CAN THE IMPLEMENTATION OF AEROSPACE SCIENCE IN ELEMENTARY SCHOOL HELP GIRLS MAINTAIN THEIR CONFIDENCE AND ENGAGEMENT IN SCIENCE AS THEY TRANSITION TO MIDDLE SCHOOL?

Margot Solberg
Elementary educator, Academia Cotopaxi, Quito, Ecuador, msolberg@cotopaxi.k12.ec;
Education consultant, Ecuadorian Civilian Space Agency (EXA), Guayaquil, Ecuador
NASA Endeavor Fellow, National Aeronautics and Space Administration, USA

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.

I. INTRODUCTION

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, 6, 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.

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.

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.

II. LITERATURE REVIEW

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.

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.

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

Literature also showed that there are social, cultural, and individual factors which contributed to girls losing interest in science as they transitioned from elementary to middle school, and these factors included low expectancies, stereotypes, unequal opportunities, and insufficient classroom climates. These factors also appeared to differ greatly between girls ages 9 to eleven, and girls aged twelve to fourteen [21]. Alarmingly, they seemed to emerge radically as girls increased in age.

As children began to form opinions about their abilities in elementary school, it was "essential for parents and educators to develop and reinforce (students') beliefs in their ability to perform well,", as they "play a critical role in consciously alleviating gender stereotypes" [6]. This was an important point, as it was found that girls and boys interested in science were treated differently by parents and teachers. It was noted that girls experienced ambivalence, a lack of encouragement, and received messages that what they were pursuing in science was inappropriate, impractical or unacceptable; while boys, on the other hand, experienced broader acceptance of their intentions, and given the message that their pursuit of science was admirable, especially with regard to future status and a career [23]. Furthermore, it was said that if a student suspected that they would not succeed, then they would not participate; however, if a student valued an activity, then they are more likely to become engaged [22]. As expectancy was related to self-efficacy and motivation, the question then became: how can negative expectations change so that girls are encouraged to become more engaged in science?

The stereotype that science is masculine was yet another factor which helped to explain the gender disparity in science when girls entered middle school [20]. There are subtleties in society which reflect the message that girls are not good at science, despite overwhelming evidence to the contrary, and this gave girls the message that they were therefore not well-matched for the subject area. Additionally, "research indicates that the sex-role stereotyping of science as a masculine endeavor is one of the most powerful deterrents to adolescent girls enrolling and excelling in science courses" [23]. Research shows that females receive inferior science education than males, and this is especially evident with classroom instruction; where girls are called on less than boys, are asked fewer higher -order thinking questions, and received less attention, feedback and wait-time. Consequently, differences such as these resulted in girls having a more negative attitude towards science education, as well as less of an interest in enrolling in science courses, especially as they continued on to high school [24].

Shedding a light on such inequities leads to another explanation for the gender gap in middle school science, which was the lack or imbalance of opportunities; which studies show are critical for cultivating an interest in STEM. For example, when girls in the early grades participated in science fairs and summer camps, they were 2.7 times more likely to consider careers in STEM [25]. Additionally, STEM toys tended to be geared towards boys [23, 26], and there was a great lack of female scientists to emulate. Why so few role models? The retention in STEM careers is low for women. As an example, of the already low 20% female STEM graduates in the US evident in 2012, only 11% practiced engineering because many dropped out due to lack of opportunities for advancement, and the US Department of Commerce discovered that only 26% of women with STEM degrees actually entered STEM careers [4].

The classroom climate was yet another factor when considering gender differences in science achievement. With regard to the physical environment, "Teachers who retained girls in science had classrooms as modular, open-concept arrangements with flexible seating and attractive classrooms which were well-equipped and maintained" [23]. These girls were not retained if the classrooms were behind locked doors, or in outdated or traditional labs with bolted chairs and tables. With regard to instruction, girls tended to believe that their abilities were innate and unchangeable, while boys believed that they developed their scientific ability through effort and practice [27]. Additional research supported the assertion that "having confidence in one's ability and believing that hard work and effort can increase intelligence are associated with higher achievement in math and science among girls… (and that) perception of one's ability or capability is more important for a girl than her actual

ability or knowledge, and changing this perception can lead to more entry in STEM domains." [4].

Thus, the implication was that educators should give feedback based on effort and persistence, and not on qualities (such as being "smart" or "clever"), in order to encourage girls to think of themselves as capable in predominantly male fields. Otherwise, gender inequalities in the classroom – even unintentional ones which aren't addressed – result in girls being spectators rather than active participants [27].

A review of the literature showed that elementary school girls expressed an interest in science, but that a variety of factors needed to be addressed in order to change the negative trend in science achievement which had been occurring when girls enter middle school.

Remedies for the negative science trend for girls who transition to middle school

So how do we go about rectifying the inequities with regard to girls in science? Reaching girls at a younger age and "creating STEM programming that engages girls earlier in their elementary and secondary-school education will help shift the classroom dynamic away from one that is majority boys and thus more welcoming to girls" [29]. When considering making changes, it is important to address not only the increased engagement of girls in STEM, but also ways in which to also *maintain* their interest over time. The literature review suggests that paying attention to and "fostering girls' internal assets such as confidence, self-esteem, initiative, and a work ethic", as well as "communicating high expectations while providing support for meeting those expectations" could change the current achievement of girls in science [4, 6]. Keeping girls interested in science throughout their educational careers, especially during critical transition points like middle school, needed to be a high priority for all who guide these girls along their way.

With an increased awareness of sexism taking place in the world of science, combined with the need for more gender inclusivity, our current generation of girls should begin experiencing an increase in self-efficacy towards science, as well as engagement in STEM overall. The recently developed *Framework for K-12 Science Education* (2012), which included the guiding principle of promoting equity for all, supports this quest [30]. The recognition that all individuals have valuable contributions to make toward the field of science, whether as a career or as a citizen of the world, elevated the status of diversity.

Exposure and education, both formal and informal, are important opportunities which support and encourage an interest in science for girls. Creating outreach opportunities which encouraged creativity and innovation for girls has led to an increase in confidence and self-efficacy, a key component which research revealed to be of utmost importance in keeping girls involved in science. "Exposure to voluntary, interest driven learning experiences can increase student interest and enthusiasm for science and changes over time" [22]. Examples of such activities and topics included science clubs, visits to museums, nature hikes, 4H animal clubs, cosmetic science, robotics and artificial intelligence, climate change, renewable energy, global positioning systems (GPS), astronomy, the physics of everyday things, crime scene investigation (CSI), and more. The idea was to provide positive experiences which showed girls that science was F-U-N!

A final and vital element to this education reform topic is the importance of providing professional development for educators in order to create the most conducive classroom environments possible. Furthermore, quality teaching, where a positive learning environment emboldened girls to feel comfortable asking question, was also a vital factor to engagement. The literature review also shed light on the importance of the following educational components: providing authentic learning, where connections were made between the curriculum standards and real world applications; making the presence of science known in the classroom, through posters and displays, which were representative of diversity; developing assignments based on students' interests; and eliminating examples of gender bias in the curriculum [6].

Implications for girls at the teacher researcher's educational institution

An extensive review of the literature confirmed that, as a fourth-grade educator, what the teacher researcher accomplished with regard to incorporating aerospace science in her classroom over a nine year period was likely of benefit in helping young girls maintain an interest and self-confidence in science. Evidence for this could be observed in the high expectations held for her female students, the elimination of stereotypes within the classroom, the supply of a wide variety of opportunities for engagement, and the establishment of an encouraging class climate. A high level of expectation was apparent through the encouragement of active participation by all students, both during school hours and after school clubs, and this was observed in methodologies utilized such as: providing wait time for responses, the encouragement of student effort over qualities such as smartness, and the cultivation of a positive attitude in girls' abilities to perform well [6]. Additionally, the teacher researcher provided ongoing parent education, which resulted in parents taking on an interest in their daughters' engagement in STEM and was evident through both written and verbal feedback [23].

Stereotypes were discouraged by arranging exposure to a variety of positive female role-models, and this was most effectively accomplished through Skype chats with female NASA engineers and computer scientists. Additionally, a purposeful effort was made for

science activities which catered to authentic learning, and were founded in students' interests in order to increase the value of such lessons [22]. The classroom climate fit the ideal as expressed by the literature review, as the outlay of her classroom was warm and inviting, with flexible groupings and an open-concept environment.

When Alice fell into the rabbit hole she found her place falling in a place of emptiness, yet emerged at the end in a completely new paradigm which changed her previous convictions [7]. A thorough review of the literature showed that such a transformation had the potential to also take place when approaching the current gender inequalities with regard to science, especially as girls' transition from elementary to middle school. Creating a mind shift which altered previous expectations, stereotypes, opportunities and classroom environments - and which also fostered both boys' and girls' learning equitably – would serve to fill the current global gap; which was in need of increased scientific literacy and skills in order to better address new scientific needs, in an innovative fashion.

III. METHODOLOGY

Setting and participants

The study centered around 13 female elementary students in a fourth-grade, core classroom (students ages nine and 10) at Academia Cotopaxi; a private international, American school located in Quito, Ecuador. Additionally, two fourth-grade girls participated from the other fourth-grade class, as a part of the afterschool Space Club program, and 12 girls from grades five to seven also contributed their perspectives of science since leaving the teacher researchers class in elementary school.

This college preparatory school consisted of approximately 800 students, from pre-kinder to grade 12, and followed both the Primary Years Program (PYP) and International Baccalaureate Program (IB)[31]. It was also accredited by the New England Association of Schools and Colleges (NEASC, 2015), and was a member of the Association of American Schools in South America (AASSA, 2015)[32, 33]. While English was the primary language of instruction, elementary students received 45 minutes of Spanish instruction daily, and the majority of students spoke Spanish outside of the core and specialist classrooms (including PE, art, computers and music).

The 13 core students who participated in this study came from international backgrounds and all, at varying levels, spoke and understood both English and Spanish. Of these, nine were native Spanish speakers from Hispanic countries, three native English speakers from the United States, and one a native Italian speaker from Italy. Two of these students were in the English as a Second Language program (ESL), and three received reading intervention services; all of whom received Pull-Out services and various accommodations. The teacher-researcher who instructed the class had 21 years of experience, a Master's Degree in Education, and had, for nine years prior, embedded general aerospace education into her classroom instruction out of personal interest and to motivate her students in general regarding all curricular areas.

In addition to including the regular classroom students in this action-research project, the teacher-researcher also included students from her weekly after school Space Club, which included 9/13 classroom girls (69%) and two girls from the other fourth-grade class, both of whom were native Spanish speakers from Hispanic countries. As for the 12 girls from grades five to seven, nine were native Spanish speakers from Hispanic countries, one was a native mandarin speaker from China, one was a Korean speaker from Korea, and one was a native English speaker from England.

The core of the action research project took place over a nine week period, from January to March of 2016. Science attitude survey results, however, were included from September 2015, from the beginning of the school year. Girls in grades five to seven were also included in the project, as they were prior students of the teacher researcher who had exposure to a variety of aerospace activities while transitioning from elementary to middle school. Lastly, parent perspectives were included in the form of surveys, emails, and informal conversations.

Materials and procedures

With regard to the curriculum, the school followed the American Education Reaches Out (AERO, 2015) educational standards, which also aligned with the Common Core standards from the United States (Common Core, 2015) [34, 35]. As is the norm for the classroom researcher, since the beginning of the school year, September 2015, students in the core classroom were exposed to space exploration in a variety of ways including: embedding the curriculum and enriching class content as applicable, decorating the class with space themes, providing afterschool participatory opportunities, and seeking out professional development for the teacher educator.

Space concepts were mainly embedded in the classroom, as applicable, in the areas of math and science. Class content was enriched through the use of NASA video clips, such as those from the International Space Station (ISS) or This Week @ NASA, and class discussions; such as the implications of astronaut Scott Kelly's year spent on the ISS [36]. These topics of discussion frequently espoused a positive mindset and effort in STEM, with a special emphasis on female role-models as groundbreakers and the importance of equality and diversity with job opportunities. The class climate also promoted space exploration in a comfortable and appealing fashion throughout the year by including models, furniture (rugs and pillows), items hanging from the ceiling and walls (such as the solar system), and

framed pictures of notable activities accomplished by students in the past (such as speaking with the International Space Station). Lastly, souvenirs were gifted throughout the year, such as stickers, pencils and the like.

In the area of science, space education was included in one PYP unit titled "Technological Solutions,", where students completed hands-on activities with regard to robotics (Sphero robotic ball and programming robots), coding (The Hour of Code), learning from guest speakers (3D prosthetics and Snap Circuits), and a field trip to the Campus Party technology expo in the previous fall; meanwhile embedding aerospace technologies which applied to each of these areas [37, 38]. The purpose was for students to align these technological advances with world problems in order to create their own technological solutions using the Design Process.

Much of this action research project was centered on the afterschool Space Club, where a student-designed invitation was posted to encourage girls, especially, to participate. Engaging interactive and hands-on activities were utilized to give students an understanding of space history, rocketry, Newton's Laws of Motion, the ISS, the Ecuadorian Civilian Space Agency (EXA), landers and the physiology of living in microgravity. Activities included Skype chats-with Ecuador's cosmonaut, Commander Nader, and the retired risk-manager of the ISS and risk specialist of Space X, Michael Lutomski – creating and evaluating models through the Design Process, and conducting experiments (see Figures 1 to 4).

Fig. 1: Students use NASA resources to show their understanding of how their creation of a "cloud tower" can help solve global warming.

Fig. 2: Students create space landers using the Design Method (left), and gather data when simulating how microgravity can affect physiology (right).

Fig. 3: Constructing and launching paper rockets (left) and Skype chatting with Ecuador's only cosmonaut, Commander Ronnie Nader (right).

Fig. 4: Girls participate, as school representatives, in a robotics workshop provided by the Universidad de Las Américas [39].

Regarding girls in grades five to seven, in addition to having a history of participating in an aerospace-embedded classroom in their past, during

second and/or fourth-grade as the teacher researcher's students, several also joined in a variety of additional activities. All three grades used live NOAA satellite downloads from weather satellites, via a virtual ground station provided by the Ecuadorian Civilian Space Agency (EXA), as an authentic means of learning math concepts; such as gathering weather data to learn the concepts of mean, median and mode [40]. Data was also obtained from resources such as Pilot Brief and NASA's online Weather Data Learning Center (WDLC) [41, 42]. Additional activities included Skype chats with female NASA engineers – including Ecuadorian EVA Hardware Test Engineer/Project Manager, Juniper Jairala – speaking live with both astronauts and cosmonauts aboard the International Space Station, and flying to the south of Ecuador as special guests of EXA to observe the launch of Ecuador's second satellite, decoding satellite code through ham radio, and participating in media events to share their collaborations with EXA [43, 44]. Hence, the girls in grades five to seven had a wealth of background experience in aerospace education with which to contribute to the goals of this action research project.

Regarding professional development for the teacher-researcher, she enhanced her skills in the area of aerospace science by speaking at, and attending, NASA's Space Exploration Educators Conference (SEEC) at the Johnson Space Center in February 2016 [45].

The research-based methodologies utilized when conducting this action research included hands-on learning, student-centered instruction, inquiry, collaborative groupings, project-based activities, Blended Learning and the Design Process [46, 47, 48].

Research questions and data sources

The purpose of this study was not only to better understand *why* girls tend to lose interest in science as they progress from elementary to middle school and *which* factors contribute to this decline, but also to illuminate *how* the educational establishment can help girls maintain an interest in science so that greater numbers of women enter and contribute to the global STEM workforce for the betterment of humanity. Thus, the research question addressed was *can the implementation of aerospace science in elementary school help girls maintain their confidence and engagement and science overall as they transition from elementary to middle school?* A mixed-method approach, consisting of both qualitative and quantitative data, provided the triangulation – the use of multiple data sources - necessary for an action research project which was both comprehensive and robust [49, 50]. Qualitative sources for grade-four students included a writing prompt, photos, videos, posts in the student blog, and field observations; while the quantitative sources were a parent questionnaire, a pre- and post- student science attitude survey, and the summative assessments for the PYP science unit titled, "Technological Solutions". Qualitative sources for students in grades five to seven included interviews (both individual and in groups) and video; while quantitative sources included a student science attitude survey and a parent questionnaire.

Quantitative data

As an important aspect of this action research project involved girls' perspectives towards science, especially as they grow and transition to middle school, quantitative results were used through the use of attitude scales. Girls' beliefs and feelings towards science were rated on a 5-point Likert Scale, including numeric data which involved ranges as well as averages. The surveys comprised of questions based on Weinberg, Basile and Albright's study titled, "The Effect of an Experiential Learning Program on Middle School Students' Motivation toward Mathematics and Science". Questions addressed the following values: *Interest value* ("Science is exciting to me"), *utility value* ("What I learn in science will be useful to me later in life"), *Attainment value* ("Being good at science is an important part of how I am."), *expectancy for success* ("I think I will do well in science") [22]. For girls in grades five to seven, an additional question regarding *confidence* ("I am good at science") was also added. As the literature review noted that parent involvement in their child's education is directly related to their success in school, parents were consulted in the action research project through the use of a questionnaire [51].

While it would also be ideal to include quantitative data from standardized testing as well, it was not possible to do this with the educational institution's Northwest Evaluation Association's Measures of Academic Progress (MAP) online testing resource, as our overseas school only utilizes the language arts and math sections of this assessment resource [52]. Nonetheless, the possibility existed to utilize the summative assessment for a PYP science unit titled, "Technological Solutions".

Qualitative data

Both student surveys, for fourth-grade and grades five to seven, included comment sections for qualitative purposes, and the grade four pre- and post- survey also included the request to "draw a scientist" in order to discover if any gender bias might emerge. Data was also gathered through a writing prompt which asked the question, "What is your opinion of using space education in the classroom?" Students were asked to answer the question freely, without feeling obligated that they should write what the teacher might want to hear. Furthermore, observations were noted as the teacher-researcher took on the alternate positions of both the active participant and observer; depending on how each position pertained to any particular learning session at hand. Data was obtained during class and afterschool Space Club activities through utilizing photos, videos, and postings in the student blog [43].

With the girls in grades five to seven, structured interviews, both individually and in small groups, were implemented in order to note whether or not a link existed between participation in previous aerospace activities and their current interest in science. The interviews were informal and sought to seek out any further trends which might emerge, as well as to collect a shared understanding of the participants. The interviews involved both convergent (open-ended) and convergent (closed) questions, thereby allowing for a variety of possible responses and increasing the strength of the triangulation process in general [50].

The rigor of this action research project relied heavily on the triangulation of its data as, "by not relying on a single method, researchers can be more confident of their research results, due to increased reliability and validity. Moreover, by following a multi-method research approach, a more complete, holistic and contextual portrayal can be captured of the units under study" [53].

In addition to noting which factors, both within the classroom and after school, increased or decreased girls' confidence and interest in science, an additional objective was to discover what helped girls maintain an interest in science. While the focus of any action research project is on internal validity and the transferability of the findings [50], the utilization of a control group – with girls, from fifth to seventh grade, who did not participate in any space exploration related activities – was employed in order to discover what the data revealed. Although the use of a control group then bent the study slightly more towards generalizability, doing so likely helped to sway those of the more traditional research realm to consider the validity of the action research project; one which they might not have been reviewed otherwise. Despite the use of a control group or not, the study still maintained the main features of an action research project, that of a teacher-focused inquiry for the purpose of improving the lives of students and educators [50].

The validity of the qualitative data was sustained by factors which made it trustworthy, and those included its credibility, transferability, dependability and confirmability. The credibility of the project arose by the fact that it included prolonged participation of the students, persistent observation on the part of the researcher, and the collection of documents throughout the process. Furthermore, triangulation was established by including questionnaires, anecdotal records, photos, videos, blog posts, a written reflection, and semi-structured interviews. Transferability of the findings was ensured by providing detailed and descriptive data, while the dependability was evident through the overlap of methods and the establishment of an audit trail [50]. Lastly, confirmability was achieved through cross checking the data and reflecting upon any assumptions or biases which emerged. Reliability of the data became relevant with the quantitative data, which included a parent questionnaire, attitude surveys, and the consistency and trustworthiness of scores were addressed through analyzing the data in a multitude of ways.

The analysis of this project attempted to "fully and accurately summarize and represent the data that has been collected" [50], and was conducted both formatively and summatively. One of the appealing aspects of action research was that the direction of the study, including the original question, was able to change course according to what trends developed from the data over time. The flexibility of this method of analysis then became increasingly relevant towards improving the lives of students and educators in the final analysis, as it allowed for ongoing moments of insight which then further refined the research [50]. Regarding organizational methods which assisted with the data interpretation, a coding system based on patterns, as they made themselves known, served to simultaneously create an emerging concept map of how the themes potentially related to one another. This facilitated the emergence of patterns and connections, as well as brought light to what was missing in the data and begged further investigation. Likewise, looking for "causal relationships" encouraged a review of the literature periodically in order to determine how the data coincided and/or challenged the current literature; as well as potentially have an impact upon a future action research cycle [50].

As for analyzing the quantitative attitude surveys, a variety of graphs and visuals were used to explain the findings. The use of descriptive statistics was helpful in explaining the Likert scales, regarding what - on average - girls believed and felt regarding science, and the measures of central tendency revealed the mean, median and mode of the group overall [57]. As the school used the online MAP standardized assessment only for math and language arts, attaining any other numeric data had to come from science scores with regard to specific grade-level content, as well as the surveys and questionnaire.

Both a triangulation and the exploratory method - looking for qualitative themes first, and then using a quantitative attitude survey to find support or contradictions afterwards - were utilized [50]. As an extension of the analysis, the data was used as a means to "point, rather than lead" the way as to what the findings implied [57]. Lastly, referring to contextual findings in the literature was also important to making connections and revealing consistencies, or discrepancies, which arose in the data analysis as they related to current research findings [50]. This last point was especially important when sharing findings with colleagues and administrators, as well as ensuring that the results of the study were worthwhile and applicable for other educators.

Analysis of the data is a critical piece in any action research project, and this one was no exception. By repeatedly reviewing the triangulation of data, and analyzing the emerging themes in a cohesive and valid

format, the summative findings ultimately were sound and worthy of making a valuable contribution to the current literature on how to keep girls' confidently engaged in science as they transition from elementary to middle school.

IV. FINDINGS

Data results revealed a positive impact from utilizing aerospace science, both during and after school, as a means of increasing engagement and confidence with girls' perspectives towards science; as well as maintaining that interest as girls transitioned from elementary to middle school. Seeking out patterns in the data sources independently resulted in emergent themes in the final analysis across all data sources. Sources included attitude surveys, parent questionnaires, writing prompt, interviews, photos, student work, student blog posts, observation and videos. The four themes that emerged as being influential factors correlating to girls' engagement and confidence in science were that the topics be *interesting, inquiry-based, purposeful, and fun!*

Results in grade four

Factors related to engagement in science with grade four girls.

Qualitative data included attitude survey comments, a writing prompt, parent questionnaire, class work, observations, photos and videos. With regard to the student survey, it is important to note the following response rate: 13 girls completed the pre-survey in September, 15 girls completed the survey at the start of Space Club in January (13 in the core classroom plus two from the other grade four class), and 12 completed the post-survey. Of the three girls missing in the post-survey, one moved away, one was sick, and the other was unavailable.

Notably, when aerospace science topics were either embedded into the classroom curriculum or addressed in afterschool Space Club, both observation and school work showed highly engaged and enthusiastic girls participating fully. When Space Club girls were asked which activities they enjoyed the most, the girls reported that Skype chats and constructing items using the Design Process were the most interesting activities. Comments provided in both the student post-survey and writing prompt provided further evidence of this positive engagement:

- "Space is really useful for my life because I love technology. We have to have more hours of space (in the class) because, like that, you learn science and math. Space has taught us to be risk-takers and never give up, (and) an example is Apollo 13."
- "I think that the education about space is great because we learn how to help the whole world, and what is happening to Earth right now."
- "I also think (space education) is important because Ms. Margot keeps mentioning that there should be more girls at NASA and (with) equal opportunities, and diversity is very important to learn."

Likewise, parent feedback provided through the questionnaires supported an observation of increased engagement with their girl's as a direct connection to experiencing aerospace activities at school. More importantly, parents reported that their girl's engagement had increased to the extent of that they were requesting space related toys over traditional requests, such as BB8 Sphero's, and also extended their interest to home projects (see Figure 6).

Fig. 6: After Space Club had concluded, two girls chose to use their play date time to develop six landers, each with a specific goal, by using the Design Process they had practiced during a previous club activity.

Parent feedback, such as this example, revealed how girls' interest in science grew as a result of embedding aerospace science in the curriculum:

> *It is so rare that children have first-hand experiences related to aerospace science that I think it heeds immense value as a motivator that triggers interest and curiosity. I have noticed how my daughter has been able to make new connections on her own and outside of school. i.e. she is now watching a series of documentaries called "Cosmos" and prefers to have scientific toys as presents. That is a significant increase in interest that I think is directly linked to her ability to better understand these topics and their possible uses.*

When comparing the grade four pre- and post-surveys, from September 2015 to March 2016, the quantitative data further supports this increase in girls' engagement in science as a result of exposure to aerospace

activities. While there was no change with regard to girls feeling that science was useful in their lives, remaining at an 80% high average in perception, they did show a 3% average growth in feeling that science was an important part of who they were. Most striking was the 12% average growth in perception that science was exciting for them. Table A shows the results when comparing the pre- and post- science attitude survey results for fourth grade.

Item #	Survey questions	September 2015	March 2016*	% change
1	Science is exciting for me	85%	97%	+ 12%
2	What I learn in science will be useful to me later in life	80%	80%	Same
3	Being good in science is an important part of who I am	77%	80%	+ 3%

* In the post-survey results included one less student who had moved away, and one extra student who attended Space Club from another class.
N= 13 (September) and 12 (March).

Table A: Pre- and Post- Science Attitude Survey Results for Fourth Grade.

Of the ten parents that responded to the parent questionnaire, they felt that their daughters had an average 76% interest in science at the beginning of the school year, in September 2015, and now – six months later – believed that their daughter's interest in science was at a 98% average. This is a growth of 22%! Lastly, they reported an average of 92% approval rate when asked if they believed that their daughter's interest in science was the result of having experienced space exploration activities in the curriculum during the school year.

Factors related to confidence in science with grade four girls

When asked to "draw a picture of a scientist" on the pre-survey, the drawings done by the girls at the beginning of grade four, compared with those drawn six months later, are very telling. Only 31% chose to draw a female at the beginning of the year, while 83% depicted a woman as a scientist (see Figure 7). This change in gender choice might attest to changes in perception, as female role models and discussions regarding the importance of equality and diversity in STEM pervaded aerospace discussions.

Fig. 7: When asked to draw a picture of "a scientist", most grade four girls chose to draw a male figure at the beginning of the action research project, with Einstein being a common choice (picture on left); while the majority drew a figure of a woman by the end of the research project (picture on right).

Equally powerful, was the change in perception observed of the boys' behavior by the teacher researcher. Vocabulary became more inclusive, as was noted in this writing prompt response by one of the grade four boys who said, "I think using space education in the class is good because you have fun and more people participate. It also inspires boys and girls to be a [sic] astronaut or an engineer."

Quantitative data from the student survey, however, showed minimal change in perception, from the pre-survey to the post-survey. When girls were asked about expectancy for success with the statement, "I think I will do well in science", the pre-survey showed an average positive response of 86%, while the post-survey only rose by 1%.

Also necessary to take into account was the negative feedback provided by two students through various data sources. One girl felt that, while she loved learning about math through aerospace science, shared that both she and her mom felt that it was taking away from learning traditional math and that they were afraid she'd fall behind in the concepts. Meanwhile the second student, while her survey showed a growth of 40% in her interest in math and wrote that aerospace education was "cool anyways", also felt that it was not useful or an important part of who she was.

Results in grades five to seven

Factors related to maintaining engagement in science with grade five to seven girls

Qualitative data was obtained through interviews with the experimental group, both individual and small groups, and video. Results from the data showed that

while the majority of girls maintained an increasing interest in science as they progressed to middle school, they were also helpful in being direct and opinionated as to what they felt both engaged and discouraged them from learning science in general.

A trend, in both the surveys and interviews, showed that girls were getting discouraged due to the lack of engaging lessons and/or topics of interest. Comments included the desire for more hands-on experiments, as had been done in elementary school, and less note taking. Recommendations included going into nature, perhaps on field trips, to make learning more "real". Likewise, many girls mentioned wanting to have more choice in what they learned about, as well as being able to explore with more time (depth over breadth); with a group of girls exclaiming, "We'd just learned about a new topic for one week, and already we were being given a quiz!". Others suggested the use of an afterschool class to pursue topics of interest, thereby having the time desired to explore and the elimination of assessments. When asked for recommendations to help girls have an increased interest in science as they transition to middle school, many suggestions included showing "them things they feel interested in, make science fun by playing games." Lastly, remarks were made about giving science equal weight as other subjects, like reading and math. One student expressed this opinion quite brilliantly when she pronounced on her survey that teachers should "make questions so girls can be curious or solve it…try to talk more about it (science) so (girls) can start talking like if it was politics."

For the purpose of comparison, the student science attitude survey was given anonymously to both the experimental group (19 prior students of the teacher researcher) and a control group (22 students not exposed to the teacher researcher's ongoing aerospace activities). When comparing the survey answers related to engagement, the experimental group showed an increase over the control group in all areas: a 6% gain regarding interest ("Science is exciting to me"), 10% gain in utility ("What I learn in science will be useful to me later in life"), and a 7% gain in attainment ("Being good in science is an important part of who I am"). Table B shows the survey results regarding the experimental and control groups and their interest towards science.

Item #	Survey questions	Control Group	Experimental Group	% Gain
1	Science is exciting for me	74%	80%	6%
2	What I learn in science will be useful to me later in life	73%	83%	10%
3	Being good in science is an important part of who I am	61%	68%	7%

N= 19 (experimental group) and 22 (control group)

Table B: Science Attitude Survey Results for the Experimental and Control Groups with Regard to Engagement

When asked about their daughter's interest in science as they got older and, only five parents responded to the questionnaires and there was no notable change when asked to rate their child's interest in grade 4 compared to "now". However, when asked "to what extent do you believe that space exploration activities in grade four had a positive impact on your daughter's interest in science overall", they responded with a positive average of 92%. One parent also observed, much like the students shared, that his daughter enjoyed "the experiments more than the theory".

Thus, both the qualitative and quantitative data show that girls, as they matured through the grades into middles school, still had an interest in science, the change in methodologies used were discouraging them from doing what was most interesting to them; which was experiments, research and learning in "fun" ways.

Factors related to maintaining confidence in science with grade five to seven girls

Interviews with the girls in the experimental group showed them to be both enthusiastic and confident when speaking about science; and when it was a scientific topic not to their liking, they not only expressed their dissatisfaction with evidence to back up their opinions, but also gave suggestions on how they felt teachers could remedy their discontent. Girls who felt confident in their scientific abilities had the following to share:

- Teachers can help girls like science more by making us curious and doing it more frequently."
- "Learning about space in fourth grade kept me wondering….it made me ask questions."

These same girls also offered their opinions on why girls get discouraged pursuing science, and offered suggestions on how to help girls feel more confident in the subject area:

- "Adults and students think that boys are smarter than girls in science, and can do more stuff than

girls. I think this happens because, like we learned in our Global Contributor Unit in second grade, most inventors are boys…I think this can be changed by seeing more girls role models, so girls will be encouraged to be like that person."

- "Maybe girls get frustrated because it's too difficult or they don't understand it, so they give up"
- "I heard that boys are more left brain and girls are more language based."
- "It's a big move to go to middle school. Teachers are stricter, things are harder, there are more tests and fewer experiments. In elementary school there were more experiments and less tests."

When it came to girls who expressed lack of self-efficacy with regard to science, the emerging trend was a lack of exposure. Girls in the control group make comments on their surveys such as "I can't say a lot about science because in all my classes we don't do science", or "my brother takes science and he says it's fun." It should be noted that the girls at this grade level have less exposure to science and it is not initiated until the last two units of the school year. The couple of girls who commented on a lack of confidence in the experimental group referred to not understanding concepts and feeling embarrassed about expressing what was perceived as a weakness.

While addressing this feedback will be important to note in the conclusion portion of this action research paper, the quantitative data aligns with the qualitative results in showing that the experimental group showed great gains in feeling confident in science than the control group. In the attitude survey, the experimental group had a 6% average gain in both expectancy for success ("I think I will do well in science this school year") and confidence ("I am good at science"). Still, it's worth noting that both scores, regarding confidence, were fairly low for both groups at 66% and 70%. Table C shows the comparison in confidence with regard to science, between the experimental and control groups.

Item #	Survey questions	Control Group	Experimental Group	% Gain
4	I think I will do well in science this school year	77%	83%	6%
5	I am good at science	66%	70%	4%

N= 19 (experimental group) and 22 (control group)

Table C: Science Attitude Survey Results for the Experimental and Control Groups with Regard to Confidence

CONCLUSIONS

Alignment between the literature and the action research project

This action research project began with addressing how to help girls maintain their confidence and engagement in science overall as they transition from elementary to middle school. Inherent in this inquiry was to find out what increases and decreases both an interest and self-efficacy with regard to science. When reviewing data for trends, the themes that repeatedly emerged were that the majority of girls in the study had a desire to learn more about science in general and, in that quest, they wanted it to be: *interesting, inquiry-based, purposeful, and fun!*

These desires aligned with what the literature review showed to be beneficial for making science more appealing and inclusive for girls. First, that *expectancy* has a direct impact upon self-efficacy, and when adults are available to support girls in success and failure – thereby reinforcing a growth mindset – they show an increase in interest with regard to science. Such an environment was provided in both the teacher researcher's classroom and afterschool Space Club, and girls specifically mentioned that some of their favorite space activities involved engineering tasks utilizing the Design Process.

Secondly, the literature review noted the importance of *cultural factors* as being a motivational influence or a hindrance. As classroom climate is a cultural factor, and the data showed that addressing the topics of diversity and acknowledging gender equality can have a positive impact on girls. These topics were brought up in class discussions, and inclusiveness was further reinforced by bringing in female guest speakers for the science unit on technology, and showing videos of female groundbreakers at NASA in all STEM fields. Evidence of the appreciation of girls in the realm of science was also present in both the observations and writing prompts completed by the boys in the grade-four class. Girls in grades five to seven additionally had Skype chats with female engineers in NASA.

A third factor mentioned as being relevant in the literature review was with regard to providing *opportunities* for girls, many of which have historically been unavailable females. The literature revealed that gender barriers and underrepresentation have a direct effect on achievement in science for girls, as they lose interest when the opportunities are not provided. In addition to seeking out and strongly encouraging the grade four girls in the teacher researcher's core classroom to participate in the afterschool Space Club, of which 79% were girls, they had extensive hands-on opportunities to actually "do stuff", share their learning through the student

blog, and learn about potential careers from female role models in videos. As for the girls in grades five to seven, they also had the opportunity to fly to the south of Ecuador and interact with the Ecuadorian Civilian Space Agency, and meet cosmonauts in person (see Figure 8). As the teacher researcher has a history of sharing memorabilia and souvenirs from NASA, EXA and Space X, the idea of science then permeates the girls' lives.

Fig. 8: Students are invited to fly to the south of Ecuador to participate in the inauguration of Ecuador's second satellite, Krysaor, and meet the team of the Ecuadorian Civilian Space Agency. The opportunity allowed girls to ask questions of engineers (photo on left) and meet Ecuador's only cosmonaut, Commander Nader (photo on right).

Fourth, the literature speaks to the importance of the *physical environment.* The classroom utilized for this action research project had all the elements noted as being important for girls to engage in science: an open-concept, flexible seating, diverse posters, and decorations that were attractive.

The action research project shows that embedding aerospace education in the curriculum is a means by which to both spark an interest in science for girls and help maintain that interest as they enter the period traditionally known to diminish that initial interest ignited in elementary school. It also goes without saying that the interest-driven learning provided in this action research project also met the needs that emerged from the data, that science be *interesting, inquiry-based, purposeful, and fun.* This alignment was due, in no small part, to the professional development that the teacher researcher was able to attain both during the period of this project and long beforehand.

Room for improvement

Although the girls who displayed dissatisfaction with either aerospace science or science in general were only a few, the study shows the need to check for understanding more frequently. In doing so, the teacher can have a better understanding of who needs extra help with comprehension, or may be feeling too shy to ask for help. Likewise, the study showed that at least one student and parent needed additional education on how research supports inquiry over traditional learning as an enhanced means of learning and retaining information. In doing so, students and parents can better understand the usefulness of the research-based methodologies used in this study.

If the project were to continue, the following changes would be recommended in order to gain additional data which may provide further insights:

- Include the question on confidence, "I am good at science", in the grade four survey.
- Conduct interviews also with the control group in grades five to seven.
- Ensure that all boys in fourth grade complete the post-survey.
- Interview boys at all grade levels, fourth through seven.
- Include a control group for grade four.
- To avoid confusion, add to question #7 in the middle school survey that the recommendations are for the teachers, not other students.

Recommendations for helping girls maintain and interest in science

Practical recommendations for implementing aerospace science in an educational institution, for the benefit of keeping girls interested in science as the get older, would be to implement an afterschool Space Club at all divisional levels. This study shows that girls increased their engagement and confidence most when space activities included hands-on and project-based learning, utilized the Design Process, provided female role models, and interactive Skype chats with professionals in STEM careers. Professional development that encourages activities which are *interesting, inquiry-based, purposeful, and fun* – the four themes that emerged from this study – are also highly encouraged; and many can be found on the websites of various space agencies online.

Ultimately, there is a STEM void to be filled globally, as well as the need for diversity and equality in all science areas. To underscore, providing "opportunities in science…early on in a girl's academic experience is critical for cultivating an interest in STEM [6]. Technology is advancing exponentially, the gender gap is widening, and our girls have a wealth of perspectives to contribute to our world. What better way to light their fire than to expose them to the new frontier…s-p-a-c-e?!

ACKNOWLEDGEMENT

I would like to thank the Academia Cotopaxi community for supporting my efforts in space education over the last 10 years, and the NASA Endeavor Teaching Certificate Project for its fabulous professional development. Additionally, much gratitude goes to Commander Ronnie Nader (EXA), Juniper Jairala (NASA) and Michael Lutomski (Space X) for continuing to inspire Ecuador's children to reach realms which they

never before thought possible. Lastly, and most importantly, I am forever grateful for my family's unending support; as well as that of my principal, Dan Kerr, for cheering on every effort in the name of student learning!

REFERENCES

1. OnlineCareerTips.Com. (2012). *The science, technology, engineering & math (STEM) workforce shortage.* Retrieved from http://onlinecareertips.com/2012/10/the-science-technology-engineering-math-stem-workforce-shortage/.
2. U.S. News. (2015). *The U.S. News/Raytheon STEM Index shows gender and racial gaps widening in STEM fields.* Retrieved from http://www.usnews.com/info/blogs/press-room/2015/06/29/the-us-news-raytheon-stem-index-shows-gender-and-racial-gaps-widening-in-stem-fields.
3. U.S. News. (2015). *Women still underrepresented in STEM fields.* Retrieved from http://www.usnews.com/news/articles/2015/10/21/women-still-underrepresented-in-stem-fields.
4. Girl Scout Research Institute (GSRI). (2012). *Generation STEM: What girls say about science, technology, engineering, and math.* Retrieved from https://www.girlscouts.org/research/pdf/generation_stem_full_report.pdf.
5. Hawthorne, M.J., Henley, T.B. & Naizer, G. (2014). *Narrowing the gender gap: enduring changes in students' attitude toward math, science and technology.* Retrieved from https://www.researchgate.net/publication/270227071_Narrowing_the_Gender_Gap_Enduring_Changes_in_Middle_School_Students'_Attitude_Toward_Math_Science_and_Technology
6. Heaverlo, C. (2011). STEM development: A study of 6^{th}-12^{th} grade girls' interest and confidence in mathematics and science. *Graduate Theses and Dissertations.* Paper 10056.
7. Penwell, R. (2004). *Advance placement environmental science: Implications of gender ethnicity.* Retrieved from http://wolfweb.unr.edu/homepage/crowther/ejse/penwell.pdf.
8. The Dreaming Wizard. (2007). *A guide to dream interpretation.* Retrieved from http://thedreamingwizard.com/down-the-rabbit-hole_279.html.
9. Academia Cotopaxi. (2017). Retrieved from www.cotopaxi.k12.ec.
10. National Aeronautics and Space Administration (NASA). (2017). Retrieved from http://www.nasa.gov/.
11. Ecuadorian Civilian Space Agency (EXA). (2017). Retrieved from http://exa.ec/index-en.html.
12. Virgin Galactic (2017). Retrieved from www.virgingalactic.com.
13. SpaceX. (2017). Retrieved from www.spacex.com.
14. The Observatory on Borderless Higher Education. (2014). *The global race for STEM skills.* Retrieved from http://www.obhe.ac.uk/newsletters/borderless_report_january_2013/global_race_for_stem_skills.
15. The Business-Higher Education Reform (BHEF). (2005). *A commitment to America's future: Responding to the crisis in mathematics and science education.* Retrieved from http://cte.ed.gov/nationalinitiatives/gandctools_viewfile.cfm?d=600187.
16. York Times. (2015). *Teacher Shortages Spur a Nationwide Scramble (Credentials Optional).* Retrieved from http://www.nytimes.com/2015/08/10/us/teacher-shortages-spur-a-nationwide-hiring-scramble-credentials-optional.html?_r=0.
17. NPR. (2011). *Transcript: Obama's State of the Union Address.* Retrieved from http://www.npr.org/2011/01/26/133224933/transcript-obamas-state-of-union-address
18. IEEE Spectrum. (2013). *The STEM crisis is a myth: An ongoing discussion.* Retrieved from http://spectrum.ieee.org/static/the-stem-crisis-is-a-myth-an-ongoing-discussion.
19. Denissen, J.J., Zarrett, N.R., & Eccles, J.S. (2007). I like to do it, I'm able, and I know I am: Longitudinal couplings between domain-specific achievement, self-concept, and interest. *Child Development, 78* (2), 430-447.
20. Davis, H. (2016). *Gender gaps in math and science education.* Retrieved from https://www.kon.org/urc/v7/davis.html
21. Sorge, C. (2007). *What happens? Relationship of age and gender with science attitudes from elementary to middle school.* Retrieved from http://eric.ed.gov/?id=EJ783419.
22. Weinberg, A., Basile, C.G., Albright, L.(2011). *The effect of an experiential learning program on middle school students' motivation toward mathematics and science.* Retrieved from http://www.academia.edu/1199180/The_Effect_of_an_Experiential_Learning_Program_on_Middle_School_Students_Motivation_Toward_Mathematics_and_Science.
23. Kahle, J. (1984). *Girls in school/women in science: A synopsis.* Retrieved from http://eric.ed.gov/?q=Kahle%2c+J.+(1984).+Girls+in+school%2fwomen+in+science%3a+A+synopsis&id=ED258812.
24. National Association for Research in Science Teaching (NARST). (2017). Retrieved from

https://www.narst.org/publications/research/gender.cfm
25. The Globe and Mail. (2014). *Early engagement key to getting girls into science careers, Canadian study says.* Retrieved from https://www.theglobeandmail.com/news/national/education/early-engagement-key-to-getting-girls-into-science-careers-canadian-study-says/article16461308/
26. Goldie Blox. (2017). *Toys for future innovators.* Retrieved from http://www.goldieblox.com/.
27. Dweck, C.S. (2008). *Mindsets and Math/Science Achievement*. Retrieved from file:///C:/Users/Margot%20Solberg/Downloads/mindsets,%20gender%20differences.pdf
28. Center for Teaching Excellence. (2015). *Teaching to promote gender equality.* Retrieved from http://cte.virginia.edu/resources/teaching-a-diverse-student-body-practical-strategies-for-enhancing-our-students-learning/gender-dynamics-in-the-classroom/teaching-to-promote-gender-equality/
29. TIME. (2015). *How to get more girls involved in STEM.* Retrieved from http://time.com/3835310/girls-stem-school/?xid=tcoshare.
30. The National Academies Press (2017). *A framework for K-12 science education.* Retrieved from http://www.nap.edu/catalog.php?record_id=13165#.
31. International Baccalaureate (IB). (2017). *Primary years programme (PYP).* Retrieved from http://www.ibo.org/programmes/primary-years-programme/.
32. New England Association of Schools and Colleges (NEASC). (2017). Retrieved from https://www.neasc.org/.
33. Association of American Schools of South America (AASSA). (2017). Retrieved from www.aassa.com.
34. American Education Reaches Out (AERO). (2017). Retrieved from http://www.projectaero.org/.
35. Common Core State Standards Initiative. (2017). Retrieved from http://www.corestandards.org/.
36. This Week @ NASA. (2017). Retrieved from https://www.nasa.gov/multimedia/podcasting/twan_index.html.
37. Sphero. (2017). Retrieved from www.sphero.com.
38. Code. (2017). Retrieved from www.code.org.
39. Universidad de las Américas (UDLA). (2017) Retrieved from http://www.udla.edu.ec/.
40. National Oceanic and Atmospheric Administration (NOAA). (2017). Retrieved from www.noaa.gov.
41. WSI Pilot Brief. (2017). Retrieved from https://pbo.pilotbrief.com/pbologin.html.
42. Weather Data Learning Center (WDLC). (2017). Retrieved from https://www.us-satellite.net/wdlc/.
43. Solberg, M. (2017). *Ms. Margot's class – student authors.* Retrieved from http://msmargotsclass.blogspot.com/
44. Solberg, M. (2017). *Margotmania: The Adventures of an Educator in Aerospace Education!*. Retrieved from http://margotmania.blogspot.com/
45. Space Exploration Educators Conference (SEEC). (2017). *Teacher Programs.* Retrieved from http://spacecenter.org/education-programs/teacher-programs/teachers-seec/.
46. Edutopia. (2017). *What works in education.* Retrieved from www.edutopia.org.
47. BIE. (2017). *Why project based learning (PBL)?* Retrieved from www.bie.org.
48. Learn. (2017). *What is design methodology?* Retrieved from www.learn.org.
49. Commonwealth of Learning (2004). *Mixed research methods.* Retrieved from http://www.col.org/SiteCollectionDocuments/A5.pdf.
50. Mills, G.E. (2014). *Action research: a guide for the teacher researcher.* Retrieved from https://www.pearson.com/us/higher-education/product/Mills-Action-Research-A-Guide-for-the-Teacher-Researcher-5th-Edition/9780132887762.html
51. Hoover-Dempsey, K.V. & Sandler, H.M. (1995). *Parental involvement in children's education: Why does it make a difference?* Retrieved from http://www.vanderbilt.edu/peabody/family-school/papers/childrens_education.pdf.
52. NWEA. (2017). *Measures of academic progress (MAP).* Retrieved from https://www.nwea.org/assessments/map/.
53. Holtzhausen, S. (2001). *Triangulation as a powerful tool to strengthen the qualitative research design: The resource-based Learning Career Preparation Programme (RBLCPP) as a case study.* Retrieved from http://www.leeds.ac.uk/educol/documents/00001759.htm.