STEM Self-efficacy, Career and Problem-Solving

New Jersey City University

Assessment and Evaluation

Terri Evans

Introduction

Modern society largely depends on technology. It is pervasive and surrounds us from the youngest ages. As dependence on technology continues to grow, so does the need for fulfilment of STEM careers, however, these are fields that women do not pursue often enough. Additionally, students nationally are unable to apply technology and engineering to real life situations based on NAEP TEL scores. The National Association for Educational Progress uses a scenario based assessment called the Technology and Engineering Literacy Assessment, to examine students' ability to apply problem solving skills. Girls Who Code has provided a national template for clubs of school age girls to learn and apply coding concepts as a means to close the STEM gender gap. This includes application of solving problems with code based solutions. Girls Who Code has a mission of closing the gender gap in STEM related fields. This qualitative study will examine the girls' perception of themselves, how participation in the club influences career choices and the impact club activities have on the girls' ability to solve real life problems.

Research Problem

The study is needed to discover what is missing that if put in would make a difference in students performing greater than 50% when it comes to real world problem solving skills. The TEL study found girls within 3 percentage points of the boys which reinforces the thoughts that is not ability that separates girls and boys. The factors that lead to the gender disparity are elsewhere. The push toward girls clubs stems from the realization that many young women who are strong problem solvers and have strong mathematical abilities choose non STEM careers or downplay their capabilities. The intent of the study is to uncover girls self perception as problem solvers and how club participation has shaped that perception. The study may inform how the personal development of students who participate in

programs that forward 21st century problem solving skills lead to positive self development, persistence and lead to accessibility of STEM careers for girls.

Research Questions

How does middle and high school girls' perception of themselves shift from participation in GWC?

How has participation in the club influenced possible career options?

Does problem solving abilities and persistence increase with club participation?

Literature Review

School aged females participating in the Lang Science Program at the Museum of Natural History in New York city, were engaged with science education through peer collaboration and mentorship outside of school hours. The young women described themselves as being outsiders at their school because of their interests in science. In this program, they had the opportunity to work with like minds. The young women began to see themselves as participants in science. As they continued to work with the program and work through the application of concepts and principles, feelings of intimidation began to wane and the culture of acceptance strengthened their self perception and skills (Adams, 2014).

Girls are socialized in a way that hinders their natural ability to take risks. Taking on solving problems, requires taking risks. Boys are raised to take risks and girls are raised to be perfect. Girls are more likely to take on tasks they are inherently good at, as opposed to trying things that require inquiry or trying things were their abilities must be developed. This is related directly to solving problems that require the creation of a solution (Saujani 2016). Girls Who Code, engages young girls with a curriculum that stimulates interests and cultivates exposure through community support at the same time that technical skills are being developed. In a study of 500 young ladies, 95% said they are more likely

to study a STEM Career after participating in a GWC summer immersion program (Stem, Reid, Bancroft 2015).

Carr (2015) refers to The ABC of Gender Equality in Education: Aptitude, Behavior, Confidence which suggests the STEM gender gap will not be narrowed unless efforts are made to impact girls anxiety regarding mathematics and improve confidence. The study suggests that the best STEM education program will not be successful if efforts to build confidence are missing from it. The OECD reports students give themselves freedom to fail when they are more self confident. When students are more self confident, they are more apt to engage in processes that include trial and error.

A multiple step approach is needed to sustain female interest in STEM careers. Bystydzienski, Eisenhart and Bruning (2015), discovered that even when females had like abilities to males in ability and self confidence, the absence of social support and fear of failure were enough to prevent females from participating in STEM programs that lead to STEM careers. Exposure and interest were not enough even as STEM programs are beginning to be introduced to lower grades. Bystydzienski, Eisenhart and Bruning (2015) found that fears were particularly strong is the females were the first to attend college in their family or if they were concerned about the possibilities of scholarships to study these areas in college. Feelings of not belonging were strong for students who pursue STEM fields and many completed their studies in academic areas they experiences as “more supportive”.

Role socialization and competitive norms have a large impact in the choices females make when considering careers, including highs school paths that would lead to participation in STEM programs of study (Patterson & Johnson, 2017). This study find efficacy in isolation is not a deciding factor. It is the combination of efficacy, socialization and in many instances ethnicity that keep females from strongly considering a future in STEM (Patterson & Johnson, 2017).

People in STEM are often stereotyped and the stereotypes are proliferated through many cultures. To counteract these beliefs, students need to be shown that they are false. Negative stereotypes keep many females from considering careers in science, technology, engineering and mathematics.If they have an interest they lose it and, or the negative stereotypes keep them from expressing or developing an interest for career exploration. People in stem are stereotyped as folks lacking social skills and having eccentric ideas. The National Science Board pool of gifted and talented identify 51% female. These statistics have remained stable since 2000. Given these measures it is not likely that females are absent from STEM careers due to academic ability. (Boston, Cimpian, 2018). Stereotypes of women are global. Intellect is frowned upon. These stereotypes are reinforced from childhood. Even if girls don't believe the stereotypes, the views of society impact their experience of being able to fit in and experience being valued. Exposure to successful female role models and providing opportunities for low stakes success may support development of a growth mindset.

The Girls Who Code Outreach program targets the engagement of girls in grades 6-12. Recently Girls Who Code introduced a program for elementary school aged girls. The learning targets include the development of computational thinking skills; providing a real world context to computer science and a social context for community impact. The combination of learning targets offer girls the opportunity to practice as they learn new skills in a fun and social context. The intention is that girls will have enough of a social context to choose computer science as a career. (Adams, Reed, 2015).

STEM project based learning provided a means for high school girls to participate in STEM. The project-based approach increased problem solving capabilities, however it was the enhancement of gender role beliefs and female engineer role models that increased self-efficacy and commitment to engineering (Liu, Lou, 2014). Liu, Lou based on the findings in the study, advocate to add project based

learning to high school curricula in order to facilitate the acquisition and application of problem solving skills within a social context.

Cooper & Heaverlo (2013), suggest providing girls with opportunities for expressing creativity and real world problem solving as a way to combat loss of interest, lack of confidence and increasingly negative attitudes toward STEM. Problem based learning and the potential solutions created by it are a potential learning motivator. Collaboration is emphasized and the focus is on what students can do with knowledge instead of focus on the knowledge they have. Experiential learning, related problem based learning activities and anchored instructional approaches that incorporate problem solving, creativity and design, strengthen opportunities for all students, and have significant impact on reversing the trends that keep female students from participating.

Interactive hands-on outreach programs are commonly used to engage young females in STEM fields. Creating hands-on solutions to real world engineering problems is a common methods of immersing females into STEM and strengthening problem solving abilities. One of the projects introduced students to C02 emission challenges based on the oil industry. Another used robotics challenges. Each used a problem based approach to sustain interest and increase problem solving skills which are pertinent to the field (Cloutier, Yew, Gupta, Dissanayake, Manaco, 2018).

Kerr (2016) discusses the disparity of female participation in stem and as others have discussed, identifies socialization as the culprit. “Where have girls developed the perception that their answers in the classroom must be correct? Or that knowledge is innate or only ‘known’ or ‘not known’ with no room in between for a good guess or a starting point? They do not seem to see knowledge as being achievable through discovery, inquiry, collaboration or (heaven forbid) risk. When did this predominantly female-held perception begin, and how did we, as teachers, parents, and society, allow it?” (Kerr. p. 39). The program developed to engage girls in STEM disciplines not only increased

academic ability but also increased persistence and accelerated problem solving skills. "The classroom must be set up to promote risk-taking and unrestrained" sharing of ideas. Kerr, p. 49.

Guerra, 2013) states the urgency that exists to apply measures for student learning and experience that will begin to close the gender gap in STEM related fields. Perception is one of the challenges that keeps women of color away form careers in science, technology, engineering and math. The program studied found that communities of practice that the girls applied to problem solving. They discussed the problems and tested solutions among one another. The emphasis on the persistence of the girls reinforced by their ability to collaborate.

During the science and math enrichment studied by Redmond, Thomas, High, Scott, Jordan and Docke in 2011), the 2 year problem based learning for middle school students achieved positive results for the participating girls. The researchers noticed that as the girls began to solve problems, they increasingly communicated with one another. The female college student mentors provide a familiar framework and girls began to see science and math activities as activities they can be successful with. Solving problems was framed differently than in a classroom where girls are expected to have the correct answer and not willing to take risk. In the enrichment setting the girls were encouraged to use what they knew and to experiment to find an answer that worked.

High school girls participating in a pre college engineering course were studied by Rutz and Shaffer (2011).. The students reported that group work was the preferred method for reporting, recording, solving problems and otherwise preferred to work in a community as identified on the pre-tests. Solving problems with a group facilitated increased complexity with decision making which supported their ability to seek solutions that were more and more complicated. Additionally, their teamwork and collaboration skills when discussing possible paths to success and alternatives were developed to a greater capacity. The project based learning environment suited the girls interest and

intellect and provided a culture of support that allowed them to be comfortable while it was uncomfortable when they were struggling to create solutions.

Methodology

Grounded theory will be used as data will be collected simultaneously and sequentially Creswell, 2015). Survey and interview data will be analyzed immediately. Categories will be created. Participants and the site for the study were selected by purposefully seeking girls who are participating in Girls Who Code clubs. Homogeneous sampling accounts for the clubs made up of girls in grades 6-12. Students in grades 6-12 are included to provide an opportunity to examine the perspectives of students based on the number of years each has participated in club activities. Permission is required from club and from the parents of the participants who are minors in grades 6-12. Data will be collected in the form of survey, interviews and observations. Protocols will be used to record information to facilitate the organization of the information (Creswell, 2015). Additionally, participants will be observed as they participate in Girls Who Code activities. Participants at the single site will be studied. Permission will be requested from the club advisor and the library that is the club meeting place. Data will be collected in the form of survey, interviews, observations and images. Observation provides an opportunity to witness the view of the participants. Open-ended interview questions will be asked of participants in a focus group of four to six participants and individual interviews. Open ended questions on questionnaires will also be utilized.

Sampling Overview

The participants will be sampled from the Plainsboro Free Public Library Girls Who Code Club. The club includes coders in grades 6 - 12. The club will be be contacted to request permission to do a study that will forward the knowledgebase of the impact girls who code clubs have on the girls regarding self-efficacy, future career and aptitude for solving real-life problems. Permission

will be requested to attend a club meeting to share information with parents regarding the research and to distribute and collect permission slips and answer any questions or concerns. It is expected that a smaller sample will be interviewed after the initial survey is analyzed.

Instruments

Survey and interview data will be developed to glean specific information regarding the girls self perception, career choices and problem solving abilities. The questions were developed in response to gathering data that allows an in depth examination of the experiences of girls in the program. Interview questions will be asked gather students self perceptions before participating with the club and after. This will include comfort level working on teams and how well they create solutions. Questions will include how to solve a design process and evaluate trade-offs among different solutions; reasoning behind a design solution and consequences; predicting outcomes of and explaining design changes;the ability to use digital technology to communicate and collaborate. Interview questions will be asked to gather students self perceptions before participating with the club and after. This will included comfort level working on teams, how well they think critically to create solutions.

Procedures

Send a permission letter to the club leader and the local library the club meets in. Explain the reason for the study is to discover the role that self-efficacy has in girls choosing to or not to pursue careers in STEM fields and how Girls Who Code clubs impact not only a girls self-efficacy but also her problem solving abilities. This information may be used to create additional opportunities for girls to increase self confidence and expand their problem solving capabilities. A permission letter will be sent to parents explaining the purpose of the study and requiring a signature in order for the students to participate. Club participants will be asked to complete the first survey at the end on one of the meetings. Observations and interviews will be scheduled. It is expected that multiple visits will be

needed to complete the interviews.

Appendix A

Permission Letter

Principal Investigator Signature Date

Dear Parent/Guardian,

I am a graduate student in the New Jersey City University Educational Technology Leadership Department. I will be conducting a research project under the supervision of Dr. Christopher Carnahan, an NJCU professor of Assessment and Evaluation, as part of my doctoral research. My research project will study self-efficacy and problem solving skills of middle school aged girls who participate in the Girls Who Code club. The goal of the study is to determine how self-efficacy impacts career choices and perceived problem solving abilities.

Each student will complete a survey and will be interviewed to develop a deeper understanding of the impact Girls Who Code has on each participants' development. Interviews will be recorded. I will retain all recordings at the conclusion of the study. To protect the identity and confidentiality of every student, only initials will be used to identify them. The recordings may only be heard by other researchers when the data is presented at a professional conference. All data will be reported in terms of group results; individual results will not be reported.

Your decision whether or not to allow your child to participate in this study will have no effect on your child's standing in the club. At the conclusion of the study a summary of the group results will be made available to all interested parents. If you have any questions or concerns please contact me at 732-328-8211, Dr. Carnahan at (201) 200-2547, or Dr. Ashok Vaseashta, chair of the NJCU Institutional Review Board, at 201-200-2453 or avaseashta@njcu.edu.

Sincerely,

Terri Evans

Please indicate whether or not you grant permission for your child to participate in this study by checking the appropriate statement below and returning this letter to your child's teacher by Month, Date, Year.

☐ I grant permission for my child, _____, to participate in this study.

☐

I do not grant permission for my child, _____, to participate in this study,

Appendix B

Survey

Research_GWC_survey_instrument

https://njcu.co1.qualtrics.com/jfe/form/SV_71zLAXJy0gON14N

Thank you for taking the time to complete the survey questions. They are part of a research study to discover the ways in which the Girls Who Code club program impacts career decisions and problem-solving capabilities of middle school aged girls from their perspective.

Q2 Enter your Full Name as an indication of your agreement to participate in this study of your own free will.

Q3 What do you like best about the Girls Who Code program?

Q4 What activities has the facilitator helped you with?

Q5 How often do you attend ?

Q6 What impact has the Girls Who Code club had on your ability to identify possible careers?

Q7 How likely are you to continue participating in STEM programs?

Q8 How would you describe the impact the Girls Who Code club has had on your ability to prepare solutions to real-life solve problems.

Appendix C

Instrument

Open-Ended Interview Questions

What is your full name?

How long have you participated with the GWC club?

Does anyone in your family work in a STEM field and if so what type of work does he/she do?

Tell me about the project you are working on.

What problem does your project impact?

How do you plan to address a social problem with your club project?

How would you describe your interest in STEM before participating in GWC?

How would you describe your interest in STEM careers now that you are participating in GWC?

Are you active in STEM activities in school?

Why do you think technology and problems solving skills are so important for girls?

What career options do you think are a good fit for you?

Has participation with the club impacted the choices of career you will consider?

How would you describe learning environments that are the most effective for you?

What kind of environment do you do your best work in?

How would you describe your problem solving skills?

What actions do you take when you don’t know the answer to a problem?

Appendix D

IRB

NJCU Institutional Review Board Application for
Review of Research Proposal

Email: IRB@njcu.edu

FOR OFFICE USE ONLY			
File Number			
Review Type	Exempt ☐	Expedited ☐	Full ■
PI			

Date of Submission December 1, 2018

Proposal type:
■ Original ☐ Revised*

*If this is a revised application, there is no need to complete the remainder of this form. However, please describe in detail the changes that you have made in response to the IRB's concerns.

Principal Investigator	Dr. Christopher Carnahan
Proposal title	Self-efficacy, Careers and Problem-Solving
Proposed start date	February 1, 2019
Anticipated duration of research	3 months

Type of Research

☒ Student/Classroom project
☐ Faculty project
☐ Staff project
☐ External researcher project (All external researchers must have an NJCU sponsor.)

NJCU Investigators (Please list additional investigators as necessary.)

Principal Investigator (For all student research, the faculty advisor is the PI.)

Name Dr. Christopher Carnahan
Department Educational Technology Lea
Telephone 201-200-3078
Email ccarnahan@njcu.edu

Co-Investigator (including student researchers)
Name Terri Evans
Department Educational Technology Lea

Telephone 732-328-8211
Email tevans2@njcu.edu

Co-Investigator(including student researchers)

Name
Department
Telephone
Email

Co-Investigator(including student researchers)

Name
Department
Telephone
Email

*Any NJCU investigator who plans to work on this project either with or for a Principal Investigator or a Co-Investigator at another institution must identify those investigators and their institutions.

External Investigators

Name
Title
Institution

Name
Title
Institution

Name
Title
Institution

Name
Title
Institution

NJCU Sponsor (if the researcher is not affiliated with NJCU)

Name
Department
Telephone
Email

Data Sources

Number of participants 23

How was this number determined (e.g., power analysis) purposeful homogeneous sampling

Does this project require the collection of new data? ■ Yes ☐ No

If Yes: How will participants be selected or recruited? _____

Will subjects participate on a fully voluntary basis? ■ Yes ☐ No

Will subjects be compensated for their participation? ☐ Yes ■ No

If yes: Please briefly describe the compensation.

_____

Does this project make use of human tissue or cell lines? ☐ Yes ■ No

Briefly describe the research methodology(ies) to be used in this study (e.g., focus group, participant observation, survey, experiment).

_____

Does this project use data that have already been collected for a non-research purpose or by another researcher?

☐ Yes ■ No

If yes: What is the source of the data?

_____

Are the data accessible in the public domain? ☐ Yes ☐ No

If no: Are fields included that would allow identification of individuals, either directly or indirectly? ■ Yes ☐ No

If yes: Please explain briefly how participant confidentially will be safeguarded

names will be changed to initials

Participant Risks

Will participants be exposed to any stresses (e.g., anxiety, pain, etc.) or physical harm (e.g., injury, infection, etc.) in connection with this research? ☐ Yes ■ No

If yes: Please briefly explain what risks may be involved in the research, what specific steps will be taken to minimize and monitor the risk, and what will be done to compensate and/or treat participants who are harmed by the research.

_____

Does the research design require that participants be deceived? ☐ Yes ■ No

If yes: Please briefly explain why deception is necessary and what steps will be taken to reduce potential harm from this deception.

_____

Potentially Vulnerable

Populations Will this research involve:		
Physically/Mentally Challenged Individuals		
Young children (ages 0-13)	■ Yes	☐ No
Older children (ages 14-17)	■ Yes	☐ No
Senior Citizens (over age 65)	☐ Yes	☐ No
Pregnant Women	☐ Yes	☐ No
Prisoners	☐ Yes	☐ No

If yes to any of the above: Please briefly explain how the rights of this (these) population(s) will be protected.

parental permission required

Informed Consent

Will participants be fully informed about:

The voluntary nature of their participation and the freedom to withdraw without penalty at any time	■ Yes	☐ No
The purposes and procedures of the research	■ Yes	☐ No
Any reasonably foreseeable risks or discomforts	■ Yes	☐ No
Any benefits to them or to others from the research	■ Yes	☐ No
The extent to which confidentiality will be maintained	■ Yes	☐ No
The compensation and/or treatments available if injury occurs (This question need only be answered for research that involves risks.)	☐ Yes	☐ No
Whom to contact for information about the research participants' rights and any research-related injury	■ Yes	☐ No

If the answer to any of the above is no, please briefly explain why the research requires an alteration of the standard elements of informed consent.

How will participants' informed consent be documented? Please check all that apply.

■Signature on written consent document
☐Signature on document to be read to the participants and witnessed by another party
■Written documentation of informed consent will not be obtained because one or more of the following criteria is satisfied (check all that apply):

☐ The only link between the subject and the research would be the informed consent documentation and the primary risk is loss of confidentiality.

☐ The risks to participants, including risks associated with the loss of privacy, are no greater than those ordinary encountered in daily life and the research involves no procedure for which written consent is normally required outside of the research context.

Who will obtain the informed consent from the participants?

☐ Principal Investigator
■ Co-Investigator
☐ Sponsor (in cases where PI is not affiliated with NJCU)
☐ Other
☐ Not applicable

Please include your protocol summary (5 pages maximum) and your recruitment materials (as applicable).

External Reviews and Funding

Has this protocol been reviewed by an Institutional Review Board or Human Subjects Review Committee at another institution(s)? ☐Yes ■No

If yes: At what institutions(s)?

_____

What is its status? ☐Approved ☐Rejected ☐Pending (or provisionally approved)

Has this protocol been submitted for Federal Funding? ☐Yes ■No

If yes: Agency or Organization:_____

Submission Date: _____

Funding Start Date: _____ ☐Anticipated ☐Actual

Contact Person: _____

Contact's Telephone: _____

Has this protocol been submitted for any other types of funding? ☐Yes ■No

If yes: Agency or Organization: _____

Submission Date: _____

Funding Start Date: _____ ☐Anticipated ☐Actual

Contact Person: _____

Contact's Telephone: _____

Proof of NIH or CITI Certification

Please provide documentation of current CITI and/or NIH certification in human subjects research for all researchers involved in this project.

Certificate of Agreement

The signatures of all researchers involved in this project must be provided.

I certify that I agree to comply with the requirements of both NJCU and the Office for Human Research Protection (OHRP) of the United States Department of Health and Human Services as described in 45 CFR §46.

_____ _____

PI Signature Date

_____ 12/01/2018

Co-PI Signature Date

_____ _____

Co-PI Signature Date

_____ _____

Co-PI Signature Date

_____ _____

Co-PI Signature Date

Please submit the completed application and accompanying documents as one document or pdf to IRB@njcu.edu and kresch@njcu.edu.

All applications must be submitted by the NJCU faculty or staff member who is serving as the Principal Investigator (PI). Neither students nor external researchers may submit an application.

Appendix E

Citi Certificate

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