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How to Encourage Middle School Girls Interested in STEM+C Education: An Assessment of Current Status

Sushma Mishra
mishra@rmu.edu

Donna Cellante
cellante@rmu.edu

Diane Igoche
igoche@rmu.edu

Computer Information Systems Department
Robert Morris University
Moon, PA. 15108. USA

Abstract

The goal of this study is to understand what motivates young girls to get engaged in the Science, Technology, Engineering, Mathematics and Computing (STEM+C) curriculum. The authors want to describe what teachers and administrative support can do to nurture and foster this interest. It is important to attract more women in STEM+C related educational paths and careers. The authors believe that this can be addressed at the secondary school level, preferably at middle school curriculum level. This paper highlights some of the things that can be done to pique the interest of girls in the STEM+C fields.

Keywords: STEM+C, Middle School Education, Females, Curriculum.

1. INTRODUCTION

Women are historically underrepresented in Science, Technology, Engineering, Mathematics and Computing (STEM+C) careers. Although women fill close to half of all jobs in the U.S. economy, they hold less than 25 percent of STEM jobs and hold a disproportionately lower share of STEM undergraduate degrees (US Department of Commerce Economics and Statistics Administration, 2011).

There has been a federal emphasis on STEM education at all levels for more than two decades now (Gonzalez et al, 2012), but women's participation in computing has gone down from 35% in 90s to a mere 26% in 2010 (Corbett et al, 2015). To increase women participation in these male dominated fields, it is important to address the current misconceptions about these careers, confront stereotypes, establish job prospects and viable career paths for women, and most importantly inculcate and foster a keen interest in such fields of inquiry at an early age in young girls (Stross, 2008).

There are many reasons for such a disparity in male and female numbers in computing and STEM fields. Women need role models and mentors who can encourage and guide young girls in the competitive male dominated space (Mishra et al, 2013). There exists an unconscious bias that

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science and math are typically "male" fields while humanities and arts are primarily "female" fields (Hubman, 2012).

There are many possible factors contributing to the discrepancy of women and men in STEM jobs, including a lack of female role models, gender stereotyping, and less family-friendly flexibility in the STEM fields (Beede et al, 2011). Gunderson et al. (2012) describe how negative stereotypes about women's math abilities are transmitted to girls by their parents and teachers (Shapiro and Williams, 2012). Gonzalez et al (2012) argue that barriers for females in computing arise from lack of self-confidence and fluency in technical skills and a belief that technology careers are an isolating and non-social lifestyle.

It is important to attract more women in STEM and Computing related educational paths and careers. To address this problem of lack of interest in female population, it is critical that we address it in secondary school level, preferably at middle school curriculum level. Initiatives to attract more females to computing have found success in tailoring the educational content to common interests for females. It is important to understand the differences in learning styles of male and female students, content delivery customized to the female population, such that girls get excited about these disciplines early on.

The goal of this study is to understand what motivates young girls to get engaged in the STEM+C curriculum, and what can be done from the teachers and administrative side to nurture and foster this interest.

The specific research questions that this study addresses are:
RQ1: How can teachers and administrators encourage middle school girls to consider STEM+C disciplines as viable career options?
RQ2: What can educators and administrators do to sustain the interest of middle school girls in STEM+C education?
RQ3: What can be done to motivate middle school teachers to engage middle school girls in learning STEM+C?

The remainder of this paper has been organized in the following manner. This section is followed by an extensive literature review on lack of young females' participants in STEM+C education at secondary school level and the underlying reasons for this disparity. The literature review section is followed by the methodology section presenting data collection and data analysis performed on the data with results. The implications of the results are listed in Discussion section with contributions and future research suggestions. In the final sections, conclusions are drawn from this study.

2. LITERATURE REVIEW

Girls are losing interest and have already formed a bias about STEM and computing related disciplines by the time they are in high school. Early intervention is essential to sow the computational thinking perspective in girls that could lead to a more engaged and open perspective towards STEM+C education. Girls need to be engaged sooner than later in understanding the fundamental role of STEM and computing disciplines. The stereotype of computing being a "nerdy" profession needs to be addressed early on (Mishra, et al, 2013). A study based on how girls chose their major in IT related fields suggests that these girls had early (middle school) exposure to computing concepts and high confidence in their abilities to work in male dominated fields. Overall, girls have a limited perception of IT and computing fields, which needs to be broadened, and the best place to do this is secondary school (Mishra et al, 2014). Computing is an elective course in many schools. Also, the tools and technology that are being used is outdated at best garnering no further interest within girls. The acknowledgement that girls learn differently than boys and their self-efficacy in computing is built on their initial interaction with technology is not adequately addressed in the way computing and STEM disciplines are being offered in school districts, especially middle school.

Research suggests that girls learn better in informal, social, and less stressful environment. Usage of after-school activities and summer clubs have consistently proven to be effective techniques for engaging girls in more productive environments than traditional classroom settings. Broad efforts exist to improve computing literacy on a larger scale, like the "Georgia Computes" initiative funded by the National Science Foundation, to engage entities across the state of Georgia. This multifaceted program improves high school teachers with training, innovated undergraduate computing education, helps getting local student access to universities, offering graduate programs, but overall this program struggles with proper assessment (Bruckman et al, 2009).

ISSN: 2473-3857
v2 n4003

Mishra, Kavanaugh, and Cellante (2013) propose strategies to engage female students, at middle and high school levels, in technology curriculum which includes: provide hands-on experience with technology, introduce programming at middle school level, make course content more relevant to the girls' population, use interactive tools such as Alice (3D environment) and establish after-school club activities. Denner, Werner, and Ortiz (2012) conducted a study to investigate the role of computer game programming as a strategy to engage middle school girls in computer science concepts. The findings show that students engaged in programming activities and created games with a moderate level of usability. The evidence suggests that activities such as game creation involving design and programming concepts supports the learnings of computer science and engages the students.

It is important for teachers in secondary schools to get adequate training in the latest technologies in the area of STEM+C to be able to provide the teachers in secondary schools the needed access to latest technology tools and instructional modules that integrate STEM disciplines with computing in a meaningful way.

It is important to understand and explore how computing can be projected as a tool to solve problems in STEM disciplines, in a fun and engaging manner. This can be done during professional development activities. Initiatives to attract more females to computing have found success in tailoring the educational content to common interests for females. One example is connecting programming to wearable smart devices and fashion design. Another effort targeting middle school females (primarily Latina) used culturally relevant themes involving animal conservation and Mayan heritage connected with computing; the effort showed significant interest in computing for a college major and career (Marcu et al, 2010).

To summarize, research in this area suggests that different strategies are required for females to engage them in STEM+C concepts. It is also important that there are adequate professional development opportunities for teachers in secondary schools to engage in new ways of teaching such important concepts in an appealing and fun manner to this population.

3. METHODOLOGY

A survey instrument of 21 questions was developed and distributed to 628 teachers (Business, Math, Technology Education and Computing), and Administrators in 76 schools in South-Western Pennsylvania via QuestionPro.com. The email addresses of the project sample was released to potential participants in the first week of March, and it was made available for participation for a period of three weeks. A reminder email was sent out to the previously emailed sample at the end of the third week to encourage more participation.

The survey instrument consisted of six (6) open-ended and multiple choice questions. The researchers believed that it was important to gather the individual perspectives of the respondents on the current status of the interest of girls in computing at their various schools and their thoughts on the ways to encourage this interest.

Demographics of Respondents
There were a total of 26 responses, with 137 potential respondents viewing the survey, 68 embarking on the survey and 38% completing the survey. The responses were manually analyzed by the researchers; questions were analyzed based on question type (open ended or otherwise).

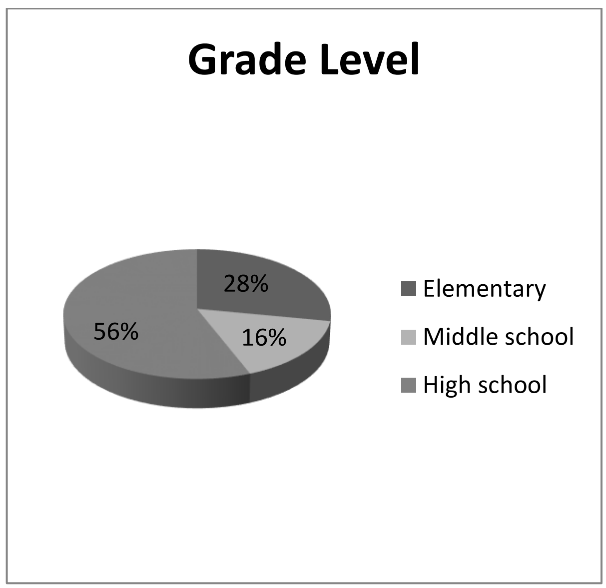

Figure 1-Respondents Level of Teaching

Twenty-eight percent (28%) or seven (7) were elementary school teachers, 16% or four (4) were teachers in the area middle schools, and 56% or 15 identified as high school teachers as shown in Figure 1 below. There were no responses from Administrators. Thirty-two percent (32%) or eight (8) of the respondents have obtained a

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Bachelor's Degree, 68% or 18 have a Master's Degree and none of the respondents have received a Doctoral degree as shown in Figure 2 below. 18 of the respondents identified as female and eight (8) identified as male. The respondents identified a diverse age range, two (2) were between 21-30 years of age, five (5) were between 31-40 years of age, 11 were in the 41-50 range, and seven (7) were between 51-60 years old.

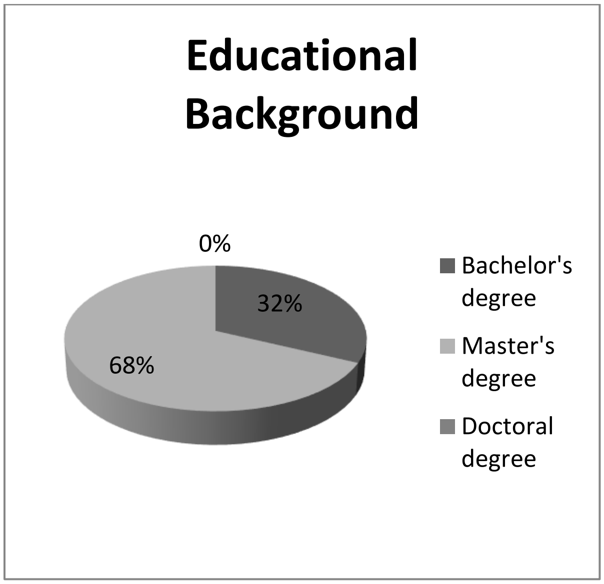

Figure 2-Educational Background of Respondents

4. DISCUSSIONS

RQ1: How can teachers and administrators encourage middle school girls to consider STEM+C disciplines as viable career options?
In response to the question above, the participants suggested that all girls should take Tech Ed, that we should show the girls how STEM+C can be applied to everyday life, and we should expose them to fun and exciting things happening in STEM+C to spark their curiosity. There were many responses about a Career Day, guest speakers, advisors/mentors in the field, and clubs to expose them to real people doing "real things" with STEM+C.

When asked if there are any differences in the learning attitudes of male and female students towards STEM+C, many respondents answered "yes." Males take class for a specific purpose, but females take classes for experience and to learn something they didn't already know. Boys are generally more interested in the field, but girls interested in STEM+C tend to be high achievers. Males like to break things down to understand how things work whereas girls want to know "what's in it for me?" Males seem more confident than females in the STEM courses.

RQ2: What can educators and administrators do to sustain the interest of middle school girls in STEM+C education?
When asked what can be done to make STEM+C more appealing, the respondents mentioned guest speakers, Facetime interviews, and e-Presentations.

They also suggested providing greater exposure to STEM+C, using it themselves in lessons, and demonstrating how it can be used and for what. Introducing project-based learning with a community impact, initiating hands-on learning that is fun and interactive, and providing more opportunities in a variety of means are all ways educators and administrators can make STEM+C more appealing.

RQ3: What can be done to motivate middle school teachers to engage middle school girls in learning STEM+C?
In answering the question above, the teachers believed more training is needed to prepare the teachers and increase their comfort level with STEM+C. The teachers also stated that more resources, such as updated instructional materials and the latest technology, are critical. They need more planning time with their team as well as support from the administrators.

When asked what other motivators would help teachers engage middle school girls in learning STEM+C, many of the participants answered "I am not sure." The participants that did offer suggestions admitted that there needs to be more female teachers in the STEM+C plus more female role models for the girls to see and interact with. Some of the participants suggested all-girl competitions, STEM+C Clubs, and more parental support and buy in. It was also mentioned that the teachers need to relate STEM+C to the "real" world with projects and demonstrations.

5. CONCLUSION

In order for middle school girls to engage in STEM+C disciplines, a few things must happen. First, teachers and administrators need to demonstrate ways that STEM+C can be applied to everyday life. For example, teaching a lesson incorporating technology with STEM concepts. Second, teachers and administrators need to provide opportunities for project-based learning

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v2 n4003

that has a community impact. Girls seem to want to new learn things that can solve a problem. Last, students need to be exposed to role models/mentors in the field. They need to see "real" women in the field either through guest speakers, career day, or clubs.

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