse workforce.

Although prior research has begun to examine girls' perceptions of computer science, little is known about how adolescent girls perceive cybersecurity, or the unique ways in which we might engage more adolescent girls in cybersecurity. The focus of this research is to seek to understand middle school girls' perceptions of cybersecurity and build a framework for increasing and engaging females in the field of cybersecurity that can be implemented in the CybHER program.

CybHER is a project focused on supporting and engaging more girls and women in cybersecurity. The name of the project was just the beginning. Prior efforts of reaching girls with one-time outreach events and camps was not enough. Developing and designing a more comprehensive program was the next step. This research was a part of that process.

Research Questions

Utilizing data gleaned from interviews with 14 middle-school girls, this study examines the following research questions:

1. How do middle school girls perceive the cybersecurity field?

2. What are some promising practices to engage middle school girls in cybersecurity?

3. How can the promising practices be applied to and enhance the CybHER project?

Structure of Paper

Table 1: Structure of Paper

Chapter 1	**Introduction**
	Justification of research
	Chapters Orientation
Chapter 2	**Awareness of the Problem**
	Literature Review
Chapter 3	**Research Methodology and Method**
	Design Science and Qualitative Research Process
	IRB approval information
Chapter 4	**Data Analysis**
	Framework Development
Chapter 5	**Artifact Development – the CybHER Project**
	Evaluation of the Artifact
Chapter 6	**Conclusion**
Bibliography	A list of the sources used as references in this research.
Appendices	A body of separate supplementary material is provided to give clarity or further details.

Chapter 2: Literature Review

Introduction of Literature Review

      This chapter provides background literature on related theories, practices that have been deemed effective for engaging females, challenges girls face in cybersecurity through the lens of computer science, policies and programs currently in effect, and support for reaching adolescent girls. It concludes with career development theory related to anchoring females to a career.

Social Belonging and Social Cognitive Theory

      Women in cybersecurity have a disadvantage when it comes to identifying with a group. In 2016, only 11% of information security professionals were women (Sullivan, 2017).   Social belonging proves to be important to intellectual achievement. Social belonging is a basic human desire (Baumeister & Leary, 1995) and group identities can be fundamental to a person's self-concept (Tajfel & Turner, 1979). Both social belonging and group identities can influence a young girl's career path and self-efficacy.

      The social cognitive theory identifies self-efficacy, which relates to personal beliefs about capabilities to learn or perform (Bandura, 2000). Self-efficacy influences academic motivation, learning, and achievement (Pajares & Schunk, 2001). Environmental factors influence self-efficacy, and in the case of girls' interest in cybersecurity, the environmental factors tend to be masculine.

      There is a fine line between the desire to belong and the desire to be different (Hornsey & Jetten, 2004). The core value of individualism indicates that people should be free to explore their individuality and to express their true selves (Bellah, 1985; Spindler & Spindler, 1990). Social connection causes individuals to ask, "Do I belong?" When an individual's social connection is threatened, motivation to pursue individual desires or interests can be affected.

      When individuals are in a state of belonging uncertainty, they may notice threatening cues that they may otherwise overlook (Kleck & Strenta, 1980; Mendoza-Denton, Downey, Purdie, Davis, & Pietrzak, 2002). As young girls interested in computing enter middle school, they notice the threatening cues of conformity to social expectations, gender stereotypes, and gender roles. Middle school is a time when girls expand their social group and reassess their academic abilities (Pajares & Schunk, 2001).

The widely expanded social reference group, coupled with the shift in evaluation standards, requires that students reassess their academic abilities. Consequently, perceptions of academic competence typically begin to decline during middle school (Harter, 1996; Midgley, Feldlaufer, & Eccles, 1989). As elementary and middle school girls face belonging uncertainty they are influenced to look at areas of study that they feel a belonging in. Research has shown that these societal level factors have influenced female student's career choices and commitment to a field (Shih, Pittinsky, & Ambady, 1999; Steele & Ambady, 2006).

In his hierarchy of needs, Maslow (1968) placed the need to form loving social bonds immediately above other drives, such as satisfying hunger (Hall & Nougaim, 1968). The need to belong does not have to be fulfilled through interpersonal relations; it can also be fulfilled through group memberships. A supportive group can motivate individuals to continue to explore an area of study. The underrepresented group of women in cybersecurity can benefit from belonging to a social group that encourages, motivates, and provides opportunities for education in cybersecurity. Women in male-dominated professions experience social identity threat more significantly than women in more gender-balanced fields (Richman, Vandellen, & Wood, 2011). Providing a community to girls starting at a young age will give girls the sense of belonging that will help them persist in cybersecurity studies.

Policy and Programming to Recruit Women into STEM

To increase gender diversity in the STEM and computing fields, many outreach programs targeting female adolescents have been created by the higher education community. These programs use outreach activities and classes to introduce girls to computing and the format varies from after-school programs to day workshop to summer camps.

Governments and organizations worldwide are concerned about the cybersecurity skills crisis. The Cyber Security Act (2009) was created by Congress to address this problem (Rockefeller, 2010). National efforts to promote computer science have been prominent in the last decade. Table 2 outlines a sample of these efforts. Most of the efforts include computer science, technology, and cybersecurity awareness.

Table 2: Efforts to increase participation in cybersecurity.

Project	Website	Sponsor	Objective
Computer Science Principles	csprinciples.org	NSF and College Board	Focused on developing an Advanced Placement course to "broaden participate in computing and computer science" ("CS Principles,").
GenCyber	gencyber.org	NSA	Learning cybersecurity principles in a fun and inspirational way ("GenCyber," 2017).
CyberCorps Scholarships for Service	sfs.opm.gov	NSF	Scholarships for students at CAE designated schools ("CyberCorpsÂ®: Scholarship for Service," 2017).
National Initiative for Cybersecurity Education (NIST)	nist.gove	US Department of Commerce	"The mission of NICE is to energize and promote a robust network and an ecosystem of cybersecurity education, training, and workforce development" ("National Initiative for Cybersecurity Education (NICE)	NIST," 2016).
NCWIT	ncwit.org	National Center for Women & Information Technology (NSF is the primary sponsor)	A national non-profit organization tha tworks to increase meaningful participation of girls and women in computing (Ncwit, 2017).
AAUW	aauw.org	The American Association of University Women	AAUW empowers women to improve their lives (Aauw, 2017).
Girl Scouts	girlscouts.org	Girls Scouts	The Girl Scouts have added a cybersecurity badge to their program (Gsblog, 2017).
Girls who Code	girlswhocode.com	Girls who code	Mission: "Girls Who Code was founded with a single mission: to close the gender gap in technology" (Gwc, 2017).

Despite these and other attempts to broaden participation, not enough progress has been made in closing the gender gap and recruiting more cybersecurity workers.

Role models

Research shows that female role models positively impact women in typically male-dominated fields (Grabisch & Rusinowska, 2010; Young, Rudman, Buettner, & McLean, 2013). Role models increase a woman's implicit identification within the field, while decreasing the implicit gendered stereotypes. Limited access to female role models in cybersecurity reinforces the image of the field (Catherine Ashcraft, 2012) and continues to hinder the field.

Promoting STEM at Middle School Age

Evidence suggests that girls are becoming uninterested in computer science in adolescence. Educators have learned that waiting to engage female students until high-school is too late (LeClair & Pheils, 2016). By focusing on girls in middle school, options are offered that may grow into anchors for their future studies and careers.

A 2017 survey by Microsoft found that young girls in Europe become interested in STEM subjects around the age of 11. Girls lost interest around the age of 15. "Conformity to social expectations, gender stereotypes, gender roles and lack of role models continue to channel girls' career choices away from STEM fields," said psychology professor Martin Bauer of the London School of Economics, who helped coordinate the survey of 11,500 girls across 12 European countries (Petroff, 2017). And once interest is lost, it doesn't appear that girls ever rebound.

The underrepresentation of girls and women in cybersecurity and computer science has a unique set of challenges. Research shows girls tend to express less confidence and rate their computer knowledge lower than boys, however achievement levels are similar (Cooper, 2006; Moorman & Johnson, 2003; Shapiro & Williams, 2012). Girls also perceive the computer science field as masculine, 'geeky', and isolated (Cheryan, Drury, & Vichayapai, 2013; Margolis & Fisher, 2003; Shumba et al., 2013).

When individuals are in a state of belonging uncertainty, they may notice threatening cues that they may otherwise overlook (Kleck & Strenta, 1980; Mendoza-Denton et al., 2002). Young girls interested in computing notice the threatening cues of conformity to social

expectations, gender stereotypes, and gender roles. Middle school is a time when girls expand their social group and reassess their academic abilities (Pajares & Schunk, 2001).

A 2016 report by Accenture and Girls who Code shows that women entering computing jobs is declining. The report suggests that "universal access to computing in schools will not address the gender gap, and only by tailoring to girls' specific needs can we boost their commitment to computing (*Cracking the Gender Code in Computing - Accenture and Girls Who Code*, 2016)." Finding novel ways to bring cybersecurity topics to middle school girls serves to address the recognized national need for recruitment. This would begin to address the widening gap between the availability and demand for qualified and diverse security professionals. Designing security interventions that are creative, socially relevant, and accessible to an underrepresented population in cybersecurity is a challenge that informs how education and outreach can be performed within other contexts.

Schein's Career Anchor Theory

The career anchor theory was first developed by Schein (Schein, 1971), who later described a career anchor as "his or her self-concept, which consists of self-perceived talents and abilities, basic values, and evolved sense of motives and needs as pertaining to a career" (Schein, 1996). Schein's research shows that this self-concept evolves over time, however once formed, "it functions as a stabilizing force, an anchor, and can be thought of as the values and motives that a person will not give up if forced to make a choice" (Schein, 1996). Fifty percent of women leave the cyber field within 12 years (Glass, Sassler, Levitte, & Michelmore, 2013), a rate more than two times what it is for men (Hewlett, 2008) and 10% more than the already abysmal attrition rate for women in general engineering (Silbey). Creating anchors is a necessity to achieve a vibrant and diverse workforce. Anchors can be identified and created through education and outreach (Noteboom & Rowland, 2017).

This leads to a very important question, how can anchors be formed? Schein identifies eight anchors that most people's self-concepts revolve around. These include 1) autonomy/independence; 2) security/stability; 3) technical-functional competence; 4) general managerial competence; 5) entrepreneurial creativity; 6) service or dedication to a cause; 7) pure challenge; 8) life style.

Summary of Literature Review

From the literature review I note that to expand the number of females as cybersecurity professionals more attention needs to be placed at the middle school age. Middle school girls are at a critical turning-point that will either motivate them to learn more about cybersecurity or will cause a disinterest that will be hard to reclaim in future years (LeClair & Pheils, 2016; Pajares & Schunk, 2001; Petroff, 2017).

I also note that while there are intervention programs, more needs to be done. Research needs to be continued recognizing that generations change, but the problem has not. Role models, community, and social engagement are three key elements that draw girls to explore cybersecurity. This research will identify key elements and promising practices of the current generation of middle school girls and relate those to an intervention program.

And finally, while current programs may peek an interest, anchoring girls to this area is vital. Anchors are defined as "a heavy object attached to a boat or ship by a rope or chain that is thrown into the water to hold the boat or ship in place" (Merriam-Webster). This study also looks at 'holding' female students 'in place'.

Chapter 3: The Research Methodology and Method

Introduction

This chapter will address the research methodology and research method. The research methodology is the broad philosophical base of the chosen research methods. Research methodology addresses how the research is done and includes the steps that are generally adopted by a researcher in studying the research problem (Kumar, 2008). Kumar (2008, p. 5) defines research methods as 'the methods the researcher uses in performing research operations.' In this research methodology chapter, I will first outline the design science research process and conclude with qualitative research.

Design Science Research (DSR) mixed with qualitative research will be the methodology used for this project. DSR addresses the social context and has the best potential for influencing practice by producing tangible programs and products. Qualitative research yields data that provides depth and detail to create understanding of a phenomenon and lived experience. Studies using mixed methods combine quantitative and/or qualitative approaches during different phases of the research process to create a product that is aligned with pragmatic paradigm (Tashakkori & Teddlie, 1998). Using qualitative and design science provides a better understanding of the research problem and the design of the artifact. Exploratory interviews will be conducted to critically review the initial list of predetermined key concepts, to clarify the problem and to identify perceptions which could be investigated and addressed when developing the artifact.

The goal of this research is to design a framework from the qualitative results that will be utilized in a program, therefore the design science methodology will be used in conjunction with the qualitative method.

Design Science

Design science will be the primary research method followed. The design science research method is intended to understand a phenomenon. While the gender gap has been in existence, a significant change has not occurred. The shortage of women in computing is still a challenge for the US economy and global competitiveness.

- Currently much of the research around the gender gap is based on descriptive knowledge (explanatory science) (Mike Gallivan, 2013; Michael Gallivan & Benbunan-Finch, 2008), which is theory driven and includes the development of knowledge by understanding the social world including describing, explaining, and possibly predicting shared understanding (van Aken, 2004).

- DSR is focused on practical problem solving and includes prescriptive or solution-oriented knowledge where the results are from scientific justification including predicting, understanding, or explaining a phenomenon. Scientific justifications can be used in designing solutions to complex problems. DSR is used to design solutions to field problems by describing and analyzing alternative courses of action.

Simon's inspired Design Science in The Sciences of the Artificial (Simon, 1969). Simon argues that an important source of knowledge can be found from the human-constructed world of the 'artificial'. These 'artificial' sciences focus on usefulness and contingency (possibility). "Whereas natural sciences and social sciences try to understand reality, design science attempts to create things to serve human purposes" (Simon, 1969). This research is intended to design a framework to serve human purposes, specifically to understand middle school girls' perceptions of cybersecurity, identify promising practices, and provide a program that will reach girls and ultimately increase the numbers of females in cybersecurity.

Design science was introduced to the research community in the late 1960s, but it is a relatively new approach within the Information Systems discipline (Hevner, March, Park, & Ram, 2004). The ultimate goal of design science is development of design knowledge. Van Aken included social innovations as an artifact, and stated that "the ultimate mission is to develop design knowledge, i.e. knowledge that can be used in designing solutions to problems" (van Aken, 2004).

While there may not be one best research methodology to undertake a particular research project, the researcher has to be able to make an informed choice. This study uses DSR as the philosophical approach for discovering and identifying opportunities relevant to increasing the number of women in cybersecurity. This study will look at creating a new or improved conceptual means to address this problem and will look at establishing a link to the theoretical

explanation at the end of the process. DSR is not concerned with the action itself, but with the knowledge to be used in designing solutions (van Aken, 2004).

There are many models in DSR that are reported in high-impact journals (Hevner, 2007; Järvinen, 2004; March & Smith, 1995; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Vaishnavi & Kuechler, 2004). The main processes are 1) establish awareness of problem, 2) development of the artifact and evaluation, 3) connecting to theory (developing knowledge).

I will use the 6-step design science process created by Peffers, et al, which are outlined later in this chapter. This research model incorporates three objectives related to IS research: consistent with prior literature, provides a process for doing DS research, and provides a model for presenting and evaluating DS research (Peffers et al., 2007).
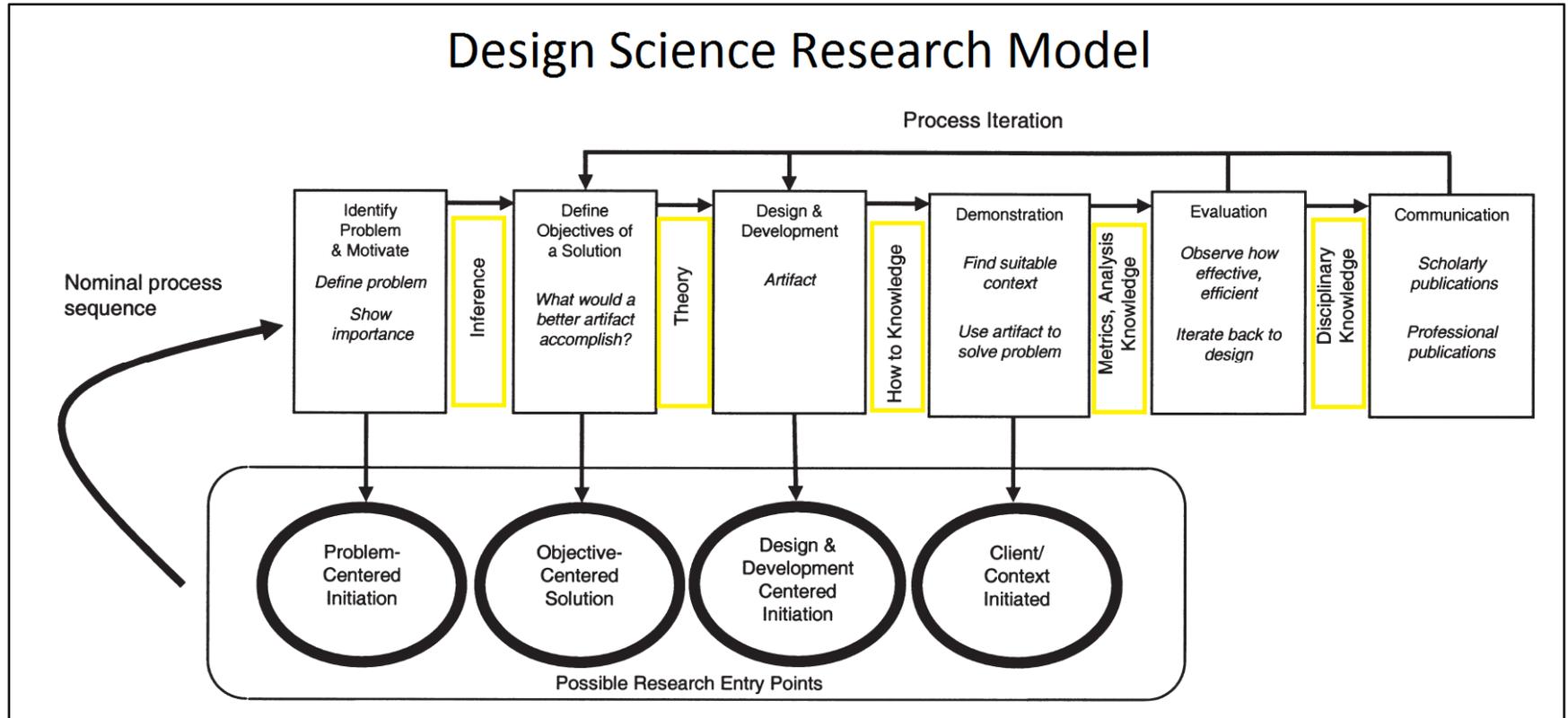
Figure 2: Design Science Research Model

Qualitative Exploratory Interview Research

A strength of the qualitative research portion of this study is that it yields data that provides depth and detail to create understanding of a phenomenon and lived experience. Past studies have shed light on the gender gap primarily in Computer Science or other STEM fields, have motivated intervention programs, but have yielded little results in closing the gender gap, and very few studies have focused specifically on cybersecurity. Hence, this study is designed to provide a current understanding of middle school perceptions around cybersecurity by focusing on the qualitative aspects. Interview questions will elicit data based on common community perceptions related to the closest field, computer science, while also seeking specific data related to cybersecurity. By identifying characteristics, this study will strengthen the knowledge base on which decisions can be made to recruit more girls into the cybersecurity field. This study will draw attention to some important dynamics that prevail within the current middle school community.

The qualitative research interview is intended to seek, describe and obtain meanings of central themes in life situations. The main task is to understand the meaning of the interviewee's dialog (Kvale, 1996).

Interviewing is particularly useful to get the story behind the participants experiences. Interviews are more time-consuming and resource intensive than questionnaires, however they are more personal. By using exploratory interviewing, I can start with an initial list of questions and explore responses during the interview process. This will give the me more opportunity to discover meanings and themes by asking follow-up questions. Interviews are also found to be easier for the respondent, and because I am seeking opinions and impressions from middle-school girls, this will be a valuable means of data collection.

I will be using the general interview guide approach which is intended to ensure the same general areas of information are collected from each interviewee while allowing follow-up exploration. This approach provides more focus than a conversational approach where there are no predetermined questions, while still allowing some freedom and adaptability in gaining information.

Telephone interviews will be used for the personal interview. The interviews will be set up with the student after the parent has been contacted and a consent form has been signed.

Phone interviews are used because it is easier to connect with the students, it is a more personal approach than a survey, and it is easier to ask open-ended questions and follow-up questions. The disadvantages of the phone interview process are that the interviewer can be biased, it requires strong interviewing skills, can reach only a small sample, and analysis can be difficult.

Since the interviews control the quality of the results, I have prepared by reading Kvale's guide to interviewing several times as well as other resources (Kvale & Brinkmann, 2009b). As a student researcher, one of the disadvantages to this method is lack of experience. As the researcher, I have prepared ahead of time and followed the stages and suggestions closely. Interview bias is acknowledged, and awareness is key to staying unbiased.

Seven Stages of an Interview Investigation

I will be following Kvale and Brinkmann's seven stages (Kvale & Brinkmann, 2009a).

1. Thematizing an interview – the why and what of the investigation – the research aim.
2. Designing – protocol of how interview is to be undertaken
3. Interviewing – conduct the interview
4. Transcribing – preparing the interview material for analysis
5. Analyzing – coding the data and discovering themes
6. Verifying – ascertain validity and reliability
7. Reporting – communicating findings

Questions

Research interviews are a conversation between two individuals. Knowledge is created within the points of view of the interviewer and the interviewee (Kvale & Brinkmann, 2009b). Utilizing a semi-structured interview seeks to obtain descriptions of the world of the interviewee. There is openness to change the sequence and forms of the questions to follow up on specific answers given. As stated by Spradley:

> *"I want to understand the world from your point of view. I want to know what you know in a way you know it. I want to understand the meaning of your experience, to walk in your shoes, to feel things as you feel them, to explain things as you explain them. Will you become my teacher and help me understand? (Spradley, 2016)"*

Questions have been developed utilizing guidelines, prior research, and these helpful ideas from *Interviews, Learning the Craft of Qualitative Research Interviewing* (Kvale & Brinkmann, 2009b):

- Questions are brief and simple. One question will be asked at a time.
- Introductory questions are engaging.
- Interview questions focus on:
    - Behaviors - what a person has done or is doing.
    - Opinions/values - what a person thinks about the topic.
    - Feelings - what a person feels rather than what a person thinks.
    - Knowledge - to get facts about the topic.
    - Sensory - what people have seen, touched, heard, tasted or smelled.
    - Background/demographics - standard background questions, such as age, education, etc

Constructs identified within the literature review are explored. Questions and related constructs can be found in Table 3.   A full list of questions can also be found in Appendix B, while keeping in mind that I am using exploratory interviews that allow for follow-up questioning. Constructs used in development of the questions are as follows:

- Influence (Bright, Pryor, Wilkenfeld, & Earl, 2005; Chai & Kim, 2012; J. C. Turner, 1991; S. V. Turner, Bernt, & Pecora, 2002)
- Community support (Barr & Stephenson, 2011; Springer, Stanne, & Donovan, 1999; Williams, Wiebe, Yang, Ferzli, & Miller, 2002) and Social activities (J. C. Turner, 1991)
- Knowledge and perceptions of cybersecurity
- Self-efficacy – one's belief about one's own abilities (Bandura, 1982; Busch, 1995)
- Mentorship (Newton & Wells-Glover, 2000)

Table 3: Relationship between Questions and Constructs

	Influence	Community Support / Social Activities	Knowledge and Perceptions of Cybersecurity	Self-efficacy	Mentorship
Can you tell me a time you were inspired to try something new? (How are you inspired? Or What motivated you?)	X	X			X
Who is most influential in your decisions when selecting classes and how does this influence happen?	X	X			X
Who is most influential in selecting summer or after school activities and how does this influence happen?	X	X			X
Do you ever select an activity because of someone's influence, and not because you want to? Give me an example.	X	X			X
Do you ever not join an activity due to your influencers even though you want to? Give me an example.	X	X			X
What kinds of social or educational groups are you a part of? Why did you become a part of those groups? How does it make you feel to be a part of this(these) group(s)? (Is being a part of a group or community important to you? Why or why not?)		X			
On a scale of 1-5 (one being very low and five being extremely high), what is your interest in cybersecurity?			X		
What comes to your mind when I say cybersecurity?			X		
What kinds of feelings do you experience when you hear the word cybersecurity?			X		
On a scale of 1-5 (one being very low and five being extremely			X	X	

	Influence	Community Support / Social Activities	Knowledge and Perceptions of Cybersecurity	Self-efficacy	Mentorship
high), how to you rate yourself on cybersecurity knowledge?					
What kinds of jobs do you think of when you think of a cybersecurity career? Could you tell me how you feel about these types of jobs?	X		X	X	X
What does a typical cybersecurity professional look like?					
When you are unsure of a subject or topic, how do you learn more about the subject/topic?	X			X	
Do you enjoy computing classes?			X	X	
Looking back, do you enjoy computing classes more or less now than in the last two years?			X	X	
Would you tend to take computing classes, why or why not?				X	
What three classes do you typically feel like you belong in? (or in other words, you feel most like you are a part of)	X	X	X		X
Do you have a role model? How did that person become your role model?		X			X
What characteristics do you want in a role model or mentor?		X			X

Design Science Research Process

Activity 1: Problem identification and motivation.

Two types of research methods will be used to establish awareness of the problem: 1) literature review and 2) interviews utilizing qualitative research.

This research study is started with a critical literature review, see Chapter 2. The review is done to establish an in-depth understanding of the gender gap in cybersecurity and the current models or programs designed for middle school girls. While there are several theories and

enrichment activities, there is need for a program that could provide consistent and lasting impact to girls.

Exploratory interviews will be conducted with middle-school girls. The IRB process will be followed. These interviews will identify current perception of cybersecurity among middle school girls. Interview questions are listed in Appendix A. Interviews will be transcribed, deidentified, and coded using Atlas.ti and researching processes.

During the analysis the data will be condensed (summarized), grouped (categorized), and relationships will be identified between categories as a narrative to support meaningful analysis (Kvale & Brinkmann, 2009b).

Activity 2: Define the objectives for a solution.

Research Objectives:

1. To understand how middle school girls perceive the cybersecurity field.
2. To identify some promising practices to engage middle school girls in cybersecurity and create a framework.
3. To apply the framework to a project.

Activity 3: Design and Development.

This is the creation of the artifact, which will be a program. To develop the program, four to seven general themes for classification need to be identified. These themes will emerge through literature review and interview data collection (Creswell & Clark, 2007). The categories will be descriptive and analytical links will emerge between the categories and interpretation of the data (Corbin & Strauss, 1990). The themes will be put into a framework that can be used in other programs and projects.

Activity 4: Demonstration and Activity 5: Evaluation.

In some DSR projects, one would build a solution through synthesis and try it out in practice. However, in this research study, existing practical (that is they are clearly working in practice) solutions that are compatible with the conceptual solution (Simon, 1969; Venable, Pries-Heje, & Baskerville, 2012) have been identified, and the program will be evaluated by experts in the field. Future research will evaluate actual participants as the program is integrated.

Activity 6: Communication.

The results of this research will be shared through scholarly publications, my dissertation publication, and presentations at conferences. I will make a strong contribution to applied practice through this dissertation research. Table 4 outlines the relationship between the design science research process and the research techniques.

Table 4: Research Process and Research Techniques

Research Process	Research Technique	Research Objective
Establishing awareness of the problem	Literature Review Initial interviews	To familiarize myself to current research, programs, and opportunities. Objective 1: To understand how middle-school girls perceive the cybersecurity field.
Qualitative Research	Interviews and analysis	Objective 2: To identify some promising practices that engage middle-school girls in cybersecurity and create a framework.
Design Science – development of project	Develop a program.	Objective 3: To apply the framework to a project.
Demonstration	Identifying a practical solution.	Objective 2: To identify some promising practices that engage middle-school girls in cybersecurity Objective 3: To apply the framework to a project.
Evaluation	Quantitate and Qualitative Survey questions will be given to experts in the field to access the likelihood of the program meeting its goals.	Objective 3: To apply the framework to a project and to evaluate the effectiveness of the framework and the project.

Research Method

Interviews and Analysis

Chapter 3 outlined the interview process. In this chapter I will further explain the research method, clarify the participants and the ethical issues of the research, identify limitations, and finally cover the data collection process.

Research Method

To analyze the interview data, I used qualitative techniques. The qualitative techniques allowed me to explore and focus on a smaller number of interviews to help illuminate, clarify, and deepen my understanding of middle school girls perceptions towards cybersecurity (Neuman, 2002). The interviews allowed me to understand the phenomena within real-life contexts (Berg, 2004). This study addresses the real-life context of middle school girls' experiences, influences, and knowledge of cybersecurity. Additionally, I explored their interests and how they use social media. I also examined perceptions based on the literature and the constructs identified in Table 3.

The key steps involved for this interview study are found in Figure 2. This process has a series of feedback loops underlining the developing character and emerging findings. Preparation is very important for the interviews to produce worthwhile findings. Kvale and Brinkmann call this 'thematising' the study (Kvale & Brinkmann, 2009a). Through my research questions and knowledge of existing theory, I have a clear understanding of my topic. This process also helped me identify issues and formulate relevant questions.
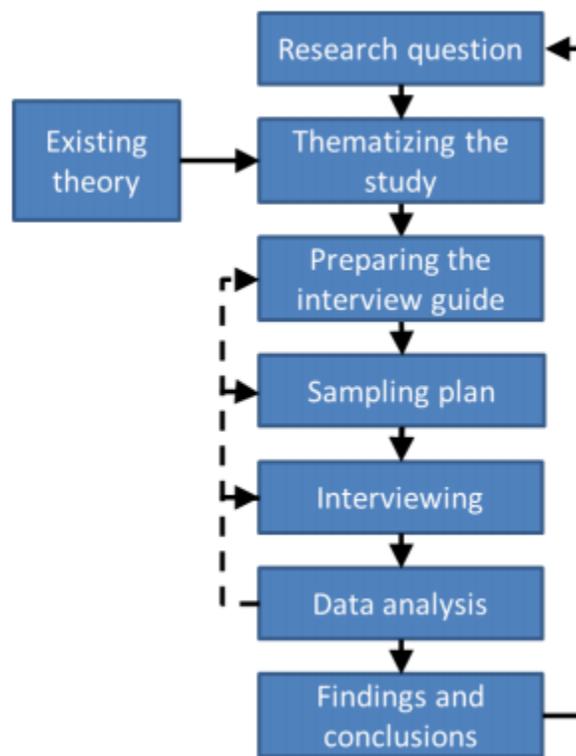
Figure 3: Steps in an interview study (Rose, Spinks, & Canhoto, 2014)

Kvale and Brinkmann's seven stages (Kvale & Brinkmann, 2009a) were followed closely and are outlined previously in Chapter 3.

Participants

This study was approved by the Institutional Review Board (IRB). Participants for this study were middle school girls from Midwest schools. To develop the list of participants, I contacted middle school principals, teachers, and parents in the community. After interviewing a participant, I would ask them for additional contacts who might be able to contribute to our study. This technique of identifying participants is sometimes called the snowball technique or chain referral technique. Although this approach may have issues, if managed appropriately it can be useful for qualitative research (Biernacki & Waldorf, 1981).

Ethical issues

The main ethical issues to consider when interviewing middle-school girls are consent, confidentiality, and the issue of consequences (Dixon, 2015). All ethical issues were addressed through the university IRB process.

Informed Consent

Informed consent ensures that all subjects participating in the interview freely and voluntarily consent to participate. This includes informing participants of their rights to withdraw at any time. The IRB approval process ensures protection of the participants in the study.

Confidentiality

Confidentiality means that private data cannot be linked to participants and will not be disclosed. Participants were provided with the information regarding how I will protect their identity. Each interview transcription was de-identified, and all private data was removed.

Consequences

The risks of harm were addressed in the IRB process. The potential benefits and importance of knowledge gained outweighed any harm to the participant. I felt this study was justified because exploring middle-school girls' perceptions about cybersecurity could lead to creating a framework for reaching more middle-school girls to explore this area.

Limitations of sample

Although the sampling technique and purposiveness allowed for the development of in-depth and rich information about middle school girls' perceptions, there are some limitations and problems. One of the major limitations is that the results are not generalizable. A majority of the interviews came from one region in one Midwest state with a unique culture and context, thus the results are context bound (Museus, 2010). Another limitation is the lack of a comparison group. For future research, comparing female students' responses to male students would indicate if the perceptions were unique to females, if there were crossover, or if any were uniquely different. A third limitation, is selection bias. The initial set of students were selected by principals and teachers, and it is possible that they selected individuals they felt would respond well to a cybersecurity research project. This bias was addressed through soliciting three additional participants from the Boys and Girls club.   And finally, a part of qualitative research is the influence of researcher bias (Kaplan & Maxwell, 2005). As a cybersecurity professor and being deeply involved in outreach to middle school girls, it is likely that my experience and knowledge of previously reviewed literature shaped my perceptions and interpretation of the data analysis.

Data Collection Process

The initial 11 interviews were conducted within the local population. To expand my population base, I reached out to boys and girls clubs and industry contacts in larger cities. Unfortunately, this only expanded my interviews by three individuals. The challenge was found in getting parental support. While I did not get many additional interviews, the interviews confirmed initial findings.

The process of the interview and data collection consisted of the following steps:

1.   The parent was contacted to sign an informed consent form. I went over the form with the parent to point out the main points, which including indicating that the phone conversation would be recorded.
2. The parent and student signed the consent form.
3. The phone number given was called to set up an interview time.
4. At the interview time, a recording app was used to record the interviews.
5. The interviewee was informed that they did not have to answer any questions they did not want to and given the opportunity to ask any questions about the process.

6. Semi-structured interview questions are listed in Appendix B.

7. After the interview was conducted, the recording was sent to a transcription company to be transcribed.

8. Once the transcription was returned, it was deidentified before data analysis.

The participant demographics are summarized in Tables 5 & 6.

Table 5: Demographics of Participants and Transcripts (*recording failed)

Participant	Grade	Location Midwest (MW) or Southwest (SW)	Number of transcribed pages	Minutes of recording	Number of codes
P1	8	MW	9	22	43
P2	8	MW	9	16	54
P3	8	MW	5	10	23
P4	8	MW	3	15	7
P5	8	MW	5	12	26
P6	6	MW	6	13	20
P7	7	MW	5	11	26
P8	6	MW	6	13	38
P9	6	MW	4	6	14
P10	8	MW	6	12	31
P11	6	MW	1	0*	4
P13	6	MW	5	9	24
P14	7	SW	7	15	23
P15	8	MW	26	11	24
Totals			**97**	**165**	**357**

Table 6: Demographics cont.

Total Participants	14
Number of Schools Represented	5, four Midwest and one Southwest
Number in 6th grade	5
Number in 7th grade	3
Number in 8th grade	7
Total Transcribed Pages	97
Total Minutes	165
Total Codes	357

Transcripts were deidentified, and initial coding was done using Atlas.ti, a textual analysis tool. While Atlas.ti is an aid for thought, "computers don't analyze data, people do" (Weitzman & Miles, 1995). The researcher is responsible for the interpretation of the data.

Coding takes place in the following steps (Kvale & Brinkmann, 2009b):

1. Researcher reads through the transcripts and codes passages,

2. With the aid of Atlas.ti, the coded passages can be retrieved and inspected over again,

3. Recoding was conducted, and relevant codes are combined.

Coding involves applying one or more keywords to a passage of text. Coding can be either concept-driven or data-driven. Concept-driven utilize codes that have been developed in advance by the researcher through exiting literature in the field. When the researcher does not start with any codes, it is data-driven. Flick and Gibbs suggests that anything can be coded (Flick & Gibbs, 2007). The coding of text meanings allows the researcher to quantify how often themes are addressed in a text. Frequency of themes can be compared and analyzed in a useful manner. Coding categories can arise during the analysis, but they can also be taken from theory or the interviewees.

Chapter 4: Interview Analysis and Development of Framework

Data Analysis

This research has adopted thematic analysis with a theoretical approach, at a semantic level of analysis, and epistemologically founded on the realist paradigm (Braun & Clarke, 2006). Each of these areas are outlined in the following paragraphs.

From the various data analysis methods, thematic analysis has been chosen. Thematic analysis can be defined as 'a process for encoding qualitative information' (Boyatzis, 1998). The objective of thematic analysis is to identify themes for understanding the research, in this case middle-school girls' perceptions of cybersecurity. A theoretical approach is used which uses the researcher's theoretical ideas drawn from previous literature. The research questions also guide the themes that emerge from the interview transcripts.

The data analysis uses a semantic or explicit approach, which required me to pay attention to manifest meanings in the text. This goes beyond the description of the text, but stresses the interpretation and significant themes (Braun & Clarke, 2006).

And finally, the epistemological approach used is founded on the realist paradigm where language is believed to be a clear reflection of meaning and experience. In this approach, I can analyze the data in a direct manner in regards to the motivations and experiences of the participants (Braun & Clarke, 2006).

To summarize, I am utilizing themes for understanding the meanings in the text. The language of the participants is a clear reflection of what they have experienced and the knowledge they portray.

Building on the details in Chapter 3 regarding the interview process and data analysis, the coding process lead to 363 pieces of text. These were further broken down into 13 code groups, which were compared to the constructs identified in Chapter 2 and shown in Table 7. Each of the code groups related to one or more of the constructs, although influence had the largest representation in the code groups. These code groups can be seen in Table 7.

Table 7: Code Groups

Code Groups	Constructs	Influence	Community Support / Social Activities	Knowledge and Perceptions of	Self-efficacy	Mentorship
Team or Group activities	Middle school girls enjoy team and group activities. They are fun, enjoyable, character building, social, provide a sense of importance, educational	x	x			
Belonging	Primarily girls feel they belong in a particular class or group because they are good at it or because of the people in the class. Only one felt like she really belonged in a computer class.	x	x			
Cybersecurity Knowledge	Key words relate to someone they know of an experience they have had. There was not a strong knowledge of what cybersecurity is. Key words were anything that related to computers or people. Computer classes are enjoyable but easy. Girls want a challenge			x	x	
Cybersecurity Feelings	Lots of opportunities but may conflict with something else they want to do. Cybersecurity feelings: fun, smart, nervous, safe, confused, difficult, sad, happy, impressed, challenging, enjoyable			x		
Cybersecurity professionals	Cybersecurity professional perceptions: knowledgeable, anyone, computer focused, problem solving, smart, glasses, nerd, counselor, professional looking			x		
Confidence	Girls believe they can be anything				x	
Online Learning	Learning is done online or by teachers				x	
Social Media	Only used for friends	x	x			
Influencers	Family, friends or professionals	x				x
Inspirations/motivators	Family, friends or professionals	x				x
Role Models	Family, friends or professionals	x				x

Role Model Characteristics	Role model characteristics: amazing, composed, determined, giving, integrity, entrepreneur, good attitude, kind, nice, overcomes failures, stable, trusting, understanding, hard working	x					x
Adventure						x	

To further understand the data, I calculated the number of times a construct was represented in the code groups. A breakdown of this data can be found in Table 8.

Table 8: Constructs represented in Code Groups

Construct	Definition	Number of times represented in code groups
Influence	To have an effect on the behavior of someone.	7
Community Support / Social Activities	The support from a community and being a part of a community through activities.	2
Knowledge and Perceptions of Cybersecurity	Current knowledge and ideas related to cybersecurity.	3
Self-efficacy	One's belief about one's own abilities.	4
Mentorship	A relationship with a more knowledgeable person to help guide a less knowledgeable person.	4

Influence and mentorship can be closely related, so it is no surprise that these are the top constructs with self-efficacy being equal to mentorship. This indicates that middle-school girls relate their perceptions and interest in cybersecurity most closely to their influencers, mentors, and what they believe about their own abilities.

Through the data analysis process and relating the results to the constructs, a framework has emerged to be included in efforts to reach middle-school girls for cybersecurity. To peek their interest, anchor their interest, and grow their interest, this framework should be woven into outreach, recruitment, and retention efforts.

Results

In Figure 4, I present the CISSE (siss-e) framework. This framework indicates what is important to middle school girls and how to shape their experiences, motivation, and perceptions of cybersecurity. The framework emerged from the interview results, code groups, and meanings of data.

There are five key areas that should be utilized in any effort to reach middle-school girls for cybersecurity.

Figure 4: The CISSE framework

Community

Middle school girls enjoy team and group activities. The participants indicate these activities are fun, enjoyable, character building, educational, and provide a sense of importance. Girls have a sense of belonging when they are good at an activity or a valuable part of the community. Social media is a community that they belong to, however, I have put social media as an element of its own, as participants shared the importance of that connection.

P1 shared how an after-school program taught her teamworking and problem-solving skills, and indicated that the program gave her value and importance.

"(The) program teaches people teamwork and problem-solving skills. It's like an after-school activity, and there will be like six or so challenges you can choose. It's a really big deal…"

P2 shared that being a part of a group shapes your character:

"I think it kinda shapes who you become.   I'm a very quiet person, but like, being a part of a group helps me open up a little more."

P3 shared that after her experience at a camp based on cybersecurity that she likes learning more since being a part of the camp community. This indicates that being a part of a community really does influence perceptions of exploring cybersecurity:

"I think I like them more because I just know more about it after the camp."

P7 states *"I think it's good to be part of a group so you can make more friends and be active."*

P9 likes to be a part of a community as she would *"rather work with other people to get like different opinions."* And P10 states that being a part of a team *"feels good because I feel like I'm on a team and I like being with a team and supporting them."*

Influence

Girls are highly influenced by their family and friends, with professionals also having a part. Participants pick activities based on what their parents and friends encourage them to do. This framework recommends that influencers are provided opportunities to learn about cybersecurity opportunities, thereby allowing influencers to take a role in the recruitment and encouragement of middle-school girls in this field. Participants relate cybersecurity workers to those within their range of influence; whether that be a parent, a teacher, or a tv personality. The image they relate to is changing from past studies where the image was a nerdy, white, male. The image given by the participants included computer focused, smart, professional looking – basically anyone.

Examples of Family influence

P1 shared that she joined wrestling (primarily a male sport) because she was influenced by her brother.

"I would always go to wrestling tournaments with my brothers, so that kind of inspired me to join wrestling, watching them all the time. I thought my brothers were really cool and they seemed to enjoy it."

P3: *"My mom inspires me to do things. She always wants me to do the best that I can."*

P4 also had an experience of being influenced to start a primarily male activity and discovering that she enjoyed it:

"When I was little my dad would always bring home ducks he shot and I started to like that and now I hunt all the time."

Examples of Friend influence

P2: "*Well, my friend is a little more outgoing, so she has ideas and then we kinda work it out together*." (In regard to attending an activity) *"My friend was going, and then I ended up liking it."*

P5 doesn't like to participate in activities unless her friends are, and she indicates that it is fan to be a part of the acidity and learn something new in the community.

"Like if there is sometimes when none of my friends or something are going I usually don't: I like having somebody that I know… It's fun because I get to have fun with my friends and learn new things and it's another activity to be a part of."

P6 was influenced to try coding by her friends:

"In fifth grade we did a little coding and I guess a lot of – a couple of my friends actually – liked that and so I kind of did some of that too."

P8 was influenced by her friends to try a new activity:

"I had seen some of my friends doing it and I had gone and watched some games and I thought it would be fun to try it."

Cybersecurity image and Professionals as an influencer

P1 indicated that a cybersecurity professional spent time "*sitting in front of a computer*" and imaged the professional to be a girl with:

"Like, a pretty loose ponytail, black hair, you know, really casual clothes most of the time. I don't know, just basically, like, the same picture, I don't know where I got it from, but— glasses, too."

And P1 perceives that there are lots opportunities for girls in cybersecurity, showing that the perceptions are changing.

"I feel like I could go into if I really wanted to, because I'm pretty sure there are a lot of opportunities in that. I think it's getting easier. I don't think there would be much—like, I mean,

learning in college and all that stuff would be hard, but I think the opportunities for girls are getting better, so I don't think it'll be as hard as it was."

P2 could not specifically describe a cybersecurity professional as *"People all look different."* This indicated that it could be anyone. And P3 states, *"It (a cybersecurity professional) could be anybody."* And P8's image also indicates it could be anyone: *"well, I guess it could be anyone really, but mostly I think of somebody like with glasses and really into that kind of stuff, like always carrying around his phone or something technology like."*

P7 relates the image of a cybersecurity professional to someone she knows who has influenced her: *"A person that I picture is someone that looks like (name) because I know her and that she works with computers a lot, so she comes to my mind."* And P8 relates the image to her dad: *"what my dad did and I really liked his job so I want to do that when I get older."*

P8 is influenced by professional gymnasts indicating that middle-school girls can be influenced by professionals:

"I'm a gymnast and a lot of times during the Olympics when I watched Olympic gymnasts I get inspired when I see them do all these crazy splits and stuff."

She adds to this that the professionals motivate her to do more:

"Well, just seeing how good they could be and knowing that they had to try really hard to get there and that I can do the same."

P9 shares that she is influenced by high school girls (professionals to her): *"I watched like the high school girls I kind of wanted to do what they're doing."* This shows that influencing can come from anyone that motivates you to want to know more. Programs can incorporate a role-model/mentoring aspect to meet this need.

Social Media Connection

Social media is the primary way middle-school girls connect to friends. Currently, none of the participants follow educational groups on social media. When given the idea, they comment that "they had never thought of that". A few of the participants follow professionals in an area of interest, which would indicate that given an opportunity to experience cybersecurity professionals as role models, middle-school girls would follow them as well.

When asked about following educational groups on social media P2 stated, *"Not really. I never thought about that."* And P7 follows that sentiment: *"I never really thought of using it that way."*

P6 says social media following is *"mostly just my friends."* P12 also confirms this by saying, *"I usually just follow my friends so then I can just talk to them."*

Self-Efficacy

Self-efficacy is one's beliefs in one's abilities to succeed, accomplish a task, and generally affects how one approaches goals and challenges they are faced with (Bandura, 1982). Increasing self-efficacy in girls related to cybersecurity knowledge and perceptions can help girls as they set goals for their education and careers. Self-efficacy increases academic motivation, learning and achievement (Pajares & Schunk, 2001). The girls in this study recognized that their self-efficacy is developed by influencers, education, community, and social media – all the other components of this framework. I have added this as a category as its own to point out the importance of their individual beliefs and how this shapes their self-efficacy.

This group of middle school girls believed that they can do anything. P8 stated, "*I can do anything.*" Her personal self-efficacy was influenced by others as she stated:

"*Well, just seeing how good they could be and knowing that they had to try really hard to get there and that I can do the same.*"

P9 shares that she believes she can succeed by watching other succeed: "(When I see) *cool skills and I want to try them.*"

When asked about classes they felt they most belong in, many of the responses were in relation to classes they felt they were good at, were challenged, and felt successful at. P2 states, "*I like math. It can get frustrating, but everything else is boring for me.*"

Prior experiences with cyber-related activities have proven to increase their self-efficacy. P3 had attended a GenCyber camp and stated, "*I learned different ways that I can be in the cyber field.*" And that she enjoys computer classes more because "*I just know more about it after camp.*" P4 increased in her belief in herself through camp and stated, I learned that "*I really like coding and stuff, and I have fun doing it.*"

Education

Girls indicate that computer classes are fun, easy, and boring. Some participants just want to have an opportunity to take a computer class, as they have not had that chance in their location. Participates want to be challenged and they want more opportunities to learn. Participants believe they can be and do anything, and they desire the opportunities to explore new things. Participants have differing feelings of cybersecurity ranging from nervous to safe

and sad to happy. Education would move the more negative feelings to positive feelings. Participates indicated that when they seek knowledge on their own, they conduct a google search or go to YouTube.

P1 shared that she related cybersecurity to the feeling of "*nervous*", while also indicating it gave her a sense of feeling "*safe*".

P1 shared that in middle school they are learning coding and "*it's pretty interesting*".

P2 wants to *"learn more about it and wants to be more knowledgeable,"* however she doesn't "*really have an opportunity for computer classes."*

P5 indicates it is fun to learn when you are a part of a community:

"It's fun because I get to have fun with my friends and learn new things and it's another activity to be a part of."

P5 also indicates that computer classes are more fun when she knows a little bit about the topic:

"Definitely now because I know a little bit more about it and it's more interesting because it's not just like little stuff; it's more bigger in detail."

P6's feelings of cybersecurity are that it *"would be really difficult to do,"* but she is interested in learning more and says*, "that would be fun."* This is an indication of girls wanting a challenge. P8 also shows the desire for a challenge when thinking of cybersecurity when she says, *"(it's) probably like a little bit of confusion but then fun too."*

When wanting to learn more P6 says, "*I guess just ask questions or look them up online most the time."*

P9 wants to: "*learn new skills and I liked learning new skills and meeting new friends."*

P13 also reinforces the need for a challenge and learning: *"(I like classes where I) like learning it and going more in-depth about it and like understanding it more"*

Conclusion

Middle-school girls perceive cybersecurity as a profession for anyone. They are highly influenced by family, friends, and sometimes professionals when choosing an activity or interest to explore. The girls want to be a part of a community, and through a community experience are more likely to anchor themselves to an interest. Social media is their main connection to one of their influencers – friends. Self-efficacy will be increased through community, education, and influences. Self-efficacy is closely related to mentors, indicating that they believe they can be

who they see and influenced by and can do what they see in others. Girls want to learn more about computing and desire the chance to do so. They want to be challenged in their computing classes, and do not want the class to be easy and boring.

By incorporating a sense of community, including their influencers, capturing their interest on social media, and providing opportunities for education, we can increase self-efficacy and reach more girls for cybersecurity. These promising practices are applied to the CybHER project outlined in Chapter 5.

Chapter 5: The Artifact: The CybHER Program

The CISSE framework and prior research lead to enhancing, strengthening, and defining the CybHER program, which is building a community of knowledge, inspiration, and mentorship. By providing positive experiences to girls at an earlier age, anchors can be formed, confidence built, and commitment made to the discipline.

The CybHER Program

CybHER is an intervention method to educate and motivate girls to pursue cybersecurity. This program resulted from design-based research which leads to developing an intervention in an educational setting. It is intended to improve education and inform theory. This intervention is designed and then implemented (Collins, Joseph, & Bielaczyc, 2004). In order for others to understand the intervention, the design and the implementation will be documented (Hoadley, 2004).

All elements required for Design Science research are included:

- The literature review identified an existing, important, persistent, unsolved IS problem.
- The proposed solution is a novel artifact informed by reference theories and the qualitative research process that lead to the CISSE framework.
- The steps of requirements-gathering, solution design, and existing practical solutions constitute the development phase
- Experts evaluate the artifact.
- The framework and general outline of the program can be applied to other projects or programs wishing to increase awareness and diversity. (Peffers et al., 2007)

The CISSE framework, prior research, and successes of other programs has pointed to the current design of CybHER. CybHER is organized into five separate, but thematic, interventions. Previous approaches have provided positive but intermittent exposure, while CybHER is designed to be comprehensive and provide continuous engagement with cybersecurity concepts throughout a student's curricular and extracurricular life. Table 10 shows how the framework connects to the CybHER Themes.

Table 9: CISSE Framework connected to CybHER Themes

	CybHER	Seconds	Minutes	Hours	Days	Together
Community Support / Social Activities	Middle school girls join activities for several reasons: to be with friends, to learn, to develop their character, for a sense of belonging and importance - because they are good at it.				x	x
Influence	Influence is primarily found in parents and friends, although middle school girls also are influenced by professionals	x	x	x	x	x
Social Media Connections	Influence and education are tied into social media connections. This is one of the main ways middle-school girls connect to others.	x	x			
Self-efficacy	Girls believe they can learn anything and be anything. They want more opportunities. These educational opportunities will grow their self-worth and how they assess themselves.	x	x	x	x	x
Education	Middle-school girls relate cybersecurity knowledge to anything related to a computer. Girls want to know more and want to be challenged more. Computer classes are classified as easy, enjoyable, and boring.	x	x	x	x	x

The CybHER themes recognize time and relationships as an important element to girls. Each theme also addresses theoretical concepts found through literature and expertise.

CybHER Seconds

Constant connections lead to lasting impacts (Bright et al., 2005). Social media is a constant connection for middle-school girls. CybHER Seconds are frequent connections on social media for inspiration, connection, and to showcase current events and technological developments. Emails, tweets, snaps, and Instagrams are used to maintain communication with participating girls. These quick connections take seconds.

The content is focused on cybersecurity awareness, current events, upcoming CybHER events, new engagement opportunities, CybHER tips, and CybHER motivation. Seconds are tailored to the target population of middle-school girls but will also reach their influencers – friends and family.

CybHER Minutes

Knowledge and practice lead to confidence and self-efficacy (Pelham, 1991; Zeldin & Pajares, 2000). Providing informal, independent educational opportunities to girls will help build their confidence and excitement for this field. CybHER Minutes are engaging 3-5-minute videos and short 5-7-minute follow-up exercises that provide the girls with foundational knowledge about mainstream topics in cybersecurity. The videos will cover topics like cryptography, phishing, social engineering, internet of things, the dark web, smart phone security, and much more. Beyond being strictly theoretical, the videos will demonstrate these topics using technologies relevant to young women and be explicit about the need for their participation in the discipline, the impact they can make, the excitement in field, and the problems they can help solve. This would inspire independent exploration, promote self-efficacy, and cause the girls to build a passion for cybersecurity.

CybHER Hours

Inspiration leads to motivation and independent exploration (Geritz, Gumtov, Martin, Heron, & Summerfield, 2013). CybHER Hours will be long-form, thirty to forty-minute, inspirational videos created by leading women across the world in industry, government, research, and academia discussing their careers and areas of expertise.

These long-form videos will motivate and inspire girls through the stories of successful women. Leading women will share how cybersecurity can lend itself to a fulfilling career as well as a fulfilling and balanced life. It is important for girls to view other women in a wide-range of jobs and employment statuses as successful role models in cybersecurity, allowing students to envision themselves in similar, important careers in cybersecurity. The videos will also work to defy gender and other stereotypes. The videos will show successful women working in defiance of current assumption, talking about what they do, how they became a cyber professional, and sharing their goals for the future.

CybHER Days

Community supports a strong identity, and collaborative problem solving gives purpose (Barr & Stephenson, 2011; Springer et al., 1999; Williams et al., 2002). It is well understood that girls can excel when there is community and support. In its simplest form, CybHER Days consist of students gathering together for a day of community and learning.

These events provide learning and exploration in a community setting where girls can identify with a group, develop social belonging, and receive mentorship, which leads to an anchor in the field.

CybHER Days provide opportunities for leadership. Girls team together and work towards accomplishing goals and learning in a supportive and encouraging environment.

CybHER Days are held at schools, universities, or public locations. An example of a CybHER Day includes learning programming, networking, and security concepts through hands-on exercises. It also includes problem solving, community building activities, and creative use of technology.

CybHER Together

Supportive and engaged guardians lead to positive and long-lasting influence (Chai & Kim, 2012; S. V. Turner et al., 2002). Whereas the popular Mommy and Me and Daddy and Me classes (swimming, painting, cookie decorating, etc.) are used as a vehicle for skills building and bonding, CybHER Together reimagines this approach through the lens of cybersecurity.

CybHER Together addresses the need for supportive parents/guardians who are highly influential in their child's career choice but may not be aware of the opportunities available in cybersecurity. An October 2016 report by the National Cybersecurity Alliance and Raytheon, revealed that millennial students were most influenced by their parents when dealing with career advice (Securing Our Future: Closing the Cybersecurity Talent Gap, 2016). CybHER Together seeks to not only educate parent and child, but also to provide a fun, learning environment for the parent/guardian and child. CybHER Together events would include teaching how to code robots, learn encryption, and work with their parents to learn more about cyber.

Anchors

This project seeks to start anchors in the middle school years. Each of these themes can be tied to Schein's Career Anchors with the goal to start these anchors as soon as middle school.

Schein indicates that people discover and thus identify one or more anchors as their careers evolve (Schein, 1996). While the target audience of this research are not developing their careers, and they may not discover their true anchors for many years, there is value in starting to develop these anchors early. Anchors develop through time and as decisions and choices are made (Schein, 1996).   This concept becomes important and relevant as we work to fill the human capital need in cybersecurity as well as retain women in the field.

Table 11 connects Schein's Career Anchors to the CybHER Themes.   As Schein stated, "The only reliable prediction is that we will have to become perpetual learners, more self-reliant, and more capable than ever in dealing with surprises of all sorts. It should be a field day for those anchored in pure challenge (Schein, 1996)." CybHER activities form anchors and give girls the opportunity to become perpetual leaners while allowing them to face challenges.

Table 10: CybHER Anchor Themes

Schein's Career Anchor(Schein, 1996)	Supported CybHER Theme
Security and Stability -- Employment security as a lifetime employee can no longer be relied upon as companies shift and change. Anchoring in this area has to be dependent on oneself. The only thing a person can take from an organization is the opportunity to learn and gain experience. This will cause him or her to be more employable in some other organization.	CybHER Hours – Girls learn how professional women have experienced security and stability, therefore having foundational knowledge that this is possible CybHER Minutes, Days and Together – Learning and gaining experience
Autonomy/Independence – Individuals do not thrive when being dependent on any particular organization. This group of people have high self-reliance.	CybHER Seconds – constant self-learning CybHER Minutes – self-learning and practice CybHER Days – self-motivated to attend and learn in a group
Life Style – Economic security is one aspect of a 'life system', which is the larger part of life-style, including personal and family concerns. Autonomy and concern for self are also factors. This area involves organizations supporting the family unit, sabbaticals, and creative ways for employees to complete their work.	CybHER Hours - While this anchor is harder to experience, we believe this anchor can start girls learning about professional women in the field.
Technical/functional Competence – Individuals desire to feel competence and recognize the importance of knowledge and skill and being life-long learners.	CybHER Seconds – constant self-learning CybHER Minutes – self-learning and practice CybHER Days – self-motivated to attend and learn in a group

	CybHER Together – learning with parent/guardian
General Managerial Competence – This anchor is indicated through leadership and managerial skills. The individual with general management anchor is generally after power, glory, responsibility, accomplishment of a task, the ability to build and manage a team, or a combination of these.	CybHER Days and Together - While students will not be put into a work managerial setting, we believe that this anchor can start to develop through CybHER Days where students can experience leadership and learning. This can also happen during CybHER Together where students are showing their accomplishments to their parent/guardian.
Entrepreneurial creativity – This anchor relates to developing one's own business.	CybHER Hours - This anchor can start to form through learning about entrepreneurial successes of professional women. We believe it can also start to form through CybHER Seconds, Minutes, Days, and Together as students learn and experience.
Service/Dedication to a Cause – This anchor shows that individuals want to do something meaningful.	CybHER Seconds – constant connections on worthwhile causes and service CybHER Hours – seeing how others serve and are doing something meaningful
Pure challenge – This career anchor involves individuals that want to overcome the impossible odds and solve the unsolved problems. They are active learners and want to challenge themselves.	All CybHER themes address this anchor by challenging the students to learn and solve problems.

Evaluation

Design Science requires the artifact to be evaluated. This evaluation includes documentation and communication of the program to a broader audience and gathering feedback for continued enhancement of the programs. The purpose of program evaluation is to determine if the program will have the intended effect.

Formative Evaluation

Formative evaluation allows feedback about a project as it is being developed. This type of evaluation allows for continuous fine tuning and can increase chances that the project will succeed. Formative evaluation is used in this study and evaluation will continue throughout the life of the project. According to evaluation theorist Bob Stake, "When the cook tastes the soup, that's formative; When the guests taste the soup, that's summative (Worthen, 1996)."   This

evaluation process was used to access whether the CISSE framework applied to the CybHER program will engage and motivate girls to explore cybersecurity.

I used the six phases of evaluation as follows (NSF, 2010):

1. Develop a conceptual model of the program and identify key evaluation points – the key evaluation points are the constructs and CISSE framework
2. Develop evaluation questions and define measurable outcomes – see section below
3. Develop an evaluation design
4. Collect data
5. Analyze data
6. Provide information to an interested audience.

Questions

Evaluation questions were developed based on constructs and framework. Several steps took place in creating the questions (NSF, 2010):

Step 1: Identification of key audiences

Step 2: Formulation of potential evaluation questions

Step 3: Defining the outcomes in measurable terms

Step 4: Prioritizing and eliminating questions

While the key audience for this project is middle-school girls and their influencers, there are other key stakeholders that will be interested in the results. These include K-12 educators, collegiate cybersecurity programs, and an industry that needs cybersecurity workers. For the evaluation of this project, national experts within the field of cybersecurity education were utilized. These experts have experience with K-12, educational programs, and industry.

Questions were developed based on the framework and project and pulled from multiple existing surveys (BetterEvaluation; Owen & Rogers, 1999; Rossi, Feeman, & Lipsey, 1999). The survey was refined and evaluated by a national external evaluator and the university Director of Institutional Effectiveness and Assessment.

The questions were developed to evaluate the artifact in relation to the CISSE framework and to evaluate appropriateness, effectiveness, and efficiency.

Evaluation Results

To evaluate the CISSE framework and its connection and support of the CybHER themes, a survey was sent to nine experts in the field of cybersecurity education. These individuals were selected based on their research and national reputation in cyber education. Surveys were sent to middle-school computer science teachers, National cybersecurity education experts, and evaluators at NCWIT (National Center of Women in Information Technology). Five individuals responded to the survey request.

A five-point Likert scale was used with 1 being "not at all" and 5 being "significantly" to evaluate categories for 15 questions. These questions and responses are shown in Table 11. Three qualitative questions were given with responses shown in Table 13.

Table 11: Interview questions and Analysis

Question 1 - To what extent:	Total n	Not at all	Very little	Some what	Quite a bit	Significantly	Total	Categories	Mean	Standard Deviation
do you feel the project will broaden the participation of females in cybersecurity?	5	0%	0%	0%	20%	80%	100%	Appropriateness Community	4.8	.4
do you feel the project will contribute to creating a community for girls to engage in cybersecurity activities and education?	5	0%	0%	0%	20%	80%	100%	Community Education	4.8	.4
does the program align with the CISSE framework?	4	0%	0%	0%	25%	75%	100%	Appropriateness Align with Framework	4.75	.43
do you feel the project will contribute to the long-term goal stated as: to increase diversity	5	0%	0%	0%	60%	40%	100%	Effectiveness Influence	4.4	.48

by introducing more girls to cybersecurity, who will then transition to women in collegiate programs, and finally highly trained professionals?									

Question 2 - To what extent:	Total n	Not at all	Very Little	Some what	Quite a bit	Significantly	Total	Categories	Mean	Standard Deviation
could the program change the perception of girls about cybersecurity?	5	0%	0%	0%	20%	80%	100%	Efficiency Influence	4.8	.45
would middle-school girls have the potential to be reached as intended?	5	0%	0%	0%	20%	80%	100%	Appropriateness	4.8	.45
would the project potentially reach	5	0%	0%	0%	60%	40%	100%	Influence	4.4	.55

influencers (parents, teachers, mentors) of middle-school girls?										
do you feel the social media connection will influence girls?	5	0%	0%	20%	40%	40%	100%	Social Media	4.2	.84

Question 3 - To what extent:	Total n	Not at all	Very Little	Some what	Quite a bit	Significantly	Total	Categories	Mean	Standard Deviation
could implementation result in changes to self-efficacy of middle school girls as related to cybersecurity?	5	0%	0%	0%	60%	40%	100%	Self-efficacy	4.4	.55
is this an innovate method to reach the goal?	5	0%	0%	0%	20%	80%	100%	Effectiveness Innovative	4.8	.45

Question 4: - To what extent do you feel each of these themes can make a difference in engaging middle school girls in cybersecurity?		Not at all	Very Little	Some what	Quite a bit	Significantly	Total	Categories	Mean	Standard Deviation
CybHER Seconds	5	0%	0%	0%	60%	40%	100%	Engaging Girls	4.4	.49
CybHER Minutes	5	0%	0%	0%	100%	0%	100%	Engaging Girls	4	0
CybHER Hours	5	0%	0%	0%	80%	20%	100%	Engaging Girls	4.2	.45
CybHER Days	5	0%	0%	0%	20%	80%	100%	Engaging Girls	4.8	.45
CybHER Together	4	0%	0%	0%	50%	50%	100%	Engaging Girls	4.5	.58

								Overall Mean Score	4.5	Quite a bit/Significant

Interpreting the Quantitative Results

Table 12 shows the categories related to each question, the mean rating, and the effect related to the Likert scale. A five-point Likert scale was used with 1 being "not at all" and 5 being "significantly".

Table 12: Categories and Ratings

Categories	Mean Ratings	Effect
Appropriateness	4.8	Significantly
Community	4.8	Significantly
Education	4.8	Significantly
Align with Framework	4.8	Significantly
Effectiveness	4.6	Significantly
Influence	4.5	Quite a bit/ Significantly
Efficiency	4.8	Significantly
Social Media impact	4.2	Quite a bit
Self-efficacy	4.4	Quite a bit
Innovative	4.8	Significantly

Results of the study show that five expert evaluators ranked the following areas as high on the scale indicating that the program is significantly:

- appropriate for the age-group
- meeting the goals and intended outcomes
- creating a community
- adding to the cybersecurity education of middle school girls
- aligning with the presented framework
- effective
- efficient in meeting the goals and objectives
- innovative.

The promising practices of the CISSE framework are community support, influence, social media connection, self-efficacy, and education. The evaluators indicate that each of these areas will be meet in the CybHER project either 'significantly' or 'quite a bit'. The themes indicated to be most effective are CybHER Days and CybHER Together events with 4.8 and 4.5 respectively. CybHER Seconds, CybHER Minutes, and CybHER Hours were also rated between 4.2 - 4.4 indicating they will also make a difference on engaging middle school girls in cybersecurity.

Interpreting Qualitative Results

Participants were asked to respond to three qualitative questions to enhance my understanding of their evaluation of the program. The responses are outlined in Table 13.

Table 13: Qualitative Survey Questions

Question 1: What are the features of the project that you feel will make the most difference?
I think there is a diversity in learning objectives for girls with many different skills
I think the CyberHER Seconds and the CyberHER Days will make the most impact. Engaging middle school girls on social media will hopefully not only introduce them to more cybersecurity concepts and information but will impact the algorithm of what they see on a daily basis. If they interact with the posts, then it will be easier for additional cybersecurity resources and opportunities to reach these middle school girls. The CyberHER Days will hopefully provide a community for them to support each other and encourage their interest in cybersecurity. Research has shown us that the biggest reason for women to drop out of the tech field is lack of community. Providing that with a cybersecurity focus is key to increase the number of women in this field.
The program is geared toward a very social age group. The girls are always looking for ways to get together with friends, but not always able to manage because of transportation issues. This project is a safe environment for girls to explore and learn while still being with friends and being social.

CybHER Seconds provides a "hook" or connection to the age group of girls that are being targeted to educate them about the world of cyber security. Social media is a large part of a middle school age girl's life and so any type of connection that can be made with them through social media will have a large impact on them. Once a connection has been made with them through Seconds, then CybHER Days is a great way to really connect with the girls on a one on one basis.

The CybHER hours. They will create a good connection using the website and social media, to hear some great stories from some amazing women.

Question 2: What may help or hinder the project to achieve its objectives and outcomes?

Maintaining the relationships and keeping the kids interested is always a challenge.

I think the biggest hurdle to overcome would be interrogation into regular CS curriculum. Most states are far behind on providing basic CS courses to its students and mostly rely on tech courses that teach students the basics of typing, using Microsoft Office, and presentation skills. Cybersecurity is a niche of computing and technology and it might be limited to private charter schools that focus on tech and STEM while public schools struggle to acquire the resources necessary to provide interesting and inclusive curriculum.

That is why it is essential that CyberHER provide not only community support, resources, but direct programing as well. The Minutes and Hours campaign can do that to an extent, but those with access to technology barriers will still be excluded from meaningfully participating in the program. Providing in person events with the Days campaign will be essential to approaching these students.

One area that may hinder the project is the parent buy in. Are the parents going to continue to support and encourage their child in this field as the child grows and gets busy with high school things. You can't control the parents but making the program easily obtainable to all girls will enable the girls that don't have support to still move forward with your program.

Being in the field of middle school education, I believe one of the largest obstacles we have with today's kids are all of the other activities they are already involved with and getting them to find time for other activities beyond sports, cheer, dance, etc. I feel the CybHER themes and features really try to work with and find the holes in the time of our students to educate them about other opportunities that are there for them.
I believe that it is important to take the time to get each part working well before sharing it out. If a middle schooler sees a CybHER Hour, and it doesn't seem professionally put together it may turn them away quicker. It is important to have each part running fully before making it live.
Question 3: How could the project achieve better outcomes?
I like the program and the program just needs to maintain being fresh and the counselors to be accessible.
Ensuring that the videos and programs apply to women from all racial and socioeconomic backgrounds. Highlighting Latina, Black, and Native American women in the video will ensure that the messaging reaches women of all backgrounds and focuses on the racial gap in tech in addition to the gender gap. Context is everything and ensuring that the curriculum is inclusive and appropriately structured for that context will go a long way.
I believe to be persistent and continue to offer the programs through CybHER and get the name out there through the use of social media.
Making sure that again with the social media aspect to give some attention-grabbing aspects. try and grab their attention as they scroll through their social media. figure out what will click with them, as there tends to be a lot of fake postings with random links to follow, and CybHER doesn't want to be mistaken for those.

Question Analysis Conclusion

Question 1: What are the particular features of the project that you feel will make the most difference?

Evaluators had mixed responses on which portion of the project would make the most difference. Most of the evaluators felt that the social media connection would be the constant contact needed to keep the girls engaged on a consistent basis. Evaluators felt that the social

media connection would lead to a sense of community that would entice the girls to be involved in CybHER Days. One evaluator felt that the CybHER Hours would make the most difference by providing role models for young girls. None of the evaluators felt that CybHER minutes or Together events would make the most difference, however each of these were rated high on the scale for effectiveness. CybHER Together was ranked the second highest just under CybHER Days on the scale ranking the extent to which each of the themes could make a difference in engaging middle school girls in cybersecurity. The difference could be due to the wording of the questions and the evaluators' perceived interpretation between 'engaging' and 'making the most difference'. All aspects of the CybHER program were rated as 'quite a bit' or 'significantly' by the evaluators suggesting that all are promising approaches. Future research on the girls' perspectives will shed light on the effectiveness of each approach.

Question 2: What may help or hinder the project to achieve its objectives and outcomes?

Evaluators recognized some challenges that this program will encounter including keeping students engaged and a part of the community. They recognize that students get busy with other activities and may not prioritize a CybHER community. Parents were recognized as influencers, and it would be important to continue to reach parents with the same message of encouragement to support their students in this field. The CybHER Hours would need to be financially supported to ensure high quality production for girls to be impacted by the videos and to continue to explore future resources.

Question 3: How could the project achieve better outcomes?

The CybHER project would need constant attention and upkeep ensuring new and fresh information that keeps the community of girls engaged. The project needs to be accessible to the girls as well as their influencers which includes parents and educators. One evaluator strongly encouraged the project to include diversity of races and socioeconomic backgrounds. The evaluator recommended that the curriculum and content be inclusive. Social media will be a substantial influence and should include attention-getting posts.

Expected Results, Contributions and Discussion

CybHER provides community, influence, connection, and education while also producing anchors for girls in cybersecurity. This method will be tested over time through growth of

participants and an increase in the number of girls entering the field. Evaluators of the program indicated that the project would have a significant impact on engaging girls in cybersecurity.

The ultimate dream is to have diversity within in the cybersecurity workforce that would see equal number of males and females and to seek a qualified workforce to fill the enormous number of cybersecurity jobs that are open in our nation. Diversity of thought provides innovative solutions to cybersecurity problems.

This research and continued research will contribute to the knowledge base for cybersecurity education, outreach, recruitment, and retention, thus benefitting the K-12 system, collegiate education, and industry.

The logic model with activities, short-term outcomes and long-term outcomes can be seen in Figure 5. Prior research indicates that the CybHER program is addressing areas that will meet the short-term outcomes. Evaluators of the project indicate that CybHER will increase the sense of community, will entice girls through social media connections, and will increase self-efficacy and knowledge. The long-term outcomes will be evaluated through future research by following participates for several years.

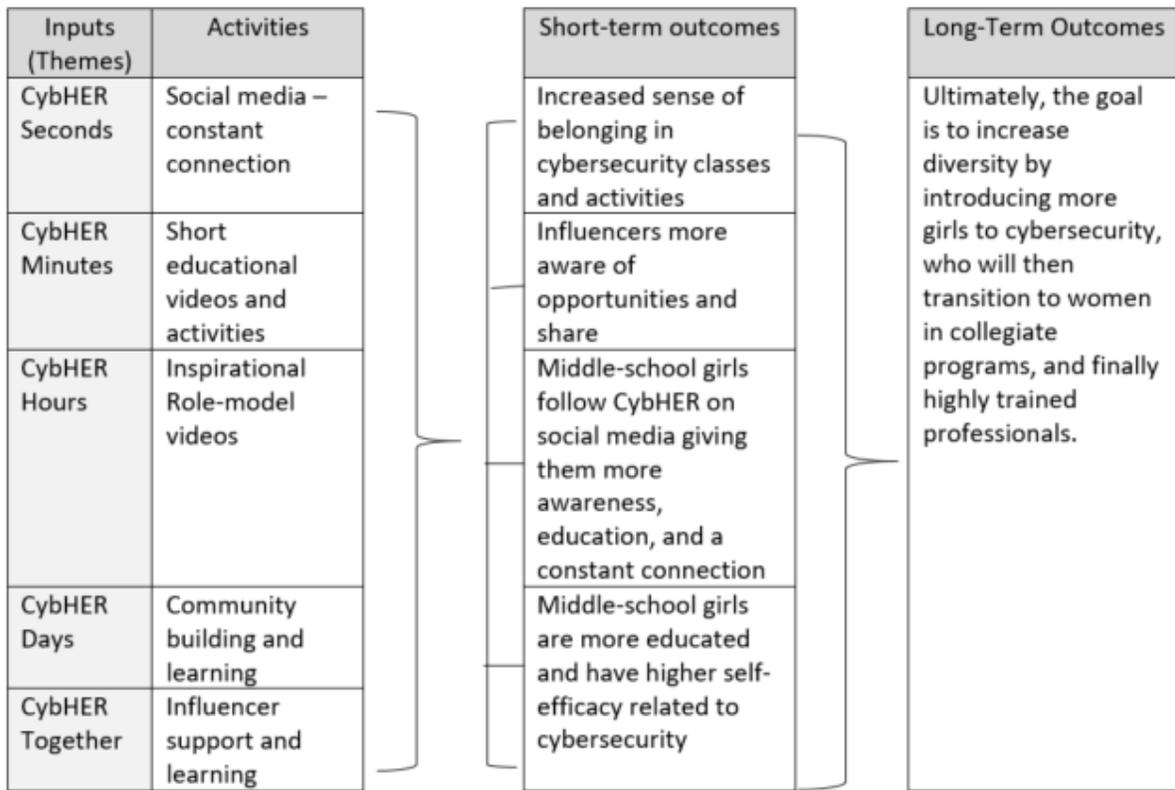| Inputs (Themes)	Activities	Short-term outcomes	Long-Term Outcomes
CybHER Seconds	Social media – constant connection	Increased sense of belonging in cybersecurity classes and activities	Ultimately, the goal is to increase diversity by introducing more girls to cybersecurity, who will then transition to women in collegiate programs, and finally highly trained professionals.
CybHER Minutes	Short educational videos and activities	Influencers more aware of opportunities and share	
CybHER Hours	Inspirational Role-model videos	Middle-school girls follow CybHER on social media giving them more awareness, education, and a constant connection	
CybHER Days	Community building and learning	Middle-school girls are more educated and have higher self-efficacy related to cybersecurity	
CybHER Together	Influencer support and learning		

Figure 5: Logic Model of the CybHER Project

Chapter 6: Discussion and Conclusion

This chapter presents a discussion on the fulfillment of the research objectives. Next, I discuss contributions to field, future research, and end with a conclusion.

Fulfilment of Research Objectives

The overall aim of this research was to understand middle-school girls' perceptions of cybersecurity which lead to promising practices. From the promising practices, a program was developed to motivate, engage, and educate middle-school girls in cybersecurity.

How do middle school girls perceive the cybersecurity field?

I conducted interviews with middle school girls to understand their perceptions of cybersecurity. I learned that the image of a cybersecurity professional is changing, and that the girls believe they can do anything they want. The interviews revealed key outreach practices that girls engage with and respond to when becoming involved with activities.

What are some promising practices to engage middle school girls in cybersecurity?

The interviewed revealed 5 promising practices that engage middle school girls. These promising practices formed the CISSE framework.

- Community – girls want community. They want to be a part of a group that is fun, educational, engaging, and provides a sense of importance.

- Influence – girls seek out influence. They are influenced by parents, friends, and other adults in their life.

- Social Media Connection – Social media plays a key role in providing community and influence. Social media is primarily used to connect with friends, although the girls stated they would likely follow an educational group if it provided value.

- Self-Efficacy – The girls believe they can be whatever they want to be, and they do not dismiss being a cybersecurity professional. They desire to learn, and through learning, belief in their abilities will increase.

- Education – Participants want to be challenged and engaged. They do not like boring computer classes. They want to solve problems and desire an education that allows them to grow and develop.

How can the promising practices be applied to and enhance the CybHER project?

The CISSE framework was applied to the CybHER program, and program themes were connected to the framework. The CybHER program was evaluated by expert evaluators whom indicated that the program will make a significant impact on middle school girls through creating a community, adding to their education, increasing self-efficacy, and influencing and motiving their exploration of the field.

Contributions

This research makes contributions to literature, theory, and practice. First, the literature review characterized middle-school girls, the gender gap, and current practices. Second, the design science research method mixed with qualitative analysis enabled pulling rich data from interviews to create a framework that would support the artifact developed. This added to the body of empirical research on middle-school girls' perceptions and promising practices for recruitment and retention in the cybersecurity workforce. The artifact was then related to Schien's anchor theory showing that the CybHER program can anchor girls to a field where the retention rate is low.

Findings resulted in a contribution to the body of knowledge about promising practices for middle school girls to explore cybersecurity as a field of study and career path. A comprehensive program, CybHER, was developed and evaluated and could be duplicated in other areas. The program also shows promises of anchoring girls to the field.

Future Research

As with any dissertation research project, many new research questions emerge. It would be interesting to compare the expert evaluations with middle school girls that attend CybHER events.

Future research could expand the CybHER program to include K-12 and early collegiate education. It would be interesting to interview high school girls and compare those results with the results of the middle-school girl interviews.

Research could reveal other areas of interest that can be added to the CybHER Program. CybHER Camp has been added since this research was started, and other CybHER themes will certainly emerge with time.

Research comparing female students' responses to male students would indicate if the perceptions were unique to females, if there were crossover, or if any were uniquely different. Future research could utilize the same interview questions with male middle-school students.

The image of a cybersecurity worker and the perception that the girls can be anything and do anything differ from the national norm. Future research could conduct this same study in other regions to test if there was a bias related to the region used in this research, which includes a cybersecurity focused university.

This research revealed the importance and influence of social media to middle school girls. I would like to research the motives and influences for girls to follow technology related organizations on social media. Social media data analysis could reveal key motivators for middle-school girls to follow and be influenced by a social media group.

To conclude, the gender gap and recruiting and retaining girls to study cybersecurity is worth further research and exploration. Community, education, social media influence, and effective mentoring practices are key areas of future research.

Conclusion

The lack of cybersecurity professionals has never been more serious. There is no magic bullet that will solve the issue of female shortages in cybersecurity. A consorted effort is needed to move in a positive direction. Government, organizations, schools, individuals, and universities play a role in moving this effort forward.

Initiatives to raise awareness over the last decade have resulted in a small amount of fruit. These initiatives and educational opportunities for students need to continue to grow and expand. It is important that females are receiving information and education about opportunities in cybersecurity. There is not one simple answer to solve the cybersecurity workforce shortage, but each positive step is a step in the right direction. Continued and sustainable efforts are required to meet the ever-increasing need. The CybHER program has the potential to immediately affect the diversity and quality of students pursuing a cybersecurity career path. Designing relevant, fun, and engaging security activities for girls that synergize with existing K-12 outreach programs, builds interest in existing programs, diversifies programs, engages new audiences, and educates that cybersecurity is a relevant and worthwhile career to explore.

This research revealed that middle-school girls relate their perceptions and interest in cybersecurity most closely to their influencers, mentors, and what they believe about their own

abilities. Girls desire activities that involve community and are fun, enjoyable, character building, educational, and provide a sense of importance. Girls want to be challenged and they want more opportunities to learn. The image of a cybersecurity professional is changing from past studies where the image was a nerdy white male. The image given by the participants included computer focused, smart, professional looking – "basically anyone". The girls believe they can be and do anything, and they desire the opportunities to explore new opportunities.

CybHER is an exciting endeavor to mentor and stay connected with girls. It seeks to inspire, motivate, educate, anchor, and walk alongside girls as they discover this fascinating field. The community created will be far reaching, and act as a catalyst for positive influence of change in an area that so desperately needs more diversity. As Grace M. Hopper (computer programmer 1943), once said, "The most dangerous phrase in the language is: We've always done it this way." CybHER seeks to do it differently. Expert evaluators indicate that the CybHER project will influence girls, have a social media impact, and will increase self-efficacy. The themes they felt would be most effective are the CybHER Days and the CybHER Together events. The other themes (CybHER seconds, CybHER Minutes, CybHER Hours) were also indicated to be effective and will make a difference on engaging middle school girls in cybersecurity.

By providing a community of support and encouragement, increasing influencers, having a constant connection through social media, and educating middle-school girls, CybHER provides anchors to this field. Cybersecurity is a broad and dynamic field that given the chance and exposure, girls will seek to enter, explore, and contribute.

Bibliography

Aauw. (2017). What We Do.

Bagchi-Sen, S., Rao, H. R., Upadhyaya, S. J., & Chai, S. (2010). Women in cybersecurity: A study of career advancement. *IT professional, 12*(1).

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American psychologist, 37*(2), 122.

Bandura, A. (2000). Exercise of human agency through collective efficacy. *Current directions in psychological science, 9*(3), 75-78.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *The journal of the learning sciences, 13*(1), 1-14.

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: what is Involved and what is the role of the computer science education community? *Acm Inroads, 2*(1), 48-54.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497.

Bellah, R. N. (1985). *Habits of the heart : individualism and commitment in American life*. Berkeley :: University of California Press.

Berg, B. L. (2004). *Methods for the social sciences*: Pearson Education Inc, United States of America.

BetterEvaluation. Specify the Key Evaluation Questions (KEQs). Retrieved from http://www.betterevaluation.org/en/plan/engage_frame/decide_evaluation_questions

Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological methods & research, 10*(2), 141-163.

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*: sage.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Bright, J. E., Pryor, R. G., Wilkenfeld, S., & Earl, J. (2005). The role of social context and serendipitous events in career decision making. *International journal for educational and vocational guidance, 5*(1), 19-36.

Busch, T. (1995). Gender differences in self-efficacy and attitudes toward computers. *Journal of Educational Computing Research, 12*(2), 147-158.

Catherine Ashcraft, E. E., Michelle Friend. (2012). Girl's In IT: The Facts. Retrieved from https://www.ncwit.org/sites/default/files/resources/girlsinit_thefacts_fullreport2012.pdf

Chai, S.-M., & Kim, M.-K. (2012). A Road To Retain Cybersecurity Professionals: An Examination of Career Decisions Among Cybersecurity Scholars. *Journal of The Korea Institute of Information Security and Cryptology, 22*(2), 295-316.

Cheryan, S., Drury, B. J., & Vichayapai, M. (2013). Enduring influence of stereotypical computer science role models on women's academic aspirations. *Psychology of Women Quarterly, 37*(1), 72-79.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *The journal of the learning sciences, 13*(1), 15-42.

Cooper, J. (2006). The digital divide: The special case of gender. *Journal of Computer Assisted Learning, 22*(5), 320-334.

Corbin, J., & Strauss, A. (1990). Basics of qualitative research: Grounded theory procedures and techniques. *Basics of qualitative research: Grounded Theory procedures and techniques, 41*.

Cracking the Gender Code in Computing - Accenture and Girls Who Code. (2016). Retrieved from https://www.accenture.com/us-en/cracking-the-gender-code

Creswell, J. W., & Clark, V. L. P. (2007). Designing and conducting mixed methods research.

CS Principles. Retrieved from http://csprinciples.org/

CyberCorps®: Scholarship for Service. (2017). Retrieved from https://www.sfs.opm.gov/

Davidson, J. (2017). Improving workforce diversity a 'national security imperative' - The Washington Post. *The Washington Post*.

Dictionary.com. (2017).

Dixon, C. S. (2015). Interviewing adolescent females in qualitative research. *The qualitative report, 20*(12), 2067.

Flick, U., & Gibbs, G. (2007). Analyzing qualitative data. *Designing qualitative research*, 104.

Florida, R. L. (2005). *The flight of the creative class*: Harper Business New York.

Foundation, N. S. (2017). *Women, Minorities, and Persons with Disabilities in Science and Engineering*. Retrieved from rlington, VA: https://www.nsf.gov/statistics/wmpd/

Gallivan, M. (2013). *A structured review of IS research on gender and IT.* Paper presented at the Proceedings of the 2013 annual conference on Computers and people research.

Gallivan, M., & Benbunan-Finch, R. (2008). Exploring the relationship between gender and career outcomes for social scientists: Implications for research on IS scholarship. *Information Technology & People, 21*(2), 178-204.

GenCyber. (2017). Retrieved from https://www.gen-cyber.com/

Geritz, R., Gumtov, K., Martin, T., Heron, G., & Summerfield, K. (2013). Methods and systems for providing career inspiration, motivation and guidance to a user. In: Google Patents.

Glass, J. L., Sassler, S., Levitte, Y., & Michelmore, K. M. (2013). What's so special about STEM? A comparison of women's retention in STEM and professional occupations. *Social forces, 92*(2), 723-756.

Grabisch, M., & Rusinowska, A. (2010). A model of influence in a social network. *Theory and Decision, 69*(1), 69-96. doi:http://dx.doi.org/10.1007/s11238-008-9109-z

Green, K. A., López, M., Wysocki, A., & Kepner, K. (2002). Diversity in the workplace: Benefits, challenges, and the required managerial tools. *University of Florida, 1*(4).

Grover, S., Pea, R., & Cooper, S. (2014). *Remedying misperceptions of computer science among middle school students.* Paper presented at the Proceedings of the 45th ACM technical symposium on Computer science education.

Gsblog. (2017). Girl Scouts Join National Cybersecurity Awareness Campaign, "Stop.Think.Connect.".

Gwc. (2017). About Us - Girls Who Code.

Hall, D. T., & Nougaim, K. E. (1968). An examination of Maslow's need hierarchy in an organizational setting. *Organizational behavior and human performance, 3*(1), 12-35.

Hevner, A. R. (2007). A three cycle view of design science research. *Scandinavian journal of information systems, 19*(2), 4.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS quarterly, 28*(1), 75-105.

Hewlett, S. A. (2008). *The Athena factor: Reversing the brain drain in science, engineering, and technology*: Harvard Business School Watertown, MA.

Hoadley, C. M. (2004). Methodological alignment in design-based research. *Educational psychologist, 39*(4), 203-212.

Hornsey, M., & Jetten, J. (2004). The Individual Within the Group: Balancing the Need to Belong With the Need to Be Different. *Personality and Social Psychology Review, 8*(3), 248-264.

Järvinen, P. (2004). Research questions guiding selection of an appropriate research method.

Jayne, M. E., & Dipboye, R. L. (2004). Leveraging diversity to improve business performance: Research findings and recommendations for organizations. *Human resource management, 43*(4), 409-424.

Joshi, K. D., & Kuhn, K. (2001). *Gender differences in IS career choice: examine the role of attitudes and social norms in selecting IS profession.* Paper presented at the Proceedings of the 2001 ACM SIGCPR conference on Computer personnel research.

Kaplan, B., & Maxwell, J. (2005). Qualitative research methods for evaluating computer information systems. *Evaluating the organizational impact of healthcare information systems*, 30-55.

Kleck, R. E., & Strenta, A. (1980). Perceptions of the impact of negatively valued physical characteristics on social interaction. *Journal of personality and social psychology, 39*(5), 861.

Konrad, A. M. (2003). Special issue introduction: Defining the domain of workplace diversity scholarship. *Group & Organization Management, 28*(1), 4-17.

Kossek, E. E., & Pichler, S. (2007). EEO and the management of diversity. *Oxford Handbook of Human Resource Management, The*, 251.

Kumar, R. (2008). *Research Methodology*: New Delhi: APH Publishing Corporation.

Kvale, S. (1996). An Introduction tot Qualitative Research Interviewing. In: Thousand Oaks: SAGE Publications.

Kvale, S., & Brinkmann, S. (2009a). Interviews: Learning the craft of qualitative interviewing. In: London: Sage.

Kvale, S., & Brinkmann, S. (2009b). *Interviews: Learning the craft of qualitative research interviewing*: Sage.

LeClair, J., & Pheils, D. (2016). *Women in Cybersecurity*: BookBaby.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision support systems, 15*(4), 251-266.

Margolis, J., & Fisher, A. (2003). *Unlocking the clubhouse: Women in computing*: MIT press.

Mendoza-Denton, R., Downey, G., Purdie, V. J., Davis, A., & Pietrzak, J. (2002). Sensitivity to status-based rejection: implications for African American students' college experience. *Journal of personality and social psychology, 83*(4), 896.

Merriam-Webster. Anchor. Retrieved from Merriam-Webster.com

Moorman, P., & Johnson, E. (2003). *Still a stranger here: Attitudes among secondary school students towards computer science.* Paper presented at the ACM SIGCSE Bulletin.

Morgan, S. C. (2016). *Cybersecurity Market Report*. Retrieved from http://cybersecurityventures.com/cybersecurity-market-report/

Museus, S. D. (2010). Delineating the ways that targeted support programs facilitate minority students' access to social networks and development of social capital in college. *Enrollment Management Journal, 4*(3), 10-41.

National Initiative for Cybersecurity Education (NICE) | NIST. (2016).

Ncwit. (2017). National Center for Women & Information Technology. Retrieved from https://www.ncwit.org/

Neuman, L. W. (2002). Social research methods: Qualitative and quantitative approaches.

Newton, E., & Wells-Glover, L. (2000). Mentors for undergraduates in technical disciplines: A collaborative effort by faculty, student development professionals, and alumni to improve undergraduate retention and success in technical majors. *Journal of College Student Retention: Research, Theory & Practice, 1*(4), 311-321.

Nolte, N. (2015). Despite Growing Cyber Threats and Workforce Gap, Women Remain Underrepresented in Information Security [Press release]

Noteboom, C., & Rowland, P. (2017). *An Exploration of Anchoring Female Millennial Students to an IS/IT Career Path: The CLASS Model.* Paper presented at the Proceedings of the 50th Hawaii International Conference on System Sciences.

NSF. (2010). *Handbook for Project Evalutation*: Directorate for Education and Human Resources.

Occupational Outlook Handbook. (2016). Washington, DC: U.S. Bureau of Labor Statistics Retrieved from http://www.bls.gov/ooh/computer-and-information-technology/home.htm.

Owen, J. M., & Rogers, P. J. (1999). *From Evluation Questions to Evaluation Findings*. London: SAGE Publications.

Pajares, F., & Schunk, D. (2001). The development of academic self-efficacy. *Development of achievement motivation. United States, 7*.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems, 24*(3), 45-77.

Pelham, B. W. (1991). On confidence and consequence: the certainty and importance of self-knowledge. *Journal of personality and social psychology, 60*(4), 518.

Petroff, A. (2017). The exact age when girls lose interest in science and math - Feb. 28, 2017.

Richman, L. S., Vandellen, M., & Wood, W. (2011). How women cope: Being a numerical minority in a Male-Dominated profession. *Journal of Social Issues, 67*(3), 492-509.

Rockefeller, J. (2010). S.773 - 111th Congress (2009-2010): Cybersecurity Act of 2010. doi:/bill/111th-congress/senate-bill/773

Rose, S., Spinks, N., & Canhoto, A. I. (2014). *Management research: Applying the principles*: Routledge.

Rossi, P. H., Feeman, H. E., & Lipsey, M. W. (1999). *Evaluation: A Systematic Approach*. London: Sage Publications.

Schein, E. H. (1971). The individual, the organization, and the career: A conceptual scheme. *The Journal of Applied Behavioral Science, 7*(4), 401-426.

Schein, E. H. (1996). Career anchors revisited: Implications for career development in the 21st century. *The Academy of Management Executive, 10*(4), 80-88.

Securing Our Future: Closing the Cybersecurity Talent Gap. (2016). Retrieved from http://www.raytheoncyber.com/rtnwcm/groups/cyber/documents/content/rtn_278208.pdf

Shapiro, J. R., & Williams, A. M. (2012). The role of stereotype threats in undermining girls' and women's performance and interest in STEM fields. *Sex Roles, 66*(3-4), 175-183.

Shih, M., Pittinsky, T. L., & Ambady, N. (1999). Stereotype susceptibility: Identity salience and shifts in quantitative performance. *Psychological science, 10*(1), 80-83.

Shumba, R., Ferguson-Boucher, K., Sweedyk, E., Taylor, C., Franklin, G., Turner, C., . . . Hall, L. (2013). *Cybersecurity, women and minorities: findings and recommendations from a preliminary investigation.* Paper presented at the Proceedings of the ITiCSE working group reports conference on Innovation and technology in computer science education-working group reports.

Silbey, S. *Why Do So Many Women Who Study Engineering Leave the Field?* Retrieved from

Simon, H. A. (1969). The sciences of the artificial. *Cambridge, MA*.

Spindler, G. D., & Spindler, L. S. (1990). *The American cultural dialogue and its transmission*: Psychology Press.

Spradley, J. P. (2016). *The ethnographic interview*: Waveland Press.

Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of educational research, 69*(1), 21-51.

Steele, J. R., & Ambady, N. (2006). "Math is Hard!" The effect of gender priming on women's attitudes. *Journal of Experimental Social Psychology, 42*(4), 428-436.

Sullivan, F. (2017). *The 2017 Global Information Security Workforce Study: Women in Cybersecurity*. Retrieved from A Frost & Sullivan White Paper: https://iamcybersafe.org/wp-content/uploads/2017/03/WomensReport.pdf

Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. *The social psychology of intergroup relations, 33*(47), 74.

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches* (Vol. 46): Sage.

Tims, H. E., Turner, G. E., Corbett, K., Deemer, E. D., & Mhire, J. (2014). Cyber value and interest development: Assessment of a STEM career intervention for high school students. *Electronic Journal of Science Education, 18*(1).

Turner, J. C. (1991). *Social influence*: Thomson Brooks/Cole Publishing Co.

Turner, S. V., Bernt, P. W., & Pecora, N. (2002). Why Women Choose Information Technology Careers: Educational, Social, and Familial Influences.

Vaishnavi, V., & Kuechler, W. (2004). Design science research in information systems. *Association for information Systems*.

van Aken, J. E. (2004). Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-Tested and Grounded Technological Rules. *Journal of Management Studies, 41*(2), 219-246. doi:10.1111/j.1467-6486.2004.00430.x

Venable, J., Pries-Heje, J., & Baskerville, R. (2012). *A comprehensive framework for evaluation in design science research.* Paper presented at the International Conference on Design Science Research in Information Systems.

Weitzman, E., & Miles, M. B. (1995). *Computer programs for qualitative data analysis*: Sage.

Williams, L., Wiebe, E., Yang, K., Ferzli, M., & Miller, C. (2002). In support of pair programming in the introductory computer science course. *Computer Science Education, 12*(3), 197-212.

Worthen, B. R. (1996). "Beyond Formative and Summative Evaluation" Revisited. *Evaluation Practice, 17*(2), 119-119. doi:10.1177/109821409601700203

Young, D. M., Rudman, L. A., Buettner, H. M., & McLean, M. C. (2013). The influence of female role models on women's implicit science cognitions. *Psychology of Women Quarterly, 37*(3), 283-292.

Yvonne Feilzer, M. (2010). Doing mixed methods research pragmatically: Implications for the rediscovery of pragmatism as a research paradigm. *Journal of mixed methods research, 4*(1), 6-16.

Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal, 37*(1), 215-246.

Appendix A: **Definition of Key Terms**

Cybersecurity - the state of being protected against the criminal or unauthorized use of electronic data, or the measures taken to achieve this.

Cybersecurity career - In the NICE Workforce Framework, cybersecurity work is where a person: Analyzes threat information from multiple sources, disciplines, and agencies across the Intelligence Community; synthesizes and places intelligence information in context; and draws insights about the possible implications.[1]

Design-based Research – a series of approaches use to produce "new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings" (Barab & Squire, 2004).

Gender Gap – the difference between women and men, especially as reflected in social, political, intellectual, cultural, or economic attainments or attitudes ("Dictionary.com," 2017).

Mixed methods – the combining of design-based research with quantitative and/or qualitative approaches during different phases of the research process to that is aligned with the pragmatic paradigm (Tashakkori & Teddlie, 1998).

Pragmatic paradigm - advocates the use of mixed methods in research, "sidesteps the contentious issues of truth and reality"(Yvonne Feilzer, 2010), and "focuses instead on 'what works' as the truth regarding the research questions under investigation" (Tashakkori & Teddlie, 1998).

Self-efficacy - The social cognitive theory identifies self-efficacy, which relates to personal beliefs about capabilities to learn or perform (Bandura, 2000).

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[1] https://niccs.us-cert.gov/glossary

Appendix B: Interview Questions

Thank you for participating in this interview. This information will assist in a project to understand middle school girls better. Please be honest, but you are not required to answer any question that you would prefer not to. This is a confidential interview. Your name will be removed from the data collected, so you will not be connected to any of your answers during the analysis. Again, thank you so much for your time.

Opening question to break the ice: "Tell me your name, age, and grade. What have you done in the last two days that you have enjoyed?"

Age:

Grade:

Can you tell me a time you were inspired to try something new? (How are you inspired? Or What motivated you?)

Who is most influential in your decisions when selecting classes and how does this influence happen?

Who is most influential in selecting summer or after school activities and how does this influence happen?

Do you ever select an activity because of someone's influence, and not because you want to? Give me an example.

Do you ever not join an activity due to your influencers even though you want to? Give me an example.

What kinds of social or educational groups are you a part of? Why did you become a part of those groups? How does it make you feel to be a part of this(these) group(s)? (Is being a part of a group or community important to you? Why or why not?)

On a scale of 1-5 (one being very low and five being extremely high), what is your interest in cybersecurity?

What comes to your mind when I say cybersecurity?

What kinds of feelings do you experience when you hear the word cybersecurity?

On a scale of 1-5 (one being very low and five being extremely high), how to you rate yourself on cybersecurity knowledge?

What kinds of jobs do you think of when you think of a cybersecurity career? Could you tell me how you feel about these types of jobs?

What does a typical cybersecurity professional look like?

When you are unsure of a subject or topic, how do you learn more about the subject/topic?

Do you enjoy computing classes?

Looking back, do you enjoy computing classes more or less now than in the last two years?

Would you tend to take computing classes, why or why not?

What three classes do you typically feel like you belong in? (or in other words, you feel most like you are a part of)

Do you have a role model? How did that person become your role model?

What characteristics do you want in a role model or mentor?

Thank you for your time today. Is there anything else you would like to share with me?

Appendix C: Informed Consent and IRB approval number

Dear Student and Guardian:

I am conducting a research project entitled CybHER as part of my dissertation at Dakota State University. The purpose of the study is to understand middle school girls' perceptions of a cybersecurity career path and the influential factors toward studying cybersecurity.

Parent/guardian, please go through this letter carefully with the student and help them to make a decision about participating or not.

Female middle-school students are invited to participate in the study by providing input through interview questions and surveys. It will take approximately 20 minutes of the student's time. Participation in this project is voluntary. The student may withdraw from the study at any time without consequence.

With the student's permission and their guardian's permission, we will be recording and transcribing the conversation. We do this to accurately analyze the conversation content for research. **The transcripts, subsequent analysis and any academic publications will be de-identified to remove personally identifying information. All names and locations will not be revealed in the results.**

There are no known risks to you for participating in this study. There are no direct benefits to you, however research in this area will provide future benefits, such as understanding influences of middle school girls and recruitment efforts. It will also influence the development of a program to educate and motivate girls to explore cybersecurity.

Your consent is confirmed by returning this letter and indicating your willingness to participate and your guardian's permission. Please keep a copy of this letter for your information. If you have any questions, now or later, you may contact me at the number below. Thank you very much for your time and assistance.

If you have any questions regarding your rights as a research participant in this study, you may contact the DSU Office of Sponsored Programs at 605-256-5100 or at irb@dsu.edu.

Sincerely,

Pamela Rowland
ABD, D.Sc.IS.
College of Business and Information Systems
Dakota State University
820 Washington Ave, Madison, SD
pam.rowland@dsu.edu

This project has been approved by the DSU Institutional Review Board, Approval No.: 2017-2018-001

<p style="color:red; text-align:center">Participant Consent Form/Child Assent Form
Participation in a Research Project</p>
<div style="text-align:center">Dakota State University
Madison, SD 57042</div>

College of Business and Information Systems
Project Director: Pam Rowland   Phone No.: 605-480-3405
E-mail: pam.rowland@dsu.edu   Date: August 28, 2017

Please read the following information:

     1. This is an invitation for you **as a student** to participate in a research project under the direction of Pam Rowland.

     2. The project is entitled CISSE - a Framework supporting the CybHER Program to Engage and form Anchors for Girls in Cybersecurity.

     3. The purpose of the project is to understand middle school girls' perceptions and influences for cybersecurity.

     4. If you consent to participate, you will be involved in a phone interview and survey which will take about 20 minutes of your time.

     5. Participation in this project is voluntary. You have the right to withdraw at any time without penalty. If you have any questions, you may contact the project director at the number listed above.

     6. There are no known risks to your participation in the study.

     7. There are no direct benefits.

     8. There is no compensation for your participation in this study.

     9. Your responses are strictly confidential. When the data and analysis are presented, you will not be linked to the data by your name, title or any other identifying item.

     As a research participant, I have read the above, have had any questions answered, and agree to participate in the research project. I will receive a copy of this form for my information.

Participant's Signature _____ **Date** _____

Because you are under 18, I will also need a guardian's signature.

As the parent of a research participant, I have read the above, have had any questions answered, and agree to allow my child _____ to participate in the research project.

Phone number to contact student:_____

Guardian's Signature _____**Date**_____

Project Director's Signature _____ Date _____

      If you have any questions regarding this study you may contact the Project Director. If you have questions regarding your rights as a participant, you can contact the DSU Office of Sponsored Programs at (605) 256-5100 or irb@dsu.edu

This project has been approved by the DSU Institutional Review Board, Approval No.: 2017-2018-001

Appendix D: IRB approval for Evaluation

DSU
DAKOTA STATE

Dakota State University   •   820 North Washington Ave.   •   Madison, SD 57042-1799

DSU Institutional Review Board
Exempt Project Approval

To: Pam Rowland

Date: 9 February 2018

Project Title: CISSE - a Framework supporting the CybHER Program to Engage and Anchor Girls in
                  Cybersecurity

Approval #:   2018-2018-10

The IRB has approved your project through 8 Feburary 2019 in accordance with the policy for the protection
of human subjects in research as described in 45 CFR 46.101 (b). The activity proposed in your protocol is
applicable to the category conditions stated below:

*Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey
procedures, interview procedures or observation of public behavior. This approval will apply so long as:*

(i)   *information obtained is recorded in such a manner that human subjects cannot be identified,
        directly or through study information linked to the subjects;*
(ii)   *measures are taken to ensure that no disclosure of the human subjects' responses will identify
        them individually.*
(iii)   *Steps are taken to assure engagement with parents and guardians of participants who are
        below the age of legal consent.*
(iv)   *No changes in methods or participant requirements will be made from the originally approved
        application.*

If you believe that you will not be able to comply with these conditions, or if there are any unanticipated
problems involving risks to subjects or others or changes in the procedures during the study, please contact
irb@dsu.edu immediately.

If I can be of further assistance, don't hesitate to let me know.

Yours truly,

Jack H. Walters, Chair
Institutional Review Board