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Can the implementation of aerospace science in elementary school help girls maintain their confidence and engagement in science as they transition to middle school?

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ABSTRACT

There is a global crisis due to a lack of qualified applicants entering STEM careers, especially in science. Add the fact that women are greatly underrepresented in science, and the solution becomes obvious. Go to the source, and find out why girls as young as 12 years old are losing an interest in scientific endeavors that they once found to be captivating. This action research project sought to find out if the implementation of aerospace science, embedded both in the classroom and in an after school Space Club, could assist girls in maintaining their confidence and engagement in science overall as they transition to middle school. Furthermore, girls in fifth through seventh grade, who had previously been the teacher researcher's students, were included in the study in order to discover if their previous participation in a variety of authentic and ongoing aerospace activities had any impact upon their engagement in science as they entered the notable years of declined interest. The research took place at an international American school, Academia Cotopaxi, in Quito, Ecuador from September 2015 through April 2016. Data was collected through both qualitative and quantitative sources, and included attitude surveys, parent questionnaires, a writing prompt, photos, video, interviews and observations. Additionally, a control group was utilized in grades five to seven for purposes of comparison. Innovative activities included engaging and first-hand experiences with the Ecuadorian Civilian Space Agency (EXA), the National Aeronautics Space Administration (NASA), Space X and the Canadian Space Agency (CSA). Inquiry-based activities included, but were not limited to, experiences with: speaking live with both astronauts and cosmonauts on the International Space Station, robotics, rocketry, Skype chats with aerospace professionals, utilizing the Design Process, online resources and more. Findings suggested that embedding aerospace science in grade four, both during and after school hours, not only increased girls' interest and confidence in science, but also served to maintain and foster an interest in STEM as they transitioned to middle school.

1. Introduction

1.1. Significance of the study

A thorough literature review, which included educational journals, mixed-method research, relevant articles and related documents, revealed that, while the global market for careers in the area of science is increasing at a rapid pace, there exists a vast shortage of qualified individuals to fill this worldwide need [1]. As women are underrepresented in science, technology, engineering and mathematics (STEM) fields in general [2,3], it naturally follows that addressing this gender inequity – especially with regard to science – effectively addresses the lack of qualified candidates to fill this global need. Furthermore, "boosting the number of women in STEM fields would expand the pool of workers, educators, and innovators for the future, bring a new dimension to the work, and potentially tackle problems that have been overlooked in the past" [4]. A literature review showed that this gender gap reveals itself as girls transition to middle school, typically grades six, seven and eight, and lose their confidence and engagement in STEM [5–7]. Thus, addressing the topic of girls' engagement in science as they transition from elementary to middle school is of great importance for our society, especially during this current time of innovation and rapid technological advancements.

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1.2. Purpose of the study

An investigative approach revealed that today's girls are "falling down the rabbit hole"; not unlike when Alice in Wonderland found herself falling down a deep hole and "entered a period of confusion and chaos, a place of change and transformation" [8]. Thus, the purpose of investigating this issue of global importance is to discover *which* factors have resulted in a decrease in girls' participation in science, *why* this trend is happening, and *how* the situation can be remedied.

1.3. Research question

As a fourth-grade teacher at Academia Cotopaxi for the past 15 years, at an international American school located in Quito, Ecuador, the teacher researcher observed a trend [9]. Female students – who previously exhibited great excitement with regard to science in her class - began losing their motivation and engagement in science as they progressed up the grade levels in their academic careers. Anecdotes included accounts of bright, middle school girls "dumbing down" in science class in order not to stand out from the crowd, or girls changing their perceptions and feeling that they no longer had the ability to perform well. The teacher researcher found this change highly discouraging, from both a local and global perspective, and took action at her educational institution to help remedy this concerning trend. The question then became: what could be done to help girls at her school maintain an interest in science as they progressed from elementary to middle school?

As the teacher researcher had a history at her educational institution for promoting space science in an innovative fashion, and in a manner which also appealed to a wide variety of students, her research question then became: *Can the implementation of aerospace science in the elementary school help girls maintain their confidence and engagement in science as they transition from elementary to middle school*? Additional questions which brought further illumination to this original question included: *Which factors increase girls' self-efficacy and interest in science? Which factors decrease girls' sense of confidence and interest in science?*

In addressing these questions, the action research project proposed the implementation of aerospace education in the classroom through a variety of formats, as it applied to all curricular areas at any given point in time during the 2015–2016 school year, including both regular and after school hours. Teaching resources were primarily attained from the National Aeronautics and Space Administration (NASA) [10], the Ecuadorian Civilian Space Agency (EXA) [11] and commercial space agencies [12,13]. Ultimately, the goal of this research project was to get a glimpse into the world of our young girls by focusing the following objectives: learning how educators can *best help* young girls to emerge from their middle school "rabbit hole" in science; how to *maintain* the confidence and engagement towards science that is generally observed in girls' elementary years; and how to utilize their dynamic energy for a *global future* which so readily needs their unique contributions, especially during this time of exponential growth in STEM.

2. Literature review

2.1. The need for more girls to engage in science

With regard to current trends in STEM jobs in the United States, the past ten years has seen a growth of three times the level of non-STEM jobs, and it is projected that this will continue through the next decade. However, there are not enough qualified candidates to fill all of these estimated positions [6]. Furthermore, this need is expected to grow twice as fast by 2018 [14]. It is predicted that there will be a shortage of 283,000 math and science teachers in the US by the year 2015 and onward [15,16]. President Obama addressed the issue in his 2011 State of the Union address and emphasized the need for 100,000 STEM teachers over the next decade [17]. In addition, these statistics address only one country worldwide.

A shortage of candidates to fill STEM fields exists globally as well, and is evidenced by countries which are beginning to enact limitations concerning qualified applicants leaving their home countries, as well as providing enticements for others to return to their countries of origin [1]. The global shortage is even more crucial in under-developed and developing countries, as they become increasingly dependent on foreign assistance [18].

Rather, current developments are revealing that the global STEM industry is growing rapidly and that countries worldwide are currently unable to fill this vital need; and, as such, it only makes sense to tap a yet undeveloped resource … young girls and women in pursuit of science. The irony in this big picture is that, while research shows that girls like STEM and enjoy the creative and problem solving aspects of these fields – and perform as well as boys in math and science - there still exists a gap between STEM interest and career choices. This gap was evident in a study run by the Girls Scouts Research Institute, where 81% of the girls surveyed expressed an interest to pursue STEM fields, but only 13% of those stated that it is their first choice [4]. Consequently, STEM education experts agree that "boosting the number of women in STEM fields would expand (the US) pool of workers, educators, and innovators for the future, bring a new dimension to the work, and potentially tackle problems that have been overlooked in the past [4]. It naturally follows, therefore, that the same would be true at a global level.

2.2. What is happening to girls in science as they transition from elementary to middle school?

Research by Burke (2007), in his paper "Women and Minorities in Science, Technology, Engineering, and Mathematics: Upping the Numbers," revealed that "by the age of 12, children have already formed firm beliefs about the subjects at which they excel and those at which they fail" (p.30) [6]. This statement has enormous implications for the importance of self-efficacy, especially as girls enter their middle school years. Furthermore, research indicates that the greater confidence a child has, the greater his or her interest and vice versa. In other words, a student's attitude towards science affects his/her science achievement [7,19].

So what are girls, themselves, saying is happening? The Girl Scout Research Institute conducted a large scale study in which it was discovered that girls tended to lose an interest in STEM in middle school due to a variety of factors such as perceived gender barriers and the underrepresentation of women [7,20] For example, in 2012 only 20% of women accounted for bachelor's degrees in engineering, computing and physics. In addition, while 20% of female college freshmen tended to show a 20% interest in majoring in a STEM field, the same was true for 50% of young men [4].

The gender disparity in STEM is not an issue of a difference in science achievement; rather it is a loss in STEM *interest and confidence* [6]. Surprisingly, while males displayed a more positive attitude towards their abilities in science [7], this gap in gender attitudes was maintained even when females outperformed males in science [25].

What we do know is that the girls who maintained an interest in STEM were high achievers with supportive adult networks and were exposed to STEM fields [4]. Not only did the research show that it was important for "middle level students to be exposed to stimulating science education … (but also) especially (for) females … to be exposed to and experience careers in science" [26]. Ultimately, the literature review indicated that self-efficacy played a vital role in the success, or failure, of a girl to continue to engage in and pursue science as she transitioned from elementary to middle school.

2.3. Why are girls losing an interest in science as they get older?

Literature also showed that there are social, cultural, and individual