

## **K-12 Aerospace Academy: An Out-of-School Authentic and Experiential STEM Learning Experience for College and Career Pathways to Aerospace/Aviation**

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# **K-12 Aerospace Academy: An Out-of-School Authentic and Experiential STEM Learning Experience for College and Career Pathways to Aerospace/Aviation**

## **Abstract**

The paper presents implementation and evaluation of an Aerospace Academy program geared towards exposing K-12 student population, especially underrepresented population, to high-demand aerospace and aviation fields. The program activities are designed to increase interest in a science, technology, engineering, and mathematics (STEM) fields and improve college readiness and career exposure through aerospace/aviation-themed STEM activities. Students learned about potential college and career opportunities that exist in these fields and why background in advanced science and mathematics is crucial to achieve these careers. Elizabeth City State University (ECSU) received funding through NASA and private foundations to implement a comprehensive K-12 Aerospace Academy program to expose students to STEM learning, especially minorities from rural counties surrounding ECSU. Student activities were delivered through Friday Academy, Saturday Academy and Summer Academies with participation from 235 middle and high school students. The participants comprised of 43.83% Male and 56.17% Female, participating in a total of thirty-six (36) to forty (40) hours of hands-on experience. The three key components of K-12 Aerospace Academy program at ECSU are: (i) Curriculum Enhancement Activities (CEAs) – Hands-on, inquiry-based K-12 STEM curricula, (ii) Aerospace Educational Laboratory (AEL) – both stationary and mobile, and (iii) Family Connection – parental involvement and informal education. The curriculum supports the Next Generation Science Standards and contained a strong emphasis on math and science literacy for 21<sup>st</sup> century learners. Evaluation data was gathered through Student Feedback Survey. Topics discussed in the paper will include implementation of K-12 Aerospace Academy program at ECSU, program components, participant demographics, student activities, and project evaluation.

## **Introduction**

Over the next ten years, more than half of all jobs will require some education beyond high school [1]. While adopting the Common Core State Standards should lead to more college-ready students over time, students will still need programmatic supports from secondary and postsecondary educational institutions to better prepare them for a successful transition to postsecondary education and career [2]. Students' middle and high school experiences often do not prepare them adequately for postsecondary education and the world of work. Special attention should be paid to increasing the rigor, relevance, and engagement of the high school curriculum, including for students who have traditionally faced barriers to successful postsecondary transitions.

STEM jobs, especially engineering and technology, in the United States are expected to grow nearly twice as fast as other fields by 2020 [3]. An increasing number of jobs at all levels require knowledge of mathematics and science. Hence, STEM education is crucial to the ultimate success of our young people. Several reports have linked K-12 science and math education to continued economic growth in the United States [4]. Unfortunately, there is a shortage of both interested and adequately prepared K-12 students, especially among minority youth and young

women. There are significant gaps in Scholastic Aptitude Test (SAT) achievement between student population groups: the black/white, Hispanic/white, and high-poverty/low-poverty gaps are often close to 1 standard deviation in size [5].

Gaps exist in science and math achievements for students - the foundation for engineering, thereby, impacting college readiness and completion. The reasons are many, including: lack of authentic learning activities in STEM subjects, little time for science in elementary school, inadequate K-12 teacher preparation in STEM content, poor alignment of K-12 and college curricula [6]. This achievement gap for students, especially minorities must be closed; so more youth can reach their potential in fast-growing and in demand engineering and technology fields.

Research has shown that the out-of-school environment—after school and summer—advances STEM knowledge and increases interest in STEM-related careers [2][7]. These summer and/or out-of-school-time (OST) STEM programs combined with 21<sup>st</sup> century learning environment are required to close the opportunity gap that prevents underrepresented youth from reaching their full potential in fast-growing STEM fields [8][9]. The OST activities should not only focus on motivation and engagement outcomes, but also on student learning, which includes developing competencies in math and science. The program must aim to foster students' interest in core subjects, engagement in learning activities, and improved self-efficacy, which is central to the development of students' academic motivation [10].

Studies have shown that rural students are less likely to attend colleges, have greater gaps between high school graduation and entering college, and are less likely to be continuously enrolled in college [11]. In addition, many rural students don't see the connection between their high school education and careers. Math and science focused programs can help rural students aim high while providing real-world, experiential learning opportunities. These experiences can motivate students to engage in more rigorous coursework, envision pursuing postsecondary education, and prepare for high-demand careers [11]. Several factors are associated with students' continued participation in STEM disciplines, and ultimately, their pursuit of STEM careers. An important factor is student interest in STEM. Research indicates that hands-on, inquiry-based activities delivered in informal environments are key factors in helping to develop critical thinking skills and play a significant role in increasing students' interest and engagement in STEM and the likelihood that they will consider science-related occupations [12].

The engineering-focused STEM Academy project is a partnership between an institution of higher learning, school districts, state agencies, private foundations, and other STEM enrichment programs. The key components of the project at ECSU are Curriculum Enhancement Activities (CEA) and an Aerospace Education Laboratory (AEL). NASA Aerospace Academy program at ECSU aligns with existing literature on enhancing student interest and engagement in STEM, particularly in informal settings.

### **Aerospace Academy (AA) Program at ECSU**

The NASA AA program at ECSU is a partnership between an institution of higher learning, school districts, state agencies, private foundation, and other outreach/community engagement

programs. The AA program at ECSU is unique in that it introduces groups traditionally underrepresented in STEM fields to careers in aerospace and aviation through a balanced mix of theory, hands-on activities, field trips, and guest seminars/lectures.

Hands-on learning activities integrated modern educational technology tools and inquiry-based learning to reinforce science and mathematical concepts required to enter STEM careers, especially high-demand aerospace and aviation fields. Students learned about potential college and career opportunities that exist in these fields and why a background in advanced science and mathematics is crucial to achieve these careers. However, a balance must be met for providing a rigorous academic environment for the students while allowing them to enjoy the program's activities so that they will remember the experience positively and perhaps consider engineering-related college programs and eventually pursue such careers in these fields. We met this challenge by supplementing classroom instruction with exposure to hands-on experiments, engineering design challenges, virtual simulations, guest speakers, and field trips that exposed the students to a wide variety of topics and experiences in STEM.

The program offered out-of-school-time hands-on STEM learning experience for students from middle and high school grade levels. The project target area comprised of 21 counties surrounding ECSU. This region has long suffered the effects of poverty and has lacked the opportunities for most students to encounter the 21<sup>st</sup> century workplace that is readily accessible in more urban areas of the state. However, with recent growth in the manufacturing, biotechnology, aviation and aerospace industry in the region, there now exists the potential to link K-12 STEM education to these industries. Since the beginning of the program, over 500 middle and high schools have participated in activities that were delivered through Friday Academy, Saturday Academy, and Summer Academy.

#### Project Goals:

The overarching goal of NASA AA program site at ECSU is to improve college readiness and develop career pathways to STEM fields, especially aerospace and aviation. Three specific program implementation goals are:

**Goal 1:** Advance STEM literacy by engaging students, family members and teachers through the integration of emerging technologies.

**Goal 2:** Educate students utilizing a STEM curriculum that meets national STEM standards aligned to NASA's mission directorates.

**Goal 3:** Inspire and prepare a more diverse student population to pursue college and careers in STEM-related disciplines.

#### Program Components:

The three key components of the Aerospace Academy program are: (i) Curriculum Enhancement Activities (CEA) – Hands-on, inquiry-based K-12 STEM curricula (ii) Aerospace Education Laboratory (AEL) (iii) Family Connection (FC) – parental/guardian involvement and outreach.

The program team developed curriculum enhancement activities (CEAs) by adopting a well-established Southern Regional Education Board (SREB) Advanced Career (AC) curriculum and NASA STEM curriculum with problem-based learning at its core and integrated 3D printing technology, sensor-based measurement systems, and mini Unmanned Aerial Vehicle (UAV) design activities to enhance authentic and experiential learning experiences. Integration of these technologies added an additional dimension to the value of scientific inquiry and shows how to apply scientific knowledge, procedures and mathematics to solve real problems and improve the world we live in. The curriculum supports the Next Generation Science Standards and contained a strong emphasis on math and science literacy for 21<sup>st</sup> century learners. Students participating in the outreach program completed a total of thirty-six (36) to forty (40) hours of hands-on experience.

Hands-on learning was provided through the AEL, a state-of-the-art laboratory that features collaborative learning environment and equipped with hardware and software to support curriculum enhancement activities. The hands-on activities included 3D Printing, Data/sensor acquisition, mobile Robotics programming, Wind and Solar Energy, Computer Programming (Raspberry PI/Arduino), Wind Tunnel experiments, Science Experiments and more, ready to inspire the next generation of STEM professionals. Wherever appropriate, instruction included covering relevant mathematics and science concepts needed for the hands-on activity. Activities also included demonstration to reinforce STEM topics taught during the week at respective schools where participants came from.

The FC is an interactive forum that provides STEM education and parenting or caregiving information to any supportive adult role model(s) who interacts with the students. The FP involved parents/families as a partner with the ECSU AA site in the planning, design and implementation of the NASA inspired curriculum. Parents/Guardians were provided STEM skills to engage them in supporting their children's learning at home.

## **Program Delivery and Activities**

### Student Participation:

The outreach and intervention initiative in this project targeted middle and high school students, especially from underrepresented background within the 21 county school districts. This region is by far one of the most economically disadvantaged, underserved, and rural communities in the state and nation. In order to meet our targets, ECSU AA site established partnership with school districts, STEM-focused schools, and NC Math and Science Education Network (NC-MSEN) program on campus. Using this approach made it easier for the site to recruit students for the program. Additional funding for project activities came from private foundations and state agencies.

The program offering was marketed to all the schools in the 21 county areas to develop ongoing school partnerships. Marketing materials created in the program development stage (Brochures, Flyers, Emails and Web links) were distributed to each district office and school in the targeted area. Additionally, project team members contacted each school superintendent directly, distributed applications to guidance counselors, and were available for questions.

The team members took time to explain that the purpose of this endeavor to provide awareness to middle and high school students, particularly minority, female and disadvantaged youth, about STEM careers and encourage them to consider a STEM-related course of study in higher education and career pursuits. Applications were made available online to download from the project website. The program had set up a target of at least sixty percent (60%) participation from underrepresented ethnic groups and at least fifty percent (50%) female participation. The NASA AA program is offered at no cost to participants.

A total of 235 students participated in the AA program at ECSU during the second year of implementation. Students participated through Friday Academies, Saturday Academies, and Summer Academies.

Program Sessions and Activities:

Program activities were critical in achieving program goals of advancing STEM literacy, educating students utilizing a curriculum that meets national STEM standards, and inspire and prepare a more diverse student population to pursue college and careers in STEM-related disciplines. Program activities included CEAs, field trips, guest speakers, laboratory visits, mentorship, interactions with professionals, team projects, engineering design competition, and other confidence building exercises. All program activities were conducted under the supervision of ECSU faculty members and certified K-12 instructors from partnering school districts.

A summary of program activities and sessions are shown in Table 1.

Table 1: Program Activities

Sessions	Duration	# of Sessions	Grade Level	Activities/Topics
Friday Academy (Spring and Fall)	3-4 hours	10-11	Middle Grade only (6-8 grade)	Engineering Design Principle, Lego Robotics “Mission to Mars” Challenge, sensors, renewable energy, basic electronic circuits, sensor, interaction with scientist, visiting research lab
Saturday Academy (Spring and Fall)	3-4 hours	10-11	Middle and High (6-8, 9-12)	Robotics, computer programming, Arduino microcontrollers, basic electronic circuits, guest speaker, field trip, SAT/ACT preparation, college level writing, study skills, time management, high school course selection, college/scholarship application process, financial planning
Summer Academy – Residential	1 week (7-8 hours/day)	2 camps	High School only (9-12 grade)	Engineering Design Principle, Wind Turbine design challenge, electronics, mobile robotics, rocketry, Arduino microcontrollers, renewable energy, computer programming, field trips, guest speaker.

K-12 Professional Development	6 hours/day	3 sessions	K-12	Engineering design, robotics, programming
Parental Involvement	2-3 hours	4 sessions		Showcase student activities, college preparation, dual credit, college admission requirements and scholarships, hands-on STEM activities, guest speaker
Field Trip		6 trips		Virginia Air and Space Museum, Wright Brothers Memorial, NC State University, Amazon Wind Energy Farm, USCG Air Station
Guest Speakers	1-2 hours	4 speakers		Careers and Opportunities with NASA, Significance of STEM, Careers in Aerospace and Aviation, Preparing for College and Beyond

## Program Evaluation and Results

### *Evaluation Instruments*

Data collection instruments that were used for conducting evaluation included Student Application/Parental Survey and Student Feedback Survey. The participating students were administered evaluation instrument only after all necessary release of privacy documents as prescribed by ECSU Institutional Review Board (IRB) procedures were completed. ECSU AA project team has received IRB approval (IRB Approval Notice #17-0009 NASA Minority University Research and Education Project (MUREP)) via an expedited review process.

A brief description of evaluation instruments that were used to evaluate AA program at ECSU are as follows:

*Student Application and Parental Survey:* Student application and parental survey were used during the application process to collect student grade level, gender, county, parental marital status, household economic status, employment status, education, their reasons for enrolling their children in AA program camp and exposure to STEM careers if parents worked in the industry.

*Aerospace Academy Student Feedback Survey:* This survey will be completed by student participants after completing at least 36hrs on hands-on learning. The survey is used to assess the overall interest towards STEM degree and careers. ECSU AA Program adopted (and modified) a post only survey originally developed by The Program Evaluation Group for Science enrichment programs.

In addition, a survey will be developed by the project team to follow up with student progress in their academic pursuit. The participants' will be made aware that they will be getting a follow-up survey by mail and/or email. Student participant follow-up study will help determine how many student participants were admitted or attending college in STEM field, track students throughout their college careers, and how their experience in the AA program at ECSU helped them to attain their college goal. The follow-up survey will be sent out in Spring 2019.

## Results

The bar graph in Figure 1 shows the program participants by grade level.

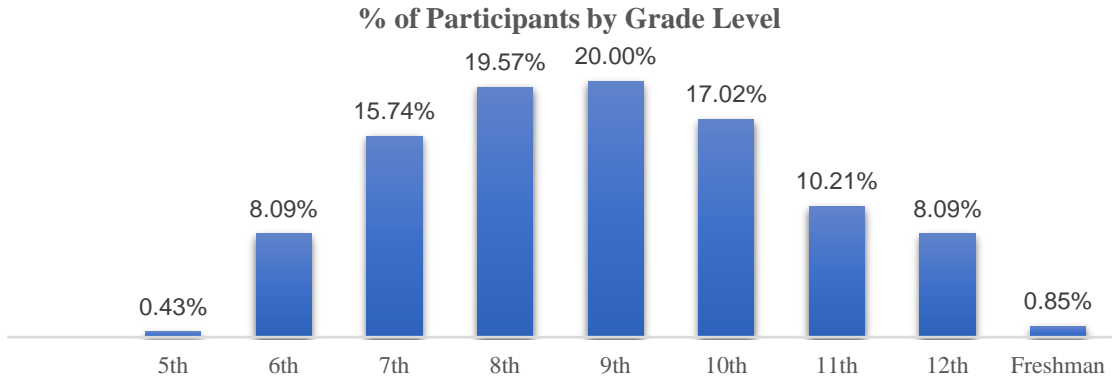


Figure 1: Grade Level of Student Participants

The graph shows that, approximately 56% of participants were from high school and 44% of participants were from middle school grade level. 56.17% of the participants were female and 43.83% were male as seen in Figure 2.

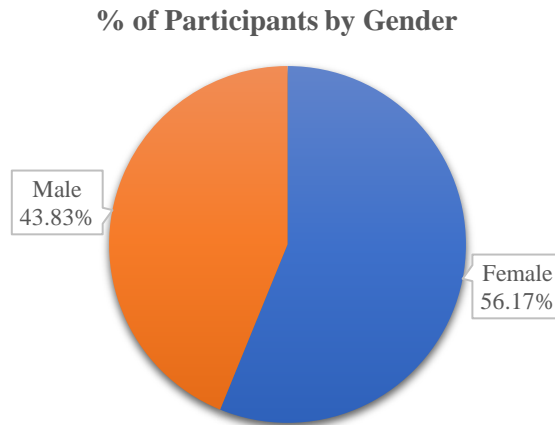


Figure 2: Participants Gender

Figure 3 shows program participants by ethnicity. As shown in the Figure 3, over 65% of participants came from minority groups.



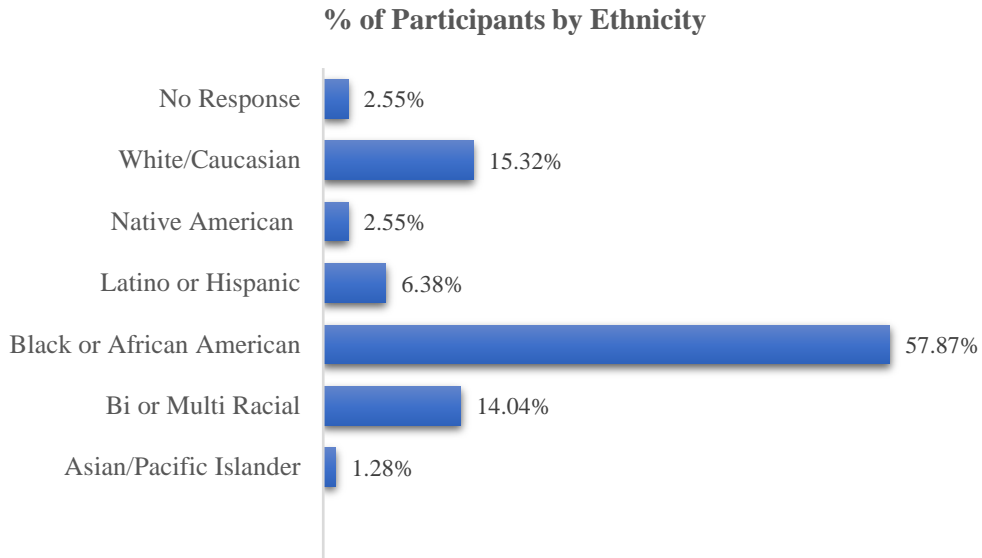


Figure 3: Program Participants Ethnicity

The graph in Figure 4 indicates over 70% of participants came from families where neither of the parent had a STEM degree and were not working in a STEM field.

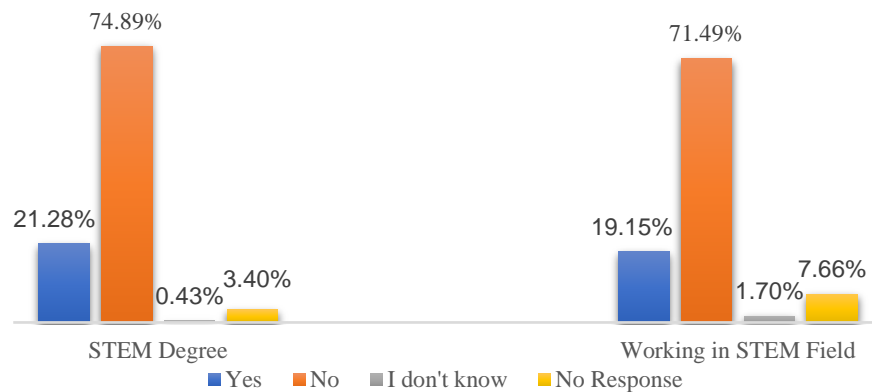


Figure 4: % of Respondents with a Parent that that a STEM degree or work in STEM-related field

Table 2 shows how Student Feedback Survey questions are mapped to three program goals.

Table 2. Mapping Aerospace Academy program goals to Student Feedback Survey questions

Goal 1: Advance STEM literacy by engaging students, family members and teachers through the integration of emerging technologies.	Student Feedback Survey (Q1a-d) at the end of Friday Academy, Saturday Academy, and Summer Academy sessions
Goal 2: Educate students utilizing a STEM curriculum that meets national STEM standards aligned to NASA's mission directorates.	Student Feedback Survey (Q1e-f), Q3, and Q4
Goal 3: Inspire and prepare a more diverse student population to pursue college and careers in STEM-related disciplines.	Student Feedback Survey (Q1g) and Q5

The bar graph in Figure 5 shows responses to Q1a-g from Student Feedback Survey instrument. Students responded to each question on a five-point Likert scale of: Strongly Disagree; Disagree; I don't know; Agree; Strongly Agree.

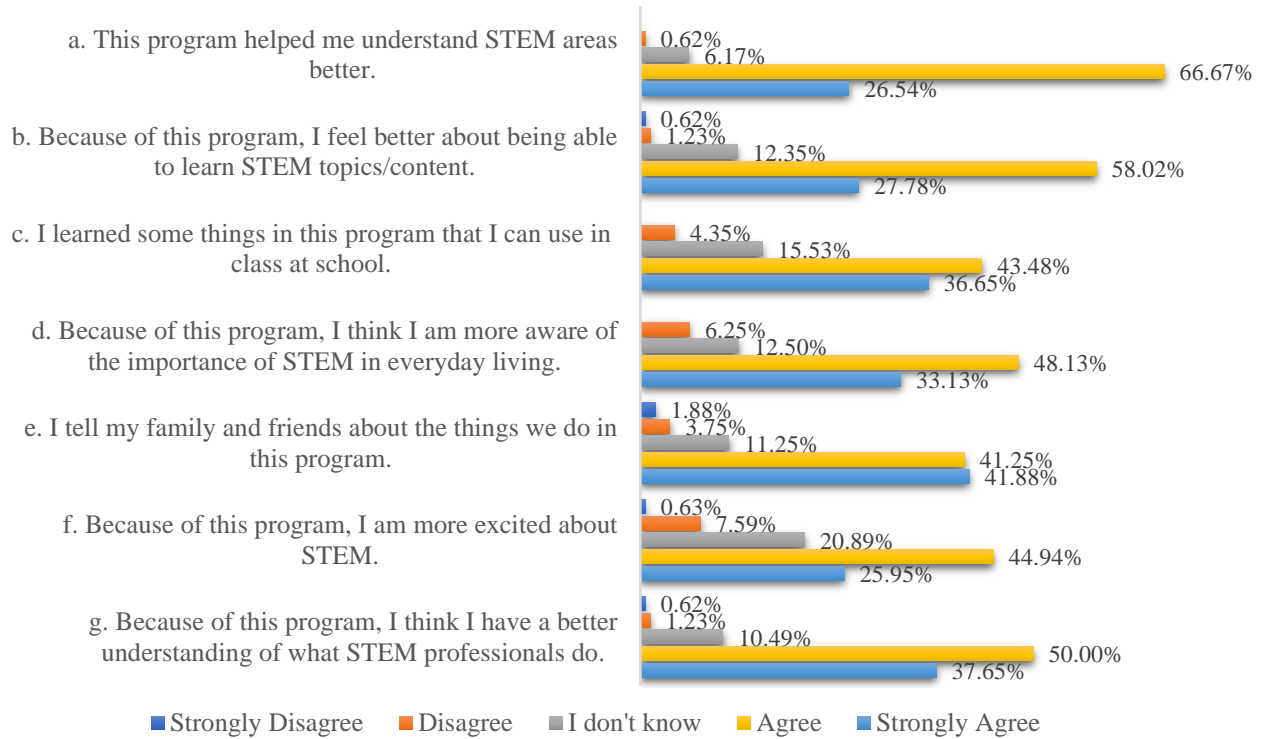


Figure 5: % Respondents to Question 1a-g on Student Feedback Survey

Figure 6 indicates the percentage of students who responded with yes on whether they will participate in another program or recommend the AA program to their friends.

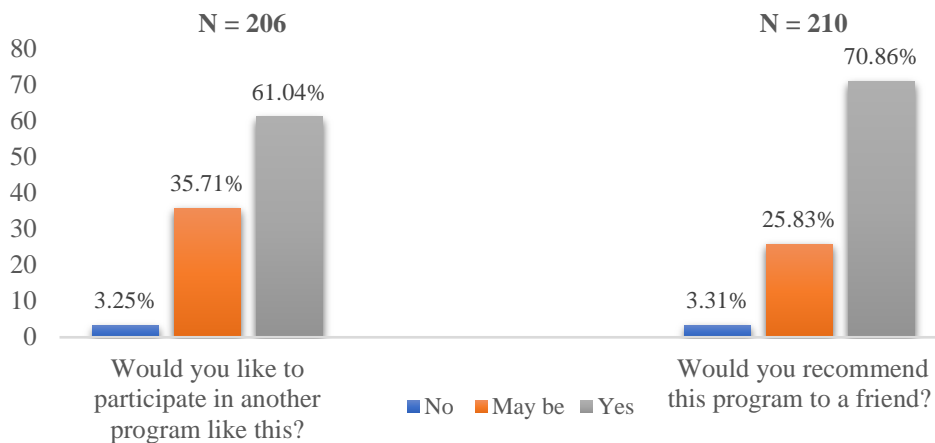


Figure 6: % Respondents to Q2a-b

Figure 7 indicates change in interest towards STEM learning after participating in the program.

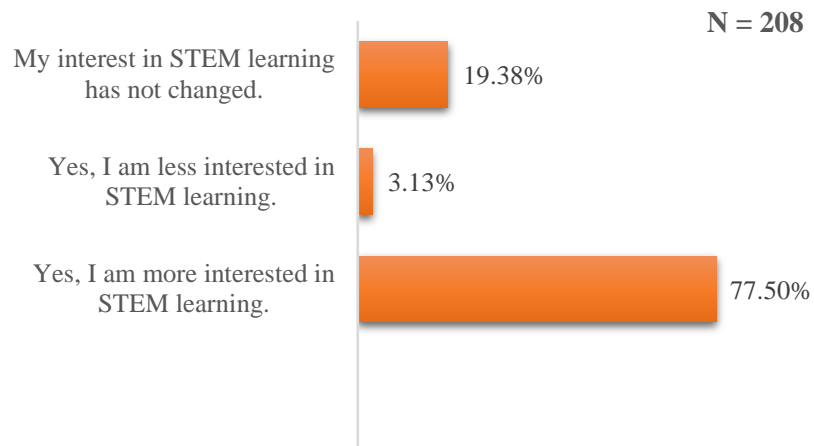


Figure 7: Change in interest towards STEM learning

As shown in the Figure 7 graph, 77.50% of valid respondents (N=208) indicated they are more interested in STEM learning after participating in the program. Approximately 20% indicated their interest about STEM learning has not changed. The responses to change in interest level towards STEM learning (Q3) were cross-tabulated by gender as shown in Table 3a.

Table 3a: Q3 responses cross-tabulated by gender

Q3		Has this program changed your feelings about STEM learning? (N=199)			
		MORE (1)	LESS (2)	NO CHANGE (3)	
GENDER	Female (1)	<b>86</b> <b>(78.89%)</b>	3	20	<b>109</b>
	Male (2)	<b>69</b> <b>(76.67%)</b>	2	19	<b>90</b>

As seen from Table 3a, within the gender, 78.89% of female respondents out of total female respondents and 76.67% of male respondents out of total male respondents expressed increase interest in STEM learning.

Table 3b show responses to Q3 cross-tabulated by ethnicity. For data presentation purposes the ethnic groups (Asian/Pacific Islander, Native American, Hispanic, Bi or Multi racial and Other) were categorized as Others.

Table 3b: Q3 responses cross-tabulated by Ethnicity

Q3		Has this program changed your feelings about STEM learning? (N=208)			
		MORE (1)	LESS (2)	NO CHANGE (3)	

ETHNICITY	African-American (1)				
	African-American (1)	<b>96 (79.33%)</b>	4	21	<b>121</b>
	White (2)	<b>23 (71.87%)</b>	1	8	<b>32</b>
Others (3)	<b>41 (74.54%)</b>	2	12	<b>55</b>	

As seen in Table 3b, 79.33% (96/120) of total African-American respondents, 71.87% of total White respondents, and 74.54% of total “Others” respondents indicated they were more interested in STEM learning after AA program participation.

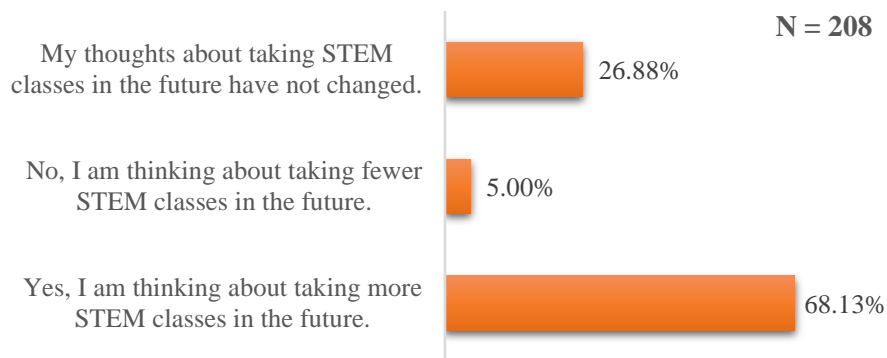


Figure 8: Change in interest in towards taking STEM classes in future

Figure 8 captures change in interest in taking STEM classes in the future. As shown in Figure 8, 68.3% of valid respondents (N=208) indicated that they are thinking about taking more STEM classes in the future.

Table 4a presents cross-tabulation of responses to Q4 by gender. As seen from Table 4a, within the gender, 74.31% of female respondents out of total female respondents and 66.67% of male respondents out of total male respondents expressed increase interest in taking more STEM classes in the future.

Table 4a: Q4 responses cross-tabulated by Gender

Q6 Has this program encouraged you to think about taking more STEM classes in the future? (N=199)				
	MORE (1)	FEWER (2)	NO CHANGE (3)	

GENDER	Female (1)	<b>81 (74.31%)</b>	5	23	<b>109</b>
	Male (2)	<b>60 (66.67%)</b>	5	25	<b>90</b>

Table 4b show responses to Q4 cross-tabulated by ethnicity.

Table 4b: Q4 responses cross-tabulated by Ethnicity

Q6 Has this program encouraged you to think about taking more STEM classes in the future? (N=205)					
		MORE (1)	FEWER (2)	NO CHANGE (3)	
ETHNICITY	African-American (1)	<b>82 (68.33%)</b>	8	30	<b>120</b>
	White (2)	<b>22 (70.96%)</b>	1	8	<b>31</b>
	Other (3)	<b>39 (72.22%)</b>	2	13	<b>54</b>

As seen in Table 4b, 68.33% (82/120) of total African-American respondents, 70.96% of total White respondents, and 72.22% of total “Others” respondents indicated they were more interested in taking STEM classes in future.

Figure 9 presents data regarding change in student attitude/interest about getting a job in STEM-related career.

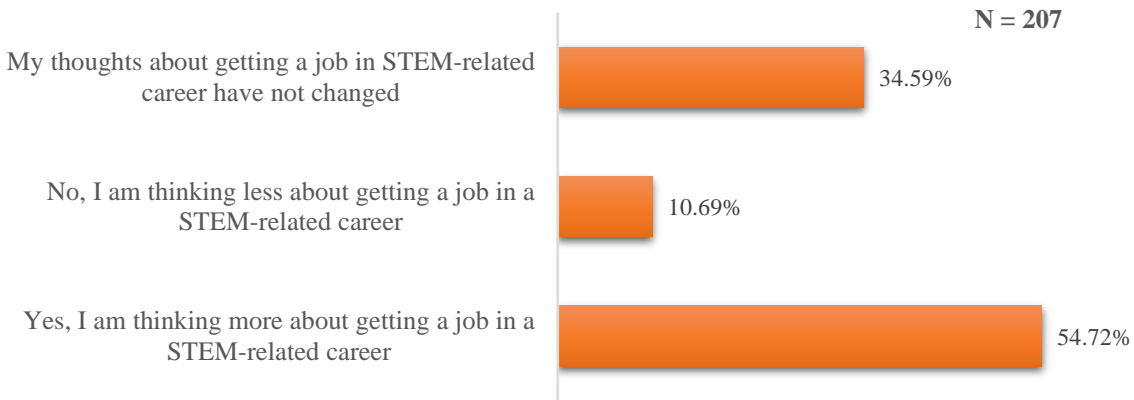


Figure 9: Change in attitude towards taking STEM classes in future

As shown in Figure 9, approximately 55% of valid respondents indicated that they were thinking more about getting a job in a STEM-related career after participating in the program. Table 5a presents cross-tabulation of responses to Q5 by gender. As seen from Table 5a, within the gender, 62.38% of female respondents out of total female respondents and 63.33% of male respondents out of total male respondents expressed increase interest in getting a job in a STEM-related career.

Table 5a: Q5 responses cross-tabulated by Gender

Q5		Has this activity encouraged you to think more about getting a job in a STEM-related career? (N=199)			
		MORE (1)	LESS (2)	NO CHANGE (3)	
GENDER	Female (1)	<b>68</b> <b>(62.38%)</b>	12	29	<b>109</b>
	Male (2)	<b>57</b> <b>(63.33%)</b>	8	25	<b>90</b>

Table 5b shows change in attitude towards getting a job in STEM-related career cross-tabulated by ethnicity.

Table 5b: Q5 responses cross-tabulated by Ethnicity

Q5		Has this activity encouraged you to think more about getting a job in a STEM-related career? (N=205)			
		MORE (1)	LESS (2)	NO CHANGE (3)	
ETHNICITY	African-American (1)	<b>78</b> <b>(65.00%)</b>	11	31	<b>120</b>

White (2)	<b>17</b> <b>(54.83%)</b>	2	12	<b>31</b>
Other (3)	<b>33</b> <b>(61.11%)</b>	6	15	<b>54</b>

As seen in Table 5b, 65.00% (78/120) of total African-American respondents, 54.83% of total White respondents, and 61.11% of total “Others” respondents indicated they were more interested in STEM-related careers because of participation in AA program.

### **Conclusion**

Northeastern North Carolina has long suffered the effects of poverty and has lacked the opportunities for most students to encounter the 21<sup>st</sup> Century workplace that is readily accessible in more urban areas of the state. However, with recent growth in the aviation and aerospace industry in the region, there now exists the potential to link K-12 education to the aviation and aerospace industry. The paper presented implementation and evaluation of an Aerospace Academy program geared towards exposing K-12 student population, especially underrepresented population, to high-demand aerospace and aviation fields. The program activities are designed to increase interest in a science, technology, engineering, and mathematics (STEM) fields and improve college readiness and career exposure through aerospace/aviation-themed STEM activities. A total of 235 student participated during the second year of implementation. The program was delivered through Friday Academy, Saturday Academy, and Summer Academy. Program was successful meeting its target of recruiting over sixty percent (60%) from underrepresented groups. Through field trips, guest speakers, and career awareness sessions, students learned about potential college and career opportunities that exist in these fields and why background in advanced science and mathematics is crucial to achieve these careers. After the end of third year, a follow-up survey will be sent out to all participants to determine how many participants were admitted or attending college in STEM field, and how their experience in the program helped them to attain their college goal. The Aerospace Academy program at ECSU will contribute strengthening the STEM pipeline and seek opportunities to create pathways leading students to post-secondary degrees, and ultimately to life-long, sustainable careers. The project will increase the number of students prepared to enter college and pursue STEM degrees and careers.

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