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ENGAGING SATELLITE EDUCATION AND OUTREACH THROUGH ECUADOR'S ASTERIA PROGRAM

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Initiated in August 2012, the Ecuadorian Civilian Space Agency (EXA) created the ASTERIA program for the purpose of educating students, the general public and the global community regarding its innovative advancements in recent satellite developments. While ASTERIA includes an agreement among three Ecuadorian schools, the focus of this paper is with specific regard to one of the schools in particular, Academia Cotopaxi (AC) in Quito, and initiatives completed by EXA's education consultant in conjunction with EXA. In this two year period, ASTERIA's objectives were met through innovative satellite presentations, participation in World Space Week, student Skype chats, online education, postings in student and educator blogs, published papers, award recognitions, a Ministry of Education observation, student participation in a unique satellite inauguration, two pilot programs, and information shared with the public through a wide variety of media outlets. These events involved individuals from all aspects of the local and global community including, but not limited to, the following: students from first grade through college level, educators, parents, administrators and other space agencies. These outreach enterprises aligned with the launching of Ecuador's first satellite (Pegasus), in April 2013, and its second satellite (Krysaor) in November 2013; both of which have live, onboard video cameras for educational purposes. As Pegasus was sideswiped by space debris a month after its launch, this unexpected event also provided a unique opportunity for the global community to learn about technological advancements which allowed its signal to be recovered eight months later with the assistance of Krysaor. Included in community education events was how, through two pilot programs at AC, elementary students have downloaded live satellite weather images by utilizing a virtual ground station in the classroom, thereby attaining educational objectives in an authentic manner. Sharing such engaging educational practices in science, technology, engineering and mathematics (STEM) with the community at large has contributed not only to increasing public awareness of satellite education in Ecuador and abroad, but in a fashion which also addresses the educational standards presented in the *A Framework for K-12 Science Education,* the *Common Core* and *Next Generation Science Standards*. In this paper we discuss the methods utilized in implementing a variety of engaging outreach events, the results obtained, and the lessons learned for future advancements in outreach with regard to satellite education.

I. INTRODUCTION

EXA's history

In 2007 Ecuador established its first Ecuadorian Civilian space Agency (EXA), along with its first astronaut, Commander Ronnie Nader. The space agency began with a microgravity flight program, and then in 2009 progressed to establishing its own HERMES-A/MINOTAUR ground station.

ASTERIA

On August 23, 2012 EXA initiated the ASTERIA program in Ecuador for the purpose of introducing satellite education in its schools, and with the overall intention of increasing student engagement in science, technology, engineering and mathematics (STEM) and engaging the general public. ASTERIA was originally established as a collaboration between three schools within Ecuador, one of which was Academia Cotopaxi (AC), in Quito, and is the focus of this paper; as the teacher-researcher is an educator at this institution, as well as EXA's education consultant. Thus, the research question addressed in this paper is *what are effective methods in which to engage others in satellite education and outreach through the ASTERIA program?*

First pilot programs

A precursor to ASTERIA was the development of EXA's first pilot program, which took place at Academia Cotopaxi in 2009, and was titled "A Satellite in the Classroom". This program allowed second grade students to download live weather satellite images through the utilization of a virtual ground station within the classroom. The focus of this first program was on enhancing students' understanding of geography and new technology, the outcome of which showed positive academic gains [1]. Subsequently, a paper on this project was presented at the 61st International Astronautical Congress in Prague, Czech Republic in 2010.

In August of 2012, EXA created ASTERIA, which established a collaborative agreement between three Ecuadorian schools: Academia Cotopaxi in Quito, Colegio Rosa de Jesus Cordero in Cuenca, and La Unidad Educativa Nuevo Mundo in Guayaquil. The agreement between EXA and these schools was that students would be given access to the live video camera onboard Ecuador's first satellite for educational purposes [2]. Additionally, these schools would share any educational resources which were developed as a result of this collaboration.

<u>First satellites: Pegasus (NEE-01) and Krysaor (NEE-02)</u>

On April 25, 2013, Ecuador launched its first nanosatellite, Pegasus (NEE-01), which inspired EXA's second pilot program at Academia Cotopaxi; the focus of which revealed additional positive effects, this time on math achievement and attitudes when incorporating satellite education in a fourth grade classroom (see Figures 1and 2) [3]. Results of this action research project were presented at the 64th International Astonautical Congress in Beijing, China in 2013.

Fig. 1: Ecuador's first nanosatellite, Pegasus.

Unfortunately, a month after launching, Pegasus was sideswiped by space debris and rendered inoperable for a period of time. Due to EXA's tenacity, nonetheless, when its second satellite, Krysaor (NEE-02), was launched in November of the same year, technological innovation allowed this second satellite to recapture Pegasus' original signal on January 25, 2014 [4].

Since the establishment of ASTERIA in 2012, satellite education outreach has taken place in Ecuador through a variety of formats, the result of which action research has shown to promote authentic teaching and learning, as well as an increased engagement in STEM.

Fig. 2: Students at Academia Cotopaxi observe live video footage of the earth from Ecuador's Pegasus satellite, while also attempting to decode its signal with laptop software.

II. LITERATURE REVIEW

A review of the literature revealed that three components can have a positive impact on educational outreach, especially when attempting to promoting systemic change: providing training, engaging students beyond the classroom, and including the local and global community in space exploration advancements.

<u>Providing training</u>

Research shows that individuals who *engage in training, formal or informal are more likely to engage in some level of education and public outreach*. With regard to a specific 2012 study on the factors which contributed to amateur astronomer's involvement in education and public outreach, it was found that those who received training had an *increase in confidence and ability* with the subject matter. As might be expected, the opposite was also found to be true: that if training opportunities did not exist or were not reasonably available, then there was a decreased likelihood of participation in training [5]. Extend this concept to professional development for the classroom educator, and the impact becomes all the more powerful [6].

<u>Engaging students beyond the classroom</u>

Creating authentic learning opportunities for students, both inside and outside of the classroom, can *increase students' confidence in and abilities to solve scientific problems* [7]. Additionally "exposure to voluntary, interest driven learning experiences can *increase student interest and enthusiasm for science over time*" [8]. Thus, utilizing satellite education as a means to create interest driven learning experiences beyond the classroom walls can result in making education more meaningful for students, as well as increase their interest in STEM long-term.

Inclusion of the local and global community

NASA's Strategic Education Framework to "inspire, engage, educate and employ" is a successful one worth modeling, in that it uses educational and public space outreach activities, events and resources to "enhance the educational system and contribute to the broad public understanding of STEM" [9]. Sharing EXA's satellite achievements locally and globally serves not only to inform the public of scientific innovations taking place, but also to inspire others to take advantage of educational opportunities available in the global pursuit of STEM advancements.

III. METHODOLOGY

The outreach methodology for increasing STEM engagement through satellite education was implemented in a three-fold fashion: organizing *training* for educators, providing motivating *experiences* for students, and *informing* the local and global community of accomplishments in satellite education. When possible, experiences were *hands-on, meaningful and immediately applicable* within educational institutions, as well as promoted *collaboration* and the *promotion* of educational strides within the educational community.

Professional Development Project for educators

In October 2013 a Professional Development Project (PDP) was conducted at the Universidad San Francisco de Quito (USFQ), through their Institute of Education and Learning (IDEA) department [10]. Approximately 172 educators, representing all curricular areas from grades from pre-kinder to the university level, were in attendance. An initial 2 ½ hour, interactive workshop was presented in Spanish by the teacher- researcher, and content included: EXA's history of accomplishments since its establishment in 2007, its development of a satellite education program, and resources of interest. All elements presented had immediate applicability for the classroom environment.

After this session, 22 educators volunteered to take on the challenge of implementing three satellite lessons in their classrooms, either from lessons provided by the EXA consultant or through developing their own, over a four week period. Despite much support, however, ultimately only five educators actually completed the follow-up objectives in the end.

The purpose of the PD workshop and follow-objectives were to inspire educators to *embed* weather satellite education into their regular curriculum standards in order to increase student engagement in STEM. After the workshop, participants completed a pre-survey with the following 10 questions: How frequently do you teach about weather in your classroom? How often do you utilize earth observations in your lessons? How frequently do you use maps or satellite images in your classes? How often do you utilize weather images to teach in an authentic manner? To what extent do you observe your students showing dedication, interest and motivation in class? How interested are your students in STEM? To what extent do you use online resources for your instruction? How aware are your students of Ecuador's satellite program? How aware are you of Ecuador's satellite program? To what extent do you use inquiry/investigative methods of learning in your classroom?

After completing the survey, and for accountability purposes, participants were then asked to sign an agreement that they understood they were to implement at least three lessons within an allotted time and complete a post-survey, after which they would receive a letter of participation to present to their administrators. Additionally, USFQ also gave each educator a Certificate of Participation for having attended the initial workshop session. To assist with the follow-up implementation in the classroom, project participants were provided with the 22 satellite lessons (developed during the second pilot program), as well as online resources in Spanish and English; including a link to live weather satellite downloads completed by Academia Cotopaxi students through EXA's Minotaur ground station [11].

During the following month, weekly email check-ins were conducted by the teacher- researcher to see if any assistance was needed, as well as to monitor progress. After this period, teacher participants completed a post-survey and were encouraged to also share documentation of their achievements.

Beyond the classroom

Skype chatting with Ecuadorian astronaut, Commander Nader, was one way in which students were able to connect STEM with authentic learning outside of the classroom (see Figure 3). Students were able to prepare their own relevant questions and receive first-hand responses to their inquiries [12]. Additionally, students added to their aerospace knowledge base by completing Skype chats with an

Ecuadorian NASA engineer and retired risk-manager for the International Space Station as well. After participation in these events, the students proudly shared their experiences with the global community through the World Space Week website [13] .

Fig. 3: Skype chat with Ecuadorian astronaut, Commander Ronnie Nader.

A more extensive and impressive event was when 16 students, along with their parents, flew from the north of Ecuador, to EXA in the south, in order to witness the first public demonstrate of the onboard video and signal from the Krysaor satellite. During this time students were able to: observe the EXA team in action at Mission Control; listen to Ecuador's president exalt the accomplishments via television during his regular Saturday address to the country, called the "Sabatina"; and, afterwards, the EXA team was available for student's to ask personal questions regarding what they'd witnessed (see Figures 4 and 5). Additionally, the ASTERIA members from Cuenca attended as well a representational group of astronomy students. The event was hands-on, meaningful and inspirational.

Fig. 4: A student asks questions of the EXA team regarding satellite orbits.

Fig. 5: Students meet and ask questions of Ecuador's only astronaut, Commander Ronnie Nader.

Inclusion of the local and global community

With the launching of Ecuador's two nanosatellites, much publicity took place both locally and globally. In alignment with those events, and from ASTERIA's educational perspective, students also shared their learning through a wide variety of media sources including TV, radio, educational articles, website postings and a student blog. These resources included written reflections, interviews, videos and photographs which showed an engagement in STEM through satellite activities.

Additionally, EXA's satellite accomplishments were shared with 300 high school students, as well as faculty from the secondary and university levels, at the First Science and Technology Youth Congress. This event took place at the Machala University in the south of Ecuador, hosted by the Obelisk Science & Technology Club [14] , and involved audiovisual presentations by three guest speakers in the space education community; two being ASTERIA members from Quito and Cuenca (see Figure 6).

Fig. 6: Satellite presentation at the first Science & Technology Youth Conference in Machala, Ecuador.

Afterwards a presentation for 1,500 students took place at the Nueve de Octubre School in Guayaquil, along with a private meeting with the vice-provential premier of the El Oro province. The purpose of meeting with government entities was to strengthen the ongoing support between the Obelisk Club and the government; which included the provisions of a meeting room in a government building, along with various technologies to further their pursuits in STEM.

Addressing educational standards

The implementation of the satellite education and outreach was based on the scientific and engineering practices found in *A Framework for K-12 Science Education* [15] and the *Next Generation Science Standards (NGSS)* [16]. These essential practices included: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, and constructing explanations and designing solutions.

IV. DATA COLLECTION

A mixed-methods approach, which included both qualitative and quantitative research, was used and sources included surveys, written responses, photographs, interviews, observations, videos, articles, anecdotal notes and email exchanges.

PDP : Outreach in the classroom

USFQ workshop participants were required to fill out a post-survey, as were those who chose to pursue the Professional Development Project (PDP). With PDP participants, a 5-point Likert Scale was used to compare pre- and post-survey results; the latter of which was similar to the pre-survey but also included a comment section. Comment questions included: What were the positive and negative aspects of implementing this PD project in your classroom? If you crated your own lessons, what were they (and please attach or describe them)? Give an example of how you integrated math and/or science and the use of the satellite images in your satellite lessons. Do you have any other feedback to share?

PDP follow-up participants shared a wide variety of innovative opportunities in which they embedded satellite education into their curriculum. These included using EXA's website, creating satellite models from recycled materials, crafting cloud posters, visiting the local planetarium and learning about constellations during a night camp out at school (see Figure 7).

Fig. 7: Students at Colegio Becquerel conduct research and create their own satellites with recycled materials.

Outreach in the community

Anecdotal notes showed that, during the Skype chats with Ecuadorian astronaut Nader, the students were most interested in seeking responses to the following satellite questions: "Where did you learn to build nanosatellites and what were the challenges?" "How did it feel to build Krysaor and Pegasus for Ecuador?" "What do you hope to study with the satellites?" "How do you get money to build satellites?", and "What if there is more space junk in space, will Krysaor spin like Pegasus did?"

For the Krysaor EXA Event in Guayaquil, a post-survey was sent for feedback to all participants, and approximately half of the parents and students responded. In addition to a comment section, a 5-point Likert scale was used and the student survey included the following three questions: How much did you feel you learned about space education and satellites that you didn't know before? To what extent are you now more interested in space and/or satellites, now that you went to the EXA event? And, after having attended the EXA Event, are you curious to learn more about STEM as a result? The parent survey included three slightly different questions: To what extent did the EXA Event inform you or increase your awareness of space education as it relates to satellites? To what extent did your participation in this event, as a parent, potentially influence your future interest in space education? And to what extent to do you believe that your child's interest in STEM increased as a result of the EXA event? In addition to the surveys, observations, photographs and videos were collected as well[17].

Outreach in the global community

Videos, photographs, written reflections and interviews documented ASTERIA's progress through the following multimedia channels: Ecuavisa TV [18, 19] (see Figure 8), ECTV [20], Radio Quito [21], *Para El Aula* educational magazine published by USFQ's IDEA department [22], the South American educator AASSA newsletter [23], Ms. Margot's Class Student Blog [24], a professional educator blog [25], Obelisk Science and Technology Club Facebook page [26], EXA Facebook page [27], World Space Week web page [28], the First Science and Technology Youth Congress in Machala, Ecuador [29], and student satellite image downloads [30]. Data collected was extensive, detailed and reached both the local and global community.

Fig. 8: Students being interviewed by Ecuavisa TV regarding the impact of satellite education on STEM engagement in the classroom.

V. DATA ANALYSIS

Analysis of the data revealed a positive impact when including a three-pronged approach to engaging the community in satellite education for the purpose of STEM engagement. The analysis involved looking at the data sources independently, thereby seeking out emergent themes. Common themes across all data sources included: *an increased awareness and interest in STEM amongst educators;* greater STEM *engagement and motivation with students*; and *positive feedback and curiosity in satellite education with both the local and global* populace.

Educators make an impact

Results on USFQ's post-survey regarding the workshop provided showed a high success rate based on participants having *learned something new* (80% strongly agreed and 20% agreed), having learned something they could *apply* in their classrooms (75% strongly agreed, 19% agreed, 4% disagreed and for 2% it was non-applicable), and having *enjoyed* the workshop (75% strongly agreed, 23% agreed and 2% didn't agree). Comments included: "many ideas to implement in the classroom" "very interesting" and "more attention needs to be given to Ecuadorian classrooms and the implementation of innovative ideas like these". It was also reported that the director of a local school contacted USFQ directly to report that her teachers returned from the workshop motivated, happy and enthusiastic to apply ideas which were useful and applicable. It needs to be noted, however, that the workshop combined both classroom management and satellite education, so it was not always possible to know to which part the workshop feedback referred to. Nonetheless, as a result of this workshop, Montebello Academy, a rural school located an hour outside of the capital, contracted the same presentation for their faculty of 50 educators [31]. An informal interview after this second workshop also revealed positive feedback from educators regarding all aspects that were presented.

As for negative comments regarding the USFQ workshop, two participants felt that satellite resources shared couldn't be applied to young children, and that the socioeconomic reality of Ecuador's classrooms wouldn't allow access to technology which they felt would be needed to implement the ideas presented. Had these opinions been shared during the workshop, a paradigm shift could have presented itself in sharing facts regarding how Ecuador's government has made impressive strides in improving education overall in the country. Examples of such STEM progress include the upgrading of educational infrastructures through the Millennium School Project [32], improving technological tools and professional development in the schools [33], providing education scholarships to study abroad [34], investing in technology at the university level and through international collaborations [35], the SEED project in Ecuador [36], and more. As for incorporating satellite education with young students, it is possible to adapt all ideas to all ages, as was evident with EXA's first pilot program.

With regard to the pre- and post-survey results for the follow-up PDP participants, the most notable areas of growth were with regard to the following areas: teaching about weather, earth observations and/or using satellite images; and student and teacher awareness of Ecuador's satellite program. In the post-survey, 84% reported that the lessons provided were *easy to adapt* for their classroom needs, and 84% also said that they were *likely to use these new ideas in the future*. Unfortunately, these results represented a very small sample size, as only five of the original twenty-two participants who volunteered actually completed all project requirements. The low sample size occurred despite the implementation of many interventions; such as checking in with the participants via email and phone calls and offering a Certificate of Participation. Also, an oversight on the pre-survey did not clarify that participants should give responses based on how they felt *before* having attended the workshop, the result being that the data results might be inaccurate for some survey questions and could account for why little or no growth was shown in some areas (see Figure 9).

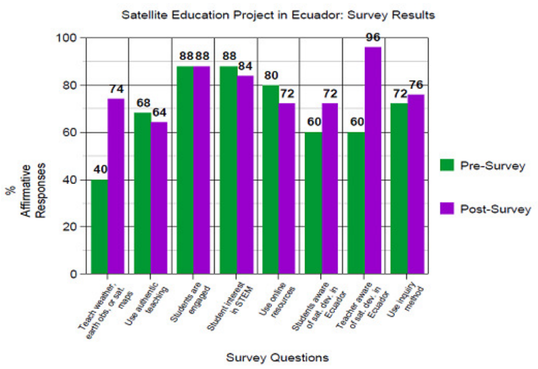

Fig. 9: Pre- and post-survey results for the Professional Development Project on embedding satellite education in the classroom.

Nonetheless, the overwhelmingly positive comments on the post-survey revealed that systemic change in STEM engagement had initiated as a result of embedding satellite education in the curriculum (see Figure 10).

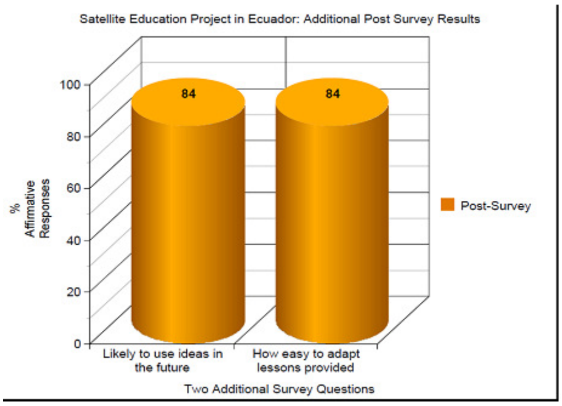

Fig. 10: Professional Development Project: satellite education post-survey results.

When looking solely at the pre-survey data, which included all 22 initial participants, it appears that the areas in which Ecuadorian educators could have most benefitted from systemic change, had all completed the PD project, were in: using earth observations, maps and satellite images for instruction, educating students about EXA, and using authentic learning practices. This information is important to keep in mind when developing future professional development opportunities for local educators.

Post-survey comments from the satellite education PDP participants were overwhelmingly positive, and educators reported that: there was an *increase in student curiosity and emotion*, the lessons provided were *helpful, teachers enjoyed the innovative ideas and approaches,* what was utilized was completely *new for educators and students alike,* students became *passionate about Ecuador's satellite program,* technology helped to *capture the students' attention and provide authentic learning,* the material was *different and enriching,* the project allowed for teachers to *organize and deepen their curriculum,* the project was *enjoyed by parents as well, the material was motivating,* and the experience *broadened students expectations* regarding the application of satellites in society.

Negative comments were few and revolved around difficulties with access to technology, and finding online resources in Spanish. In a nutshell, it appeared that educators wanted more access and training with technology in order to better implement the innovative ideas presented at the initial USFQ workshop.

Other feedback from PDP participants included the connections that the educators made with math and/or science with regard to satellite education. Examples included using weather videos to discuss climate change and social responsibilities, showing how satellite images can benefit humanity, using weather data to teach addition to young children, and investigating meteorological conditions in Ecuador's four geographic regions. Teacher-created lessons included drawing satellites, research and building models, learning about cyclones and typhoons, using satellite weather images to teach Spanish to native English speakers, creating fictional stories, graphing local weather and making connections with astronomy. Lastly, educator comments included that *students and teachers alike learned quite a bit of new STEM information* (i.e. some students thought that only one satellite existed in all of the world), *gratitude* was expressed for the opportunity to participate, and four of the five teachers said that they'd *like to have future professional development opportunities* to participate in innovative practices similar to what was possible through this PD project.

Parents and students emerge with raised awareness and interest

Surveys conducted after the EXA Krysaor Event indicated that 88% of the students reported positive outcomes, which included feeling *more informed* and *more interested* in satellites and STEM as a result. Comments included the following: "It felt very professional to be there with all the cameras and tech systems" "The EXA experience was so amazing, and "I really want to learn more about STEM."

On the parent surveys, 83% reported feeling more informed about satellites and that the event influenced their future interest in space education, as well as their child's interest in STEM (see Figure 11). Parent responses included the following:

- *I believe that one of the failings of school education, including at the university level, is transferring what is learned to the real world. With the EXA event I could see that it is possible to achieve this: learn math through real events, while also teaching science and technology and engage our children in real areas and interests, opening their minds to new experiences. Spectacular!*
- *It was very inspiring to spend time with Commander Nader and I think that it definitely helped raise interest and motivation, not only during and after the(Krysaor) event but also before it (my son prepared himself enthusiastically). It was very worthwhile to be part of the event. Thank you!*

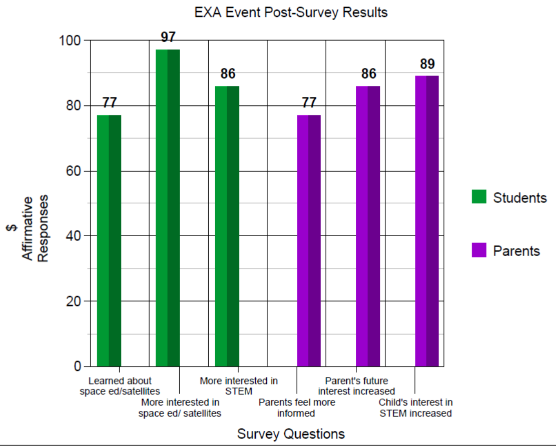

Fig. 11: EXA Event Post-Survey Results.

Additionally, after the EXA Krysaor Event, many students began showing an *increased interested in space engineering* in general, choosing to draw pictures and create prototypes out of recycled materials; both during and outside of class time. The vast majority of these designs were collaboratively created, *with those who had attended the EXA event inviting, inspiring and engaging those who did not attend* (see Figures 12 and 13).

Fig. 12: Three girls collaborate to create their idea of a space society in the future, and build models afterwards; including a space hotel and school.

Fig. 13: A student creates a space elevator prototype after sketching a layout of her concept.

The world eagerly responds

Media and educational outlets enthusiastically sought out, celebrated and informed the public of the advancements in Ecuador's satellite developments as they related to education. Radio Quito hosted a session regarding ASTERIA due to the "great interest" expressed by the public, and ECTV pronounced that these satellite advancements would "open doors to a new generation with newfound knowledge and educational developments in Ecuador [20]." The news report went on to extol the benefits of introducing a new technology into the classrooms, which would consequently allow students to see the world from a new perspective.

Various media also revealed the support of the Ecuadorian government at all levels – from the provincial premier of El Oro, to the governor of Guayas, to the Ecuadorian president himself - with regard to satellite developments in the country and the educational implications which accompanied such STEM progress[19].

As a result of these educational advances, EXA's first pilot program was recognized as a finalist for the national "Innovation in Education" award presented by the Foundation for Integration and Development in Latin America (FIDAL) [37]. In May of 2013, representatives from the Ecuadorian Ministry of Education observed satellite education in action at Academia Cotopaxi and gave the program high marks, resulting in a nomination for the Rita Lecumberri Excellence in Education award [38].

Prestigious award nominations, public interest, and government support reflected the extent to which satellite education had become known both inside and outside of Ecuador, as well as the value with which this pioneering concept was being upheld by the public.

VI. FINDINGS

With the objective of using ASTERIA and satellite education as a means to inspire, engage and educate others with regard to STEM, the educational and public outreach activities, events and resources used were successful. Data revealed that a spark was ignited in the Ecuadorian community.

Both the USFQ workshop and satellite education Professional Development Project revealed that participants enjoyed the *new opportunities, learned many new STEM concepts* and would *like to participate* in similar PD opportunities in the future. Albeit a small sample size, *positive systemic change was beginning to occur* with the classroom teachers who embedded satellite education into their classroom curriculum; as was evident from feedback that the satellite lessons provided were easily adaptable and helpful, and new inquiry lessons were additionally created. With regard to content, teachers showed that they not only used satellite imagery and online resources to become more familiar with satellite developments at EXA, but their comments revealed that all invested parties gained from the PD Project experience. Furthermore, the project allowed teachers to select satellite education content which was relevant for their classrooms, and educators utilized this in a manner which was engaging for their students, while also addressing the content standards. With regard to STEM pedagogy, email exchanges and photos revealed that students engaged in authentic learning experiences and inquiry practices which enhanced STEM learning and ignited a passion for satellite and space exploration in general.

With regard to engaging students in satellite education outside of the classroom, the opportunities addressed proved to be highly successful in providing knowledge in *STEM context*, while also sparking a *desire to explore more* STEM related ventures in the future. Furthermore, *involving parents in the EXA Krysaor Event also served as a catalyst* for inspiring engagement in science, technology engineering and mathematics as a family unit. Extending beyond the EXA event, when students returned to the classroom with a desire to create space engineering designs, the vast majority of the models were *collaboratively created, with those who had attended the EXA event inviting inspiring and engaging those who had not been present.*

Additionally, including the local and global community in ASTERIA's educational developments proved to be beneficial in making *the public aware and interested* in this novel approach to stimulating STEM interest through satellite education. Both private and public organizations sought out additional information, which resulted in a greater responsiveness towards this aspect of space exploration.

Lessons learned

With regard to outreach, a lesson learned was to scale back on expectations and encourage educators to take on new, innovative projects in "*baby steps*". As teachers are often limited in time, and may not have an equal drive or passion for STEM as it relates to aerospace education, it would be beneficial to realize that what some educators consider to be a simple undertaking can seem monumental for others. This point became evident when 15 of the original 22 PDP volunteers didn't complete the prescribed objectives. Instead, understanding that, for systemic change to take place, it is better to demonstrate innovative strategies which provide short-term gains in small increments; thereby allowing the potential for educators to reflect upon making gradual changes in their teaching practices.

Although the goal was to have 12 educators initially participate in the PD Project, instead of five, the fact that the survey comments were overwhelmingly positive - including the fact that a school requested that the workshop be presented for their own faculty - reveals that the original objective of initiating systemic change had begun.

Furthermore, many educators commented that they would like this kind of inquiry and project-based professional development to continue to be implemented throughout Ecuador.

VI. DISCUSSION

The action research addressed how best to engage others in satellite education and outreach for the purposes of increasing an interest in STEM education. One outcome of the literature review revealed that, "STEM teaching is more effective and student achievement increases when teachers join forces" (Fulton, K. & Briton, T, 2011, p.4), the outcomes of the Professional Development Project discussed in this paper imply that *project- based collaborations or mentoring among educators, whether in school or after school, can have positive results for all in the learning community.* Additionally, extending learning outside of the classroom and sharing these experiences with others, as occurred during the EXA Krysaor Event, also has the potential to exponentially reach and inspire larger audiences to become engaged in STEM, *including those who didn't actually attend the event themselves.* It is also worth noting that *parental involvement* in STEM activities served to also increase interest and engagement overall. Lastly, the outcomes of this research project reveal that *utilizing multimedia sources can serve to educate the public regarding satellite education, as well as extend this STEM outreach to a global audience.*

Challenges to engaging local and global communities in satellite education and outreach for the purposes of increasing an interest in STEM include the following: *funding* for materials and events, *administrative support* for educators with regard to technology and preparation time; *finding those* teachers who have an interest in embedding space exploration as a means for authentically addressing the curriculum standards; providing *training* for educators in a fashion that best fits their needs and time constraints, and incorporating a *larger network of educators* for providing outreach and education in general .

VII. CONCLUSION

Both the quantitative and qualitative data gathered in this action research assert that satellite education and outreach, as occurred in Ecuador through the ASTERIA program, can be positively attained through teacher training, providing authentic learning with students, and engaging the public through media discourse. These findings help contribute to the body of knowledge in aerospace education outreach as, to date, few action research projects have taken place with regard to incorporating satellite developments in the educational community.

Limitations of this action research are apparent in the limited examples provided, as well as the narrow aspect of outreach and education being proposed by a single teacher-researcher in this research project. For this reason, it is recommended that ongoing, long-term studies be conducted with regard to ways in which aerospace education can be utilized to engage an interest in STEM.

The importance of engaging students, parents, educators, administrators and the general public in STEM has a direct correlation to research which shows that STEM fields are in bigger demand globally, yet it is projected that there will be a global shortage of qualified STEM workers [39]. Aerospace education, whether it be with regard to satellites or other space exploration, can be the means by which authentic learning and outreach takes place and moves humanity forward towards 21st century advancements.

VIII. ACKNOWLEDGEMENT

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