Spring 2023

The Influence of In-School Time (IST) and Out-of-School Time (OST) Learning Experiences on Aviation Career Entry

Andrew Koch
Embry-Riddle Aeronautical University, kocha4@my.erau.edu

The Influence of In-School Time (IST) and Out-of-School Time (OST) Learning Experiences on Aviation Career Entry

Andrew Koch

Dissertation Submitted to the College of Aviation in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Aviation

Embry-Riddle Aeronautical University

Daytona Beach, Florida

March 2023

The Influence of In-School Time (IST) and Out-of-School Time (OST) Learning Experiences on Aviation Career Entry

By

Andrew Koch

This dissertation was prepared under the direction of the candidate's Dissertation Committee Chair, Dr. Jennifer Thropp, and has been approved by the members of the dissertation committee. It was submitted to the College of Aviation and was accepted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Aviation.

Jennifer E. Thropp Digitally signed by Jennifer E. Thropp Date: 2023.03.21 17:29:07 -04'00'

Jennifer E. Thropp, Ph.D.
Committee Chair

Kadie Mullins Digitally signed by Kadie Mullins Date: 2023.03.22 13:58:42 -04'00'

Kadie Mullins, Ed.D.
Committee Member

Jing Yu Pan Digitally signed by Jing Yu Pan Date: 2023.03.22 14:53:20 -04'00'

Jing Yu Pan, Ph.D.
Committee Member

Michael E. Wiggins, Ed.D Digitally signed by Michael E. Wiggins, Ed.D Date: 2023.03.22 22:06:19 -04'00'

Michael E. Wiggins, Ed.D.
Committee Member

Jake Heibel, Ed.D.

Jake Heibel, Ed.D.
Committee Member (External)

Steven Hampton Digitally signed by Steven Hampton Date: 2023.04.14 09:50:22 -04'00'

Steven Hampton, Ed.D.
Associate Dean, School of Graduate Studies, College of Aviation

Alan J. Stolzer Digitally signed by Alan J. Stolzer Date: 2023.04.14 10:49:32 -04'00'

Alan J. Stolzer, Ph.D.
Dean, College of Aviation

Lon Moeller Digitally signed by Lon Moeller Date: 2023.04.14 11:24:27 -04'00'

Lon Moeller, J.D.
Senior Vice President for Academic Affairs and Provost

April 13, 2023

Signature Page Date

Abstract

Researcher: Andrew Koch

Title: The Influence of In-School Time (IST) and Out-of-School Time (OST) Learning Experiences on Aviation Career Entry

Institution: Embry-Riddle Aeronautical University

Degree: Doctor of Philosophy in Aviation

Year: 2023

Increased demand for aviation has created a skill and workforce gap. An understanding of how to increase this potential workforce is vital to ensure the ongoing success and sustainability of the commercial aviation industry. This research explores science, technology, engineering, and math (STEM) programs as a potential avenue for increasing the available aviation workforce. Specifically, it explores how STEM programs and their associated learning experiences influence career entry.

Utilizing a mixed methodology approach, this research retrospectively explored the self-reported effect of out-of-school time (OST) and in-school time (IST) STEM experiences on aviation career development. Through interviews, a survey instrument was developed and validated that allowed for an assessment of the impact of STEM experiences on career interest. Through data analysis, specific major factors were extracted. The results were analyzed and assessed in the context of the existing aviation and career development literature.

Data analysis revealed that STEM participation type impacted both the professional interaction and career knowledge constructs. Those participants who were involved in both an OST and IST STEM program had higher mean professional interaction and career knowledge scores compared to those individuals that only participated in an IST STEM program. Individually examining each variable revealed key findings related to mentor interaction, career focus, and career confidence. The results are discussed in the context of the existing literature and social cognitive career theory (SCCT). In particular, the career focus and career confidence findings, related to the SCCT concept of self-efficacy, suggests that OST STEM education is more impactful upon aviation career self-efficacy than IST STEM education. Recommendations are made for future aviation and non-aviation STEM programs.

Keywords: STEM education, career development, SCCT, mentoring

Dedication

To my parents, Paul and Kathy Koch, who have always been my biggest supporters in life.

Acknowledgments

To my family, who supported me and believed in my potential. They were there in the background providing support throughout both the struggles and successes.

To my dissertation committee, for their time and thoughtful contributions. I would especially like to thank Dr. Kadie Mullins, Dr. Haydee Cuevas, and Dr. Jennifer Thropp for serving as committee chairs throughout this effort.

To the faculty, staff, and students at Embry-Riddle Aeronautical University, for facilitating a vibrant academic environment. I would especially like to thank Cohort 10 for sharing this journey with me and providing so much support and encouragement.

To Naval Air Warfare Center Aircraft Division, for supporting and funding my higher education while also providing me with the opportunity to serve my country as a civil servant. The work we do there is making a difference. I'm grateful to the Navy for investing in me and providing continuous support as I grow my professional skills.

To my friends and family at Lexington Park Volunteer Rescue Squad, for teaching me the importance of service. From my entry as a teenager to my current role as a chief officer, I've learned so much about my community. Every day I better understand the importance of leadership and why I should value what I have.

Finally, to my friends and colleagues at growingSTEMS and FIRST Team 836, The RoboBees, for developing my passion for STEM education and outreach. Each and every one of my students has taught me something valuable and influenced who I am. I'm proud to see where they are now and what great things they are accomplishing.

Table of Contents

Page

List of Tables

List of Figures

Chapter I: Introduction

This study investigated the role that out-of-school time (OST) science, technology, engineering, and math (STEM) programs have on the recruitment and retention of the aviation workforce. An OST program, which refers to an after-school learning activity that takes place outside the normal school curriculum, can provide unique benefits to career development. The field of aviation requires a large and highly specialized workforce. Increased demand for aviation has created a skill and workforce gap (Boeing, 2016). This research explores OST STEM programs as a potential avenue for increasing the available aviation workforce. Chapter I focuses on the background prompting this research, explores the underlying concepts in the extant literature, and identifies the research questions and hypotheses investigated in this study.

Background

The aviation field is experiencing a shortage of trained and experienced individuals, including (but not limited to) pilots, air traffic controllers, and maintainers. Recent changes to pilot requirements, including increased flight hours, combined with mandatory retirements, have resulted in a shortage of qualified pilots (GAO, 2018). Simultaneously, many flight schools are having difficulty recruiting potential pilots and filling their class capacity (GAO, 2018). This challenge can be attributed to various factors, such as the high cost of flight training and the lack of qualified instructors (GAO, 2018). This blockage in the training pipeline leads to a lack of entry-level as well as experienced aviation personnel, limiting growth in a time of increased retirements. It is, therefore, important that the field of aviation collectively ensures a suitable workforce by improving the recruitment and retention of personnel.

In addition to the factors that inhibit the training of aviation personnel, such as rigorous certification requirements, the growth of the aviation industry itself is creating demand for pilots, aircrew, and aircraft maintainers that outpaces the current level and status quo. A report by Boeing (2016) predicts that the aviation industry will require more than two million additional aviation personnel between 2016 and 2035. It is also estimated that between 200,000 and 790,000 new pilots will be needed in the next two decades (Caraway, 2020). This growth can be attributed to the increase in air travel across the globe, resulting in increased demand, as well as a result of workforce attrition. While a large amount of the anticipated growth is expected to occur in the Asia-Pacific region, substantial growth is still expected in North America (Boeing, 2016).

Various, recent global events have negatively affected the aviation industry. Of note, these include the heightened security threats following the September 11, 2001, terrorist attacks, the Great Recession of 2007-2009, and, more recently, the COVID-19 global pandemic depression in air travel and the associated reduction in the workforce due to incentivized retirements and furloughs. These events and factors have changed, and have the potential to continue to change, the mid to long-term outlook of the aviation workforce.

The long-term future of the aviation employee workforce is uncertain. Research cannot definitively predict the future recovery of the industry, especially as a result of depression resulting from an unprecedented pandemic with no historical data to draw upon. The existing literature (Miani et al., 2021) indicates concern among some pilots in training regarding their future in the aviation field. Those who are new entries into the aviation field may believe there is a potential oversupply of pilots, as a result of a reduction in flights due to COVID-19. However, some consultants (Murray, 2021) believe that contrary to the perception of an oversupply of aviation personnel, there may continue to be a personnel shortage in the long term. Recent forecasting reveals additional pilot shortages attributed to the early retirements at the peak of COVID-19 ("Pilot Shortage Expected to Worsen over next Decade," 2022)

The unpredictable and rapidly changing nature of the aviation field may turn away potential pilots and aviation personnel in favor of a more stable career field. Those individuals interested in consistent, long-term careers without the risk of furloughs and significant workforce changes may opt to pursue a field that is less susceptible to rapid change. The nature of this unfavorable career environment, combined with increased retirements and furloughs, could further result in a shortage of trained aviation personnel. One estimate places it at a global shortage of between 35,000 and 50,000 pilots by 2025 (Murray, 2021). Another estimate predicts a global shortage of 80,000 by 2032 ("Pilot Shortage Expected to Worsen over next Decade," 2022). Regardless of the exact number of positions, there will likely continue to be some deficit in trained personnel. This potential deficit will need to be addressed by the aviation industry.

This aviation workforce shortage encourages companies to explore different methods and avenues of recruiting and retaining individuals in the aviation workforce. One such alternative strategy is to encourage the exploration of aviation careers in youth, with a focus on examining how the aviation industry can promote interest in pursuing a career in aviation. An individual's career selection process is a complicated and multifaceted issue that can be influenced by choice factors (e.g., interest, ability considerations), contextual factors (e.g., social/family influences, work experience), and barriers (e.g., financial, negative experiences) (Lent et al., 2002). Specific to STEM fields, exposure to STEM concepts at a young age is important for long-term career interest in a STEM-related field (van Tuijl & van der Molen, 2016). Students who displayed a high level of STEM interest by early high school were nine times more likely to report STEM career interest when in undergraduate school than those who did not display a high level of STEM interest by early high school (P. M. Sadler et al., 2012).

In addition to the impact provided by traditional STEM education occurring in classrooms, an individual's interest in STEM might be influenced by their participation in out-of-school time (OST) activities. OST programs fulfill a niche in the STEM education area. These programs differ from school-based programs in that they tend to supplement, rather than replace, the general education provided by schools. They should not be seen as an extension of in-school time (IST) STEM programs, as they draw on different resources and seek to achieve different outcomes (Bevan et al., 2010). For example, whereas an IST STEM program, developed and implemented primarily by educators might have the primary goal of increasing STEM knowledge and entry into higher education and academia, an OST STEM program developed and implemented by STEM industry partners might have the primary goal of increasing STEM workforce participation.

As these OST programs often have different goals than IST STEM programs, they often operate and function differently. OST STEM programs tend to develop supportive and low-stakes environments in which students can engage in learning activities and explore interests (Bevan et al., 2010). These OST programs, such as STEM summer camps (Mohr-Schroeder et al., 2014) and STEM competitions (Miller et al., 2017), have been shown to increase STEM career interest in participants. In fact, OST programs have been directly associated with an increase in STEM career interest up to the university level (Dabney et al., 2012).

In addition to the benefit of increasing STEM interest, OST STEM programs have been shown to positively influence self-determination and career motivation (Covert et al., 2019). Traditionally, OST STEM programs tend to focus on engaging students in practical and concrete activities. Preference for these activities is associated with “a stronger likelihood of pursuing STEM careers than those who do not prefer such activities.” (Blotnicky et al., 2018, p. 13). This real-world relevance, characterized by the overt similarity of student activities to those activities conducted by professionals, has been shown to be a major factor in the success of STEM programs, with at least one study (Kitchen et al., 2018) indicating that the presence of real-world relevance in a STEM OST program is a deciding factor as to the effectiveness of a STEM program at enhancing interest in STEM careers, the ultimate goal of STEM programs. Evidence of this appears in other non-aviation fields. Research has shown that exposure to the emergency medical services (EMS) field outside high school is shown to be a predictor of entry into that field (Holloman & Hubble, 2012). Similar results can be seen with regard to the general medical field (Fernandez-Repollet et al., 2018) and environmental science (Flowers et al., 2016).

The importance of this real-world relevance in OST STEM programs suggests a beneficial impact on STEM career aspirations. Kitchen et al. reveal that participants in OST STEM programs had “1.4 times the odds of reporting end of high school STEM career aspirations, relative to their nonparticipating peers” (2018, p. 540). Additional research supports the value that OST STEM programs have on promoting STEM career interest (P. J. Allen et al., 2019; J. R. Young et al., 2016). While not necessarily focused on aviation, these OST STEM programs incorporate some features conducive to enhancing interest in the aviation field. These features can include access to mentors in the industry and experience in real-word STEM applications. Individuals who choose a career in aviation tend to have a high level of career focus and often report an interest in aviation before the college level (R. T. Allen & Barnhart, 2006). Furthermore, they often have developed this interest due to personal activities, such as through interaction with aviation professionals (R. T. Allen & Barnhart, 2006). Many point to friends or family members as being large influences on their career decision (Pendergrass, 2008). OST STEM programs, which take place outside of traditional school hours, often involve industry professionals who replace or supplement teacher participation during these afterschool sessions. This participation by industry professionals allows a direct connection to aviation careers.

Aviation-focused OST STEM programs are less prevalent than those of general OST STEM. Some programs, such as the Aviation Career Education (ACE) Academy (Esser & Ryan, 1998), have also been in existence for several decades and focus on aviation and general STEM topics. These programs often have a primary or secondary goal of encouraging aviation career development (Rawat et al., 2018; Surra & Litowitz, 2015). Though some research has examined aviation-based OST STEM programs, this research has not yet fully examined the impact of these aviation-based OST STEM programs on the participants' career choices (Baguio et al., 2015; Demirci, 2018; Esser & Ryan, 1998). Furthermore, there is a dearth of research available on the factors that make these aviation-based OST STEM programs effective at achieving their goal of increasing aviation career interest. Existing research assumes that STEM education is beneficial to aviation career interest (Garcia & Manaia, 2019; Rawat et al., 2018; Surra & Litowitz, 2015). However, an in-depth analysis of how these STEM education programs contribute to aviation career interest is lacking. How well do these aviation-based OST STEM programs fulfill the goal of encouraging employment in the aviation field?

Statement of the Problem

The aviation field is currently facing workforce deficits (GAO, 2018). The scarcity of pilots, aircrew, engineers, maintainers, and support staff can cause long-term damage to the aviation industry, including the contraction of regional airlines and their operations (Klapper & Ruff-Stahl, 2019). Even though a major barrier to pilot development involves issues related to training (GAO, 2018), providing a larger pool of interested applicants can provide the aviation industry with additional flexibility in employment.

To achieve this goal of drawing additional applicants, a better understanding of how individuals are inspired to enter the field of aviation is required. Gaining insight into this process provides the opportunity to develop strategies that allow employers in the aviation industry to more effectively reach out to the nascent youth population. To accomplish this goal, this study explored the intersection of aviation and education, specifically the aspect of OST STEM education.

STEM programs have historically shown high efficacy in promoting both youth interest and self-efficacy in STEM fields (Chan et al., 2020), which is associated with an interest in STEM careers (Wiebe et al., 2018). OST STEM programs, in particular, have been shown to be valuable in promoting STEM interest (Chan et al., 2020; J. R. Young et al., 2016). Based on the existing literature focused on general STEM careers (Dabney et al., 2012; Saw et al., 2019), it is believed that OST STEM programs provide features (e.g., industry mentors, access to unique equipment, real-world experience) that would offer an advantage in enhancing aviation career interest. However, to date, there are no known studies that examine OST and IST STEM programs in the context of aviation career interests. Furthermore, as noted in the literature (Dabney et al., 2012), there is a lack of understanding of the specific features of OST STEM programs that modify student interests. How, exactly, these learning experiences translate to STEM interest and, ultimately, career outcomes is not completely known.

In order to assist in addressing the aviation workforce deficits, this research examined the impact of student participation, as retrospectively perceived by those student participants, on OST STEM programs on aviation career interest. By exploring this under-researched area, this study provides a better understanding of how these OST STEM programs can influence career interest.

Purpose Statement

The purpose of this exploratory sequential mixed methods study was to examine the perceived impact of OST STEM experiences, as compared to IST STEM experiences, on the career path of current aviation employees. Specifically, the increased understanding of these factors, seen through the context of Social Cognitive Career Theory (SCCT), and the comparison between OST and IST STEM learning experiences, provide a basis for theoretical contributions and efforts aimed at promoting the aviation workforce development efforts. As there is a relative lack of information about the topic of STEM programs in aviation workforce development, this research initially took an initial qualitative approach to examine the impact of STEM education on the aviation field. The subsequent quantitative analysis further explored and validated the initial qualitative findings, as well as served as a method of hypothesis testing. The findings can be used to develop OST STEM programs that better emphasize the programmatic features that are shown to increase interest and promote career choices related to the aviation career field, indirectly addressing the aviation workforce gap.

Significance of the Study

This research addresses the gap in the available literature concerning the unique aspects of OST STEM programs as compared to IST STEM programs, including how these factors influence career entry. This study contributes to the existing theory of career development by identifying specific factors of learning experiences that ultimately influence aviation career development and promote career choice.

This dissertation provides practical contributions by identifying the specific areas by which existing STEM education efforts excel at influencing career development. Finding these effective methods of increasing aviation career interest will benefit future STEM students by providing the opportunity for more targeted career guidance. The results also benefit the aviation industry by facilitating more effective aviation STEM programs and, ultimately, a potential increase in the available workforce for STEM-focused career fields.

Research Question and Hypotheses

The purpose of this study was to examine the influence of OST STEM learning experiences on the career path of aviation employees. To this end, two research questions were developed to aid in this investigation. Each question touched on a specific aspect of the OST STEM experience as it relates to the aviation career field.

RQ_1 What type of learning experiences do former participants of OST STEM programs self-report as influencing entry into their aviation career?

RQ_2 How do OST STEM program learning experiences differ from IST STEM learning experiences, either alone or in combination, at increasing interest in an aviation career?

Examination of these various research questions ultimately required null hypothesis significance testing (NHST), with hypotheses generated from data collected from an initial qualitative analysis. The following alternative hypotheses were utilized in the data analysis, further explained in Chapters III and IV.

H_A1 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the professional interaction construct.

H_A2 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career knowledge construct.

H_A3 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the industry interaction variable.

H_A4 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the mentor interaction variable.

H_A5 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the community interaction variable.

H_A6 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the aviation exposure variable.

H_A7 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the aviation skills variable.

H_A8 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the hands-on education variable.

H_A9 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the skills development variable.

H_A10 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career development variable.

H_A11 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career confidence variable.

H_A12 There is a statistically significant difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career focus variable.

Delimitations

Participation in this study was limited to those individuals who had participated in a STEM program during their K-12 education and were currently employed, or have been employed, in the field of aviation. Therefore, this study was delimited to focusing primarily on the experiences associated with discrete OST STEM programs. OST STEM programs can be contrasted to those STEM-associated experiences that take place in the context of the school curriculum and those that primarily occur during school time. However, this research also examined IST STEM programs in the hope of exploring the unique features of OST STEM programs. That is, IST STEM experiences were used as a metric against which to examine OST STEM programs. This study focused on those individuals who had gained employment in direct aviation fields (e.g., pilots, air traffic controllers, aircraft maintainers, flight attendants, aeronautical engineers) and not those individuals who are in a field that supports aviation (e.g., accounting, business administration). However, individuals were given flexibility in interpreting whether they were employed in the aviation field.

Limitations and Assumptions

One of the major limitations of this research was that, by collecting post-hoc data, it could only examine the experiences and perspectives of those individuals with occupational ties to the aviation career field. It was not feasible to obtain a suitably representative sample or understanding of those not in the aviation career field, even if those people have had a similar or identical OST STEM experience as those currently employed in aviation. Limiting the population to the aviation field removed the need to control for the potential confounding effect of other STEM and non-STEM occupations, which would have required many additional participants. As a result, this research was unable to answer the question as to whether this OST STEM experience itself directly leads to more aviation employment relative to other careers. Nonetheless, the goal of this project was not to assess whether OST STEM experiences are more or less likely to contribute to a career in aviation compared to other career fields. Instead, this study was limited to characterizing the OST learning experiences that the participants could attribute to their aviation career interest, thereby allowing for an analysis of these themes and aspects.

This one-time sampling of participants has longitudinal limitations. It was not possible, with complete accuracy, to consider how self-perceptions of aviation OST STEM education have changed across the span of the participants' careers. The research was not able to accurately examine how a particular person's views have changed across their career, as recollections of past self-perceptions may not be entirely accurate. This longitudinal limitation has the potential to introduce age or experience-associated effects, with those of a certain age or experience providing substantively different responses. That is, an individual who is five years into an aviation career may have a different understanding of how their education influenced their career trajectory compared to someone who is 20 years into a career. This snapshot of an individual's perceptions of their career trajectory could be beneficial in providing a broader view of career development and may represent an area for future research.

This research was also limited in scope. The sampling strategy provided a limited ability to generalize across the entire population. Certain factors, such as age, gender, and ethnic background, may not be representative of the population. This limitation in generalization is discussed during the data analysis, as it may affect the conclusions and how the recommendations can be applied in the future.

Another limitation is the many confounding variables that affect the interpretation and conclusions of this research. For example, students who participated in an OST STEM program may have also participated in a STEM program during school time. Indeed, a large number of those reported that they participated in equal IST and OST STEM programs. These individuals were analyzed separately. However, just because an individual primarily participated in an OST STEM program did not mean they didn't also participate in some type of small IST STEM experience. The impact of each of these programs on those individuals is not able to be easily disentangled.

As with most studies that rely on human responses, there was the assumption of honest and truthful responses on the part of all participants. While honesty was assumed and there was no expectation of dishonest responses in this study, as the topic is not considered especially sensitive, the possibility of an observer-expectancy or social desirability bias is, of course, present. This is more relevant for the qualitative interview, as the quantitative survey portion was completely anonymous.

Summary

The use of STEM engagement at the K-12 age presents a valuable opportunity to increase engagement and inspire youth to enter a career in the aviation field. This has the potential to address deficits in the current and future workforce. In order to better leverage this opportunity, a more refined understanding of the effect of STEM engagement, especially those OST STEM experiences, is required. This will enable future programs to better tailor program content to facilitate aviation career interest, providing a better return on the investment of time and money.

Utilizing a mixed methodology approach, this research retrospectively explored the self-reported effect of OST and IST STEM experiences on aviation career development. Through the use of qualitative data collected from interviews, a survey instrument was developed that allowed for a quantitative assessment of the self-reported impact of STEM experiences on career interest.

Through this quantitative data, specific major factors were extracted. The results of the survey were analyzed and assessed in the context of the existing aviation and career development literature.

Definitions of Terms

Attitude	A complex, latent, and enduring, psychological construct that influences a person's thoughts and behaviors. Allport (1935) refers to it as "a mental and neural state of readiness, organized through experience, exerting a directive and dynamic influence upon the individual's response to all objects and situations with which it is related." (p. 810)
Aviation exposure	An item/variable in the career knowledge construct. This item is intended to measure and

	quantify exposure to aviation information and concepts.
Aviation skills	An item/variable in the career knowledge construct. This item is intended to measure and quantify the participant's exposure to, and experience in, relevant industry skills.
Career confidence	An item/variable in the career knowledge construct. This item is intended to measure and quantify the participant's belief in success in their intended career field and career goals.
Career development	An item/variable in the career knowledge construct. This item is intended to measure and quantify the participant's progression along their career path.
Career focus	An item/variable in the career knowledge construct. This item is intended to measure and quantify the participant's intentions to enter a career field.
Career knowledge	An identified construct that encompasses an individual's knowledge of the aviation field as it relates to information about careers in the aviation field and how those careers are viewed by the individual.

Community interaction	An item/variable in the professional interaction construct. This item is intended to measure and quantify the participant's exposure to a community of peers.
Community of practice	A "relatively informal, intra-organizational group specifically facilitated by management to increase learning or creativity" (Cox, 2005, p. 538).
Financial knowledge	An item/variable that was originally included in the career knowledge construct but excluded during later analysis. This item was intended to measure and quantify the participant's knowledge about the financial benefits of a career field.
Hands-on education	An item/variable in the career knowledge construct. This item is intended to measure and quantify the participant's exposure to opportunities that provided experiential learning (i.e., learning by doing).
In-school time (IST) program	A program or course that takes place during school hours and as an official part of the school curriculum.

Industry interaction	An item/variable in the professional interaction construct. This item is intended to measure and quantify the participant's exposure to industry professionals.
Interest	The attention that is provided to something due to its significance to an individual.
Mentor interaction	An item/variable in the professional interaction construct. This item is intended to measure and quantify the participant's exposure to mentors and role models.
Out-of-school time (OST) program	An after-school activity that takes place outside the normal school curriculum. This program may be associated with a school or it may be a community or industry-based program, such as a robotics club or a summer camp.
Professional interaction	An identified construct that encompasses the individual's interaction with the aviation community, including interactions with peers, mentors, and industry
Self-efficacy	The self-perception of an individual's ability to perform a task.
Skills development	An item/variable in the career knowledge construct.

STEM	A concept that groups together the science, technology, engineering, and math disciplines.
Workforce development	The recruitment and retention of employees in a business, industry, or career field.

List of Acronyms

AE	aviation exposure
AGFI	adjusted goodness of fit
ANOVA	analysis of variance
AS	aviation skills
AVE	average variance extracted
CBO	community-based organization
CC	career confidence
CD	career development
CF	career focus
CFA	confirmatory factor analysis
CFI	comparative fit index
CI	community interaction
DWLS	diagonally weighted least squares
EFA	exploratory factor analysis
EVT	expectancy-value theory
GFI	goodness of fit
HE	hands-on education
HTMT	heterotrait-monotrait ratio of correlations

II	industry interaction
IRB	Institutional Review Board
IST	in-school time
FK	financial knowledge
MANCOVA	multivariate analysis of covariance
MANOVA	multivariate analysis of variance
MI	mentor interaction
NFI	normed fit index
NHST	null hypothesis significance testing
OST	out-of-school time
RFI	relative fit index
RNI	relative noncentrality index
RMSEA	root mean square error of approximation
SCCT	social cognitive career theory
SD	skills development
SME	subject matter expert
STEM	science, technology, engineering, and math
TLI	Tucker–Lewis index
WLSMV	weighted least square mean and variance

Chapter II: Review of the Relevant Literature

The purpose of this chapter is to provide a high-level overview of the relevant concepts of STEM education that occur outside the traditional school environment. This review firsts cover the gaps in the literature that lead to this research. Starting with an introduction to the field of OST and IST STEM programs, it covers the basic structure of OST programs, including a comparison of OST programs to IST programs. It then examines the impact of OST STEM-based programs on the development of STEM career interest, especially regarding aviation career interest. Next, it discusses the specific aspects of OST and IST STEM education that the research addressed and identifies known gaps in the literature. After the literature gaps have been established, this chapter presents an overview of the theoretical framework of this study. Social cognitive career theory (SCCT) serves as the theoretical basis for examining how the identified learning experiences influence entry into an aviation career.

OST Programs

While activity at school is a large component of a child's life, the time spent outside the school day and outside the home has a substantial impact on the direction and well-being of a student. The majority of students participate in some type of OST program, with a reported 57% of students participating in an OST program nearly every day (Duffett et al., 2004). OST programs typically take place outside the normal school curriculum and, potentially, setting. The experience of an OST program can also be considered a form of informal learning; learning that takes place outside a school and outside of a structured school curriculum (Rennie, 2007). These activities can take various forms, but a report by the RAND Corporation (McCombs et al., 2018) delineates an OST program according to four components. These programs include structured activities for students, are overseen by at least one adult, require regular attendance, and occur in a physical location. Rennie (2007) summarizes many existing definitions by characterizing informal OST learning as 1) voluntary, 2) consisting of a non-didactic and open underlying structure, 3) not assessed, evaluated, or graded, and 4) consisting of heterogeneous age groups, rather than stratified by age as in typical school environments. Put succinctly, “learning outside of school is learner-led and intrinsically motivated, rather than teacher-led and extrinsically motivated” (Rennie, 2007, p. 127).

These definitions are broad, covering a large number of different OST programs. Within these definitions, there are multiple different ways of categorizing and describing the current breadth of OST programs available. McCombs et al. (2018) break down these programs into three separate categories, depending on their focus and expected outcome. In that way, the programs can be separated into three categories, specialty programs, multipurpose programs, and academic programs. Specialty programs are those that focus on promoting a specific skill, multipurpose programs involve multiple different activity types, and academic programs focus on providing academic and scholarly support.

Afterschool activities, in particular, can also be categorized into either expanded learning or extended learning (Bevan & Michalchik, 2013). In extended learning, students participate in activities that are, essentially, an extension of the school curriculum (Bevan & Michalchik, 2013). These activities are intended to directly improve academic and standardized testing performance, fulfilling many of the same goals as IST programs. In this way, extended learning is very closely associated with IST programs.

Expanded learning, on the other hand, involves students participating in activities that are not related to IST programs (Bevan & Michalchik, 2013). This may involve activities that are fundamentally different from those found in a school curriculum. This more closely aligns with other OST programs, such as summer camps or robotics clubs, which typically focus on topics that are not covered in IST programs.

Programs can also be categorized based on the settings in which they take place. Kotys-Schwartz et al. (2011) break down K-12 informal learning into 1) everyday experiences, 2) designed settings, and 3) programmed settings. These everyday experiences encompass normal daily activities. Designed settings refer to areas that are focused on teaching, such as museums and environmental centers. Programmed centers are those structured programs that take place both inside and outside school.

Dryfoos (1999), however, separated these afterschool programs based on sponsoring agency, identifying school-administered programs, community-based organization (CBO) administered, and community schools programs. School-administered programs, as their name indicates, are administered by the school and have a focus on academics, recreation, or social purposes. This definition of school-administered programs, for example, specifically includes extended day programs. CBO-administered programs are administered by organizations that are not part of the school system, such as nonprofits or private organizations. These programs, while not sponsored by the school, do operate inside the school environment and often focus on outcomes other than academics, such as reducing high-risk behavior. Finally, joint community school programs are sponsored by both CBOs and schools. These programs focus on academics and community development.

The administration method or approach used in classifying these OST programs is separate from the intended purpose of the OST programs. The goals of OST programs can span the gamut but mostly focus on enhancing the well-being of the participants. Some programs are focused on increasing students' academic achievements (Beckett et al., 2009), providing social opportunities (Durlak & Weissberg, 2007), providing childcare for younger students, reducing at-risk behavior, or for many other reasons. These program goals can take multiple forms. Some programs use content as a mechanism for accomplishing goals. For example, one OST program might use art or dance as a vehicle for youth development (Hauseman & English, 2016). OST STEM programs exist as a subset of overarching STEM programs and serve to extend and expand an individuals' interest and competency in STEM topics.

OST STEM Programs

Like the other forms of OST programs, OST STEM programs serve as a valuable source of experiences for students. These OST STEM programs can take the form of summer camps, science fairs, robotics clubs, or any of several different mechanisms. However, the defining factor that separates them from other OST programs is the emphasis on the STEM domain. These programs focus on content that fall into the traditional STEM criteria.

These programs arose out of a desire to increase STEM exposure to students outside the traditional school setting (National Research Council, 2009). A report by the U.S. Department of Education (2007) placed informal learning as a cornerstone of U.S. academic policy (National Research Council, 2009; U.S. Department of Education, 2007). While this was certainly not the genesis for the rise in STEM education, it explains the emphasis that educational authorities have placed on providing students with exposure to STEM education outside the school curriculum.

There exists a multitude of programs that are aimed at presenting STEM content in an approachable and engaging manner. Often these programs are focused on a specific topic area or utilize a specific platform to achieve their purpose. FIRST and VEX robotics, two large, international competitive robotics organizations, use robotics kits and competitions to educate and inspire students. The SeaPerch program takes a similar approach, using underwater remote-operated vehicles to reach students in STEM and encourage career interest, while at the same time teaching basic ship design and nautical principles.

However, there is a scarcity of programs that are focused specifically on aviation goals, at least compared to the available general science and engineering-focused programs. Some programs, like the AOPA High School Initiative (Aircraft Owners and Pilots Association, n.d.) and Southwest Airlines' Adopt a Pilot program (Southwest Airlines, n.d.) are IST aviation programs. A few distinctive OST STEM programs exist that have an aviation focus. For example, the Aviation Career Education (ACE) Academy (Federal Aviation Administration, 2020; McGerald et al., 1993), and the derivative Aviation Career Education Specialization (ACES) Academy (Esser & Ryan, 1998), are summer programs that focus on teaching aviation concepts to elementary, middle, and high school students. Since 1989, this program has provided lessons related to the science and history of aviation, experience with aircraft design and maintenance, and trips to aviation sites (Esser & Ryan, 1998; Federal Aviation Administration, 2020).

Another aviation OST program is the Young Eagles. Launched in 1992, the Young Eagles program has focused on providing participants, aged 8 to 17 years, with free rides in aircraft (Experimental Aircraft Association, 2020; Rigelman, 2013). Run by the Experimental Aircraft Association, the self-stated goal of this program is to “introduce and inspire kids in the world of aviation” (Experimental Aircraft Association, 2020, p. 1). This program has met with some reported success. A study conducted in 2011 found that “those who took a Young Eagles flight were 5.4 times more likely to earn a certificate than individuals of the same age who had not received a flight” (Tallman, 2011, p. 1).

A large portion of the existing OST aviation programs appear to be small and local efforts, focused on existing organizations or companies. Rather than franchised efforts, like FIRST robotics or VEX, these efforts are smaller in scale and do not tend to have much research conducted on them. An example would be the reported effort by the Navy League Memphis in their Naval Air Orientation Day (Walter, 2015) or the Idaho Drone League (Ryu et al., 2020)

A gap exists in the aviation community around these OST aviation programs. More of these outreach programs are needed to continue recruiting the next generation of aviation professionals (Lutte, 2016). The low number of these programs could be attributed to the lack of research that ties OST STEM experiences, particularly those that focus on aviation content, to aviation career outcomes. Examining how career interest has been reported to develop from these activities, especially in the context of SCCT, can provide a more complete understanding of the benefits of implementing them.

Impact of OST STEM Participation on STEM Career Selection

OST STEM programs can have a large impact on students and could, potentially, shape their future career choices. In some ways, these experiences can be one of the largest contributors to the desire to pursue a STEM field. A 2015 study polled scientists from the American Association for the Advancement of Science, asking them to identify the "one or two most significant experiences influencing your decision to become a scientist" (Funk et al., 2015, p. 69). The most popular answer, at 30% of the respondents, was that it was the intellectual challenge that most motivated them. The next three most popular answers identified mentors, professors, and teachers (24%), lab, fieldwork, internships, and science fairs (13%), and family encouragement or inspiration (12%). National parks and museums (8%) and popular culture (8%) were also identified. However, only 6% of respondents identified high school or middle school education as a factor. How and why were these OST STEM experiences so impactful?

This study focused on OST STEM experiences, which are uniquely separate from IST STEM experiences. OST STEM impacts individuals through different mechanisms than traditional, school-based IST STEM experiences. By virtue of taking place outside the traditional school environment, OST STEM experiences are perceived and interpreted differently by students. One of the large benefits of OST STEM programs is the low-stakes environment, which provides several advantages. Students in OST STEM programs are provided with opportunities to learn with reduced fear of failure, take on new roles, and experiment with new fields (Bevan et al., 2010). Failure during participation in OST STEM programs does not affect students' grades, for example. As a result, students may be more willing to take risks and experiment in OST STEM programs.

OST programs, such as afterschool programs, are also afforded more flexibility and creativity in how STEM concepts are taught (Noam & Shah, 2013). This puts less risk on the OST STEM instructors, who are often not required to align to specific curricula or testing standards. This enables the programs to better target the needs and desires of individual students. These programs can also leverage external resources and expose students to technology and concepts that they very well might not be able to experience inside the classroom. “Big science,” like electron microscopes and radio telescopes can be inspirational for students but is often financially limiting (Braund & Reiss, 2006).

Partly because of this flexibility of the instruction, as well as due to the nature of the time and location in which they take place, OST programs can also draw on labor resources other than school-based instructors. This is important because a limitation of STEM education can be the value that is provided based on the background and ability of the instructors. Not all school instructors are comfortable with STEM concepts. Access to external OST programs is associated with greater comfort levels in teaching STEM. A study by Cohen (2018) found that 92% of OST staff who worked with external organizations were comfortable teaching STEM concepts. However, only 77% of staff in non-networked environments felt that way. A similar gap in favor of networked organizations was shown with technology (92% vs 69%) and engineering (67% vs 46%) topics (B. Cohen, 2018). The value of these external mentors extends beyond the direct technical skills and knowledge that these individuals bring. Providing a mentor to whom students can aspire to can be valuable for reaching certain subgroups, especially those students who are underrepresented or underserved (J. L. Young et al., 2019).

Finally, the nature of the topics covered and how they are presented in OST STEM programs have a substantial impact on OST STEM programs. While some IST programs emphasize connecting lessons to practical concepts, OST programs have an advantage in that they can leverage environments outside the classroom. This creates a closer connection between the knowledge gained and the world outside the classroom. While classroom learning is valuable, a substantial amount of students' initial interest in STEM is generated from experiences outside the classroom (Maltese et al., 2014; VanMeter-Adams et al., 2014). There is a pedagogical push to leverage these experiences outside the classroom to keep students engaged and interested.

The extensive hands-on and experiential learning, featured heavily in OST STEM programs, focuses on the application of learning to practical problems. Experiential learning has been shown to also be an important factor in STEM self-efficacy (Beier et al., 2019). It is this authentic experiential learning that acts as a major difference between OST STEM programs and traditional IST STEM programs. Therefore, OST STEM programs have impacts on career development by 1) providing an opportunity for students to experiment in low-stakes environments; 2) offering pedagogical flexibility; 3) featuring instructors and mentors from outside the school environment; and 4) providing opportunities for authentic experiential learning.

STEM Interest

Participation in OST STEM programs has been shown to be a consistently positive influence on the STEM interest of individuals. OST STEM participation impacts

STEM interest primarily through the modification of self-efficacy and outcome expectations. The existing literature shows evidence for this, especially when considering the unique benefits that OST STEM experiences provide.

Initial interest in STEM is, of course, strongly associated with the desire to continue to be interested in STEM. That is, some prior interest in STEM is likely to be a contributing factor to the desire to continue to involve oneself in STEM activities. The value provided by OST STEM programs can be crucial for maintaining this long-term and continuing interest in the STEM field (VanMeter-Adams et al., 2014). This is supported by the existing literature that examines the link between OST STEM programs and STEM interest. For example, research conducted by Chan et al. (2020) provides evidence to support the impact of OST STEM experiences on STEM interest. The authors analyzed the data from the High School Longitudinal Study of 2009, which followed a population of students from high school entry to post-high school with surveys about their academic experiences collected at regular intervals. The authors found that participation in STEM OST programs was associated with higher levels of self-efficacy and STEM interest.

As another example, Maltese et al. (2014) examined college students and their self-reported influences on their STEM interests. The authors found that undergraduate students currently in a STEM-focused degree program (compared to those who were not in such a degree program) were more likely to report that their interest in STEM was the result of innate interest and the influence of parents/guardians compared to that of teachers (Maltese et al., 2014). This finding is consistent with research conducted by VanMeter-Adams et al. (2014), who surveyed graduates of a high school/college-based

STEM internship program. These authors found that extracurricular experiences were cited by 65.5% of participants as the strongest contributors to STEM interest, compared to those who cited classroom (18.6%) or hands-on projects (15.9%).

Chittum et al. (2017) examined motivational beliefs about science between participants in an after-school STEM program and non-participants, both before and after STEM program implementation. The authors developed a science questionnaire to examine constructs derived from expectancy-value theory and the MUSIC® Model of Motivation, attainment value, interest value, utility value, and competence. The authors also examined the intention to attend college. Prior to the STEM program, both groups displayed similar motivation scores, except where STEM students displayed higher science attainment values. However, after the implementation of the program, those participants scored higher in the areas of college planning, science attainment, science interest, science utility value, and science competence compared to the non-participants.

Chittum et al. (2017) also observed that the science attainment, science interest, and science utility scores decreased over time, with college planning and science competence staying static. However, the STEM participants displayed static college planning scores, science attainment, science interest, and science utility. Science competence, on the other hand, increased compared to pre-program scores.

Finally, a meta-analysis, conducted by Young et al. (2016), examined 15 studies that looked at the effect of OST programs (ranging from summer camps to afterschool programs) on STEM career interest. With a statistically significant effect size of .37, along with a fail-safe N (the number of negative studies needed to increase the p-value above the threshold) of 1,033, this link is very robust. Combined with the previously discussed findings (Chan et al., 2020; Chittum et al., 2017; Maltese et al., 2014; VanMeter-Adams et al., 2014), this shows strong evidence for a link between OST STEM programs and career interest.

STEM Career Intentions

However, STEM interest itself is not synonymous with entry into the STEM career field, or even intention to enter the STEM career field. Interest in a STEM field does contribute to STEM career choices. The same is true for career intentions. For example, Tai et al. (2006) found that eighth-graders who expected to have science careers were 1.9 times more likely to earn a life science degree by the age of 30. However, STEM interest and STEM career choices are still separate phenomena. Therefore, it is important to explicitly describe how OST STEM programs have been reported to contribute to STEM career intentions. Like STEM interest, participation in OST STEM programs has shown to have a positive impact on the reported interest in STEM careers or the intention to enter a STEM career.

To illustrate, Dabney et al. (2012) conducted a retrospective study that examined undergraduate students enrolled in an English course, which provided access to students with and without an interest in a STEM career. The authors administered a 50-question survey, developed for the Persistence Research in Science and Engineering (PriSE) project, to examine the self-reported perceptions of science interest and attitudes at various stages of life. A logistic regression model was developed to examine how OST club/competition participation was associated with STEM career interest. The authors found that reading/watching non-fiction/science fiction outside of school, at least a few times a year, was associated with 1.3 times higher odds of STEM interest in university

(Dabney et al., 2012). Participation in a science-focused club or competition was even more impactful, resulting in 1.5 times higher odds of STEM interest in university (Dabney et al., 2012).

This study by Dabney et al. (2012) also reveals that middle school interest in STEM is highly correlated with STEM interest in university. Those that had an interest in science in middle school had 1.8 times higher odds of pursuing a STEM in university and those that had an interest in math in middle school had 1.9 higher odds of the same (Dabney et al., 2012). Of course, as is common, gender is a much more impactful predictor of STEM interest in university, with males 4.5 times more likely to pursue STEM compared to females (Dabney et al., 2012). A compounded analysis reveals that participation in OST activities itself can be a large predictor of STEM interest in university. A student who participated in OST STEM activities in middle school and had an interest in math and science in middle school had two times greater odds of STEM interest in university compared to those who had no participation in OST STEM activities but did report an interest in math and science in middle school (Dabney et al., 2012).

A similar retrospective study by Kitchen et al. (2018) examined the impact of high school OST STEM participation, in the form of a summer camp, on end-of-high-school STEM career aspirations. Using the same scale developed for the PriSE project and used by Dabney et al. (2012), Kitchen et al. (2018) found that there was no significant difference in end-of-high-school career aspirations for students who participated in a high school STEM summer program that did not have a link to real-life STEM relevance compared to students who did not participate in any STEM summer program. This is compared to the 1.6 times higher odds of STEM career aspirations in students who participated in an OST STEM program with real-world relevance compared to those students that participated in an OST STEM program without real-world relevance (Kitchen et al., 2018). In terms of STEM career aspirations, students who participated in an OST STEM that had no real-world relevance were no different compared to those students who did not participate in a program (Kitchen et al., 2018).

In addition, research conducted by Chan et al. (2020) revealed that participation in STEM OST programs in eighth grade is positively associated with choosing a STEM major in college. This effect was not seen at the high school level which, as the authors note, is striking due to the expectation in SCCT that cumulative learning experiences are important to developing a career interest (Chan et al., 2020). This is especially intriguing when considering that the authors found that pre-high school OST STEM participation was not associated with high school OST STEM participation (Chan et al., 2020).

Finally, a retrospective study conducted by Allen et al. (2019) examined the self-perceived impact of STEM-focused afterschool programs on multiple aspects of STEM outcomes, as measured by the Common Instrument Suite – Student (CIS-S). Participation in afterschool STEM programs was associated with statistically greater interest (medium effect size) in STEM careers (as defined by the motivation to pursue a career in STEM).

All this existing research highlights the importance of OST STEM experiences on STEM career intentions. There is a significant body of evidence (P. J. Allen et al., 2019; Chan et al., 2020; Dabney et al., 2012; Kitchen et al., 2018) to show that OST STEM experiences are associated with higher levels of STEM career intentions.

STEM Identity

Individuals can hold many different future and past representations of themselves that shape and change their future actions. Markus and Nurius note that “an individual’s repertoire of possible selves can be viewed as the cognitive manifestation of enduring goals, aspirations, motives, fears, and threats” (1986, p. 954). An important aspect in the development of STEM career intentions is the formation of a STEM identity. A STEM identity refers to the perception of a possible self as a STEM professional. It is to the extent that an individual, based on their existing knowledge, can see themselves doing STEM. It is the “understanding of oneself as a person who can do STEM and be in STEM” (P. J. Allen et al., 2019, p. 9).

The development of this STEM identity can partially be explained by the additional exposure that OST STEM programs provide their participants. By continuing to immerse themselves in STEM experiences, they continue to take in these experiences into a STEM identity. An ethnographic study, conducted by Calabrese Barton and Tan (2010) examined how agency and identity of low-income urban youth were impacted by involvement in a community-based science club. The authors describe the process by which individuals leveraged their experience to develop themselves into community science experts and develop a STEM identity.

The development of a STEM identity, the view of oneself as a “STEM person,” has been linked to higher levels of STEM career interest. The persistence framework, introduced by Graham et al. (2013), posits that students are more likely to persist in STEM degrees if they are able to “identify as a scientist” (2013, p. 1455). This ability to identify as a scientist is developed through learning, especially that learning that occurs in research opportunities, introductory courses, and, importantly STEM learning communities (Graham et al., 2013).

Estrada et al. (2011) explored the factors that influenced educational outcomes in undergraduate minority students. The authors found that science identity was more of a predictor of scientific integration (and ultimate career intentions) than self-efficacy. However, Byars-Winston and Rogers (2019) explored a model that included science identity, finding that science identity contributed to career intentions through outcome expectations and was mediated by research self-efficacy.

The impact of identity on career choice is clear. Dou et al. (2019) utilized multiple linear regression models to explore how STEM identity predicts STEM career intentions and, importantly, how informal science experiences predict a STEM identity. The authors found that students at "the high end of our STEM identity indicator had 21.7 times higher odds of choosing a STEM career than did students at the low end of the identity indicator" (Dou et al., 2019, p. 6).

OST STEM programs are effective at enhancing the development of a STEM identity. As seen by Allen et al. (2019), participation in OST STEM programs is revealed to be associated with statistically higher levels of STEM identity (small/medium effect size). Therefore, the development of STEM identity should be a focus of OST STEM programs.

STEM Career Outcomes

Just as STEM interest is not synonymous with career intentions, neither are career intentions synonymous with career outcomes. STEM career outcomes refer to actual performance in the STEM field. This is important to explore because one of the ultimate goals of STEM education is to build the existing workforce. While the intention to enter the career workforce is important, there are many factors that can cause students to drop out of the STEM pipeline, even if they have the intention to enter a STEM field.

There is evidence that exposure to STEM concepts affects student outcomes in a dose-dependent manner. That is, the magnitude of the outcome changes as the amount of STEM exposure changes. For example, a longitudinal study by Wai et al. (2010) examined measures of STEM accomplishment in a large sample of STEM students. They found that higher levels of exposure to STEM, which includes OST programs such as special academic training, science fairs, and research, are associated with higher levels of STEM PhDs, publications, tenure, and occupations (Wai et al., 2010). This is true even when accounting for ability. Students who were exposed to a high dose of STEM, compared to a low dose, were 1.2 times more likely to enter a STEM occupation (Wai et al., 2010).

In addition, Habig et al. (2020) conducted a mixed-methods study that focused on an OST program based out of the American Museum of Natural History. They found that participation in the program, when compared to national averages, resulted in a statistically significant increase in engagement in a STEM major. Overall, a higher percentage of the program participants were engaged in a STEM major (87.5% males/72.7% vs 11.7% males/26.0% females). This finding also held across ethnicity and gender, with underrepresented populations of each group exceeding the national average.

These studies (Habig et al., 2020; Wai et al., 2010) provide evidence that OST STEM programs product effects beyond the interest/intention phase. Unfortunately, much less research is available that examines solid career outcomes, possibly due to the longitudinal nature of the research.

Impact of Mentoring on STEM Career Interest

As discussed previously, OST STEM programs can often take place outside the normal school environment or after normal school hours. One valuable aspect of OST STEM programs is the ability to provide students with more involved and tailored mentoring experiences. Compared to IST STEM experiences, which may often involve dozens of students vying for time and attention from a single instructor, OST STEM programs have the potential to have a lower student/instructor ratio than IST programs. Additionally, even for programs that are not tailored to focus on gender, OST programs have been reported to have benefits for underrepresented women in STEM. A study by Price et al. (2019) found that female participants responded strongly to the personal relationship-building that is found in a STEM OST program.

Experiential learning can be a valuable tool for gaining knowledge in a particular field. However, guided development during the process of experiential learning is also particularly valuable, especially in regard to enhancing motivation (Nargundkar et al., 2014). The importance of other individuals to a person's learning cannot be overstated. Just as social cognitive theory holds that human agency and all that entails, results from the complex interaction with an individual's environment (Bandura, 2018), so, too, does knowledge result from that interaction with one's environment and other people.

The philosophy of Lev Vygotsky, an early 20th-century Soviet psychologist, focuses on the importance of social interaction to learning (Burkholder & Peláez, 2000). His theory of a zone of proximal development defines a range of behaviors that occur with support, known as scaffolding, from another individual (Burkholder & Peláez, 2000). As the individual grows, less scaffolding is required, and the zone of proximal development expands. The scaffolding can be removed, and the student can perform without the previous support. Through this, it can be seen how mentors can help in guiding the development of students, especially those with less experience and support.

This effect of mentoring extends beyond the theory and into practice. Previous literature provides support for the idea that mentoring can have significant positive effects on the mentee. A meta-analysis conducted by Eby et al. (2008) found that mentoring is positively associated with positive behavior, attitudinal, health, relational, motivational, and career outcomes. Of particular value to this study, the aspect of motivational outcomes studied by Eby et al. (2008) involved how mentors can shape the career commitment and aspirations of the mentees. While this particular analysis did not find a significant relationship between youth mentoring and motivational outcomes, it did indicate a significant relationship for both workplace and academic mentoring. The authors note that this could be related to the more general nature of youth mentoring, as compared to the high level of career focus involved in both workplace and academic mentoring (Eby et al., 2008).

Even non-career-focused mentoring has been shown to be associated with positive outcomes in early career outcomes (McDonald & Lambert, 2014). Research by DiRenzo et al. (2013) found that high mentor relationship quality is positively associated with high levels of general and career-based self-efficacy and, subsequently, career aspirations. Access to highly qualified STEM teachers has been identified as a factor that significantly affects student success, especially regarding academic achievement, college enrollment, and the likelihood of declaring a STEM major in college (Lee & Mamerow, 2019)

This is represented in a structural model that is consistent with existing research on career development. For example, research conducted by Byars-Winston et al. (2015) examined undergraduate mentoring from the mentee perspective, using a model of career interest development as a basis for their analysis. They found that mentor effectiveness and research skills were factors that influenced research self-efficacy, which in turn influenced enrollment in further higher education. Therefore, mentoring fits cleanly into the existing identified factors that contribute to STEM career development.

Indeed, we can see evidence that mentoring, such as that provided by OST STEM programs, can have a beneficial impact on career interest and outcomes. Students have identified that access to STEM professionals is an important component of STEM summer learning experiences (Roberts et al., 2018).

However, additional research is needed to examine how mentoring in OST STEM programs can influence the process of developing an intention of entering the aviation career field. Mentoring may impact other areas or factors, such as career outcomes. Or, perhaps, mentoring may have a large effect in the aviation field than in other STEM fields.

Aviation Career Development

The literature on why individuals pursue a career in aviation is sparse. Much of the existing literature takes a high-level approach, focusing on early career identification of interest in aviation. Many of these studies, however, do not provide the level of detail required to answer the questions that this study sought to answer. For example, Pendergrass (2008) found that the perceived excitement of the aviation field was a major factor in an aviation career choice. The high pay of aviation, along with a family or friend connection to the aviation field, also ranked highly as factors that had the greatest influence on aviation career choice (Pendergrass, 2008).

Research on a population of Puerto Rico aviation students (Blanco, 2017) examined the factors, broken down into personal perception, personal experiences, influences of other individuals, and minor, that were perceived to have contributed to interest in the aviation career. Of the factors examined, personal perception of the aviation career field was shown to be the most impactful. The author noted that the perception of aviation may be very impactful due to the economic condition of Puerto Rico (Blanco, 2017). Interestingly, this research found minimal impact by other individuals on aviation career interest. Although it was noted that "factors related to personal experiences were not as significant because of the lack of exposure to aviation-related enrichment experiences" (Blanco, 2017, p. 95). This research also found that 54% of the students surveyed became interested in aviation between 12 and 20 years old (Blanco, 2017). This is significant because it underlies the temporal importance of adolescence, rather than childhood, in the development of career interest.

Steckel et al. (2010) conducted similar research, focusing on a U.S.-based sample of students at a single aviation science department. They found that the top two responses for pursuing an aviation career were a desire to be a professional pilot and a desire to be in the aviation field. Other factors included job satisfaction, the desire to work with technology, an opportunity for career advancement, prestige, travel opportunities, and the desire for a challenging career (Steckel et al., 2010). Similarly, research on a sample of students from 23 four-year post-secondary commercial aviation programs found that the field of aviation itself was a major factor behind the reason that students enrolled in the program (Clark, 2004, 2006). That research found that 62.6% of those students ranked attributed a desire to be a pilot as very favorable to their program choice (Clark, 2004, 2006).

A phenomenological qualitative study of female pilots explored the social and educational factors that sparked interest in an aviation career (Gagliardo, 2020). One major finding is that over 90% of the participants attributed attending an aviation event (e.g., field trip, air show, camp, aircraft flight) as a contributing factor. Furthermore, 79% of those individuals reported that their introduction to aviation occurred during elementary school age. Family support is shown as impactful, with 90% attributing the support of their parents as a major factor. Furthermore, 55% reported that having access to someone in aviation was significant. It is important to not overlook the value of a mentor during the time of identity development. Of particular importance to this study is the finding that "over 80% of participants were involved in extracurricular activities that were either directly related to aviation or were not traditionally feminine." (Gagliardo, 2020, p. 112). Furthermore, these individuals were encouraged by teachers (45%) and drawn to hands-on activities (>45%) at a young age (Gagliardo, 2020).

This review of the literature highlights common factors that influence entry into the aviation field. Exposure to aviation at a young age, the desire to be a pilot, and the perception of the aviation field as a whole were major factors. However, many of these factors are not specific and the gap in the literature is apparent. More granularity and detail on the specific experiences and process of aviation career development, especially as it relates to OST/IST STEM, is warranted.

STEM Career Assessment Tools

A variety of different methods of evaluating STEM career intentions and outcomes. Several existing and validated methods exist. To begin, the *Dimensions of Success (DoS)* is an observational instrument that allows for the evaluation of OST STEM program quality (Shah et al., 2014). Through the assessment of 12 dimensions, utilizing a structured rubric and trained observers, the DoS allows program managers and educators to gain insight into a specific program, examine how the program is implemented, and better understand the impact that the program has on the participants.

Consisting of a four-domain structure, this instrument's dimensions can be grouped into features of the learning environment (organization, materials, space utilization), activity engagement (participation, purposeful activities, engagement with STEM), STEM knowledge and practices (STEM content learning, inquiry, reflection), and youth development in STEM (relationships, relevance, youth voice). Of the four domains, youth development in the STEM domain appears to be the most relevant to this study. The relationships dimension assesses interactions between the students and facilitators and how these interactions influence participation in STEM activities, the relevance dimension examines how these activities make STEM relevant to student's lives, and the youth voice dimension examines how the activities support personal/group responsibility (Shah et al., 2014).

Of note is the similarity of these three dimensions to the previously described constructs identified as important to career development. Specifically, that of learning experiences, self-efficacy expectations, and outcome expectations. Ultimately, however, this instrument is significantly limited in its utility for this study because the focus is on the program, rather than the student. The results of this instrument do not provide substantial insight into the effect of the OST STEM program on the student, either in the short or long term.

The *Common Instrument Suite for Students (CIS-S)* scale is a self-report measure designed to examine after-school/OST STEM programs (P. J. Allen et al., 2019). Like the DoS, this instrument was designed to assess the quality of OST STEM programs. To that end, it contains domains such as perseverance, relationship with peers, critical thinking, and STEM activity participation. However, it also contains domains that measure STEM identity, STEM career knowledge, and STEM career interest. In that aspect, this instrument is much more appropriate for examining the impact of OST STEM programs on career interest compared to the DoS. However, it still lacks the granularity to measure certain learning experiences and a wider variety of factors that influence career interest.

The *STEM Career Interest Survey (STEM-CIS)* scale is very relevant to the interest of this particular study. The STEM-CIS was developed, using SCCT as a foundational theory, to both measure STEM career interest and examine how STEM programs affect changes in student interest in STEM careers and subjects (Kier et al., 2014). Focused on the middle school population, this scale was validated with over 1,000 students (Kier et al., 2014). Further research has validated this scale for use with the high school student population (Wei-Cheng et al., 2019). The STEM-CIS has been used for many different applications. It has even been utilized to examine how student STEM career aspirations differ after participation in extracurricular activities (Altoum, 2021). It is, however, important to note that this scale is designed to be used to examine immediate change in student STEM interest.

The *Student Interest and Choice in STEM (SIC-STEM)* is another scale that examines STEM interest (Roller et al., 2018, 2020). Like the STEM-CIS survey, this uses SCCT as a foundational theory. Compared to the STEM-CIS tool, this tool focuses on a broader portion of SCCT. While the STEM-CIS tool focuses only on the interest model (Figure 2) the SIC-STEM tool focuses on both the interest model and the choice model. That is, the focus is not only on the interest, self-efficacy, and outcome expectations constructs but also on the choice goals and choice actions constructs (Roller et al., 2020).

Valuable as they may be, each of these scales do not answer the questions about OST/IST STEM education that this sought to answer. That is, what are the specific learning experiences of these programs and how do they contribute to aviation career development? The literature fails to answer this question and it is this question that this research sought to address.

Gaps in the Literature

The existing literature on STEM participation focuses primarily on the development of STEM interest on a general level. Lacking sufficient depth is the understanding of how and why individuals pursue a career in the aviation industry. The existing literature, such as Pendergrass (2008), provides valuable insight into possible reasons individuals decide to enter the aviation career field. However, there is no existing literature that digs deeply into the underlying educational experiences that build this intention to enter the aviation career field.

Furthermore, the literature review laid out clear evidence for experiential learning building self-efficacy/outcome expectations, building interest, and, subsequently, enhancing career outcomes. Clearly, experiential learning and OST program participation can have an impact on career development. What is unknown, however, is what the exact aspects of the program are that best influence learning. What are the most effective characteristics of an OST STEM program for enhancing aviation career interest? Do OST STEM programs that are effective in enhancing aviation career interest look different from those OST STEM programs that are focused on general STEM career development? What learning experiences should programs focus on to positively impact students' entry into the aviation career field?

These literature gaps could be assessed through an evaluation of the aviation population who have experienced OST STEM programs. However, the literature has also not revealed the existence of a survey that is focused on investigating the learning experiences that contribute to aviation entry through self-efficacy and outcome expectations. The existing quantitative surveys present in the literature, such as the Dimensions of Success (Shah et al., 2014, 2018), focus on measuring OST STEM aspects in a contemporary vice retrospective manner. That is, these tools are focused on examining the efficacy of a program in real-time and on providing insight into how the students perceive the program in the present. The Dimensions of Success, for example, provides insight into metrics such as participation, inquiry, and relevance. However, the Dimensions of Success and any other existing scale do not directly examine the impact that these programs have on the student. Recent literature notes this outstanding problem, with Donaldson and Franck (2020), who examined OST STEM program quality in the 4-

H program, commenting that "research is needed to correlate program outcomes to an observation tool that could be used to improve practice for higher quality 4-H STEM programming" (p. 214). These existing tools focus on the engagement of the student. For much of these, the impact is assumed, as high levels of engagement would intuitively result in a long-term impact on the participant. This is, however, not made explicit.

Therefore, to summarize, the gaps in the literature consist of 1) a lack of understanding of the learning experiences that influence aviation career development, 2) a lack of detail of how OST STEM programs influence the learning experiences and influence aviation career entry, and 3) a lack of a dedicated survey focused on exploring learning experiences related to aviation, STEM, and general career entry. This research is focused on exploring and addressing these gaps in the literature.

Theoretical Framework of SCCT

This research addresses these gaps in the existing literature by building on, and leveraging, the theoretical framework of social cognitive career theory (SCCT). SCCT grew out of Lent et al.'s (1994) extension of Bandura's existing social cognitive theory (SCT), which examines the self-regulation that is inherent in human behavior and lays out a framework that considers how a person self-regulates behavior in the pursuit of goal-seeking (Bandura, 2001), SCCT (see Figure 1) focuses on exploring how career interests develop, how choices related to career decision-making are chosen, and how career success is realized (Lent et al., 1994; Lent & Brown, 2019).

The core of SCCT consists of three interlocking models, that of the interest development, choice-making, and performance models. However, additional research includes a satisfaction model and a career self-management model (Lent & Brown, 2019). Refer to Figure 2. Each model seeks to explain a different set of behavior that occurs during the process of career identification.

Figure 1

A High-level Overview of SCCT (Lent & Brown, 2019)

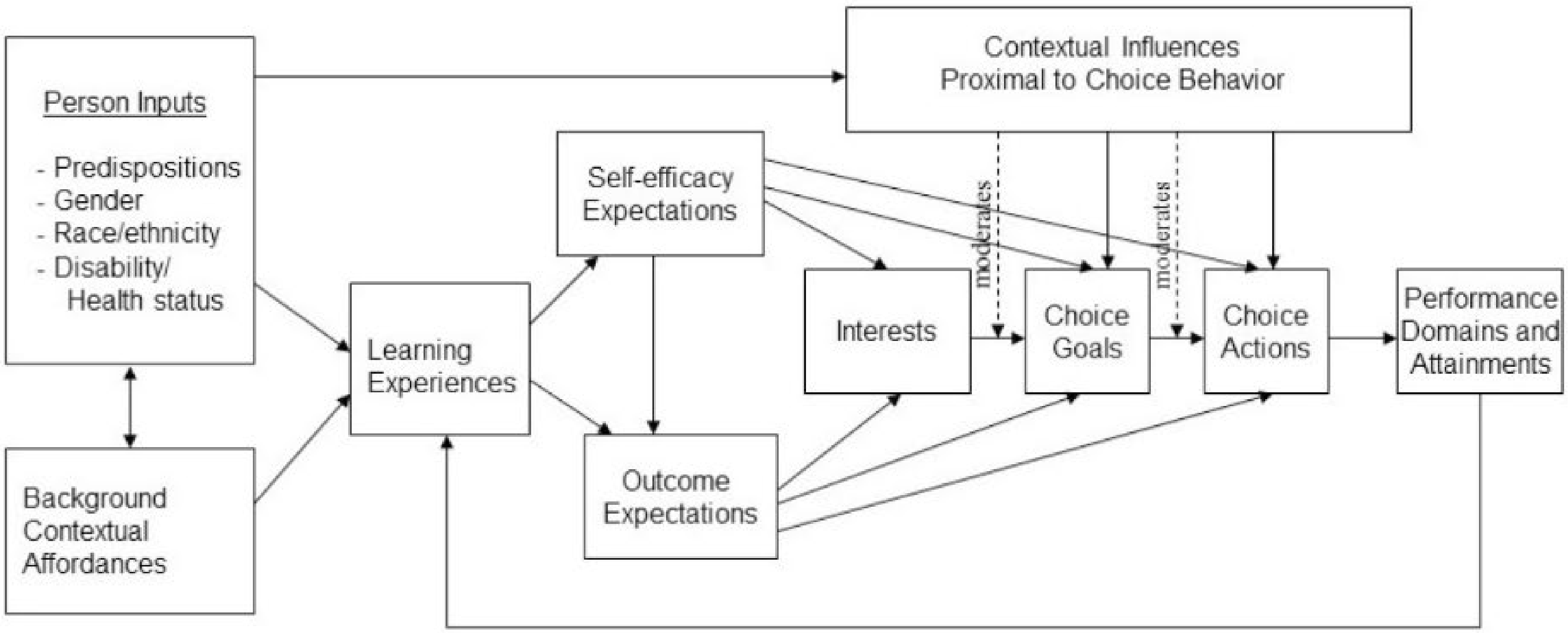
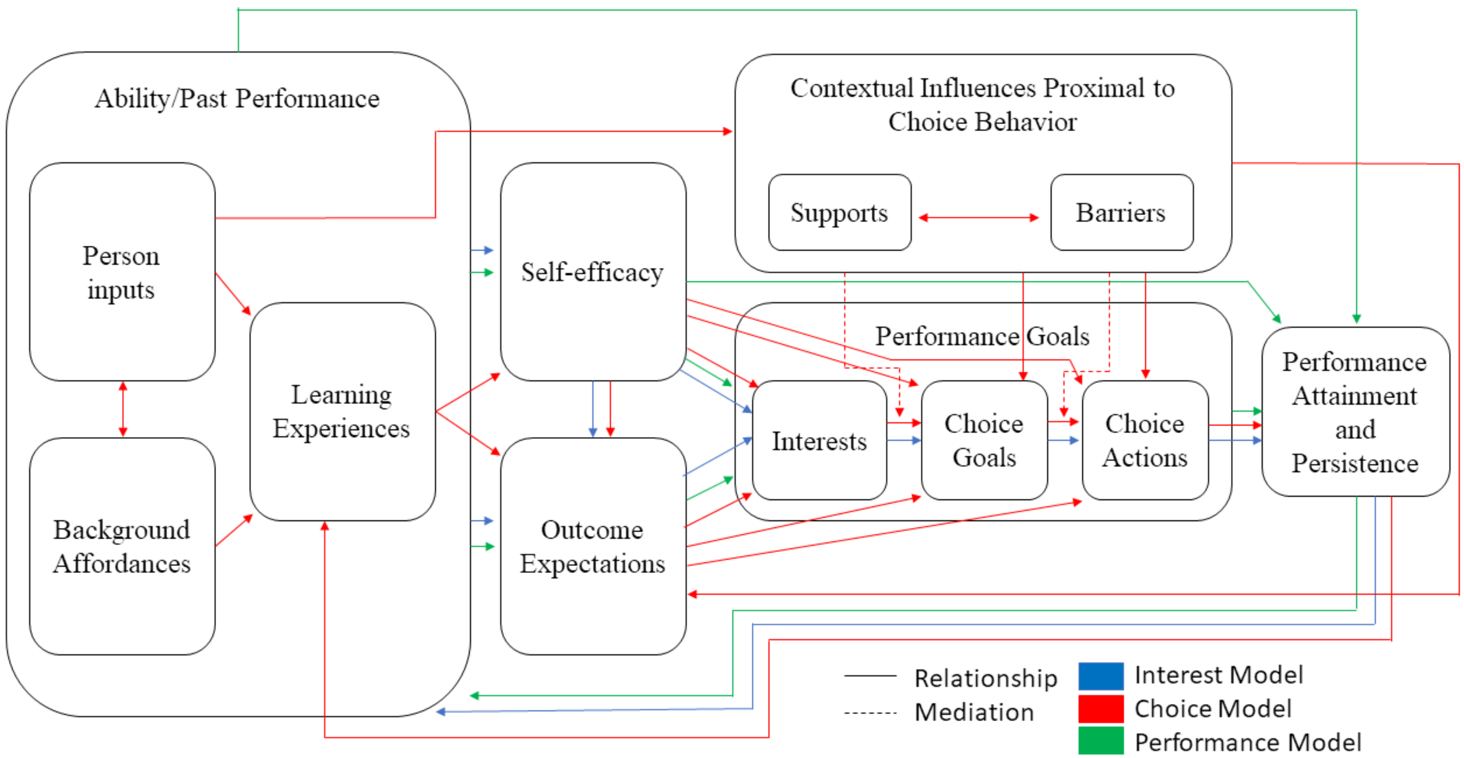


Figure 2

A Detailed Overview of the Interest, Choice, and Performance Models



Note: Figure adapted from Lent et al. (1994)/ Lent and Brown (2019).

SCCT provided the theoretical grounding for this study by serving as a foundation for understanding how STEM experiences can influence the ability of an individual to select a career or take other career-selection actions. Importantly, SCCT does not explicitly describe these experiences but, rather, focuses on how these experiences shape the career decision-making process. The exact experiences or experience types that are efficacious, especially regarding the aviation career field, constitute the literature gap that this study sought to address.

Interest Model

The interest model is one of the original components of the SCCT and is heavily intertwined with the choice model. Put succinctly, the interest model seeks to explain the sociocognitive determinants and predictors of career interests. These career interests consist of “patterns of likes, dislikes, and indifferences regarding career-relevant activities and occupations” (Lent et al., 1994, p. 88). These career interests are mediated by an individual’s environment and, as Lent et al. noted, “it is likely that people form enduring interests in activities in which they view themselves to be efficacious and in which they anticipate positive outcomes” (p. 89).

The interest model has two main contributors to interest, self-efficacy and outcome expectations (Lent et al., 1994; Lent & Brown, 2019). Also, as can be seen from the contribution of self-efficacy not only to interest but also outcome expectations (Lent et al., 1994, 2018), the glass through which people view the anticipated positive outcomes is colored by their perceptions of their ability. In this, it can be seen that the self-reflective ability of an individual to properly evaluate their performance is of great importance to developing interest in a field and, as the choice model demonstrates (Lent et al., 1994; Lent & Brown, 2019), to their decision to reflect those interests in their behavior (e.g. job applications).

Choice Model

As was mentioned, the choice model is heavily interconnected with the interest model. As Lent et al. (1994, p. 94) note, the choice model is “a developmental extension of the process of basic interest formation.” Due to that, it often makes sense to discuss both models together. However, while interconnected, both can be separated and studied independently (Lent & Brown, 2019).

The primary focus of the choice model is on exploring how individuals make choices based on their developed interests. It seeks to explain the complex set of parameters and inputs that affect the choices that are made related to career development. It focuses on the development of a choice goal based on interest, the choice actions that allow for the implementation of that choice, and the academic/career performance that can influence (through feedback to the learning experiences) those choice goals and choice actions (Lent et al., 1994).

The initial work by Lent et al. (1994) revealed that interest is related to choice goals, choice goals are related to choice actions, and choice actions influence performance and attainment. Furthermore, both self-efficacy and outcome expectations also influence choice goals and choice actions, in addition to career interest. These new relationships are one of the primary extensions to the interest model, providing additional evidence towards the interest model and extending it to show how career interest is related to career actions.

In addition to these new relationships, the choice model also adds several factors in addition to those that are explored in the interest model. The person inputs (e.g., predispositions, gender, race/ethnicity, disability) and the background contextual affordances bi-directionally interact with each other, as well as feed into a new learning experiences factor. This learning experiences factor feeds into the base interest model, the factors of self-efficacy, and outcome expectations. Therefore, this provides a mechanism for the individual's background to mediate the career interest and, ultimately, career choices.

A further additional factor is included in the form of contextual influences proximal to choice behavior (Lent et al., 1994). These are often categorized into supports and barriers and may include aspects such as family support or economic need (Lent et al., 2018). These supports promote choice goals and actions with barriers discouraging choice goals and actions (Lent et al., 2018). These supports and barriers have been shown to affect self-efficacy and outcome expectations, providing another mechanism to influence choice goals and actions (Sheu et al., 2010).

Performance Model

The performance model examines the relationship between the sociocognitive predictors to measures of academic performance. The performance model's focus is on exploring the impact of past performance on future performance. The initial work by Lent et al. (1994) revealed a relationship between past performance on both self-efficacy and outcome expectations. Like the interest and choice model, self-efficacy and outcome expectations affect each other and feed into another factor, in this case, performance goals rather than interest. As Lent et al. (1994) note, interest does not serve as an intermediate mechanism in this model as interest is not typically related to performance goals, but rather is more relevant to career choice. These performance goals impact performance attainment level, which in turn impacts past performance and is also impacted by past performance and self-efficacy. Therefore, this entire model serves as a feedback loop to regulate performance behavior.

Connections to Other Theories

The SCCT, including the interest model, is consistent with that of the Expectancy Value Theory (EVT). The basis of EVT is that an individual's expectancies and values influence their choices, performance, effort, and persistence (Wigfield & Eccles, 2000). That is, an individual makes choices, in part, because of that individual's self-perception of self-efficacy in performing the activity and the individual's expectation of the value of the activity. The parallels between EVT and SCCT are very strong, providing a large amount of weight in favor of the importance of student self-efficacy and career expectations in the student's career decision-making.

Summary

As can be seen through the gaps in the literature, there is a distinct lack of research that examines, in a detailed manner and post-hoc, the characteristics of the learning experiences and contextual choices proximal to choice behavior that influences successful STEM entry into the aviation workforce. In addition, there is a lack of existing background work on the impact of OST STEM on aviation workforce development.

This research works to fill in these literature gaps by exploring through the lens of SCCT, particularly the constructs of learning experiences and contextual choices proximal to choice behavior, how these OST STEM experiences shape an individual's career development and how, and to what extent, these OST STEM experiences encourage entry into the aviation workforce.

This study examined what factors of these OST STEM programs, including their experiential learning components, contribute to career determination. This study also sought to go beyond this limitation of the existing scales and to measure more directly the long-term impact of IST and OST STEM programs, particularly in the context of aviation. As such, a new instrument was necessary to fully capture the breadth of learning experiences across IST and OST STEM experiences. The administration of this instrument, combined with demographic data, career data, and information about past IST/OST STEM participation, allowed the researcher to contextualize how these learning experiences, which feature prominently in the SCCT choice model, ultimately influenced aviation career development.

Due to the nature of the research gaps in the literature, there was a lack of existing data upon which to develop a comprehensive quantitative survey. Without a solid foundation of information about existing STEM programs, and their effects on aviation career development, there was a risk that the resulting survey would have insufficient face and content validity. A two-phase exploratory sequential mixed method approach (Mihas & Odum Institute, 2019) allowed for the integration of qualitative and quantitative methodology to answer the research question.

The collection of the data that informed the development of the instrument comprised the qualitative research portion. The administration and evaluation of the developed study comprised the quantitative research portion. In this, the results of the first phase qualitative phase directly influenced the secondary quantitative phase.

Selecting a purely qualitative approach would not have enabled the survey development and subsequent statistical inferences that allowed for generalization. Likewise, a purely quantitative approach would have also introduced a risk of developing a survey that does not accurately measure the intended constructs.

Chapter III: Methodology

Chapter III focuses on the methodology of this study. This chapter discusses the research method, population and sampling, data collection process, and data analysis process. It also touches on the limitations of the methodology, as well as any ethical issues or concerns.

Research Method Selection

To address the stated research questions, a method of quantitatively, but non-experimentally, assessing the nature and self-reported impact of these learning experiences was required. The intention behind developing this scale was to provide a means of assessing the prevalence and self-reported impact of certain learning activities on career interest, indirectly measuring (according to SCCT) self-efficacy and outcome expectations. This scale also needed to be consistent across those learning experiences that were expected to be found in both OST and IST STEM education.

As this scale needed to be developed, a two-phase exploratory sequential mixed method approach was utilized to qualitatively assess the themes required for inclusion in the scale and quantitatively evaluate a pilot and full-scale implementation of the scale. The first phase of the research, composing the qualitative interviews and construct development, served as the exploratory component of the study. The subsequent phase, comprising the factor analysis and hypothesis testing, served as the explanatory component of the study. The existing literature, specifically Boateng et al. (2018), underly the processes for scale development and validation. NHST was used to make statistical inferences and answer the stated research questions.

Population/Sample

Population and Sampling Frame

The population of this study consisted of adult individuals in the U.S. who had participated in an OST/IST STEM program during their K-12 education and had at some point in their career been employed in the field of aviation. The primary emphasis was on recruiting those individuals who have participated in an OST STEM program and had gone on to work in an aviation-related profession. This was defined by those individuals who are engaged in traditional aviation occupations (e.g., pilots, maintainers, aeronautical engineers) as well as those who participate in STEM fields that contribute directly to the aviation field (e.g., mechanical engineers engaged in aircraft design, mathematicians who develop flight schedules, safety engineers who implement safety management systems).

The inclusion of those individuals who had participated in an IST STEM program was required for the investigation of the differences between IST and OST STEM programs. In particular, the recruitment of participants who had participated in both an IST and OST STEM program was desired, in addition to those individuals who had participated in only OST or only IST STEM programs.

The definition of participation in a STEM program is dependent on the structure of the STEM program. This research was focused on those individuals who have participated in sustained STEM experiences. This contrasts with shorter experiences, such as museum nights or small one-off events at schools. However, for ease of sampling, the survey participants were allowed to self-determine whether they had participated in a STEM program.

Sample Size

The sample size for a frequentist data analysis is an important consideration, as it heavily affects the statistical power. The sampling for the initial interviews continued until data saturation (Vasileiou et al., 2018). This saturation occurs when no additional information is discovered from the data collection process.

The survey sample size was dependent on the number of participants that were required for adequate analysis of the items. The existing literature (Boateng et al., 2018) recommended a sample size of approximately ten respondents per survey item for an effective factor analysis.

Cohen (1992) guided the suggested statistical power for the survey analysis. Initial research plans included the use of a MANOVA. The survey sample size was determined based on this plan. An *a priori* power analysis was conducted to examine statistical power. A large f^2 effect size, as might be expected here, would be measured at .25. Assuming three groups and 11 response variables, and utilizing the traditional α = .05 value, G*Power (version 3.1.9.7) reports that a MANOVA would require 75 participants.

Ultimately, a series of one-way ANOVAs rather than a single MANOVA was utilized in this research. A *post-hoc* power analysis was conducted in G*Power. The largest η^2 value of .11 (refer to Table C5), or an f of .35, was used with the final sample size of 109, three groups, and α = .05. This yielded a calculated *post-hoc* power of approximately .91.

Sampling Strategy

The sample for the interviews and survey was recruited using nonprobability snowball sampling. As this was a non-experimental study, focused on describing the population rather than on experimental manipulation, particularly for the qualitative interviews, the emphasis was on soliciting a broad array of opinions from the population rather than on creating a completely representative and random sample of the population. Although, efforts were made during participant outreach to gather a representative sampling for factors such as gender, aviation career field, and type of OST STEM participation.

The primary source of participants for this study is believed to be professional aviation organizations, large aviation businesses, and governmental organizations. While the exact employment information for the participants was not collected, information about the survey was sent to many different organizations including, but not limited to:

- Naval Air Warfare Center Aircraft Division
- Federal Aviation Administration
- Aircraft Owners and Pilots Association
- Experimental Aircraft Association
- Southwest Airlines
- ERAU Alumni groups

This wide dissemination was required to enable the researcher to reach a sufficient sample size while still enabling the collection of a somewhat overall representative aviation sample.

Data Collection Process

After the successful development of the instrument, which enabled the measurement of the STEM program factors that affect aviation career entry, the full data collection process commenced. The data collected in the full survey implementation, along with the associated statistical analysis, directly speak to the stated research questions.

Design and Procedures

The research design consists of a non-experimental quantitative analysis. It contains one quasi-independent variable (IV) with three levels, that of the influence of the program type (IST, OST, or both). There are 11 dependent variables (DVs), that of the self-reported determinants of aviation career interest (as measured by the developed scale). These DVs take the form of Likert scales, classified as non-parametric ordinal data. Additional information on survey variables is found in Table C2.

Apparatus and Materials

The developed survey instrument was implemented in a digital format. A commercial off-the-shelf (COTS) hosting service was used to administer the instrument. Google Forms was utilized to develop the participant-facing portion of the survey. As the participants completed the survey, the data was recorded in a Google Sheets spreadsheet and the data was linked directly to the R version 4.2.1 environment (R Core Team, 2022)

The data analysis utilized existing COTS software, primarily RStudio (a development environment for the R programming language). RStudio 2022.07.1 was utilized for the basic formatting of the data, including any cleanup, transformations, or mapping, and the frequentist statistical analysis of the data. JASP (JASP Team, 2022) and the underlying *BayesFactor* R package (Morey, R. D. & Rouder, J. N., 2015) were utilized for the Bayesian analysis.

Sources of the Data

The data for this research was collected using Google Forms, as consistent with the described population and sampling methodology. The data was exported and analyzed as described in the procedures. Google Forms was used to ensure the accuracy of the collected data, as well as proper implementation of procedures to protect the anonymity of the participants.

Ethical Consideration

Research that involves human participants, by its nature, can introduce ethical concerns around participant consent and potential harm. One of the primary concerns in research is the cost-benefit ratio of the benefit of society and the potential disadvantages to the individual. All research, including this project, is expected to weigh the potential for human harm against the value of the research.

To adequately address this trade-off, this research was conducted in accordance with established legal and ethical standards of research. All research was reviewed by the Embry-Riddle Aeronautical University Institutional Review Board (IRB) prior to the commencement of the study and before any data collection occurred. Additionally, the researcher was required to maintain currency with human research certification, follow established institutional policies, and ensure compliance with ethical standards at all times during the research.

This study was expected to involve no significant ethical concerns beyond what was typical of human research and the expected risk to the participants was considered negligible. This study investigated able and non-vulnerable individuals over the age of 18. While the focus of this study was to investigate the impact of education that takes place during, primarily, K-12 education, this study did not investigate minors. This eliminated a major ethical barrier involving the use of a vulnerable population.

The decision trees posted on the Embry-Riddle Aeronautical University (ERAU) Institutional Review Board (IRB) website (ERAU Institutional Review Board, 2020) were reviewed to determine if the proposed study required IRB review. IRB approval was sought, and received, prior to data collection. The approval to conduct research letters can be found in Appendix A.

The qualitative data collected during the item development of the study focused on soliciting feedback from prior STEM participants to guide the development of the survey. Audio recordings of the interviews were transcribed, de-identified, and stored in a secure location. The recordings will be stored for at least three years and only the researcher will have access to the data. A consent form was signed by all participants prior to their involvement in the research. The interview data was de-identified, with names and identifying information replaced with pseudonyms, to ensure confidentiality.

The data collection during the implementation of the survey also required approval from the ERAU IRB, as the focus of the study is on the opinions and perceptions of the participants. Approval of the IRB was obtained per established ERAU procedures. The survey data was conducted anonymously, and no identifying information was collected along with the responses.

As the study utilized a non-experimental methodology, this research did not include any experimental manipulation that could have caused lasting harm to the participants. The research did not include any type of deception by the researchers.

A written debriefing was conducted at the conclusion of the data collection period. The participants were reminded of the protocols in place to ensure either anonymity or confidentiality. They were advised of the contact information for the researcher should they have any questions. No adverse reactions were reported to the approving IRB.

Measurement Instrument

A major component of this research was the development of an instrument to enable the collection of data to answer the research questions. This instrument development leveraged the existing academic literature. Boateng et al. (2018) provided a comprehensive overview of the subject of scale development and validation.

This three-phase, nine-step process provided a structured method of developing a rigorous scale for the measurement of latent constructs. These steps, in order, consist of domain identification and item generation, content validity, pre-testing of questions, sampling and survey administration, item reduction, extraction of factors, tests of dimensionality, tests of reliability, and tests of validity (Boateng et al., 2018). Not all these steps are required for the full development of a psychometric scale. Indeed, as Boateng et al. (2018) note, the presence of an existing scale can reduce the steps to only the latter four. Or, as is also noted, time, money, and participant constraints can also serve as barriers to the full implementation of the workflow.

This study utilized this primer to guide the development of the new scale to measure learning experiences in OST STEM education and assess how they mediate aviation career development. However, not all steps suggested by the existing academic literature were utilized in this research. Specifically, only steps 1 (identification of the domain(s) and item generation), 2 (content validity), 4 (survey administration and sample size), 7 (tests of dimensionality), 8 (tests of reliability), and 9 (tests of validity) were conducted. Steps 3 (pretesting of questions), 5 (item reduction analysis), and 6 (extraction of factors) were not utilized. The initial steps taken are addressed in this section, with the tests of reliability and validity being discussed further in the data analysis section.

Survey Development

The first phase of the survey development process covers the domain identification and content validity steps. The purpose of this phase was to delineate the domain and establish the background and content for the scale. This involved the investigation of the impact of programming elements, such as hands-on mentoring. These program elements, unique to OST programs, can be the reason for the differences in career outcomes seen between OST and IST STEM programs (Kitchen et al., 2018). To fully understand the role that OST STEM programs have on the development of career interest, it was necessary to identify the learning experiences that the students were exposed to. Previous research has indicated that qualitative data can provide valuable insight into the implementation of certain pedagogy/andragogy (Wilkerson & Haden, 2014) and can be used to develop a quantitative scale for the measurement of certain phenomena (Rowan & Wulff, 2007).

This study took a primarily inductive approach to the generation of survey items. While inductive methods are less popular than deductive methods, the relative dearth of existing literature made this the most viable option for determining the most influential STEM factors for aviation workforce development. Drawing conclusions from general knowledge is difficult when there is a lack of general knowledge about how STEM education affects aviation workforce development. This inductive approach, focused on using free responses from interview participants, was supplemented by deductive inferences made from the general STEM literature. This is consistent with research that has found that a majority of scales utilized combined deductive and inductive methodology (Morgado et al., 2018).

A series of semi-structured interviews were conducted with the goal of approximately five to 10 participants. Participants were recruited through IRB-approved flyers distributed virtually, primarily across social media (Facebook, Reddit), STEM forums (e.g., Chief Delphi), and via emails to specific colleges and academic institutions. The interviews continued until saturation was reached. A total of 11 participants were interviewed over the first portion of the research. Semi-structured interviews were chosen as they strike a balance between rigidity and flexibility. This allowed the researcher to dig deeper into areas that require clarification, through unscheduled probes, and to modify the interview between participants (Berg, 2007).

While face-to-face interviews provide the richest source of information (Polkinghorne, 1983), geographical limitations necessitated the use of virtual interviews. These semi-structured interviews were conducted through the Microsoft Teams online meeting software. The list of questions used in the research is reproduced in Table 1.

Table 1

Questions for the Semi-structured Interviews

Planned Question	Type of Question
What is your current occupation?	Essential
How long have you been working in the field of aviation?	Throw-away
What led to you pursuing an aviation-related job?	Essential
Did you consider any other career field?	Throw-away
How did your school environment affect your career plans?	Essential
How did your home environment affect your career plans?	Essential
Did you participate in any STEM programs inside of school?	Essential
How did these STEM programs affect your career plans?	Probing
Did you participate in any STEM programs outside of school?	Essential
How did these STEM programs affect your career plans?	Probing
What were the major influences on your career development?	Extra

Note. Question category is derived from Berg (2007). Essential questions refer to the main thrust of the interview. Throw-away questions refer to those that are incidental and focus on developing a rapport. Probing questions serve as a follow-up to other questions. Extra questions serve as reliability checks on other questions.

The interviews were recorded, with the words auto-transcribed using Adobe Premiere Pro software. The transcription was corrected manually, as needed. The resulting interview transcriptions were imported into the Dedoose software package. The information was coded and analyzed.

The coding process focused on identifying common themes and trends from the data through the open coding process, as described by Berg (2007). As Berg (2007, p. 319) notes, “there is no single best way to code data.” The process is unique to each research question. This view is backed up by other researchers, such as Polkinghorne

(1983, p. 273) who notes that "methods are no longer considered correct or right in themselves. They are appropriate only in the relationship to the kind of question being addressed."

It is tempting to attempt to force qualitative methodology into the "objective" framework of quantitative research. Though, of course, the perceived objectivity and rigor of the traditional NHST approach, which Jacob Cohen (1994, p. 998) describes as "a mishmash of Fisher and Neyman-Pearson, with invalid Bayesian interpretation," is an ongoing discussion in academia. Regardless, traditional requirements of qualitative research, such as sample size, strict protocol adherence, randomization, and objectivity checks (such as interrater reliability) are not required for valid results (Busetto et al., 2020).

This research utilized an open coding approach, with a focus on the iterative identification of themes. In essence, the big picture was identified, enabling the little picture to be captured. Each interview was read through before coding. With each subsequent read, additional information was coded based on previously captured codes. Periodically, codes were split and combined to create a more cohesive structure. Coding ceased when saturation was reached, and no additional relevant codes were identified. At that point, codes were analyzed and grouped into similar themes of interest.

Themes such as participant-identified reasons for entry into the aviation field, areas in which the participants were exposed to aviation concepts and knowledge, and self-identified ways in which STEM programs contributed to career development and outcomes were identified and captured for later analysis. The full coding chart can be found in Table C1.

The identified themes assisted in the development of the survey items. Once the specific areas to be addressed are collected, questions were structured to enable quantitative data collection through Likert-style questions. In addition to providing the prevalence and overall importance of certain activities in aviation OST STEM programs, additional demographic data was collected to provide context to the collected sample, as well as for use in potential follow-up research.

Analysis of the coding revealed 17 major codes, categorized into three major themes. These themes were analyzed and classified as environmental influence, exposure to the field, and career outcomes. These major themes were identified by the researcher as those factors that most contributed to entry into the aviation career field. These identified themes, and the contributing codes, are depicted in Table 2.

Table 2

Identified Contributing Factors to Aviation Career Entry

Environmental Influence	Exposure to the field	Outcomes
Aviation mentors positively influenced aviation career entry	Exposure to information about the aviation field positively influenced entry into aviation	Exposure to hands-on aviation positively influenced aviation career entry
Family in aviation positively influenced aviation career entry	Exposure to aviation at home positively influenced aviation career entry	STEM programs facilitated hands-on learning and practical application of knowledge
Community influence positively influenced aviation career entry	Exposure to aviation during school activities/courses positively influenced aviation career entry	Financial prospects of the aviation field positively influenced aviation career entry
STEM programs facilitated interaction with peers with similar interests	STEM programs provided exposure to knowledge and skills	Participation in an IST STEM program positively influenced aviation career entry
	STEM programs positively influenced career focus and interest	Participation in an OST STEM program positively influenced aviation career entry
		STEM programs positively influenced self-efficacy
		STEM programs positively influenced time management and study skills STEM programs built leadership skills

These resulting themes served as the basis for the development of the survey items. As mentioned, each theme was grouped with similar themes to generate theme-based categories. Each theme was examined for relevance, reworded, combined as needed, and phrased as a question to suit a Likert scale assessment. Some items were dropped for relevance. For example, the influence of family in the aviation field was a popular theme with the participants. Six of the participants identified the presence of family in the aviation field as a contributor to their entry into the aviation field. However, this has little application to enhancing STEM program quality, as families cannot (ethically) be randomly assigned. Therefore, this particular theme, and similar irrelevant themes, were excluded from the survey development process.

Once the items were developed, basic content validity was assessed through the use of subject matter experts independent of the subject matter experts that assisted in the inductive generation of items. These included former educators, pilots, individuals involved in STEM outreach, and college administrators. These subject matter experts provided feedback on the wording of the questions and the overall scale. Feedback was obtained until the survey was deemed sufficient for administration.

The dependent variables for this research were measured using a traditional Likert scale. The questions were phrased, and the answers were recorded, as a discrete, ordinal five-point scale with 1 as strongly disagree and 5 as strongly agree.

In addition to the mentioned Likert-style questions that were generated from the scale development, demographic questions were added to aid in data analysis. The full list of questions, and their associated variables, can be found in Table C2. The final, implemented data collection device can be found in Appendix B.

Survey Administration

Once the scale was successfully designed and validated, it was administered anonymously and digitally to the targeted population based on an established sampling methodology as described earlier in this chapter. The existing literature (Boateng et al., 2018) recommended a sample size of approximately 10 respondents per survey item.

Data collection proceeded until the appropriate sample size of 110 participants was reached. As described further in-depth in Chapter IV, adjustment for missing data brought the final sample size down to 109 participants.

Reliability and Validity Assessment

The thematic structure identified from the qualitative interviews served as the underpinning for the survey. However, a test of unidimensionality was required to validate the conclusions of the qualitative research. Confirmatory factor analysis (CFA) was selected to serve as this validation.

CFA is traditionally conducted on well-established and previously validated scales. However, at its core, CFA is used to examine and test “how well the measured variables represent the constructs” (Hair et al., 2014, p. 668). It is recommended (Hurley et al., 1997) that a CFA is utilized when the researcher has an a priori hypothesized structure prior to data collection. Likewise, an exploratory factor analysis (EFA) is recommended (Hurley et al., 1997) when there is no existing a priori hypothesized structure.

A CFA analysis may be conducted subsequent to an exploratory factor analysis (EFA). However, a CFA analysis can also result from a model generated from “theoretical considerations” (Everitt & Hothorn, 2011, p. 201). Hair et al. (2014, p. 668) note that a “researcher can analytically test a conceptually grounded theory explaining how different measured items represent important psychological, sociological, or business measures.” The role of a CFA is to evaluate a model, whether it is a model based on theory or a model generated through a prior EFA.

Hurley et al. (1997, p. 672) explicitly note "there is nothing to stop one from using CFA in scale development to test whether the newly written items conform to the hypothesized structure the scale architecture had in mind." However, the authors (Hurley et al., 1997) recommend caution, noting that the restrictiveness of the CFA could prove a barrier to adequate model fitting. The authors (Hurley et al., 1997) note that, should the CFA result in a poor fit, the researchers should revert to an EFA analysis. In this case, CFA was chosen as an analysis method as the qualitative analysis served as the *a priori* basis for the hypothesized model. The interviews conducted during the exploratory qualitative interview phase, along with the thematic analysis, generated a theory-based model that was validated through a CFA.

The internal reliability of the developed instrument was assessed using the coefficient (Cronbach's) alpha (Boateng et al., 2018; Sullivan, 2011) through the cronbach.alpha() function of the R *ltm* package (Rizopoulos, 2006). Items with levels above 0.7 were deemed acceptable.

Data Analysis and Hypothesis Testing

After the successful implementation of the developed scale, the collected interview and survey data were further analyzed in the Dedoose and Rstudio program for hypothesis testing purposes.

In the next chapter, the major factors that contribute to career interest and aviation career development will be addressed in the context of the research questions. Overall, the results of these statistical analyses will provide insight into the efficacy of program factors in increasing aviation interest and career selection. Therefore, these results can be used to provide recommendations for the effective design of aviation-themed, OST STEM programs.

RQ$_1$. The raw results of the survey data, along with the interview results, speak directly to RQ$_1$. That is, what type of learning experiences do former participants of OST STEM programs self-report as influencing entry into their aviation career? These data allow for the quantification of the type of learning experiences that are perceived to be impactful in aviation career development.

The identified themes, which were extracted from the coded data as described in the survey development section, serve as the basis for thematic analysis. This thematic analysis synthesized the themes into codes, through the examination of patterns and trends across interviews. The goal was to identify commonalities between the participants regarding their STEM program participation and impact. In particular, there was a focus on identifying those factors associated with STEM program participation that were identified by the participant as playing a role in aviation career entry. This summary facilitates answering this research question in a succinct and coherent fashion.

RQ$_2$. This RQ explores how OST STEM program learning experiences differ from IST STEM learning experiences, either alone or in combination, at increasing interest in an aviation career. The survey data was analyzed through the traditional null hypothesis significance approach, with the results being interpreted in the context of SCCT. A series of Kruskal-Wallis tests and one-way ANOVAs, rather than the initially planned, single MANOVA, were ultimately conducted to examine the influence of the program type (IST, OST, or both) on the ten self-reported determinants of aviation career interest (as measured by the developed scale). As the Kruskal-Wallis is an omnibus test, analysis of group differences was conducted using Dunn's Test for Multiple Comparisons, a pairwise comparison post-hoc test.

The results of the Kruskal-Wallis and ANOVA tests provide insight into the influence of program type. Any summative relationship between IST and OST STEM programs regarding aviation career selection is visible in the participants who had participated in both program types. That is, the Kruskal-Wallis and ANOVA tests reveal how the type of program participation influences how impactful the STEM experience is compared to the IST and OST groups.

Additional Bayesian statistics provide an alternative approach for interpreting the collected data. The value of the Bayesian approach, which can complement a traditional NHST approach, is that it provides evidence for both the null and alternative hypotheses (Kelter, 2020). This means that it is possible to confirm a hypothesis whereas traditional NHST can only reject the null hypothesis. This allows for a more intuitive and flexible understanding of the data and how it relates to the research question. Bayesian analysis typically requires prior information about the data examined. One of the benefits of a Bayesian approach is that it allows for the integration of prior data to inform the prior probability. However, in this case, a noninformative prior was leveraged in the study as the prior probability.

Summary

As described in the previous chapters, this study builds heavily on SCCT. This existing model will provide the theoretical basis and justification for the research. As seen in the literature review, there is sufficient evidence to propose that aviation career interest can be positively influenced by STEM participation. However, SCCT has not previously been directly examined in the context of career development in the aviation field stemming from OST STEM programs. Furthermore, while SCCT describes how interest is developed from concepts of self-efficacy and outcome expectations, leading to realized career choices (Figure 1), it does not allow for easy identification of those learning activities and experiences that start this process. This initial exposure can be developed through a variety of methods. Additional information is required to develop a valid survey that will allow for conclusions to be drawn about OST STEM programs and the aviation workforce. This study utilizes a mixed-methods approach for data collection and analysis. A qualitative interview was conducted, which resulted in the development of a validated survey designed to assess how STEM experiences contributed to career development.

Chapter IV: Results

A series of semi-structured, qualitative interviews were conducted to provide insight into the research question "What type of learning experiences do former participants of OST STEM programs self-report as influencing entry into their aviation career?" This qualitative portion of the research was not a major emphasis of the research, but rather served as a basis for the later quantitative research. This data was also leveraged to develop the survey that would be used to answer the remaining research question, focused on whether there is a difference in STEM learning experiences, based on STEM participation type, at increasing aviation career interest and career entry.

Demographics Results

A total of 11 participants provided interviews, consisting of eight males and three females between the ages of 20 and 59. All were white, with seven holding at least a master's degree. Seven were full-time employees, two were active-duty military, and two were interns. Six identified their employment role as an engineer, two as pilots, one as aircrew, one as a mechanic, and one as an administrator. Five reported their STEM experiences to be OST based, five reported both OST and IST STEM, and one reported only IST STEM experiences. A summary of the interview demographics can be found in Table 3

Table 3

Interview Participants Demographics

ID	Gender	Age	Years Exp.	Highest Degree	STEM Type	Employment Status	Employment Type
MA	Female	20	3	Some college	Both	Intern	Engineer
AB	Male	49	25	Master's	IST	Full-time	Admin.
ZB	Male	22	1.5	Some college	Both	Full-time	Mechanic
JR	Female	33	11	Master's	OST	Full-time	Engineer
ES	Male	35	13	Master's	Both	Active-Duty	Pilot
RF	Female	24	2	Bachelor’s	Both	Full-time	Engineer
BC	Male	40	18	Master's	OST	Active-Duty	Aircrew
DM	Male	40	12	Some PhD	OST	Full-time	Engineer
CB	Male	21	-	Associate	Both	Intern	Engineer
EW	Male	33	11.5	Master's	OST	Full-time	Engineer
PK	Male	59	36	Master's	OST	Full-time	Pilot

Note: As all participants identified as white, the ethnicity column was omitted for brevity.

Description of Interview Participants

MA is a 20-year-old white female, currently an undergraduate student and a summer engineering intern at a large naval air station. She has three years of experience in the aviation field. Her STEM experiences are focused on her participation in the FIRST Robotics Competition and her in-school STEM Academy.

AB is a 49-year-old white male, currently working as a vice president at a large aviation non-profit. He holds a master’s degree and has 25 years of experience in the aviation field. His STEM experiences were primarily focused on STEM classes that he took during his school time.

ZB is a 22-year-old white male, currently working in the aviation maintenance field. He has some education beyond high school, but no degree. He has three semesters of aviation maintenance training. His STEM experiences are focused on his participation in the FIRST Robotics Competition and his high school-based vocational aviation maintenance program.

JR is a 33-year-old white female, currently serving as a general engineer for an aviation-focused government agency. She holds a master’s degree and has 11 years of experience in the aviation field. Her STEM experiences were focused on a structured, university-based, math program that she participated in during high school.

ES is a 35-year-old white male, currently serving as an active-duty naval officer and test pilot instructor. He holds a master’s degree and has 13 years of experience in the aviation field. His STEM experiences were focused on his participation in a science-focused magnet high school and multiple summer camps based out of the engineering department at a local university.

RF is a 24-year-old white female, currently serving as a general engineer for an aviation-focused government agency. She holds a bachelor’s degree and has two years of experience in the aviation field. Her STEM experiences were focused on her participation in multiple STEM-oriented summer camps.

BC is a 40-year-old white male, currently serving as an active-duty naval flight officer. He holds a master’s degree and has 18 years of experience in the aviation field. His STEM experiences were focused on his participation in a summer space camp.

DM is a 40-year-old white male, currently serving as a civilian aeronautical engineer at a large aviation-focused military agency, He holds a master’s degree, with two years of PhD study, and has 12 years of experience in the aviation field. His STEM experiences were focused on high school and college club activities.

CB is a 21-year-old white male, currently an undergraduate student and a summer engineering intern at a large naval air station. He holds an associate degree. His STEM experiences are focused on his participation in the FIRST Robotics Competition.

EW is a 33-year-old white male, currently serving as a civilian senior systems engineer at a large aviation-focused military agency. He holds a master's degree and has 11.5 years of experience in the aviation field. His STEM experiences are focused on his participation in the FIRST Robotics Competition.

PK is a 59-year-old white male, currently serving as an airline pilot for a major US-based airline. He holds a master's degree and has 36 years of experience in the aviation field. His STEM experiences were focused on his participation in the Aviation Explorers program.

Qualitative Data Analysis Results

The interviews conducted during the development of the survey provided several themes that can best encapsulate how individuals generate their initial interest in the field of aviation and the broader STEM community. Per SCCT, and the associated interest model, this initial interest is essential to ultimately developing a robust career. The factors that led these individuals to their aviation careers are identified and discussed.

Professional Interaction

One of the major factors identified through the thematic analysis related to the influence that the participant's community had on their career entry. Or more specifically, how the participants' interactions with their professional community affected their careers. Individuals in their academic and STEM environment, and the STEM environment itself, were identified as influential.

During coding analysis and survey development/validation, three major and influential types of interactions were identified as potentially playing a part in mediating STEM program influence on career development. Specifically, those of industry interaction, mentor interaction, and community interaction.

Industry Interaction. During career development, individuals place a high value on the perceptions of the career. This is seen in SCCT through the interest model, in which self-efficacy and outcome expectations feed directly into the development of a career interest (see Figure 2).

This perceived importance of the role of industry mentorship was seen in the interviews. The survey participants noted that access to, and interactions with, industry professionals affected their ultimate career development. One participant, ZB, notes that his interaction with industry mentors, and his exposure to the field of aviation, played a role in his eventual entry into the aviation field.

> Due to being so close to the Naval Air Station, we have a lot of aviation engineers, aerospace engineers. there. And hearing them talk, it kind of just pushed me over the edge. "Yeah, I want to be in aviation now."

In addition to the value provided by exposing these individuals to aviation skills and concepts, the interaction and socialization itself provide a vehicle through which career expectations can be shaped. New college graduates and entry-level employees do not necessarily have a firm understanding of their professional role post-college (Korte et al., 2019). Providing more opportunities for interactions with practicing industry professionals addresses existing concerns (Korte et al., 2019) about the lack of preparation that new employees to STEM fields experience, which serves as a barrier to retention and career development. STEM programs, especially those OST programs, could, through the mechanism of early socialization with industry professionals, positively influence the long-term career prospects of aviation employees by mitigating or removing this barrier.

Industry interaction was measured (*M* = 3.64, *SD* = 1.24, *SE* = 0.12) in the first section of the survey, where participants were asked to “Indicate the extent to which the following positively influenced your career development:” The item “Interacting with industry professionals through my STEM program participation” was selected to measure industry interaction.

Mentor Interaction. One common theme identified was the influence that mentors had on the participants' career entry. Of particular interest is the role that mentors played in shaping many of the career trajectories of the participants. In many of these instances, the aviation mentors were described as role models and facilitators.

Six of the ten interview participants reported that their interaction with aviation mentors positively influenced their entry into the aviation career field. One participant, MA, described how her aviation mentors guided her development as an engineer and served as a support network.

> I would say they exposed me a lot to engineering and the engineering design process, as well as programing and specific applications of engineering in a very hands-on way. But I would say even more so was the fact that the mentors were Navy engineers at an air station probably impacted my decision to go into aviation. Because that was sort of my network.

However, mentors can positively influence career trajectories in more subtle ways. As discussed previously, ZB reported that the large number of aviation professionals in his community served as sources of information about possible aviation careers.

> Due to being so close to the Naval Air Station, we have a lot of aviation engineers, aerospace engineers there. And hearing them talk, it kind of just pushed me over the edge. "Yeah, I want to be in aviation now."

JR reported that the actions of a mentor facilitated her entry into the field of aviation. A networking opportunity, one provided by the mentor, led to her developing and achieving her ultimate, long-term career goals.

> So my sophomore year, one of my professors approached me. Not for the right reasons. He needed a female. He told me, "I need a female and you're the highest-scoring female in my class. So would you be interested in this team?" But because of that, I got an opportunity. And I was high scoring, so there's a warm fuzzy there. So I got on the ballooning team. We did high-altitude weather balloons and did experiments on them. And that opportunity opened doors. That one singular opportunity. That opportunity got me an internship at NASA my junior year of college. And then that opportunity is what, I think, had resumes get hit for being hired in aviation.

When reflecting on his participation in the Aviation Explorers program, PK noted that the mere presence of his mentors, even though they were not able to provide career-specific advice, was influential in shaping his career development through encouragement.

> None of those guys were commercial pilots. None of them were in the Navy. So, I didn't get any good insight from them, but they did encourage me to do that stuff. You know, even though they hadn't done it themselves.

It is clear that the presence of mentors, and the interactions that they provided to these STEM participants, had a noticeable impact on these participants' careers. It is the individual and personal connection of these mentors that were reported to make the difference. Rather than simply serving as role models and inspiration to the aspirants, indirectly increasing career entry through expectancy-value theory, the motivational theory of role modeling (Morgenroth et al., 2015), and SCCT (through the interest model), these mentors directly influence entry into the career field by making personal connections and affording opportunities that might not otherwise be available.

Mentor interaction was measured ($M = 3.73$, $SD = 1.30$, $SE = 0.12$) in the first section of the survey, where participants were asked to "Indicate the extent to which the following positively influenced your career development:" The item "Interacting with mentors through my STEM program participation" was selected to measure mentor interaction.

Community Interaction. The final component of the professional interaction construct relates to the individual's relationship with their peers and the influence of a community of interest.

One interview participant, CB, notes that the general presence of a shared industry was a large influence on his choice to go into his career field.

> It's the community I grew up in. Because I grew up in St Mary's County. This is a very heavy tech engineering area. So, I was just always around it and it was... Yeah, it was convenient.

MA echoed that sentiment, noting that the presence of the surrounding aviation community was certainly a factor in her decision to work in aviation.

> I would say probably the most impactful things would be my family and just living and growing up by a Navy base. The internship opportunities that come with living and growing up by a Navy base. And robotics, which helped me get those internship opportunities.

However, the influence of community extends beyond being generally surrounded and exposed to aviation. It also involves immersing oneself in a field and connecting with like-minded peers. The development of a career interest, and the desire to see oneself in that role, can be supported by joining a community of practice. This affords the student the ability to explore potential roles and expand on interests with ease. EW expands on this concept through the lens of participation on his high-school robotics team.

> Yeah. And the other part of it was getting to work with students who are like-minded. Everyone always talks about group work, how much group work sucks. Usually it's because there's always the performer in the group and the couple people who slack off. And I was lucky enough to be on a team where most of the people were just as engaged as I was. That was really awesome. To get to work with like-minded group of students, and then also the like-minded adults, to kind of solve the problem together. You learned a lot more than just the technical things that way. You learned teamwork, leadership, and communication skills that

> you just don't get in school in a classroom because you're all doing it yourself. Typically. Even when there is group work, it's kind of pointless.

Clearly, this is true for many career fields and can be seen in the aviation community as well. AB notes that his time at Embry-Riddle Aeronautical University, an aviation-focused university and community, also strengthened his interest in aviation and further solidified his desire to go into the aviation field.

> Obviously, the exposure at Embry-Riddle was what really shaped the career because it was all about aviation and you had to be a pretty committed student at Embry-Riddle in aviation because it's not like you could switch degrees very easily.

Community interaction was measured (M = 4.22, SD = 1.05, SE = 0.10) in the first section of the survey, where participants were asked to "Indicate the extent to which the following positively influenced your career development:" The item "Working in a community of individuals with similar interests" was selected to measure community interaction.

Career Knowledge

One of the largest self-reported benefits of STEM programs is the opportunity for experiential learning. The participants reported that they valued the ability to see the real-world impact of their learning, which allowed them to further explore the career field.

During coding analysis and survey development/validation, seven major and influential types of career exploration were identified as potentially playing a part in mediating STEM program influence on career development. Specifically, those of aviation exposure, hands-on education, aviation skills, career focus, career development, career confidence, and skills development.

Aviation Exposure. The decision to enter the aviation field would certainly be a difficult one if the individual had no concept of the field of aviation. Understanding the scope of the industry, as well as the career opportunities available, is essential to promoting aviation careers.

MA partially attributes her decision to go into aviation as a consequence of her family's involvement in the field. Her father's role as a pilot and engineer provider her with access to the field and knowledge of the opportunities available.

> Yeah, I would say my parents just expected us to go to college. That was just sort of an expectation and our household conversations, a lot of time, revolved around aviation. Just because that was my dad's career and he liked his career very much. We asked him a lot of questions and we got some aviation-based lectures, as well as tours of his different squadrons. I mean, my dad used to hold me while he was doing his test pilot school homework. But we toured squadrons. We had Christmas parties in hangars. I pretty much grew up around aviation. So that probably could impact it.

Aviation exposure was measured (M = 3.70, SD = 1.37, SE = 0.13) in the first section of the survey, where participants were asked to "Indicate the extent to which the following positively influenced your career development:" The item "Learning more about aviation during my STEM program participation" was selected to measure aviation exposure.

Hands-on Education. Hands-on learning, and its more reflective parent of experiential learning, are long noted to play an important role in the education pipeline (Kolb, 1984). This is especially true for the STEM fields, where experiential learning and hands-on application of knowledge have been shown to positively impact knowledge construction (Tien Long et al., 2020) and drive interest in STEM career fields (Christensen et al., 2015). This is true for aviation (Rawat et al., 2018) and is reflected in the interviews.

One participant, CB, notes, when discussing his experiences, the importance of seeking out opportunities to see the results of hands-on learning.

> So, I guess my closing remarks is it's important for students to see what the possibilities are. i.e. me going to robotics and applying the knowledge and seeing the possibilities through a program like AESIP and RADIATE and then working hard at school and then getting, not necessarily rewarded, but I'm going to say rewarded for lack of better terms, by getting an internship and seeing your work come to fruition.

As ZB explained, when discussing his IST vocational training in aviation maintenance, it was seeing academics from a new perspective, when viewed through the lens of practical knowledge, that really encouraged him to push through to his goal.

> But then when I went to tech center and actually took the class. The math that came into it was a lot easier for me to understand than, say, in a regular math class, because it was actually practical. I could actually see the math problems.

BC expanded on this idea, noting that the application of knowledge, rather than out-of-context learning, was a key component towards making an impact on his career confidence

> Yeah, that's something, through all of my education, that helped. Learning is nice and good and necessary, but being able to visualize that application of the information and seeing or feeling how it makes an impact.

EW agrees, elaborating on the process by which his experiences in a high school robotics program contributed to his entry into the field of aviation and systems engineering.

> It was the satisfaction of solving a problem and seeing something work that you took part in, that you helped design. So, from getting a problem or a mission you need to achieve, having a discussion about how to do it, prototyping it, seeing something work, and then going into a design and integrating it and then actually watching it work. You go, "Hey, we built that. We designed that. That's our idea." And it wasn't always my idea. But the thing of, we can solve this hard problem – And, by the way, you only had six weeks to do it – in a short amount of time was really satisfying. That there was no book answer, right? Like in physics classes, until you get to doing research, real research, there's a book answer for all the problems. So there's no satisfaction in getting the right answers. I got the right answer. Cool. Move on. Next one. Do something for the first time, that no one else has done. Then seeing all the different solutions from the other teams, as well, was interesting.

Hands-on education was measured (*M* = 4.24, *SD* = 1.19, *SE* = 0.11) in the first section of the survey, where participants were asked to "Indicate the extent to which the following positively influenced your career development:" The item "Participating in hands-on learning and practical application of knowledge, related to my career field, in the STEM program" was selected to measure hands-on education.

Aviation Skills. ZB touched on the importance of having exposure to practical skills in the aviation field. It is these skills, not only hands-on but connected to a relevant and practical purpose, that contribute to their career progression.

> Before tech center, I really didn't think about aviation as a career field. I was like, "Ah man, that's too much math. That's not for some country redneck like me. You know, in the backyard turning wrenches on a car. You know, there's a lot more that goes into it." But then when I went to tech center and actually took the class. The math that came into it was a lot easier for me to understand than, say, in a regular math class, because it was actually practical. I could actually see the math problems.

Experience and participation in STEM learning experiences have been associated with the development of skills that directly to their career paths. For example, undergraduate students reported that out-of-class research experiences provided them with reported gains in communication and technical skills (Thiry et al., 2011). The same is believed to be true for the aviation field, with exposure to authentic learning experiences and aviation equipment providing STEM participants the opportunity to gain experience in aviation-specific skills, such as piloting or maintenance.

Aviation skills were measured (*M* = 3.95, *SD* = 1.13, *SE* = 0.11) in the second section of the survey, where participants were asked to "My STEM program participation:" The item "Taught me skills related to my aviation career" was selected to measure aviation skills.

Career Focus. The opportunity to have direct exposure to a desired career field prior to entering that career field is not universal.

ES noted, when discussing his participation in a summer camp focusing on UAVs, how this exposure to actual aviation firmly cemented his existing goal of entering the aviation field.

> I mean, I just fell in love with it. I just thought it was like, "I could do this for college? This is the coolest thing. I absolutely want to do this. This is definitely what I want to study." And that fully cemented it in for me. I got to go to a school that's got a good aerospace program, because that's for sure what I want to major in and study.

This opportunity to gather firsthand experience in his tentatively chosen career field afforded him focus and positively influenced his decision to enter the field of aviation. When asked whether his participation in a summer space camp program reinforced his interest in space, BC agreed noting:

> Yeah, yeah. It definitely reinforced, as you said, the idea of what I wanted to do wasn't crazy and you know, mind/body didn't agree or whatnot. But yeah. It reinforced that desire.

Career focus was measured (*M* = 4.30, *SD* = 0.98, *SE* = 0.09) in the second section of the survey, where participants were asked to "My STEM program participation:" The item "Positively influenced my career focus and interest" was selected to measure career focus.

Career Development. Participants reported that their STEM participation helped to develop and shape their future careers. Between the combination of industry mentors, hands-on and authentic learning, and the opportunity to gather more information about the STEMs field and understand the opportunities available, participants tended to report, either directly or indirectly, that their STEM participation promoted career development. EW reported how his time in an OST robotics program provided him with skills and opportunities that ultimately shaped where he is in his career.

> I would say the robotics led directly to my internship. Because I had the experience, the hands-on experience, of doing an engineering process and then actually following it through, and I could point to the concrete example, - two of them actually, two different robots - I got hired for... It was a competitive internship - at ATK at the time. Now it's Northrop Grumman - to do process engineering - as a process engineering intern on the manufacturing floor - on rocket motor. Which, it's called chamber preparations, so it's before they fill the rocket motor with propellent. Also all the painting, and power coating, and marking, and all that stuff. And then also on medium cal, which is the machining of medium caliber ammunition. So I got there as a process engineer. My whole job was to solve problems, sometimes as simple as developing a new organizational system for painting masks, right? Or a new procedure on how to clean something.

> But my job was to solve problems. And that job led directly to NAVAIR. Because when I showed up to the NAVAIR mass interview, all of a sudden I had experience with weapons and no one else did. And so I got hired into a branch because I knew which end of a missile went forward. Right? Pointy goes forward. So I had experience with weapons. I was the preferred candidate for that job. And from there, I got opportunity after opportunity to work on new systems. Work on F-35. I got work on brand new weapons and integrated it with F-35. Then the Navy actually paid for me to go back to grad school to get my system engineering degree. And I got a chance to go be a lead integrator for a big program on F-18 and just on and on, moving up. I tie everything back to getting the opportunity to be on the robotics team. I draw that direct line. Because nothing else would have happened had that not occurred.

Career development was measured ($M = 4.31$, $SD = 0.88$, $SE = 0.08$) in the second section of the survey, where participants were asked to "My STEM program participation:" The item "Positively influenced my career development" was selected to measure career development.

Career Confidence. The concept of career confidence is tied closely to the SCCT construct of self-efficacy (the belief that one would be successful in a given task or choice). More specifically, this career confidence would refer to the confidence that an individual has that he/she has in pursuing their chosen career path.

PK reported that one of the biggest impacts that his OST STEM participation afforded him was confidence in his skills and confidence in his career choices.

> But I think, to sum it up, it gave me direction. It gave me skills to be successful in the rest of high school and then college. It gave me leadership skills. And taught me how to fly! I mean, I suppose that I could have joined and decided maybe this wasn't for me. But it ended up being for me. So. It gave me confidence, too. It really... You know, to fly an airplane by yourself when you're 16 years old. That gave me a tremendous amount of confidence. That I could really do it. That I could do it. If it wasn't for that... Yeah. I joined the Navy already knowing I knew how to fly an airplane. That was huge.

As seen in SCCT, the perception that an individual can perform in the identified career field directly mediates interest in that career field. By increasing confidence in their choice of careers, STEM programs can promote sustained interest in the aviation field and encourage more individuals to enter that career field.

Career confidence was measured ($M = 4.29$, $SD = 0.96$, $SE = 0.09$) in the second section of the survey, where participants were asked to "My STEM program participation:" The item "Made me more confident in my career goals" was selected to measure career confidence.

Skills Development. The development of personal skills through STEM education can play a part in future career prospects. As the SCCT model shows, self-efficacy and the perceived ability to perform in the career field mediate, and are mediated by, the individual's success in that field. The ability to reach previously established goals (through the choice goals and choice actions components) also contributes towards career engagement and satisfaction.

STEM program participation can help individuals reach those goals by providing them with indirect skills, such as leadership and time management skills, that enable to creation and achievement of personal career goals. PK touches on the importance that OST STEM programs can have on the development of these general personal skills.

> And again, not only did it teach me how to fly, but it taught me how to be a leader. At a pretty young age. And I think that's what gave me... Started to help me develop the organizational skills and leadership skills. I initially didn't join for that. I joined just to fly airplanes.

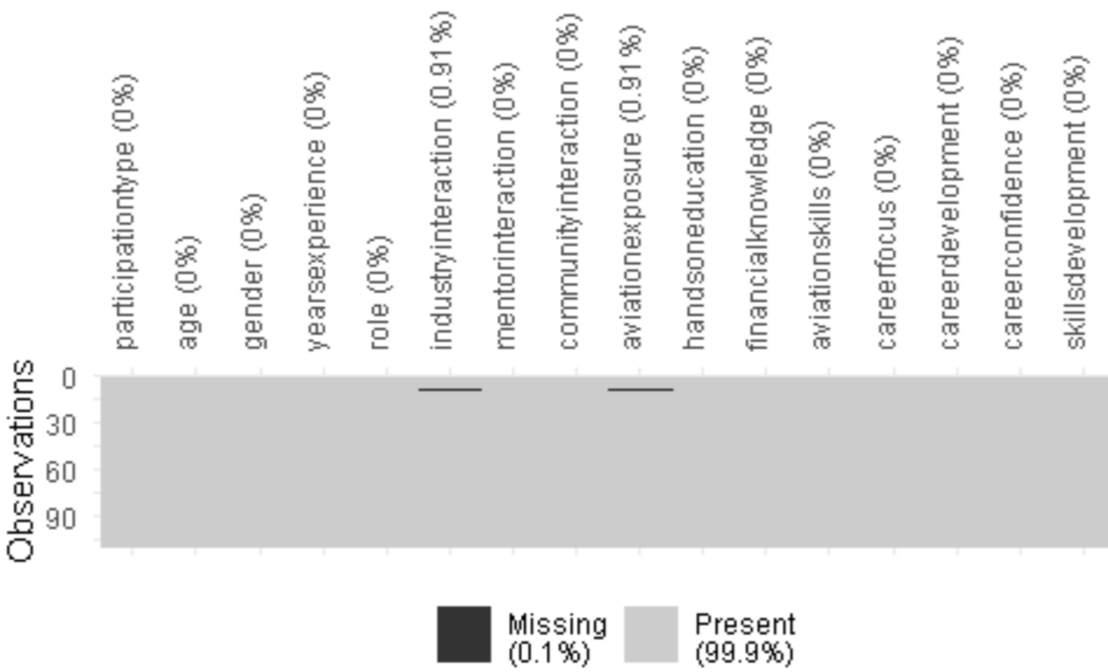
Skills development was measured (*M* = 4.00, *SD* = 1.13, *SE* = 0.11) in the second section of the survey, where participants were asked to "My STEM program participation:" The item "Provided me with skills, such as leadership and time management, to help me succeed in my career." was selected to measure skills development.

Survey Demographics

An initial assessment of the survey dataset revealed 99.9% percent data completeness, with only one participant having any missing items (industry interaction and aviation exposure). A visual representation of the missing data, calculated with the R *naniar* package (Tierney et al., 2021), can be found in Figure 3. That participant's data was dropped, bringing the total dataset to 109 responses.

Figure 3

A Visual Representation of the Missing Data



This final dataset consisted of 109 responses across 16 variables. The gender of the participants (male = 77, female = 31, prefer not to say = 1) skewed male, which was expected with the chosen population. The age of the participants (18-24 years = 21, 25-34 years = 28, 35-44 years = 19, 45-54 years = 26, 55-64 years = 13, 65+ years = 2) were well distributed across the working age. The years of experience (0-4 = 28, 5-9 = 17, 10-14 = 15, 15-19 = 10, 20+ = 39) were concentrated toward the younger and older bins. The majority of the roles were described as pilot and engineer, with lesser concentrations of scientists and management. Full role information can be found in Table 4. The program participation type (equally within and outside the school day = 34, outside the school day = 33, within the school day = 42) was roughly split equally, with a skew towards IST STEM participation.

Table 4

Summary of Participant's Job Role

Participant role	Count
Air traffic controller	2
Aircrew	3
Airport Planner	1
Airport Specialist	1
ATC SME	1
Aviation educator	4
Cybersecurity	1
Educator	1
Engineer	33
Engineering Intern	1
Engineering test pilot	1
Flight Instructor & Air Traffic Systems Engineering Manager	1
Management	9
Mechanic and pilot	1
Mechanic/maintainer	3
Pilot	36
Pilot, aircrew, engineer, mechanic	1
Scientist	8
Student engineering intern	1

Confirmatory Factor Analysis Results

Assumptions for a CFA require a lack of missing values or outliers, factorability, normality and linearity, and a lack of multicollinearity (Knekta et al., 2019). Outliers are not an issue in Likert data, due to the limited response options, and only one participant had any missing data. That data was removed.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was conducted using the *psych* package for R (Revelle, 2022). A value of .85 was found, indicating good factorability. No variable was below .76.

Table C3 supplies the summary statistics for each variable, including dependent variables. All survey items had a skewness below |2.0| and a kurtosis below |4.0|.

Mardia's test, implemented through the *psych* package (Revelle, 2022), revealed the presence of multivariate skew and kurtosis and a lack of multivariate normality. Therefore, a robust estimator algorithm, such as the diagonally weighted least squares (DWLS) or weighted least square mean and variance adjusted (WLSMV), needs to be used during the CFA to account for the violation of normality.

A polychoric correlation was conducted in R using the *psych* package for R (Revelle, 2022) to assess multicollinearity. The results are shown in Table 5. All variables measuring the same construct indicated adequate correlation (>.30), with the exception of financial knowledge which does not correlate with any variable except aviation exposure and aviation skills.

Table 5

Polychoric Correlation on the Dependent Variables

	II	MI	CI	AE	HE	FK	AS	CF	CD	CC	SD
II	1.00	0.69	0.48	0.60	0.63	0.24	0.37	0.57	0.49	0.41	0.41
MI	0.69	1.00	0.42	0.35	0.44	0.25	0.38	0.48	0.53	0.55	0.47
CI	0.48	0.42	1.00	0.40	0.40	0.17	0.39	0.36	0.50	0.51	0.37
AE	0.60	0.35	0.40	1.00	0.49	0.54	0.59	0.49	0.44	0.41	0.37
HE	0.63	0.44	0.40	0.49	1.00	0.19	0.33	0.60	0.51	0.45	0.42
FK	0.24	0.25	0.17	0.54	0.19	1.00	0.37	0.20	0.30	0.25	0.23
AS	0.37	0.38	0.39	0.59	0.33	0.37	1.00	0.69	0.70	0.65	0.50
CF	0.57	0.48	0.36	0.49	0.60	0.20	0.69	1.00	0.76	0.72	0.54
CD	0.49	0.53	0.50	0.44	0.51	0.30	0.70	0.76	1.00	0.78	0.69
CC	0.41	0.55	0.51	0.41	0.45	0.25	0.65	0.72	0.78	1.00	0.67
SD	0.41	0.47	0.37	0.37	0.42	0.23	0.50	0.54	0.69	0.67	1.00

Note. Variables were rounded to two decimal places.

As the assumptions were met, a CFA analysis, using a reflective model, was conducted using the R *lavaan* package (Rosseel, 2012). The DWLS approach was used, primarily due to the low sample size, the lack of multivariate normality, and the ordinal data being analyzed. However, the DWLS approach was only utilized to estimate the model parameters. Per the lavaan documentation, the WLSMV estimator was utilized to calculate the robust standard errors and a mean- and variance-adjusted test statistic.

The interpretation of a CFA is not straightforward and consists of multiple steps. Hair et al. (2014) describe a multi-step process of analyzing the fit of a CFA model.

- Examine the standardized loadings
- Calculate the construct reliabilities
- Examine the standardized residuals
- Examine the modification indices

CFA Model One. A chi-square test of independence was performed to examine the fit of the model. The examined factor model was significant, X_2 (41, N = 109) = 68.106, p = .0005. Common fit indices were calculated and are listed in Table 6.

Table 6

Common Fit Indices for CFA One

Index	Value	Fit
Root Mean Square Error of Approximation (RMSEA)	0.078	Acceptable
Comparative Fit Index (CFI)	0.990	Good
Tucker-Lewis Index (TLI)	0.987	Good
Bentler-Bonett Normed Fit Index (NFI)	0.976	Good
Bollen's Relative Fit Index (RFI)	0.968	Yes
Relative Noncentrality Index (RNI)	0.990	Yes
Goodness of Fit (GFI)	0.985	Good
Adjust Goodness of Fit (AGFI)	0.963	Good

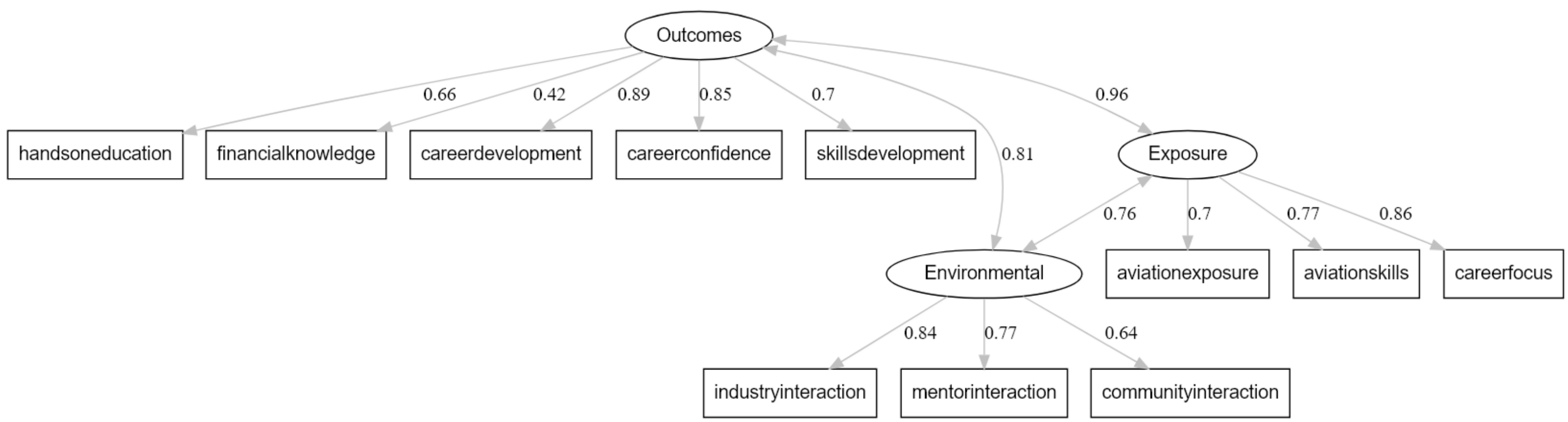
Common fit indices thresholds are obtained from Schermelleh-Engel et al. (2003), as follows, RMSEA ≤ .05 (good fit) or ≤ .08 (acceptable fit), CFI ≥ .97 (good fit) or ≥.95 (acceptable fit), TLI ≥ .97 (good fit) or ≥.95 (acceptable fit), NFI ≥.95 (good fit) or ≥.9

(acceptable fit), GFI ≥.95 (good fit) or ≥.9 (acceptable fit), and AGFI ≥.90 (good fit) or ≥.85 (acceptable fit). Hu and Bentler (1999) note that the general rule of thumb for RFI and RNI is >.9.

The path diagram, generated with lavaanPlot (Lishinski, 2021), and the associated standardized loadings of the CFA are found in Figure 3. As Hair et al., (2014, p. 686) note, "items that are indicators of a specific construct should converge or share a high proportion of variance in common, known as convergent validity." This can be assessed through three main approaches, standardized factor loading, average variance extracted (AVE), and reliability (Hair et al., 2014). The authors (Hair et al., 2014) note that the thresholds for each of these approaches are .5 (minimum) to .7 (ideal), .5, and .6 or .7, respectively. All of the loadings, as shown in Figure 4, are statistically significant at the $p = .05$ level. Two of the estimates for outcomes, hands-on education and financial knowledge, and one of the estimates for environmental, community interaction, fall under the threshold of .7. Only one factor, financial knowledge, falls under the .5 minimum loading threshold. This suggests generally high levels of convergent validity.

Figure 4

Path Diagram for CFA One



Note: The numbers indicated the standardized estimates. Only significant relationships (at the $p = .05$ level) have values provided in the graphic.

The modification indices were also calculated. The cross-loadings are represented in Table 7 and the residual covariances are shown in Table 8. Only values above the threshold of 3.84 were represented.

Table 7

Factor Cross-Loadings for CFA One

		Mod. Ind.	EPC
Environmental	Hands-on education	8.973	0.776
Exposure	Financial knowledge	6.954	3.218
Environmental	Aviation exposure	4.296	0.534

Table 8

Residual Covariances for CFA One

		Mod. Ind.	EPC
Aviation exposure	Financial knowledge	20.038	0.331
Industry interaction	Hands-on education	9.1	0.247
Industry interaction	Aviation exposure	6.596	0.212
Industry interaction	Career confidence	4.697	-0.218
Aviation exposure	Career development	4.361	-0.208

CFA Model Two. Based on the relatively low loading of the financial knowledge variable, as well as the low polychoric correlation of that item, another CFA was conducted excluding that variable.

A chi-square test of independence was performed to examine the fit of the second CFA model. The examined factor model was not significant, X_2 (32, N = 109) = 45.074, p = 0.062. Common fit indices were calculated and are listed in Table 9.

Table 9

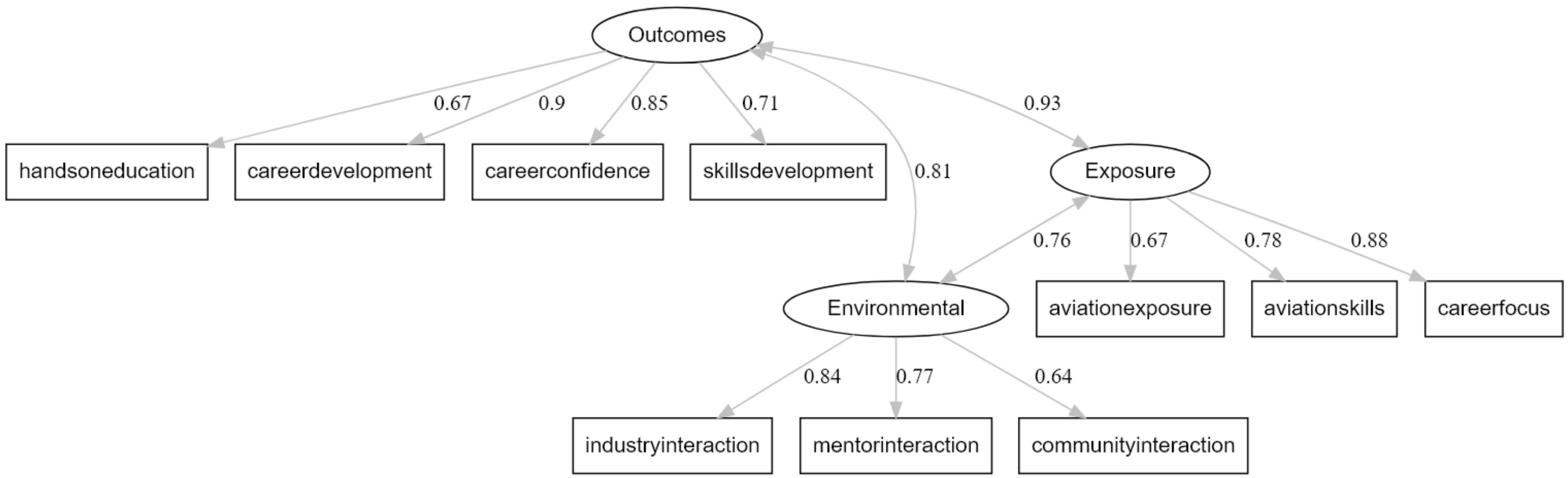
Common Fit Indices for CFA Two

Index	Values	Fit
Root Mean Square Error of Approximation (RMSEA)	0.062	Acceptable
Comparative Fit Index (CFI)	0.995	Good
Tucker-Lewis Index (TLI)	0.993	Good
Bentler-Bonett Normed Fit Index (NFI)	0.984	Good
Bollen's Relative Fit Index (RFI)	0.977	Yes
Relative Noncentrality Index (RNI)	0.995	Yes
Goodness of Fit (GFI)	0.989	Good
Adjust Goodness of Fit (AGFI)	0.972	Good

The path diagram and the associated standardized loadings of the CFA are found in Figure 5. All of the loadings are statistically significant at the $p = .05$ level, providing evidence of convergent validity. One of the item loading estimates for outcomes, hands-on education, one of the item loading estimates for exposure, aviation exposure, and one of the item loading estimates for environmental, community interaction, fall under the threshold of .7.

Figure 5

Path Diagram for CFA Two



Note: The numbers indicated the standardized estimates. Only significant relationships (at the p = .05 level) have values provided in the graphic.

The construct reliability and convergent validity were examined using the reliability() function in the R *semTools* package (Jorgensen et al., 2022). The formula the package uses for calculating coefficient alpha can be seen in (1).

$$\alpha = \frac{k}{k-1}\left[1 - \frac{\sum_{i=1}^{k}\sigma_{ii}}{\sum_{i=1}^{k}\sigma_{ii} + 2\sum_{i<j}\sigma_{ij}}\right] \tag{1}$$

Each construct, environmental = 0.7403185, exposure = 0.7407763, outcomes = 0.7826875, demonstrated sufficient coefficient alpha (above .7). The formula the package uses for calculating AVE can be seen in (2).

$$AVE = \frac{1' diag \leq ft(\Lambda\Psi\Lambda')1}{1' diag \leq ft(\hat{\Sigma})1} \tag{2}$$

The average AVE, a measure of convergence validity, for each construct (environmental = 0.5699108, exposure = 0.6088230, outcomes = 0.6229737) suggests adequate convergence, with each value above .5. Discriminant validity was assessed using the heterotrait-monotrait ratio of correlations (HTMT) approach. Values closer to 1 indicate the lack of discriminant validity (Ab Hamid et al., 2017). The results are shown in Table 10. The outcomes/exposure relationship was above the conservative threshold of .85 and the more liberal threshold of .9 (Ab Hamid et al., 2017).

Table 10

HTMT Values for CFA Two

	Environmental	Exposure	Outcomes
Environmental	1.000		
Exposure	0.741	1.000	
Outcomes	0.805	0.922	1.000

The standardized residuals of the variables were calculated and are displayed in Table 11. The largest residual of 3.54, between aviation exposure and industry interaction, suggests a poor covariance estimate. However, the standardized residuals are below the threshold of 4.0, as described by Hair et al. (2014).

Table 11

Standardized Residual Covariance Matrix for CFA Two

	II	MI	CI	AE	AS	CF	HE	CD	CC	SD
II	0.00									
MI	1.90	0.00								
CI	-1.04	-1.43	0.00							
AE	**3.54**	-0.74	1.23	0.00						
AS	**-2.56**	-1.68	0.22	1.61	0.00					
CF	0.08	-0.64	-1.52	-2.41	0.20	0.00				
HE	**2.88**	0.42	0.85	1.13	-2.40	1.21	0.00			
CD	**-3.26**	-0.73	0.76	**-2.67**	1.28	1.21	**-2.51**	0.00		
CC	**-3.52**	0.64	1.66	-2.25	1.24	0.79	**-2.82**	0.72	0.00	
SD	-1.60	0.52	-0.08	-1.27	-0.47	-0.86	-0.95	1.67	1.65	0.00

Note. Residuals were rounded to two decimal places. Residuals above |2.5| are bolded.

The modification indices were also calculated. The cross-loadings are represented in Table 12 and the residual covariances are shown in Table 13. Only values above the threshold of 3.84 were represented.

Table 12

Factor Cross-Loadings for CFA Two

		Mod. Ind.	EPC
Environmental	Hands-on education	9.036	0.673
Environmental	Aviation exposure	5.724	0.52

Table 13

Residual Covariances for CFA Two

		Mod. Ind.	EPC
Industry interaction	Hands-on education	8.788	0.245
Industry interaction	Aviation exposure	8.51	0.239
Industry interaction	Career confidence	4.948	-0.225

The high residuals for industry interaction, shown in Table 11, combined with the covariances, shown in Table 13, suggest it to be a possible candidate for deletion. However, these values are within acceptable limits and deletion would bring down the Environmental construct to only two measurement items. Likewise, the deletion of the hands-on education item would be suggested based on the residuals in Table 11, the cross-loadings in Table 12, and the covariates in Table 13. However, this would bring the outcomes construct to only three measurement items, the minimum required. Likewise, these values are not particularly concerning enough to warrant that deletion.

The discriminant validity, however, proved a barrier to the use of the model for hypothesis testing. As seen in Table 10, the environmental/outcomes and environmental/exposure relationships were above the conservative threshold of .85. As a result, the CFA needed to be modified for final acceptance.

CFA Model Three. A third CFA was conducted, combining the exposure and outcome constructs. The merged construct was renamed the career knowledge construct. The environmental construct was renamed the professional interaction construct to align with the merged construct.

A chi-square test of independence was performed to examine the fit of the model. The examined factor model was not significant, X_2 (34, N = 109) = 47.404, p = 0.063. Common fit indices were calculated and are listed in Table 14.

Table 14

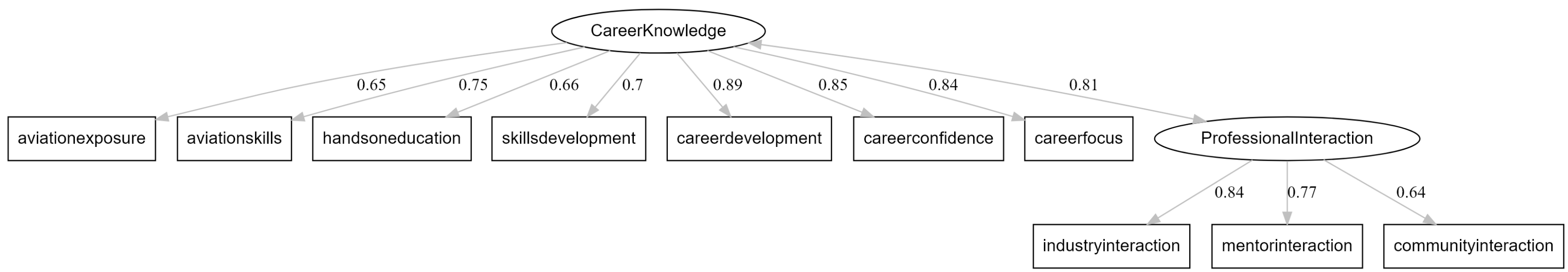
Common Fit Indices for CFA Three

Index	Values	Fit
Root Mean Square Error of Approximation (RMSEA)	0.060	Acceptable
Comparative Fit Index (CFI)	0.995	Good
Tucker-Lewis Index (TLI)	0.993	Good
Bentler-Bonett Normed Fit Index (NFI)	0.983	Good
Bollen's Relative Fit Index (RFI)	0.977	Yes
Relative Noncentrality Index (RNI)	0.995	Yes
Goodness of Fit (GFI)	0.989	Good
Adjust Goodness of Fit (AGFI)	0.972	Good

The path diagram and the associated standardized loadings of the CFA are found in Figure 6. All of the loadings are statistically significant at the $p = .05$ level, providing evidence of convergent validity. Two of the estimates for career knowledge, aviation exposure and hands-on education, and one of the estimates for professional interaction, community interaction, fall under the threshold of .7.

Figure 6

Path Diagram for CFA Three



Note: The numbers indicated the standardized estimates. Only significant relationships (at the $p = .05$ level) have values provided in the graphic.

The reliability of the constructs was examined using the R *semTools* package (Jorgensen et al., 2022). Each construct, professional interaction = 0.7403185 and career knowledge = 0.8550546, demonstrated sufficient coefficient alpha (above .7). The AVE for each construct (professional interaction = 0.5698842 and career knowledge = 0.5924200) suggests adequate convergence, with each value above .5. Discriminant validity was assessed using the HTMT approach, with the relationship between professional interaction and career knowledge calculated at 0.795, below the threshold of .85.

The standardized residuals of the variables were calculated and are displayed in Table 15. The largest residual of -3.21, between industry interaction and career confidence, suggests a poor covariance estimate. However, the residuals are below the threshold of 4.0.

Table 15

Standardized Residual Covariance Matrix for CFA Three

	II	MI	CI	AE	AS	HE	SD	CD	CC	CF
II	0.00									
MI	1.90	0.00								
CI	-1.04	-1.43	0.00							
AE	**2.95**	-0.86	1.04	0.00						
AS	**-2.62**	-1.65	0.02	2.05	0.00					
HE	**2.90**	0.48	0.89	0.91	**-2.81**	0.00				
SD	-1.37	0.60	0.01	-1.50	-0.91	-0.82	0.00			
CD	**-2.99**	-0.52	0.92	**-2.97**	0.62	-2.22	1.89	0.00		
CC	**-3.21**	0.76	1.77	**-2.54**	0.35	**-2.58**	1.80	1.44	0.00	
CF	-0.12	-0.79	-1.66	-1.23	1.88	0.91	-1.12	0.49	0.07	0.00

Note. Residuals were rounded to two decimal places. Residuals above |2.5| are bolded.

The modification indices were also calculated. The cross-loadings are represented in Table 16 and the residual covariances are shown in Table 17. Only values above the threshold of 3.84 were represented.

Table 16

Factor Cross-Loadings for CFA Three

		Mod. Ind.	EPC
Professional interaction	Hands-on education	8.772	0.620
Professional interaction	Aviation exposure	4.623	0.460

Table 17

Residual Covariances for CFA Three

		Mod. Ind.	EPC
Industry interaction	Hands-on education	8.871	0.241
Industry interaction	Aviation exposure	6.938	0.209
Industry interaction	Career confidence	4.306	-0.204

Despite the large cross-loadings, deleting further items would likely interfere with content validity. Furthermore, based on the underlying theory it is not unreasonable to expect these measures to cross-load. The field of aviation is inherently hands-on. As such, it is not unreasonable to expect an overlap in loading between the impact of hands-on education and the impact of exposure to the aviation field. Deletion of these items would not necessarily make the CFA more parsimonious, is not consistent with the underlying theory, and may result in overfitting of the model. Table 18 shows the improvement in model fit through each iteration.

Table 18

Summary of Cross-Loadings and Residual Covariances for Each Model

		Mod. Ind.	EPC	Model	Type
Environmental	Hands-on education	8.973	0.776	1	CL
Exposure	Financial knowledge	6.954	3.218	1	CL
Environmental	Aviation exposure	4.296	0.534	1	CL
Aviation exposure	Financial knowledge	20.038	0.331	1	R
Industry interaction	Hands-on education	9.1	0.247	1	R
Industry interaction	Aviation exposure	6.596	0.212	1	R
Industry interaction	Career confidence	4.697	-0.22	1	R
Aviation exposure	Career development	4.361	-0.21	1	R
Environmental	Hands-on education	9.036	0.673	2	CL
Environmental	Aviation exposure	5.724	0.52	2	CL
Industry interaction	Hands-on education	8.788	0.245	2	R
Industry interaction	Aviation exposure	8.51	0.239	2	R
Industry interaction	Career confidence	4.948	-0.23	2	R
Professional interaction	Hands-on education	8.772	0.62	3	CL
Professional interaction	Aviation exposure	4.623	0.46	3	CL
Industry interaction	Hands-on education	8.871	0.241	3	R
Industry interaction	Aviation exposure	6.938	0.209	3	R
Industry interaction	Career confidence	4.306	-0.2	3	R

Note. Cross-loading (CL) and residual (R) are abbreviated in the type column.

Reliability and Validity Testing Results

The validity of the scale, and its unidimensionality, was tested using the CFA methodology described at length earlier.

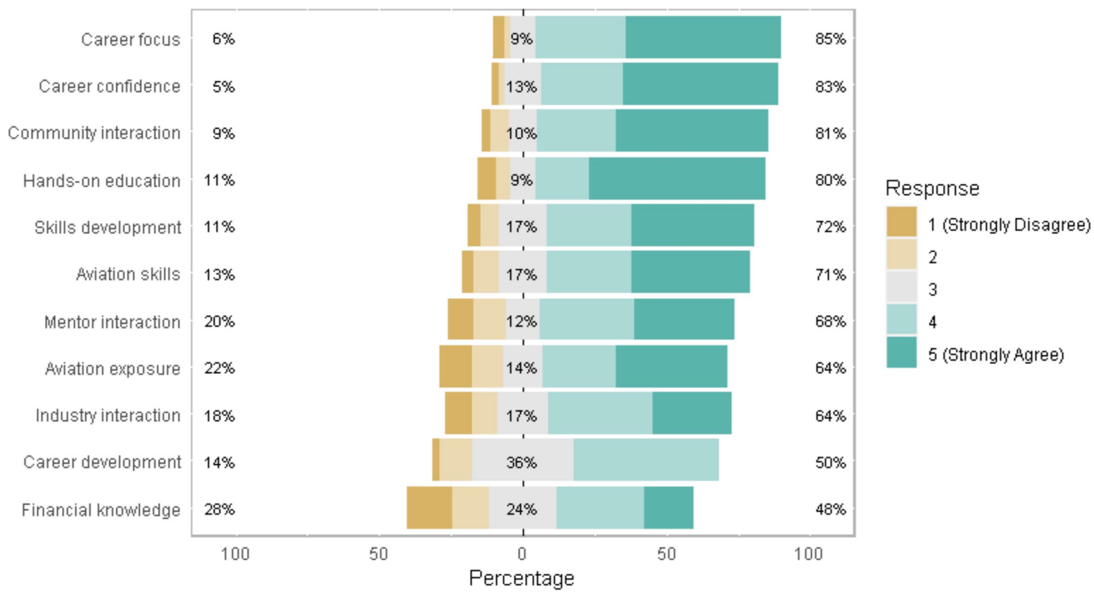
As described previously, reliability was assessed through the cronbach.alpha() function of the R *ltm* package. The overall scale was found to be highly reliable (α = .881, 95% CI = [0.800, 0.924]), with the professional interaction (α = .74, 95% CI = [0.617, 0.826]) and career knowledge (α = .86, 95% CI = [0.766, 0.912]) subscales showing good reliability. Overall, the administered survey, and the data collected, were deemed acceptable for use in hypothesis testing.

Hypothesis Testing Results

As overarching constructs extracted in the CFA were deemed valid, the appropriate survey items were collapsed across the validated constructs by calculating the mean Likert values. This resulted in two new calculated variables, the professional interaction and career knowledge variables. Figure 7 depicts the Likert responses of all participants for each dependent variable.

Figure 7

Bar Plot of the Overall Participant Likert Responses



The proper statistical inference approach for this data is complicated. The intent of this quantitative analysis was to assess RQ2 and explore the self-perceived impact of STEM program type on aviation career development. In order to do this, it was important to understand the underlying data. The overall descriptive statistic results for each variable are found in Table C3.

Testing of Statistical Assumptions

The traditional parametric null hypothesis statistic testing approaches, such as the ANOVA and its derivatives, test the probability of observing the examined data assuming homogeneity of means. This probabilistic modus tollens is the basis of NHST (Schneider, 2018). Finding a low probability of observing said data, given the assumed truth of the null hypothesis, leads to the rejection of the null hypothesis and the inevitable acceptance of the alternative hypothesis of heterogeneity of means. Or, succinctly, rejection of the null hypothesis (the belief that the means between the groups are the same), through a statistically significant finding of $p < .05$, leads to acceptance of the alternative hypothesis (the belief that the means between groups are different).

This research is seeking to either reject, or fail to reject, a series of 13 null hypotheses, initially established in Chapter I as alternative hypotheses and restated below as null hypotheses.

$H_0 1$ There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the professional interaction construct.

$H_0 2$ There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career knowledge construct.

$H_0 3$ There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the industry interaction variable.

$H_0 4$ There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the mentor interaction variable.

$H_0 5$ There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the community interaction variable.

$H_0$6 There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the aviation exposure variable.

$H_0$7 There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the aviation skills variable.

$H_0$8 There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the hands-on education variable.

$H_0$9 There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the skills development variable.

$H_0$10 There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career development variable.

$H_0$11 There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career confidence variable.

$H_0$12 There is no difference between OST STEM program participation and IST STEM participation levels, either alone or in combination, at increasing aviation career interest as measured by the career focus variable.

This parametric testing relies on four major assumptions, interval data, homoscedasticity, normality, and a lack of multicollinearity. That is, the data has to consist of ordered numbers, the amount of error has to be the same across different values of the independent variable, the data has to fall into a normal distribution, and independent variables must not be highly correlated with each other.

As this research question is only examining one independent variable, there is no issue of multicollinearity. However, the ordinal dependent variables do not meet the requirement for interval data.

Normality was assessed through the Shapiro-Wilk Normality Test through the R *stats* core package (R Core Team, 2022). The results are displayed in Table 19. Significant results, and thus non-normality, were found for each dependent variable. This is consistent with the results of Mardia's test, conducted during the investigation of assumptions for the CFA.

Homoscedasticity across the participation type independent variable was assessed through Levene Test for Equality of Variances through the R *cars* package (Fox & Weisberg, 2019). The results are displayed in Table 19. Of note, the industry interaction, hands-on education, career focus, career confidence, and career knowledge variables displayed significant results, indicating heteroscedasticity for those variables.

Table 19

The Homoscedasticity and Normality Values of Each Dependent Variable

Variable	Levene's test	Shapiro-Wilk
Industry interaction	0.03	5.75E-09
Mentor interaction	0.14	6.61E-10
Community interaction	0.30	1.61E-12
Aviation exposure	0.94	5.03E-10
Hands-on education	0.04	3.81E-14
Aviation skills	0.76	4.33E-10
Career focus	0.03	2.16E-13
Career development	0.11	6.42E-13
Career confidence	0.00	8.42E-13
Skills development	0.78	1.29E-10
Professional interaction	0.12	7.36E-07
Career knowledge	0.01	9.70E-09

Note: Both values refer to p-values. Levene's test is conducted across the independent variable of participation type.

These assumptions are important because they rely on the distribution of the underlying data to be the same. This allows for an analysis of the group means to contribute to statistical inference and decision-making.

Kruskal-Wallis Analysis of Identified Constructs

A failure to meet the requirements of parametric testing typically pushes the analysis into the realm of non-parametric testing. In the case of examining one independent variable and one dependent variable with at least three levels or groups, the typical test of choice is the Kruskal–Wallis one-way analysis of variance. This test serves as an omnibus test for examining the differences between groups.

Crucially, the Kruskal-Wallis test is not testing the probability of observing the examined data assuming the null hypothesis of homogeneity (or equivalence) of means.

Rather, the Kruskal-Wallis test is examining whether one group stochastically dominates another. The null hypothesis for the Kruskal-Wallis test is stochastic homogeneity, with stochastic heterogeneity (or stochastic dominance) serving as the alternative hypothesis (Vargha & Delaney, 1998). Putting it in less technical terms, the Kruskal-Wallis test is not examining whether the values (e.g., mean, median) differ between different groups, but rather it is examining the distributions between different groups. As Vargha and Delaney (1998) note, stochastic homogeneity does not imply equality of expected values and equality of medians when the underlying distributions are not symmetric. The shift model allows for the examination of the equality of the means or medians only if the distributions are similar and symmetric (Ruxton & Beauchamp, 2008). Distributions that are similar, but not symmetric, allow for the examination of the equality of medians (Ruxton & Beauchamp, 2008). However, when the underlying distributions are not similar, the Kruskal-Wallis test cannot be used to compare medians (or means)!

Table 20 displays the metrics of the distributions broken down by participation type. This indicates that not only are the distributions not fitting the normal distribution, but the distributions also are not similar between groups and are not symmetrical. This complicates the conclusions that can be assessed through a Kruskal-Wallis test. Nevertheless, the Kruskal-Wallis tests can still provide some useful information. Two Kruskal-Wallis tests, focusing on the professional interaction and career knowledge constructs in an attempt to explore the application of the validated model to STEM participation type, were conducted.

Table 20

The Skew and Kurtosis Values of Each Dependent Variable

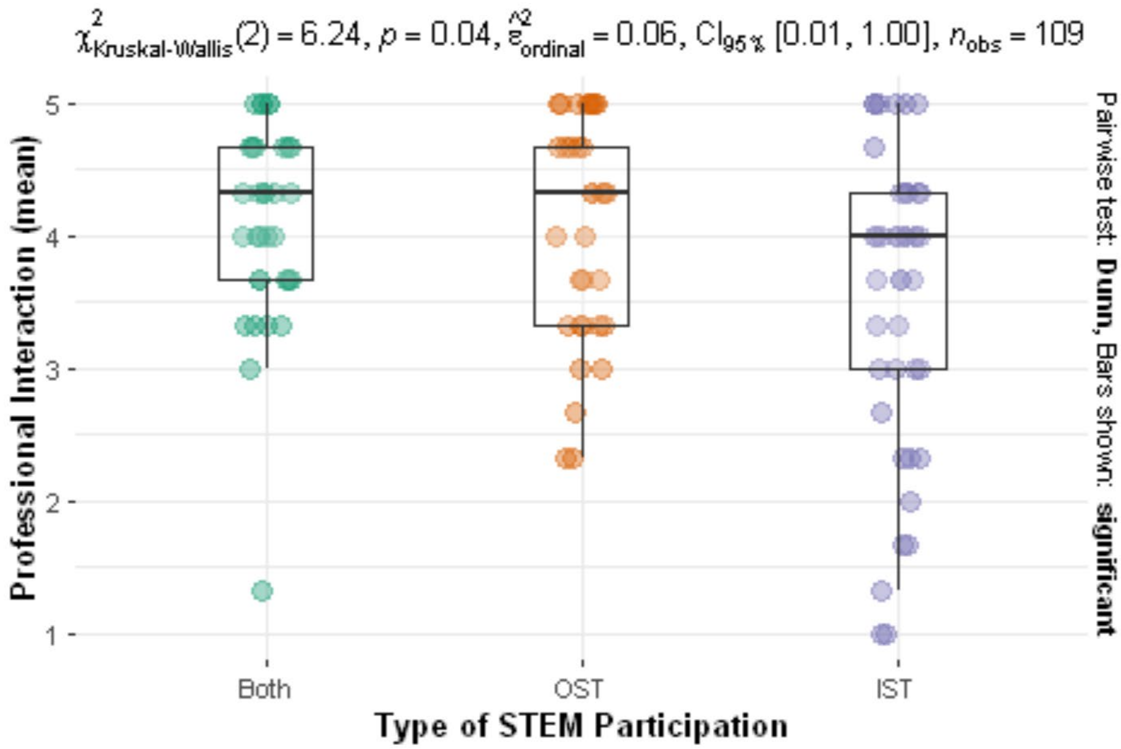
	OST		IST		Both	
	skew	kurtosis	skew	kurtosis	skew	kurtosis
Industry interaction	-1.04	0.16	-0.35	-1.23	-0.85	0.64
Mentor interaction	-0.41	-1.30	-0.48	-1.23	-1.38	1.19
Community interaction	-1.27	0.34	-1.15	0.27	-1.17	0.53
Aviation exposure	-0.81	-0.84	-0.70	-0.92	-0.56	-0.87
Hands-on education	-1.42	0.79	-0.96	-0.74	-1.10	-0.21
Aviation skills	-0.63	-0.63	-0.91	-0.14	-0.95	-0.31
Career focus	-1.88	3.96	-1.11	0.35	-0.85	-0.43
Career development	-0.86	-0.63	-1.29	1.19	-0.49	-0.93
Career confidence	-1.07	0.59	-0.95	0.08	-1.28	0.61
Skills development	-1.09	0.07	-0.88	0.02	-0.87	-0.53
Professional Interaction	-0.50	-1.02	-0.66	-0.53	-1.38	3.08
Career Knowledge	-0.96	0.56	-1.21	1.06	-0.59	0.02

A Kruskal-Wallis test was conducted using the core R *stats* package (R Core Team, 2022) with the effect size calculated using the *rstatix* package (Kassambara, 2021) and the Dunn's test calculated with the *FSA* package (Ogle et al., 2022).

The type of STEM participation was shown to significantly influence the professional interaction construct, $H(2) = 6.2398$, $p = .04416$, $\eta2 = .04$. However, pairwise comparisons using Dunn's test, with p-values adjusted with the Benjamini-Hochberg method, indicated no statistically significant difference between the Both and IST pair ($p = .08789325$), the Both and OST pair ($p = .92370057$), and the IST and OST pair ($p = .05897963$). Refer to Figure 8, generated with the *ggstatsplot* package (Patil, 2021).

Figure 8

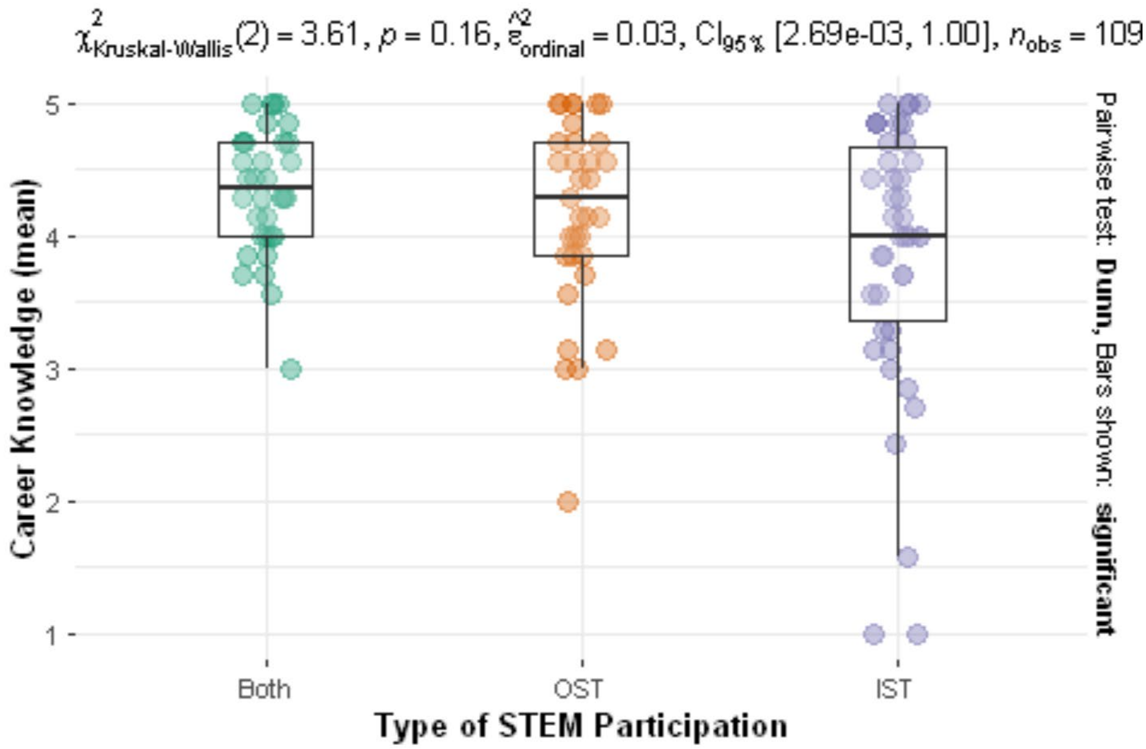
Box plot of the Professional Interaction Construct



The type of STEM participation was not shown to significantly influence the career knowledge construct, $H(2) = 3.6149$, $p = .1641$, $\eta 2 = .0152$. Refer to Figure 9.

Figure 9

Box Plot of the Career Knowledge Construct



The results of the Kruskal-Wallis conducted on the professional interaction construct revealed that the three values (OST, IST, and both) for the calculated dependent variable representing the pooled variables constituting the professional interaction construct participation types exhibit stochastic heterogeneity. That is, for the professional interaction construct, the null hypothesis of stochastic homogeneity must be rejected and the alternative hypothesis of stochastic heterogeneity must be assumed. However, Dunn's test was unable to reveal which groups displayed the stochastic heterogeneity.

Based on the results of the career knowledge construct, the null hypothesis of stochastic homogeneity is not rejected.

Kruskal-Wallis Analysis of Construct Variables

Based on the mixed results provided by the high-level examination of the constructs, a review of each dependent variable in each construct was conducted. Kruskal-Wallis tests were conducted for each variable. Refer to Figure D1.

A review of each dependent variable in the career knowledge construct revealed statistically significant differences between participation type for both the industry interaction and mentor interaction variables. A review of each dependent variable in the career knowledge construct reveals statistically significant differences between participation types for the career confidence variable. Refer to Figure C4 for a detailed summary of the Kruskal-Wallis analyses on each construct variable.

The type of STEM participation was shown to significantly influence the industry interaction variable, $H(2) = 6.0019$, $p = .04974$, $\eta 2 = .0378$. Pairwise comparisons using Dunn's test, with p-values adjusted with the Benjamini-Hochberg method, indicated a statistically significant difference between IST and OST (.0457258), but not between Both and OST (p = .3132410) and Both and IST (p = .2520188). Refer to Figure D1. There is a difference between the IST and OST distributions.

The type of STEM participation was shown to significantly influence the mentor interaction variable, $H(2) = 7.9285$, $p = .01898$, $\eta 2 = .0559$. Pairwise comparisons using Dunn's test, with p-values adjusted with the Benjamini-Hochberg method, indicated a statistically significant difference between Both and IST (p = .0148495), but not between Both and OST (p = .1880324) and IST and OST (p = .2404102). Refer to Figure D1. There is a difference between the Both and IST distributions.

The type of STEM participation was shown to significantly influence the career confidence variable, $H(2) = 9.4561$, $p = .008844$, η2 = .0703. Pairwise comparisons using Dunn's test, with p-values adjusted with the Benjamini-Hochberg method, indicated a statistically significant difference between Both and IST (p = .006322432), but not between Both and OST (p = .177957048) and IST and OST (p = .158563128). Refer to Figure D1. There is a difference between the Both and IST distributions. These results do not lead to the ability to draw many conclusions other than that there are differences in the distributions. As there is a lack of symmetry and homogeneity of variances (homoscedasticity), the Kruskal-Wallis test is unable to speak to the medians of the groups. It can only be said that the groups are different. A logarithmic transform of the data resulted in no apparent change to the skewness of the distribution. Therefore, a switch back to parametric statistics may be warranted.

Welch's ANOVA Analysis of Career Knowledge and Professional Interaction Constructs

Welch's ANOVA is applicable in situations where the assumption of homogeneity of variance is violated. This test is also reliable under violations of the assumption of equal variances. It does assume normality, but ANOVA tests are typically robust against violations of normality.

A series of Welch's ANOVAs were conducted using the core R *stats* package (R Core Team, 2022), with effect size calculated using the *lsr* package (Navarro, 2015). The participation type was found to have a significant relationship with professional interaction, $F(2, 70.276) = 3.8671$, $p = .02551$, $\eta^2 = .06132755$, and career knowledge, $F(2, 66.639) = 3.5841$, $p = .03323$, $\eta^2 = .07839456$.

Multiple Games-Howell pairwise comparisons with respect to STEM program participation type using Tukey's method for adjusting the p-values were conducted on both construct means using the *rstatix* package (Kassambara, 2021). For professional interaction, it was revealed that there was a significant difference between the group means for the Both/IST (*p* = .027, 95% CI [-1.09, -0.0538]), but not for the Both/OST pair (*p* = .98, 95% CI [-0.505, 0.430]) or the OST/IST (*p* = .055, 95% CI [-1.08, 0.00923]) pair. Those that had equal IST and OST STEM participation (*M* = 4.10 *SD* = 0.75 *SE* = 0.13) had a higher mean score compared to those who only had IST STEM participation (*M* = 3.52, *SD* = 1.14, *SE* = 0.18) but were no different from those that only had OST STEM participation (*M* = 4.06, *SD* = 0.84, *SE* = 0.15).

For career knowledge, it was revealed that there was a significant difference between the group means for the Both/IST (*p* = .027, 95% CI [-0.896, -0.0444]), but not for the both/OST pair (*p* = .527, 95% CI [-0.524, 0.198]) or the OST/IST (*p* = .286, 95% CI [-0.791, 0.175]) pair. Those that had equal IST and OST STEM participation (*M* = 4.34, *SD* = 0.47, *SE* = 0.08) had a higher mean score compared to those who only had IST STEM participation (M = 3.87, *SD* = 1.02, *SE* = 0.16) but were no different from those that only had OST STEM participation (*M* = 4.18, *SD* = 0.72, *SE* = 0.13).

Welch's ANOVA analysis of Career Knowledge and Professional Interaction Subscales

Each of the subscales of the constructs was examined in detail. This required ten additional ANOVA tests. However, as the dependent variables were grounded in theory and supported by the results of the CFA, a p-value adjustment method was not applied.

Analysis of the individual dependent variables of the professional interaction construct revealed that participation type had a significant relationship for the mentor interaction variable, $F(2, 70.418) = 4.4043$, $p = .01577$, $\eta^2 = .07975284$, but not the industry interaction, $F(2, 69.522) = 3.054$, $p = .05355$, $\eta^2 = .06300251$, or community interaction variable, $F(2, 70.448) = 1.3528$, $p = .2652$, $\eta^2 = .02860308$.

Pairwise comparison for the mentor interaction variable revealed that there was a significant difference between the group means for the both/IST ($p = .011$, 95% CI [-1.56 -0.171]), but not for the both/OST pair ($p = .379$, 95% CI [-1.00, 0.284]) or the OST/IST ($p = 0.215$, 95% CI [-1.23, 0.211]) pair. Those that had equal IST and OST STEM participation ($M = 3.79$, $SD = 0.95$, $SE = 0.16$) had a higher mean score compared to those who only had IST STEM participation ($M = 3.26$, $SD = 1.40$, $SE = 0.22$) but were no different from those that only had OST STEM participation ($M = 3.97$, $SD = 1.19$, $SE = 0.21$).

Analysis of the individual dependent variables of the career knowledge construct revealed that participation type had a significant relationship with the career confidence, $F(2, 67.042) = 7.0392$, $p = .001679$, $\eta^2 = .1089417$, and career focus variables, $F(2, 66.009) = 4.2947$, $p = .01764$, $\eta^2 = .07511063$, but not for the aviation exposure, $F(2, 69.104) = 0.106$, $p = .8996$, $\eta^2 = .002099212$, aviation skills, $F(2, 69.623) = 0.79036$, $p = .4577$, $\eta^2 = .01331642$, hands-on education, $F(2, 67.883) = 2.8989$, $p = .06193$, $\eta^2 = .05880452$, skills development variables $F(2, 68.718) = 1.5209$, $p = .2258$, $\eta^2 = .02468234$, or career development, $F(2, 68.993) = 2.6496$, $p = .07786$, $\eta^2 = .05765267$, variables.

Pairwise analysis for the career confidence variable revealed that there was a significant difference between the group means for the both/IST ($p = .002$, 95% CI [-1.24 -0.252]), but not for the both/OST pair ($p = .147$, 95% CI [-0.708, 0.0828]) or the

OST/IST (*p* = .148, 95% CI [-0.985, 0.115]) pair. Those that had equal IST and OST STEM participation (*M* = 4.68, *SD* = 0.53, *SE* = 0.09) had a higher mean score compared to those who only had IST STEM participation (*M* = 3.93, *SD* = 1.20, *SE* = 0.18) but were no different from those that only had OST STEM participation (*M* = 4.36, *SD* = 0.78, *SE* = 0.14).

For the career focus variable, it was revealed that there was a significant difference between the group means for the both/IST (*p* = .013, 95% CI [-1.11, -0.112]), but not for the both/OST pair (*p* = .648, 95% CI [-0.607, 0.279]) or the OST/IST (*p* = .162, 95% CI [-1.03, 0.133]) pair. Those that had equal IST and OST STEM participation (*M* = 4.59, *SD* = 0.56, *SE* = 0.10) had a higher mean score compared to those who only had IST STEM participation (*M* = 3.98, *SD* = 1.20, *SE* = 0.19) but were no different from those that only had OST STEM participation (*M* = 4.42, *SD* = 0.90, *SE* = 0.16).

The combined summary of the ANOVA and post-hoc statistics can be found in Table C5. Visualization of the group differences can be found in Figure D2.

Bayesian Analysis of Constructs and Subscales

The results of the Bayesian analysis, conducted with the JASP are mostly consistent with the findings of the non-parametric and parametric analyses. The Bayes factors of these results can be interpreted based on existing criteria in the literature (van Doorn et al., 2021).

There is moderate evidence to support the alternative hypothesis of STEM participation type having an impact on professional interaction (BF_{10} = 3.378). The probability of the alternative hypothesis, given the data, is 77.2%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.098, *SD* = 0.75, 95% CI [3.836, 4.360]),

IST (*M* = 3.524, *SD* = 1.136, 95% CI [3.170, 3.878]), and OST (*M* = 4.061, *SD* = 0.839, 95% CI [3.763, 4.358]) groups. Post-hoc comparisons revealed posterior odds of 0.15 for both/OST, 2.1 for Both/IST, and 1.249 for OST/IST.

There is weak evidence to support the alternative hypothesis of STEM participation type having an impact on career knowledge (BF_{10} = 1.451). The probability of the alternative hypothesis, given the data, is 59.2%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.345, *SD* = 0.472, 95% CI [4.180, 4.509]), IST (*M* = 3.874, *SD* = 1.022, 95% CI [3.556, 4.193]), and OST (*M* = 4.182, *SD* = 0.724, 95% CI [3.925, 4.439]) groups. Post-hoc comparisons revealed posterior odds of .244 for Both/OST, 1.87 for Both/IST, and 0.353 for OST/IST.

There is weak evidence to support the alternative hypothesis of STEM participation type having an impact on industry interaction (BF_{10} = 1.573). The probability of the alternative hypothesis, given the data, is 61.1%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 3.794, *SD* = 0.946, 95% CI [3.464, 4.124]), IST (*M* = 3.262, *SD* = 1.398, 95% CI [2.826, 3.698]), and OST (*M* = 3.970, *SD* = 1.185, 95% CI [3.549, 4.39]) groups. Post-hoc comparisons revealed posterior odds of 0.178 for both/OST, 0.649 for both/IST, and 1.387 for OST/IST.

There is moderate evidence to support the alternative hypothesis of STEM participation type having an impact on mentor interaction (BF_{10} = 3.586). The probability of the alternative hypothesis, given the data, is 78.2%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.176, *SD* = 1.058, 95% CI [3.807, 4.546]), IST (*M* = 3.310, *SD* = 1.473, 95% CI [2.85, 3.769]), and OST (*M* = 3.818, *SD* = 1.131, 95% CI

[3.417, 4.219]) groups. Post-hoc comparisons revealed posterior odds of 0.315 for Both/OST, 4.532 for Both/IST, and 0.445 for OST/IST.

There is moderate evidence to support the null hypothesis of STEM participation type having an impact on community interaction (BF_{10} = 3.226). The probability of the null hypothesis, given the data, is 76.3%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.324, *SD* = 0.878, 95% CI [4.017, 4.630]), IST (*M* = 4, *SD* = 1.23, 95% CI [3.617, 4.383]), and OST (*M* = 4.394, *SD* = 0.933, 95% CI [4.063, 4.725]) groups. Post-hoc comparisons revealed posterior odds of 0.154 for Both/OST, .287 for Both/IST, and .383 for OST/IST.

There is strong evidence to support the null hypothesis of STEM participation type having an impact on aviation exposure (BF_{10} = 10.587). The probability of the null hypothesis, given the data, is 91.4%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 3.735, *SD* = 1.263, 95% CI [3.295, 4.176]), IST (*M* = 3.619, *SD* = 1.431, 95% CI [3.173, 4.065]), and OST (*M* = 3.758, *SD* = 1.437, 95% CI [3.248, 4.267]) groups. Post-hoc comparisons revealed posterior odds of 0.147 for Both/OST, 0.149 for Both/IST, and 0.152 for OST/IST.

There is moderate evidence to support the null hypothesis of STEM participation type having an impact on aviation skills (BF_{10} = 6.499). The probability of the null hypothesis, given the data, is 86.7%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.147, *SD* = 1.019, 95% CI [3.792, 4.503]), IST (*M* = 3.857, *SD* = 1.221, 95% CI [3.477, 4.238]), and OST (*M* = 3.879, *SD* = 1.139, 95% CI [3.475, 4.283]) groups. Post-hoc comparisons revealed posterior odds of 0.228 for Both/OST, 0.238 for Both/IST, and 0.142 for OST/IST.

There is weak evidence to support the alternative hypothesis of STEM participation type having an impact on hands-on education ($BF_{10} = 1.288$). The probability of the alternative hypothesis, given the data, is 56.3%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.529, *SD* = 0.706, 95% CI [4.283, 4.776]), IST (*M* = 3.881, *SD* = 1.549, 95% CI [3.398, 4.364]), and OST (*M* = 4.394, *SD* = 0.966, 95% CI [4.051, 4.737]) groups. Post-hoc comparisons revealed posterior odds of 0.177 for Both/OST, 1.215 for Both/IST, and 0.461 for OST/IST.

There is moderate evidence to support the null hypothesis of STEM participation type having an impact on skills development ($BF_{10} = 3.878$). The probability of the null hypothesis, given the data, is 79.5%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.235, *SD* = 0.955, 95% CI [3.902, 4.569]), IST (*M* = 3.81, *SD* = 1.174, 95% CI [3.444, 4.175]), and OST (*M* = 4, *SD* = 1.225, 95% CI [3.566, 4.434]) groups. Post-hoc comparisons revealed posterior odds of 0.204 for Both/OST, 0.487 for Both/IST, and 0.173 for OST/IST.

There is weak evidence to support the alternative hypothesis of STEM participation type having an impact on career development ($BF_{10} = 1.219$). The probability of the alternative hypothesis, given the data, is 54.9%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.5, *SD* = 0.564, 95% CI [4.303, 4.697]), IST (*M* = 4.048, *SD* = 1.125, 95% CI [3.697, 4.398]), and OST (*M* = 4.455, *SD* = 0.711, 95% CI [3.202, 4.707]) groups. Post-hoc comparisons revealed posterior odds of 0.153 for Both/OST, 0.974 for Both/IST, and 0.572 for OST/IST.

There is strong evidence to support the alternative hypothesis of STEM participation type having an impact on career confidence ($BF_{10} = 15.992$). The probability of the alternative hypothesis, given the data, is 94.1%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.676, *SD* = 0.535, 95% CI [4.490, 4.863]), IST (*M* = 3.929, *SD* = 1.197, 95% CI [3.555, 4.302]), and OST (*M* = 4.364, *SD* = 0.783, 95% CI [4.086, 4.641]) groups. Post-hoc comparisons revealed posterior odds of 0.687 for Both/OST, 15.626 for Both/IST, and 0.566 for OST/IST.

There is weak evidence to support the alternative hypothesis of STEM participation type having an impact on career focus (BF_{10} = 2.861). The probability of the alternative hypothesis, given the data, is 74.1%. Pairwise post-hoc comparisons were calculated for the Both (*M* = 4.588, *SD* = 0.557, 95% CI [4.394, 4.783]), IST (*M* = 3.976, *SD* = 1.199, 95% CI [3.602, 4.35]), and OST (*M* = 4.424, *SD* = 0.902, 95% CI [4.104, 4.744]) groups. Post-hoc comparisons revealed posterior odds of 0.207 for Both/OST, 3.31 for Both/IST, and 0.549 for OST/IST.

The combined summary of Bayes factors and the associated post-hoc statistics can be found in Table C6.

Comparison of Frequentist vs Bayesian Results

The Bayesian analysis favors the alternative hypothesis (with at least moderate support) for the professional interaction construct. It does, however, show weak support for the alternative hypothesis over the null for the career knowledge construct. This differs from the frequentist analysis, which indicates a rejection of the null hypothesis regarding STEM program participation type for that variable.

The Bayesian analysis also favors the alternative hypothesis (with at least moderate support) for the mentor interaction and career confidence variables. This differs from the frequentist analysis, which indicates rejection of the null hypothesis for the mentor interaction, career confidence, and career focus variables.

The Bayesian analysis favors the null hypothesis (with at least moderate support) for the community interaction, aviation exposure, aviation skills, and skills development variables. This is consistent with the frequentist analysis, which fails to reject the null hypothesis for these variables.

The Bayesian analysis is inconclusive regarding the null vs an alternative hypothesis for the industry interaction, hands-on education, and career development variables. As mentioned prior, it is also inconclusive for the career knowledge construct.

Regardless of the approach provided, both approaches support the conclusion that STEM program participation type has a clear impact on the mentor interaction and career confidence variables. Of particular note is the strong evidence seen for the career confidence variable. The posterior odds reveal that the alternative hypothesis is nearly 16 times more likely than the null hypothesis. The post-hoc reveals that this difference is concentrated primarily between the Both and IST groups.

Summary

When collapsed across the three validated constructs established using the CFA methodology, an ANOVA analysis revealed that STEM participation type impacted both the professional interaction and career knowledge constructs. Those participants involved in both an OST and IST STEM program had higher mean professional interaction and career knowledge scores compared to those individuals that only participated in an IST STEM program. Additional Bayesian analysis suggests, however, that the evidence is strongest for the professional interaction construct.

Individually examining each variable revealed three key findings related to mentor interaction, career focus, and career confidence.

1) Those participants who were involved in both an OST and IST STEM program reported that their interactions with mentors through their STEM program participation positively influenced their career development more than those individuals who were only involved in an IST STEM program.
2) Participants who were involved in both an OST and IST STEM program reported that their STEM program participation positively influenced their career focus and interest (career focus) compared to those that only participated in an IST STEM program. This finding, however, is not supported by the Bayesian analysis.
3) Participants who were involved in both an OST and IST STEM program reported that their STEM program participation made them more confident in their career goals (career confidence) compared to those that only participated in an IST STEM program.

Furthermore, the Bayesian analysis allows for the direct examination of the likelihood of the null hypothesis. This adds additional conclusions, not possible with the frequentist analysis. The data suggest that there is no difference between STEM program participation with respect to the community interaction, aviation exposure, aviation skills, and skills development variables.

Taking both the frequentist and Bayesian analyses into account, this leads to the rejection of $H_0 1$ (professional interaction construct) and the partial rejection of $H_0 2$ (career knowledge construct). It also leads to the rejection of $H_0 4$ (mentor interaction variable) and $H_0 11$ (career confidence variable), as well as the partial rejection of $H_0 12$ (career focus variable). However, it also leads to the failure to reject $H_0 3$ (industry interaction variable), $H_0 5$ (community interaction variable), $H_0 6$ (aviation exposure variable), $H_0 7$ (aviation skills variable), $H_0 8$ (hands-on education variable), $H_0 9$ (skills development variable), and $H_0 10$ (career development variable).

Chapter V: Discussion, Conclusions, and Recommendations

Chapter V explores the results of the mixed qualitative and quantitative methodology approach, thematic analysis, CFA, Kruskal-Wallis, one-way Welch ANOVAs, and Bayes factors, to examine the two research questions.

The results of the qualitative analysis and coding conducted on the participant interviews, combined with the results of the CFA, provide insight into the first research question. The quantitative analysis conducted on the collected survey data, however, provides insight into the second research question. The results of the data analysis, the implications of the findings, known limitations to the analysis, and areas for future research will be discussed in this chapter.

Discussion

RQ1 What type of learning experiences do former participants of OST STEM programs self-report as influencing entry into their aviation career?

The first research question, focusing on the type of learning experiences that former participants of OST STEM programs self-report as influencing entry into their aviation career, can be answered based on the results of the qualitative interviews and the validated CFA model.

Primarily, participants reported professional interactions, such as mentoring, contact with industry, and the relationship with their community as influential experiences that contributed to their interest in aviation and their eventual desire to go into the aviation field. More specifically, participants reported that experiences that involved career knowledge concepts, such as those that provided general exposure to the aviation field, activities that improved aviation skills, those that provided hands-on education opportunities, those that improved the general skills of the participant, and those that positively influenced career development, focus, and confidence were key parameters in characterizing how their STEM experiences influenced their aviation careers.

> *RQ*$_2$ How do OST STEM program learning experiences differ from IST STEM learning experiences, either alone or in combination, at increasing interest in an aviation career?

The results of the statistical inference provided insight into the second research question of how OST STEM program learning experiences differ from IST STEM learning experiences, either alone or in combination, in increasing interest in an aviation career. The findings reveal that those participants that spent at least half their STEM program participation time in an OST STEM program, compared to those that only participated in an IST STEM program, reported that professional interactions (especially mentor interaction) greatly influenced their entry into the aviation field and that their STEM programs provided them with increased career knowledge and, more specifically, increased career focus and confidence.

These inferences suggest, but do not confirm, that OST STEM programs are more effective at providing participants with opportunities to develop mentoring relationships. Furthermore, these results suggest that OST STEM programs are more efficacious at providing career focus and interest and creating confidence in career goals.

Mentoring

One of the more interesting results was the perceived value of mentoring gained in OST STEM education. The primary methods through which the participants could have gained career value through mentoring relationships are related to a reduction in barriers to career development, enhanced career knowledge through interactions with experienced professionals, and an increase in role identification and career identity.

In the context of SCCT, mentoring can be classified under contextual choices proximal to choice behavior. These contextual factors, more or less, serve as representations of the individual's environment and how the environment can modify those choice goals and how they are implemented (Lent et al., 1994). Lent et al. (1994) discuss how these factors can be overt resources that individuals draw on at critical milestones, such as leveraging professional networks during a job search. However, they can also relate to those factors that shape interests, such as social/gender norms, role model exposure, or financial support/incentives. Lent et al. (2000) further discuss how the individuals' environment can modify the perceptions of structural barriers, specifically noting interactions with mentors as an example of a filter to these perceptions.

Through the interviews conducted in this research, we can see aspects of this mentoring relationship affecting career barriers. JR, specifically, reported how being selected by a professor to participate in a ballooning team facilitated opportunities that wouldn't necessarily be possible otherwise. MA reported that her mentors, especially those in the local aviation community, served as her "network," lowering the perceived barrier to an aviation career. ZB experienced the same phenomenon, noting that the presence of so many aviation professionals pushed him over the edge into an aviation career. These mentor relationships served to mitigate the networking barriers associated with career entries. With these connections, they were not faced with the same issue of gaining access to job openings as someone without the same networking opportunities. However, these individuals also likely experienced other benefits from this mentoring. These individuals were able to better relate to the identity of a STEM and aviation professional and had enhanced career self-efficacy as a result.

The existing literature supports the interpretation that career self-efficacy is increased as a result of mentoring. Mentoring also has been shown to feed directly into SCCT, not just from the influence of the contextual choices proximal to choice behavior but also through modifications to self-efficacy. Research by DiRenzo et al. (2013) confirmed a structural model that indicates that e-mentor, an online mentor, relationship quality influences general and career-based self-efficacy, which subsequently affects career aspirations.

Through these results, we can see that there is sufficient background literature to place mentoring as a critical component of the individual's environment or contextual factors as it relates to career development. Indeed, the existing literature (Fernandez-Repollet et al., 2018) provides evidence that mentoring can improve knowledge, interest, and motivation toward careers.

Furthermore, the impact of mentoring relationships can also be related back to SCCT and the self-efficacy construct. By providing individualized instruction, regular opportunities for feedback, and reducing various barriers to career entry (e.g., financial, networking), mentoring relationships can ultimately improve an individual's belief that they can succeed in their desired career.

Byars-Winston et al. (2015) explored similar concepts in a research context. They found that mentor effectiveness and research skills and career knowledge were tied to the mentee's research self-efficacy. Effective mentors can better contribute to the mentee's development of research and career knowledge.

In essence, the literature suggests that highly skilled and knowledgeable mentors are able to positively influence mentees, possibly by providing them with increased knowledge about career fields and serving as role models for career development.

The additional evidence supplied by this study, namely that individuals with assumed greater access to mentoring through their OST STEM participation self-report additional perceived benefit to mentoring as it relates to aviation career development compared to the IST population, lends credence to the idea that the mentoring supplied by OST STEM programs support career development.

Self-Efficacy

The two dependent variables of career focus and career confidence can be related back to the concept of self-efficacy, especially how it is modeled in SCCT. The building and sustainment of goals is a key component of the SCCT choice model established by Lent et al. (1994), whereas outcome expectations and self-efficacy feed into performance goals.

It is not surprising that participation in OST STEM education, either fully or in part, is associated with higher perceptions of STEM mediation of career focus and confidence. Research by Lent (2017) found that measures of learning experiences strongly predicted self-efficacy in a model of SCCT, with learning experiences accounting for 54% of the variance in self-efficacy. The literature has linked self-efficacy with career planning and career exploration (Rogers & Creed, 2011), as well as career choice goals (Turner et al., 2019).

Taken together, the current research suggests that OST STEM education is more impactful on self-efficacy. This, in turn, can influence career choice and planning. Those aviation individuals that participated in OST STEM programs reported a greater perceived impact on STEM career focus and confidence. It is believed that the authentic and experiential nature of OST STEM education is the mediating factor that can enhance one's perceptions toward a career and one's confidence in choosing career goals.

Existing literature supports this assertion, with project-based learning (Beier et al., 2019) and hands-on learning (Maiorca et al., 2021) being shown to contribute to STEM self-efficacy. Research by Roberts et al. (2018) explored the lived experiences of students participating in authentic, informal STEM learning. They found that this learning experience "provided students with context and purpose for formal STEM content" (2018, p. 11). These out-of-classroom learning experiences, typical of OST STEM programs, provide access to learning experiences that improve the integration of concepts, facilitate authentic and practical work, allow access to unique equipment, provide different attitudes to science than can be found in the school environment, and promote autonomy and collaboration in learning (Braund & Reiss, 2006).

Similar findings were uncovered in this research, such as with ZB reporting that the math in his hands-on and applied aviation (albeit IST) STEM vocational program was easier to grasp than the math in a more traditional classroom setting. Therefore, the non-significance of the reported impact of hands-on education in aviation STEM career development was interesting. It is possible that this learning experience provided a less overt and perceivable impact.

However, this is not to discount the role that IST STEM programs provide. K-12 education, while potentially not easily able to provide the same authentic learning experiences that industry-focused OST STEM programs provide, is incorporating more hands-on education in curricula. Therefore, both IST and OST programs could be providing similar hands-on learning experiences with OST programs having the greatest impact through the immediately apparent and authentic experiences provided by that medium.

Other Findings

Of particular interest is the non-significant finding of aviation exposure and OST/IST group differences. This suggests that aviation exposure, as it impacts aviation career development, is similar for both IST and OST STEM Programs. Students did not indicate any group differences regarding how learning more about aviation during their STEM program participation affected their career development. Of course, this could be explained away as the participants not having any exposure to aviation through their STEM program participation. This was not directly assessed but can be indirectly analyzed. The summary statistics, provided in Table C3, indicate that this variable has the second lowest mean, after financial knowledge which was discarded in the CFA, and the highest standard deviation. This suggests variability regarding aviation exposure during STEM participation. Future research should explore the implications of this.

Conclusions

Theoretical Contributions

This research, through the context of SCCT, extends the existing body of knowledge related to mentoring in OST STEM education and how OST STEM education positively influences self-efficacy through mentoring. Previous research in the field of SCCT, especially that which explores mentoring in the context of SCCT (A. M. Byars-Winston et al., 2015; Mendez et al., 2017), suggests that mentoring enables mentees to reflect on their abilities, strengthen their self-assessment abilities, and generate a stronger vision of their career development.

Mentoring relationships can also be viewed as removing a barrier to career development. The contextual factors in SCCT (Lent et al., 1994, 2000) represent barriers that mentorship can mitigate. This research provides support for how contextual barriers related to aviation career development could be mitigated or bypassed through mentoring relationships, strengthening this relationship already established in the literature.

Furthermore, this research provides additional insight into the existing SCCT body of literature regarding how OST programs can influence participant self-efficacy through mentoring and the refinement of career goals. As mentioned, existing research has found that measures of learning experiences strongly predicted self-efficacy in a model of SCCT (Lent et al., 2017). Self-efficacy is also linked with career planning and career exploration (Rogers & Creed, 2011), as well as career choice goals (Turner et al., 2019). The findings of this research, especially those career focus and career confidence variables, complement the findings of this prior research and strengthen the conclusion that OST STEM programs, through mentoring, promote greater self-efficacy in the participants.

Practical Contributions

For the aviation field, which is so heavily dominated by the practical rather than the theoretical, there are numerous opportunities for the industry to develop programs that leverage these OST STEM components, especially regarding hands-on and authentic learning (e.g., flight instruction, maintenance training), to improve positive career outcomes.

IST STEM education programs, especially those aviation-focused programs or those programs with the goal of aviation workforce development, should look to leverage these research findings to better improve the efficacy of their learning activities. Implementing opportunities for building mentoring relationships, especially between students and industry mentors, could be valuable in promoting entry into the aviation (and greater STEM) field.

This is consistent with existing literature that emphasized the importance of mentoring and role models in aviation. Garcia and Manaia (2019, p. 6) make the recommendation that the aviation field should “emphasize role models, whereby students are introduced to people working in and enthusiastic about STEM, with whom they can relate.” While focusing more on the importance of mentoring college students, Veenstra (2014) makes the same pitch, noting that mentoring helps to bridge the gap and ease the transition between college and the workplace.

This focus on mentoring would be true even for non-aviation-focused IST STEM programs, as the results suggest that some OST STEM experiences are better than no OST STEM experiences. However, the results from this research indicate that those participants who participated in only OST STEM experiences did not perceive mentoring to be any more impactful than those participants that had split their time between OST and IST STEM participation. That is, some amount of OST program participation is beneficial, but more is not necessarily advantageous.

Limitations of the Findings

This research serves as a brief, first look at characterizing the complexity of OST STEM programs in the aviation field. As an initial assessment of the problem, it does leave room for improvement. The current study has several limitations and drawbacks that should be addressed in future research.

One substantial limitation of this research is related to the sampling of the population. The sample size goal was achieved, but only just. The small sample size of the study potentially affected the ability of the statistical tests to encounter a type II error. As the sample size increases, the statistical power ($1 - \beta$), the probability of rejecting a false H_0, increases, and the probability of a type II error (β), a failure to reject a false H_0, decreases (J. Cohen, 1992).

Paired with the issue of low power, the small sample size of the study limited the ability of the research to explore different factors or covariates (e.g., gender, age, role). A brief review of the contingency tables of variables paired with the participation type variable revealed several cells with very low, or outright missing samples. These missing values prevented further analysis of the data.

In addition, the sampling methodology of the research introduced potential bias. Convenience and snowball sampling enabled the easy collection of data but does not guarantee an accurate probabilistic sampling of the population across multiple variables (G. R. Sadler et al., 2010). For example, Table 4 indicates that the occupations of the participations are heavily loaded onto the pilot and engineer career fields and do not fully represent the myriad of occupations available in the field of aviation. This can introduce barriers to generalizability of the research. A more representative sample of the entire aviation workforce, which is not primarily composed of pilots and engineers, may differ in some of the conclusions. However, future research is recommended to explore this possibility.

An additional limitation inherent to this research is related to the ex post facto, nonexperimental design of the research. There was no random assignment to STEM groups, nor any assignment at all. It is not possible to postulate a cause-and-effect relationship between STEM programs and career development. This limits the ability of the research to make definitive conclusions about how STEM participation affected aviation career entry. As the participants were already involved in aviation careers, and because no participants in other fields were sampled, it is not possible to make conclusions about how well STEM programs affect entry into the aviation field. Rather, the focus is on examining the aspects of the STEM programs that affected entry into aviation careers. Future research should look to close this gap and explore how effective STEM programs, especially aviation-focused STEM programs, are at influencing entry into the aviation career field.

This ex post facto issue is further compounded by the issue of self-report data. To some extent, the nature of this self-report data is valuable because it allows the individual to consider information that no one else may be able to provide.

However, relying on the retrospective self-reflections of the participants may mean that the research findings are not adequately representative of the true impact of the STEM programs. Imperfect human memory and conscious or subconscious bias could affect the validity of the self-report data and skew the results.

Recommendations

Recommendations for the Aviation Community

The aviation community should look to implement programs that emphasize creating authentic mentoring relationships between educators, industry mentors, and other role models. Participants perceived these relationships to be impactful in their aviation career development.

Industry, in particular, should look for ways in which it can support mentoring programs for high-school and college-aged students. This is not a novel recommendation (Veenstra, 2014), but it bears repeating. Industry-based mentoring programs have clear benefits with regard to enhancing career interest (Ilumoka et al., 2017). Having access to authentic aviation experiences, especially those outside the classroom and in the field with aviation professionals, will be the most beneficial for developing a new career interest and nurturing an existing one.

Dean Kamen, one of the founders of the FIRST Robotics Competition, explained his philosophy on mentoring during the 1998 FIRST Competition Kickoff Workshop on January 10, 1998 (*How Involved Are Your Team's Mentors in the Design and Programming Process?*, 2019).

> Again, the point of FIRST is to create, and do, for intellectual and technical things, what the Shaquille O'Neals and Michael Jordans do for unimportant things. And it gives kids an opportunity to see real role models, real heroes, not celebrities, but real heroes. So they can finish up the six weeks and say "I can do that. I want to learn these things. I'll put effort into that. I want to be like . . . you people."

Mentorship, especially from industry, has the potential to make a significant difference in the career progression of young individuals. PK reported when discussing his participation in the Aviation Explorers program.

> It gave me focus. It kind of laid out a path once I knew... I wandered in high school. I didn't do particularly well. Well, I didn't do well at all. But it seems like once I knew where I needed to go, I got better. I did better my last two years of high school, even, like I said, even though it wasn't enough to bring my grade point up. I knew I had to go to college, so I started looking into that. I want to say it was a game changer for me. It really changed my life. Really. I don't know what I would have ended up doing without it. I have no idea. I don't think I would have joined the Navy. I don't think I would have been a pilot. You know, gosh. It's crazy how one organization can really change your life. It did.

That participation in a hands-on and authentic aviation experience, especially one with a mentoring component, provided him with the opportunity to develop an aviation identity that substantially influenced his career path. Developing programs that can facilitate this will, likely, positively influence participants and encourage entry into the aviation workforce.

Both the qualitative and quantitative results of this research support the notion that mentoring is important. Students, especially those from underprivileged or underrepresented backgrounds, such as certain ethnic groups (Fouad & Santana, 2017; Gloria & Hird, 1999) and genders (Fouad & Santana, 2017), face barriers to entry in many career fields. Mentoring can provide avenues for bypassing some of these career barriers, especially those that are associated with a lack of access or knowledge (e.g., access to scholarships, information about financial resources).

Ignoring the concern of group differences leads to additional insight from the data. Figure 7 depicts the Likert responses of all participants for each dependent variable, across all combinations of IST and OST STEM programs. In addition to the previously discussed career focus and career confidence aspects, over 80% of participants agreed that working in a community of individuals with similar interests positively influenced their aviation career development.

Future aviation programs should explore how they can not only build interest in the aviation field and expose students to knowledge about aviation careers but how they can build and sustain communities of practice. These communities of practice are "relatively informal, intra-organizational groups specifically facilitated by management to increase learning or creativity" (Cox, 2005, p. 538).

Even in traditional classroom and lecture environments, communities of practice have been associated with active learning (Tomkin et al., 2019). Aviation-focused communities of practice have been associated with the formation of professional identity and an increase in self-confidence (Bates & O'Brien, 2013; O'Brien & Bates, 2015). Research by Kit et al. (2021) found that students are strongly motivated by the support of their peers.

By focusing on cultivating not only the academic experience but also the social experience, a key component of communities of practice, future aviation-focused STEM programs can develop professionals with stronger career identities.

Figure 7 reveals that 80% of the participants across the IST and OST STEM programs agreed that participating in hands-on learning and practical application of knowledge, related to their career field, in the STEM program positively influenced their aviation career development.

Hands-on education was previously discussed in the context of group differences between OST and IST STEM education. However, hands-on education, in general, can be advantageous for both IST and OST programs alike. Future aviation-focused STEM programs should explore incorporating hands-on aviation opportunities for students. Research by Rawat et al. (2018) explored an aerospace academy implementing hands-on learning aviation opportunities, finding that these opportunities positively influenced the students' perspectives on STEM.

This is consistent with existing recommendations from aviation researchers. Demirci (2018, p. 114), who focused on exploring NASA's high school aviation STEM programs, "recommends that OST STEM programs should adopt a more intuitive and engaging curriculum that focuses on hands-on learning experiences that are directly connected to real-world scenarios." This research provides evidence to support and reemphasize this message.

Recommendations for Future Research Methodology

The statistical analysis revealed several limitations that were not previously considered or addressed and which should be addressed in future research.

Analysis of the self-reported Likert data revealed several shortcomings in this approach. Table C3 reveals the summary statistics for each independent variable. With the exception of the financial knowledge variable, which was discarded during the CFA process, each variable displayed a median of 4 or 5. Most individuals did not report any negative effects from their participation in any STEM program. This meant that there was an entire tail of that distribution that was not required, potentially complicating the ability to make statistical inferences about the group means due to the ordinal nature of the data. Future research should explore removing the strong disagree to neutral aspect of the scale and rebalancing it with agree as 1 and strongly agree as a 5. Future research and modification of the survey items could also explore, in addition or in place of the rebalancing suggestion, increasing the number of ordinal values in the scale to seven or nine. This would have the same effect of providing the participants with more selection options.

Recommendations for Future Research

Future research should focus on addressing the limitations of the current study, verifying and validating the results and ultimate conclusions, and expanding on the findings.

Of particular importance for future research is the continued validation and refinement of the implemented scale. Despite the two-pronged process of qualitative model development with subsequent CFA, the scale is still relatively untested. Future research should explore the implementation of this scale, and validation of the constructs in a separate sampling of the same population (engineers, pilots) and, perhaps, a similar but somewhat different population (e.g., air traffic controllers, maintainers).

Additionally, research should further explore the implications of the perceived importance of OST STEM education in the field of aviation workforce development. As this research has tentatively identified the role that OST STEM education has on the professional interaction and career knowledge constructs, future research should focus on better characterizing these findings and explaining how they arise.

Future research should also focus on quantifying the amount of OST STEM participation that is necessary to impact these identified constructs. OST STEM programs can vary in the level of involvement, from programs that are year-round and meet multiple times a week (e.g., educational robotics) to programs that take place for a short, sustained period of time (e.g., STEM summer camps). This research did not collect information related to the amount of STEM education that the participants were involved in. Future research should explore adding that variable to the statistical model, examining any potential interactions between the amount of STEM participation and the type of STEM participation.

Future research should not be limited to the direct findings of this research, however. As was mentioned in the results section, one of the major contributors to entry into the aviation (and greater STEM) fields was the presence of immediate or extended family in the aviation or STEM fields. While, as previously noted, this is not directly related to the current research involving OST or IST STEM education, this is an important finding that helps to characterize the overall reasons for career selection. Future research should explore this finding, focusing on how and why family appears to have such a large influence on the aviation career field.

Future research should also explore the use of different statistical inference approaches. NHST, while familiar, is significantly flawed in its ability to draw conclusions (Ioannidis, 2019; Wasserstein et al., 2019; Wasserstein & Lazar, 2016). The current analysis was limited, due to time and resources, but future work should explore the implementation of a Bayesian ordered probit model (Liddell & Kruschke, 2018), which enables the application of regression analysis to ordinal variables. This would enable a more in-depth analysis of the relationships between the independent and dependent variables.

References

Ab Hamid, M. R., Sami, W., & Mohmad Sidek, M. H. (2017). Discriminant validity assessment: Use of Fornell & Larcker criterion versus HTMT Criterion. *Journal of Physics: Conference Series*, *890*, 012163. https://doi.org/10.1088/1742-6596/890/1/012163

Aircraft Owners and Pilots Association. (n.d.). *About the high school initiative*. Retrieved January 16, 2021, from https://youcanfly.aopa.org/high-school/about

Allen, P. J., Chang, R., Gorrall, B. K., Waggenspack, L., Fukuda, E., Little, T. D., & Noam, G. G. (2019). From quality to outcomes: A national study of afterschool STEM programming. *International Journal of STEM Education*, *6*. https://doi.org/10.1186/s40594-019-0191-2

Allen, R. T., & Barnhart, R. K. (2006). Influencing factors in degree selection for aviation majors at Indiana State University. *Journal of Aviation/Aerospace Education & Research*, *15*(3), 23–30.

Allport, G. W. (1935). Attitudes. In *Handbook of Social Psychology* (pp. 798–844). Clark University Press.

Altoum, R. (2021). *Relationship between attending STEM extracurricular programs and aspiration toward STEM careers* (Publication No. 2487146310) [Doctoral dissertation, Walden University]. ProQuest One Academic. https://www-proquest-com.ezproxy.libproxy.db.erau.edu/docview/2487146310

Baguio, M., Fowler, W. T., Ramirez, S., & Ries, J. G. (2015, June 14). NASA's Summer of Innovation in the Rio Grande Valley: Does summer STEM engagement increase student interest and teacher instruction among underrepresented and underserved youth? *Association for Engineering Education - Engineering Library Division Papers*. https://doi.org/10.18260/p.23342

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*(1), 1–26. https://doi.org/10.1146/annurev.psych.52.1.1

Bandura, A. (2018). Toward a psychology of human agency: Pathways and reflections. *Perspectives on Psychological Science*, *13*(2), 130–136. https://doi.org/10.1177/1745691617699280

Bates, P., & O'Brien, W. (2013). 'It's more than stick and rudder skills': An aviation professional development community of practice. *Teaching in Higher Education*, *18*(6), 619–630. https://doi.org/10.1080/13562517.2013.764862

Beckett, M., Borman, G., Capizzano, J., Parsley, D., Ross, S., Schirm, A., & Taylor, J. (2009). *Structuring out-of-school time to improve academic achievement: A* *practice guide* (NCEE #2009-012). National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. http://ies.ed.gov/ncee/wwc/publications/practiceguide

Beier, M. E., Kim, M. H., Saterbak, A., Leautaud, V., Bishnoi, S., & Gilberto, J. M. (2019). The effect of authentic project-based learning on attitudes and career aspirations in STEM. *Journal of Research in Science Teaching*, *56*(1), 3–23. https://doi.org/10.1002/tea.21465

Berg, B. L. (2007). *Qualitative research methods for the social sciences* (6th ed.). Pearson Education, Inc.

Bevan, B., & Michalchik, V. (2013). Where it gets interesting: Competing models of STEM learning after school. *Afterschool Matters*, *17*, 1–8.

Bevan, B., Michalchik, V., Bhanot, R., Remold, J., Semper, R., Shields, P., Rauch, N., Remold, J., Semper, R., & Shields, P. (2010). *Out-of-school time STEM: Building experience, building bridges*. Exploratorium.

Blanco, M. (2017). *Determine the factors of influence for young adults (21+ years) to study aviation in Puerto Rico: A quantitative descriptive study* (1945386171) [Doctoral dissertation, Northcentral University]. ProQuest One Academic. https://www-proquest-com.ezproxy.libproxy.db.erau.edu/docview/1945386171

Blotnicky, K. A., Franz-Odendaal, T., French, F., & Joy, P. (2018). A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0118-3

Boateng, G. O., Neilands, T. B., Frongillo, E. A., Melgar-Quiñonez, H. R., & Young, S. L. (2018). Best practices for developing and validating scales for health, social, and behavioral research: A primer. *Frontiers in Public Health*, *6*, 149.

Boeing. (2016). *Current market outlook: 2016—2035*.

https://www.boeing.com/resources/boeingdotcom/commercial/about-our-market/assets/downloads/cmo_print_2016_final_updated.pdf

Braund, M., & Reiss, M. (2006). Towards a more authentic science curriculum: The contribution of out-of-school learning. *International Journal of Science Education*, *28*(12), 1373–1388. https://doi.org/10/dgw54n1

Burkholder, E. O., & Peláez, M. (2000). A behavioral interpretation of Vygotsky's theory of thought, language, and culture. *Behavioral Development Bulletin*, *9*, 7–9. https://doi.org/10.1037/h0100530

Busetto, L., Wick, W., & Gumbinger, C. (2020). How to use and assess qualitative research methods. *Neurological Research and Practice*, *2*(1), 14. https://doi.org/10.1186/s42466-020-00059-z

Byars-Winston, A. M., Branchaw, J., Pfund, C., Leverett, P., & Newton, J. (2015). Culturally diverse undergraduate researchers’ academic outcomes and perceptions of their research mentoring relationships. *International Journal of Science Education*, *37*(15), 2533–2554. https://doi.org/10.1080/09500693.2015.1085133

Byars-Winston, A., & Rogers, J. G. (2019). Testing intersectionality of race/ethnicity × gender in a social–cognitive career theory model with science identity. *Journal of Counseling Psychology*, *66*(1), 30–44. https://doi.org/10.1037/cou0000309

Calabrese Barton, A., & Tan, E. (2010). We be burnin’! Agency, identity, and science learning. *Journal of the Learning Sciences*, *19*(2), 187–229. https://doi.org/10.1080/10508400903530044

Caraway, C. L. (2020). A looming pilot shortage: It is time to revisit regulations. *International Journal of Aviation, Aeronautics and Aerospace*, *7*(2). http://dx.doi.org/10.15394/ijaaa.2020.1470

Chan, H., Choi, H., Hailu, M. F., Whitford, M., & Duplechain DeRouen, S. (2020). Participation in structured STEM-focused out-of-school time programs in secondary school: Linkage to postsecondary STEM aspiration and major. *Journal of Research in Science Teaching*, *57*(8), 1250–1280. https://doi.org/10/ghnj25

Chittum, J. R., Jones, B. D., Akalin, S., & Schram, Á. B. (2017). The effects of an afterschool STEM program on students’ motivation and engagement. *International Journal of STEM Education*, *4*(1), 1–16. ProQuest One Academic; SciTech Premium Collection. https://doi.org/10/d6qg

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Alignment of hands-on STEM engagement activities with positive STEM dispositions in secondary school students. *Journal of Science Education and Technology*, *24*(6), 898–909. https://doi.org/10.1007/s10956-015-9572-6

Clark, J. M. (2004). *A descriptive research survey study that examined factors influencing selection of four -year post -secondary commercial aviation programs* (305159676) [Doctoral dissertation, The University of Mississippi]. ProQuest One Academic. https://www-proquest-com.ezproxy.libproxy.db.erau.edu/docview/305159676

Clark, J. M. (2006). The face of collegiate aviation: Factors impacting self-selection of collegiate aviation programs. *Collegiate Aviation Review International*, *24*(1). https://doi.org/10.22488/okstate.18.100342

Cohen, B. (2018). Teaching STEM after school: Correlates of instructional comfort. *The Journal of Educational Research*, *111*(2), 246–255. https://doi.org/10.1080/00220671.2016.1253537

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159.

Cohen, J. (1994). The Earth Is round (p < .05). *American Psychologist*, *49*(12), 997–1003.

Covert, H., Ilunga Tshiswaka, D., Ramkissoon, I., Sisskin, E., Lichtveld, M., & Wickliffe, J. (2019). Assessing science motivation among high school students participating in a supplemental science programme: The Emerging Scholars Environmental Health Sciences Academy. *International Journal of Science Education*, *41*(17), 2508–2523. https://doi.org/10.1080/09500693.2019.1689308

Cox, A. (2005). What are communities of practice? A comparative review of four seminal works. *Journal of Information Science*, *31*(6), 527–540. https://doi.org/10.1177/0165551505057016

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B: Communication and Public Engagement*, *2*(1), 63–79. https://doi.org/10.1080/21548455.2011.629455

Demirci, E. (2018). *The influence of NASA's High School Aerospace Scholars (HAS) Program on student's STEM attitude and 21st century skills* (Publication No. 10844761) [Doctoral dissertation, Oklahoma State University]. ProQuest Dissertations and Theses. https://eric.ed.gov/?id=ED599442

DiRenzo, M. S., Weer, C. H., & Linnehan, F. (2013). Protégé career aspirations: The influence of formal e-mentor networks and family-based role models. *Journal of Vocational Behavior*, *83*(1), 41–50. https://doi.org/10.1016/j.jvb.2013.02.007

Donaldson, J. L., & Franck, K. L. (2020). A mixed-methods evaluation to measure 4-H STEM program quality. *Journal of Youth Development*, *15*(5), 203–219. https://doi.org/10.5195/jyd.2020.835

Dou, R., Hazari, Z., Dabney, K., Sonnert, G., & Sadler, P. (2019). Early informal STEM experiences and STEM identity: The importance of talking science. *Science Education*, *103*(3), 623–637. https://doi.org/10/gft26p

Dryfoos, J. G. (1999). The role of the school in children's out-of-school time. *The Future of Children*, *9*(2), 117–134. JSTOR. https://doi.org/10/dqtxbw

Duffett, A., Johnson, J., Farkas, S., Public Agenda Foundation, & Wallace Foundation. (2004). *All work and no play?: Listening to what kids and parents really want from out-of-school time: A report from Public Agenda*. Public Agenda. https://files.eric.ed.gov/fulltext/ED485306.pdf

Durlak, J. A., & Weissberg, R. P. (2007). *The impact of after-school programs that promote personal and social skills*. https://files.eric.ed.gov/fulltext/ED505368.pdf

Eby, L. T., Allen, T. D., Evans, S. C., Ng, T., & DuBois, D. L. (2008). Does mentoring matter? A multidisciplinary meta-analysis comparing mentored and non-mentored individuals. *Journal of Vocational Behavior*, *72*(2), 254–267. https://doi.org/10.1016/j.jvb.2007.04.005

ERAU Institutional Review Board. (2020). *IRB Decision Tree*. Embry-Riddle Aeronautical University. https://erau.edu/-/media/files/university/research/irb-decision-tree-2020.pdf

Esser, D. A., & Ryan, P. J. (1998). Would ACES Academy benefit your university? *Journal of Aviation/Aerospace Education & Research*, *8*(2). https://commons.erau.edu/jaaer/vol8/iss2/6/

Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *Journal of Educational Psychology*, *103*(1), 206–222. https://doi.org/10.1037/a0020743

Everitt, B., & Hothorn, T. (2011). *An Introduction to Applied Multivariate Analysis with R*. Springer New York. https://doi.org/10.1007/978-1-4419-9650-3

Experimental Aircraft Association. (2020, August 31). *Free Young Eagles flights*. https://www.eaa.org/eaa/youth/free-ye-flights

Federal Aviation Administration. (2020, July 14). *Aviation Career Education (ACE) Academy*. https://www.faa.gov/education/ace_academy/

Fernandez-Repollet, E., Locatis, C., De Jesus-Monge, W. E., Maisiak, R., & Liu, W.-L. (2018). Effects of summer internship and follow-up distance mentoring programs on middle and high school student perceptions and interest in health careers. *BMC Medical Education*, *18*(1). https://doi.org/10.1186/s12909-018-1205-3

Flowers, S. K., Beyer, K. M., Pérez, M., & Jeffe, D. B. (2016). Early environmental field research career exploration: An analysis of impacts on precollege apprentices. *CBE Life Sciences Education*, *15*(4). https://doi.org/10.1187/cbe.15-11-0230

Fouad, N. A., & Santana, M. C. (2017). SCCT and underrepresented populations in STEM fields: Moving the needle. *Journal of Career Assessment*, *25*(1), 24–39. https://doi.org/10/ghrkhq

Fox, J., & Weisberg, S. (2019). *An R Companion to Applied Regression* (Third). Sage. https://socialsciences.mcmaster.ca/jfox/Books/Companion/

Funk, C., Rainie, L., Smith, A., Olmstead, K., Duggan, M., & Page, D. (2015). *Public and scientists' views on science and society*. Pew Research Center. https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2015/01/PI_ScienceandSociety_Report_012915.pdf

Gagliardo, B. (2020). *Against the wind: A study on aviation as a female career choice* (Publication No. 2393042820) [Doctoral dissertation, Brandman University]. ProQuest Dissertations and Theses Global. https://www.proquest.com/docview/2393042820

GAO. (2018). *Stakeholders' views on challenges for initial pilot training programs* (GAO-18-403). U.S. Government Printing Office.

Garcia, R., & Manaia, F. (2019). Attracting young talent to aeronautics. *8th European Conference for Aeronautics and Space Sciences (EUCASS)*, 1–13. https://doi.org/10.13009/EUCASS2019-853

Gloria, A. M., & Hird, J. S. (1999). Influences of ethnic and nonethnic variables on the career decision-making self-efficacy of college students. *The Career Development Quarterly*, *48*(2), 157–174. https://doi.org/10.1002/j.2161-0045.1999.tb00282.x

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A.-B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science*, *341*(6153), 1455–1456. https://doi.org/10.1126/science.1240487

Habig, B., Gupta, P., Levine, B., & Adams, J. (2020). An informal science education program's impact on STEM major and STEM career outcomes. *Research in Science Education*, *50*(3), 1051–1074. https://doi.org/10/ghtvw9

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis*. Prentice Hall.

Hauseman, D. C., & English, R. M. (2016). Youth-led community arts hubs: Self-determined learning in an out-of-school time (OST) program. *Cogent Education*, *3*(1). https://doi.org/10/ghrpvp

Holloman, J. B., & Hubble, M. W. (2012). High school allied health students and their exposure to the profession of EMS. *Prehospital and Disaster Medicine*, *27*(3), 245–251. http://dx.doi.org/10.1017/S1049023X12000787

How involved are your team's mentors in the design and programming process? - FIRST / General Forum. (2019, January 27). Chief Delphi.

https://www.chiefdelphi.com/t/how-involved-are-your-team-s-mentors-in-the-design-and-programming-process/343409/42

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Hurley, A. E., Scandura, T. A., Schriesheim, C. A., Brannick, M. T., Seers, A., Vandenberg, R. J., & Williams, L. J. (1997). Exploratory and confirmatory factor analysis: Guidelines, issues, and alternatives. *Journal of Organizational Behavior*, *18*(6), 667–683. https://doi.org/10.1002/(SICI)1099-1379(199711)18:6<667::AID-JOB874>3.0.CO;2-T

Ilumoka, A., Milanovic, I., & Grant, N. (2017). *An effective industry-based mentoring approach for the recruitment of women and minorities in engineering*. *18*(3), 7.

Ioannidis, J. P. A. (2019). What Have We (Not) Learnt from Millions of Scientific Papers with P Values? *The American Statistician*, *73*(sup1), 20–25. https://doi.org/10/gfw9b2

JASP Team. (2022). *JASP* (Version 0.16.3).

Jorgensen, T. D., Pornprasertmanit, S., Schoemann, A. M., & Rosseel, Y. (2022). *semTools: Useful tools for structural equation modeling*. https://CRAN.R-project.org/package=semTools

Kassambara, A. (2021). *rstatix: Pipe-friendly framework for basic statistical tests*. https://CRAN.R-project.org/package=rstatix

Kelter, R. (2020). Bayesian alternatives to null hypothesis significance testing in biomedical research: A non-technical introduction to Bayesian inference with JASP. *BMC Medical Research Methodology*, *20*(1), 142. https://doi.org/10.1186/s12874-020-00980-6

Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2014). The development of the STEM Career Interest Survey (STEM-CIS). *Research in Science Education.*, *44*(3), 461–481. https://doi.org/10.1007/s11165-013-9389-3

Kit, N. D. T., & Wah, C. S. K. (2021). Motivating students to learn STEM via engaging flight simulation activities. *Journal of Science Education and Technology*, *30*(5), 608–629. https://doi.org/10.1007/s10956-021-09907-2

Kitchen, J. A., Sonnert, G., & Sadler, P. M. (2018). The impact of college- and university-run high school summer programs on students' end of high school

STEM career aspirations. *Science Studies and Science Education*, *102*, 529–547. https://doi.org/10.1002/sce.21332

Klapper, E. S., & Ruff-Stahl, H.-J. K. (2019). Effects of the pilot shortage on the regional airline industry: A 2023 forecast. *International Journal of Aviation, Aeronautics and Aerospace*, *6*(3). http://dx.doi.org/10.15394/ijaaa.2019.1321

Knekta, E., Runyon, C., & Eddy, S. (2019). One size doesn't fit all: Using factor analysis to gather validity evidence when using surveys in your research. *CBE—Life Sciences Education*, *18*(1), rm1. https://doi.org/10/gfzxgk

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*.

Korte, R., Brunhaver, S., & Zehr, S. M. (2019). The socialization of STEM professionals into STEM careers: A study of newly hired engineers. *Advances in Developing Human Resources*, *21*(1), 92–113. https://doi.org/10.1177/1523422318814550

Kotys-Schwartz, D., Besterfield-Sacre, M., & Shuman, L. (2011). Informal learning in engineering education: Where we are - where we need to go. *2011 Frontiers in Education Conference (FIE)*, T4J-1-T4J-7. https://doi.org/10.1109/fie.2011.6142836

Lee, S. W., & Mamerow, G. (2019). Understanding the role cumulative exposure to highly qualified science teachers plays in students' educational pathways. *Journal of Research in Science Teaching*, *56*(10), 1362–1383. https://doi.org/10.1002/tea.21558

Lent, R. W., & Brown, S. D. (2019). Social cognitive career theory at 25: Empirical status of the interest, choice, and performance models. *Journal of Vocational Behavior*, *115*, 103316. https://doi.org/10.1016/j.jvb.2019.06.004

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., Talleyrand, R., McPartland, E. B., Davis, T., Chopra, S. B., Alexander, M. S., Suthakaran, V., & Chai, C.-M. (2002). Career choice barriers, supports, and coping strategies: College students' experiences. *Journal of Vocational Behavior*, *60*(1), 61–72. https://doi.org/10.1006/jvbe.2001.1814

Lent, R. W., Hackett, G., & Brown, S. D. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology*, *47*(1), 36–49. https://doi.org/10.1037/0022-0167.47.1.36

Lent, R. W., Ireland, G. W., Penn, L. T., Morris, T. R., & Sappington, R. (2017). Sources of self-efficacy and outcome expectations for career exploration and decision-making: A test of the social cognitive model of career self-management. *Journal of Vocational Behavior*, *99*, 107–117. https://doi.org/10.1016/j.jvb.2017.01.002

Lent, R. W., Sheu, H.-B., Miller, M. J., Cusick, M. E., Penn, L. T., & Truong, N. N. (2018). Predictors of science, technology, engineering, and mathematics choice options: A meta-analytic path analysis of the social–cognitive choice model by gender and race/ethnicity. *Journal of Counseling Psychology*, *65*(1), 17–35. https://doi.org/10.1037/cou0000243

Liddell, T. M., & Kruschke, J. K. (2018). Analyzing ordinal data with metric models: What could possibly go wrong? *Journal of Experimental Social Psychology*, *79*, 328–348. https://doi.org/10/gfdbv8

Lishinski, A. (2021). *lavaanPlot: Path diagrams for "Lavaan" models via "DiagrammeR."* https://CRAN.R-project.org/package=lavaanPlot

Lutte, R. K. (2016). Aviation outreach model and gap analysis: Examining solutions to address workforce shortages. *Collegiate Aviation Review International*, *36*(1). https://doi.org/10/ghs98t

Maiorca, C., Roberts, T., Jackson, C., Bush, S., Delaney, A., Mohr-Schroeder, M. J., & Soledad, S. Y. (2021). Informal learning environments and impact on interest in STEM careers. *International Journal of Science and Mathematics Education*, *19*(1), 45–64. https://doi.org/10.1007/s10763-019-10038-9

Maltese, A. V., Melki, C. S., & Wiebke, H. L. (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. *Science Education*, *98*(6), 937–962. https://doi.org/10.1002/sce.21132

Markus, H., & Nurius, P. (1986). Possible selves. *American Psychologist*, *41*(9), 954–969. APA PsycArticles. https://doi.org/10.1037/0003-066x.41.9.954

McCombs, J., Whitaker, A., & Yoo, P. (2018). *The value of out-of-school time programs* (pp. 1–22). RAND Corporation. https://doi.org/10.7249/pe267

McDonald, S., & Lambert, J. (2014). The long arm of mentoring: A counterfactual analysis of natural youth mentoring and employment outcomes in early careers. *American Journal of Community Psychology*, *54*(3–4), 262–273. https://doi.org/10.1007/s10464-014-9670-2

McGerald, J., Nidds, J. A., & Turney, M. A. (1993). Aviation career education: An exciting option. *The Clearing House*, *67*(2), 103.

Mendez, S. L., Conley, V. M., Keith, R. S., Haynes, C., & Gerhardt, R. (2017). Mentorship in the engineering professoriate: Exploring the role of social cognitive career theory. *International Journal of Mentoring and Coaching in Education*, *6*(4), 302–316. https://doi.org/10.1108/IJMCE-12-2016-0077

Miani, P., Kille, T., Lee, S.-Y., Zhang, Y., & Bates, P. R. (2021). The impact of the COVID-19 pandemic on current tertiary aviation education and future careers: Students' perspective. *Journal of Air Transport Management*, *94*, 102081. https://doi.org/10/gk7g23

Mihas, P. & Odum Institute. (2019). *Learn to use an exploratory sequential mixed method design for instrument development*. SAGE Publications, Ltd. https://doi.org/10.4135/9781526496454

Miller, K., Sonnert, G., & Sadler, P. (2017). The influence of students' participation in STEM competitions on their interest in STEM careers. *International Journal of Science Education, Part B: Communication and Public Engagement*, *8*(2), 95–114. https://doi.org/10.1080/21548455.2017.1397298

Mohr-Schroeder, M. J., Jackson, C., Miller, M., Walcott, B., Little, D. L., Speler, L., Schooler, W., & Schroeder, D. C. (2014). Developing middle school students' interests in STEM via summer learning experiences: See Blue STEM Camp. *School Science and Mathematics*, *114*(6), 291–301. https://doi.org/10.1111/ssm.12079

Morey, R. D. & Rouder, J. N. (2015). *BayesFactor* (Version 0.9.10-2).

Morgado, F. F. R., Meireles, J. F. F., Neves, C. M., Amaral, A. C. S., & Ferreira, M. E. C. (2018). Scale development: Ten main limitations and recommendations to improve future research practices. *Psicologia: Reflexão e Crítica*, *30*(1), 3. https://doi.org/10/gh7kw4

Morgenroth, T., Ryan, M. K., & Peters, K. (2015). The motivational theory of role modeling: How role models influence role aspirants' goals. *Review of General Psychology*, *19*(4), 465–483. https://doi.org/10.1037/gpr0000059

Murray, G. (2021, March). *After Covid-19, aviation faces a pilot shortage*. OliverWyman. https://www.oliverwyman.com/our-expertise/insights/2021/mar/after-covid-19-aviation-faces-a-pilot-shortage.html

Nargundkar, S., Samaddar, S., & Mukhopadhyay, S. (2014). A guided problem-based learning (PBL) approach: Impact on critical thinking. *Decision Sciences Journal of Innovative Education*, *12*(2), 91–108. https://doi.org/10.1111/dsji.12030

National Research Council. (2009). *Learning science in informal environments: People, places, and pursuits*. The National Academies Press. https://doi.org/10.17226/12190

Navarro, D. (2015). *Learning statistics with R: A tutorial for psychology students and other beginners. (Version 0.6)*. University of New South Wales. https://learningstatisticswithr.com

Noam, G. G., & Shah, A. M. (2013). *Game-changers and the assessment predicament in afterschool science*. https://www.informalscience.org/sites/default/files/Noam_Shah_Science_Assessment_Report.pdf

O'Brien, W., & Bates, P. (2015). "Looking and feeling the part": Developing aviation students' professional identity through a community of practice. *Teaching in Higher Education*, *20*(8), 821–832. https://doi.org/10.1080/13562517.2015.1087998

Ogle, D. H., Doll, J. C., Wheeler, P., & Dinno, A. (2022). *FSA: Fisheries Stock Analysis*. https://github.com/fishR-Core-Team/FSA

Patil, I. (2021). Visualizations with statistical details: The "ggstatsplot" approach. *Journal of Open Source Software*, *6*(61), 3167. https://doi.org/10.21105/joss.03167

Pendergrass, J. F. (2008). A study of career choice factors and students' academic success at an aviation school. In *Dissertation Abstracts International Section A: Humanities and Social Sciences*. http://ezproxy.libproxy.db.erau.edu/login?url=https://search.proquest.com/docview/621751911?accountid=27203

Pilot shortage expected to worsen over next decade. (2022, September 13). *AirGuide Business*, NA. Gale Academic OneFile.

Polkinghorne, D. (1983). *Methodology for the human sciences*. State University of New York.

Price, C. A., Kares, F., Segovia, G., & Loyd, A. B. (2019). Staff matter: Gender differences in science, technology, engineering or math (STEM) career interest development in adolescent youth. *Applied Developmental Science*, *23*(3), 239–254. https://doi.org/10/gfkw7k

R Core Team. (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Rawat, K. S., Lawrence, E. E., Mangham, R. R., & Gooden, O. D. (2018). *K-12 Aerospace Academy: An out-of-school authentic and experiential STEM learning experience for college and career pathways to aerospace/aviation*. https://peer.asee.org/30742

Rennie, L. J. (2007). Learning science outside of school. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (1st edition, pp. 125–167). Lawrence Erlbaum Associates.

Revelle, W. (2022). *psych: Procedures for psychological, psychometric, and personality research*. Northwestern University. https://CRAN.R-project.org/package=psych

Rigelman, N. R. (2013). Becoming a mathematical problem solver. *Mathematics Teaching in the Middle School*, *18*(7), 416–423. JSTOR. https://doi.org/10/ghs98s

Rizopoulos, D. (2006). ltm: An R package for latent variable modelling and item response theory analyses. *Journal of Statistical Software*, *17*(5), 1–25. https://doi.org/10.18637/jss.v017.i05

Roberts, T., Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Cavalcanti, M., Craig Schroeder, D., Delaney, A., Putnam, L., & Cremeans, C. (2018). Students' perceptions of STEM learning after participating in a summer informal learning experience. *International Journal of STEM Education*, *5*(1), 35. https://doi.org/10.1186/s40594-018-0133-4

Rogers, M. E., & Creed, P. A. (2011). A longitudinal examination of adolescent career planning and exploration using a social cognitive career theory framework. *Journal of Adolescence*, *34*(1), 163–172. https://doi.org/10.1016/j.adolescence.2009.12.010

Roller, S. A., Lampley, S. A., Dillihunt, M. L., Benfield, M. P. J., Gholston, S. E., Turner, M. W., & Davis, A. M. (2020). Development and initial validation of the student interest and choice in STEM (SIC-STEM) Survey 2.0 Instrument for assessment of the social cognitive career theory constructs. *Journal of Science Education and Technology*, *29*(5), 646–657. https://doi.org/10.1007/s10956-020-09843-7

Roller, S. A., Lampley, S. A., Dillihunt, M. L., Benfield, M. P. J., & Turner, M. W. (2018, June 23). Student attitudes toward STEM: A revised instrument of social cognitive career theory constructs (Fundamental). *Association for Engineering Education - Engineering Library Division Papers*. https://peer.asee.org/student-attitudes-toward-stem-a-revised-instrument-of-social-cognitive-career-theory-constructs-fundamental

Rosseel, Y. (2012). {lavaan}: An {R} Package for Structural Equation Modeling. *Journal of Statistical Software*, *48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

Rowan, N., & Wulff, D. (2007). Using qualitative methods to inform scale development. *The Qualitative Report*, *12*(3), 450–466. https://doi.org/10.1177/1362361315601012

Ruxton, G. D., & Beauchamp, G. (2008). Some suggestions about appropriate use of the Kruskal–Wallis test. *Animal Behaviour*, *76*(3), 1083–1087. https://doi.org/10.1016/j.anbehav.2008.04.011

Ryu, J., LaPaglia, S. K., & Walters, R. (2020). Idaho Drone League (iDrone) to stimulate STEM workforce. *Journal of STEM Education*, *21*(2), 35–41.

Sadler, G. R., Lee, H.-C., Lim, R. S.-H., & Fullerton, J. (2010). Recruitment of hard-to-reach population subgroups via adaptations of the snowball sampling strategy. *Nursing & Health Sciences*, *12*(3), 369–374. https://doi.org/10.1111/j.1442-2018.2010.00541.x

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, *96*(3), 411–427. https://doi.org/10.1002/sce.21007

Saw, G. K., Swagerty, B., Brewington, S., Chang, C.-N., & Culbertson, R. (2019). Out-of-school time STEM program: Students' attitudes toward and career interests in mathematics and science. *International Journal of Evaluation and Research in Education*, *8*(2), 356. https://doi.org/10.11591/ijere.v8i2.18702

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). *Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures*. *8*(2).

Schneider, J. W. (2018). NHST is still logically flawed. *Scientometrics*, *115*, 627–635. https://doi.org/10.1007/s11192-018-2655-4

Shah, A. M., Wylie, C. E., Gitomer, D., & Noam, G. (2014). *Development of the Dimensions of Success (DoS) observation tool for the out of school time STEM field: Refinement, field-testing and establishment of psychometric properties*. Program in Education, Afterschool, and Resilience.

Shah, A. M., Wylie, C., Gitomer, D., & Noam, G. (2018). Improving STEM program quality in out-of-school-time: Tool development and validation. *Science Education*, *102*(2), 238–259. https://doi.org/10.1002/sce.21327

Sheu, H.-B., Lent, R. W., Brown, S. D., Miller, M. J., Hennessy, K. D., & Duffy, R. D. (2010). Testing the choice model of social cognitive career theory across Holland themes: A meta-analytic path analysis. *Journal of Vocational Behavior*, *76*(2), 252–264. https://doi.org/10/dmfx82

Southwest Airlines. (n.d.). *Adopt a Pilot*. Retrieved January 16, 2021, from https://www.southwest.com/html/southwest-difference/community-involvement/adopt-a-pilot/index.html

Steckel, R., Lercel, D., & Matsuo, H. (2010). Factors that influence an undergraduate student to choose a career in aviation, and enroll in the Aviation Science Program at Parks College of Engineering, Aviation and Technology. *Collegiate Aviation Review*, *28*(2), 69–83. ProQuest One Academic; SciTech Premium Collection.

Sullivan, G. M. (2011). A primer on the validity of assessment instruments. *Journal of Graduate Medical Education*, *3*(2), 119–120. https://doi.org/10.4300/JGME-D-11-00075.1

Surra, A., & Litowitz, L. S. (2015). A STEM-based high school aviation course. *Technology and Engineering Teacher*, *74*(4), 28–30.

Tai, R. H., Qi Liu, C., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science*, *312*(5777), 1143. https://doi.org/10/cgk8nt

Tallman, J. W. (2011, March 9). Young Eagles more likely to become pilots. *AOPA*. https://www.aopa.org/news-and-media/all-news/2011/march/09/young-eagles-more-likely-to-become-pilots

Thiry, H., Laursen, S. L., & Hunter, A.-B. (2011). What experiences help students become scientists? A comparative study of research and other sources of personal and professional gains for STEM undergraduates. *The Journal of Higher Education*, *82*(4), 357–388. https://doi.org/10.1080/00221546.2011.11777209

Tien Long, N., Thi Hoang Yen, N., & Van Hanh, N. (2020). The role of experiential learning and engineering design process in K-12 STEM education. *International Journal of Education and Practice*, *8*(4), 720–732. https://doi.org/10.18488/journal.61.2020.84.720.732

Tierney, N., Cook, D., McBain, M., & Fay, C. (2021). *naniar: Data structures, summaries, and visualisations for missing data*. https://CRAN.R-project.org/package=naniar

Tomkin, J. H., Beilstein, S. O., Morphew, J. W., & Herman, G. L. (2019). Evidence that communities of practice are associated with active learning in large STEM lectures. *International Journal of STEM Education*, *6*(1), 1. https://doi.org/10.1186/s40594-018-0154-z

Turner, S. L., Joeng, J. R., Sims, M. D., Dade, S. N., & Reid, M. F. (2019). SES, gender, and STEM career interests, goals, and actions: A test of SCCT. *Journal of Career Assessment*, *27*(1), 134–150. https://doi.org/10.1177/1069072717748665

U.S. Department of Education. (2007). *Report of the Academic Competitiveness Council* (No. ED496649). U.S. Department of Education. https://eric.ed.gov/?id=ED496649

van Doorn, J., van den Bergh, D., Böhm, U., Dablander, F., Derks, K., Draws, T., Etz, A., Evans, N. J., Gronau, Q. F., Haaf, J. M., Hinne, M., Kucharský, Š., Ly, A., Marsman, M., Matzke, D., Gupta, A. R. K. N., Sarafoglou, A., Stefan, A., Voelkel, J. G., & Wagenmakers, E.-J. (2021). The JASP guidelines for conducting and reporting a Bayesian analysis. *Psychonomic Bulletin & Review*, *28*(3), 813–826. https://doi.org/10.3758/s13423-020-01798-5

van Tuijl, C., & van der Molen, J. H. W. (2016). Study choice and career development in STEM fields: An overview and integration of the research. *International Journal of Technology and Design Education*, *26*(2), 159–183. https://doi.org/10.1007/s10798-015-9308-1

VanMeter-Adams, A., Frankenfeld, C. L., Bases, J., Espina, V., & Liotta, L. A. (2014). Students who demonstrate strong talent and interest in STEM are initially attracted to STEM through extracurricular experiences. *CBE Life Sciences Education*, *13*(4), 687–697. https://doi.org/10.1187/cbe.13-11-0213

Vargha, A., & Delaney, H. D. (1998). The Kruskal-Wallis test and stochastic homogeneity. *Journal of Educational and Behavioral Statistics*, *23*(2), 170–192. https://doi.org/10.2307/1165320

Vasileiou, K., Barnett, J., Thorpe, S., & Young, T. (2018). Characterising and justifying sample size sufficiency in interview-based studies: Systematic analysis of qualitative health research over a 15-year period. *BMC Medical Research Methodology*, *18*. http://dx.doi.org/10.1186/s12874-018-0594-7

Veenstra, C. (2014). The Collaborative Role of Industry in Supporting STEM Education. *The Journal for Quality and Participation*, *37*(3), 27–29. ProQuest One Academic.

Wai, J., Lubinski, D., Benbow, C. P., & Steiger, J. H. (2010). Accomplishment in science, technology, engineering, and mathematics (STEM) and its relation to STEM educational dose: A 25-year longitudinal study. *Journal of Educational Psychology*, *102*(4), 860–871. https://doi.org/10.1037/a0019454

Walter, T. (2015, October 16). *STEM students dream big with naval aviation*. U.S. Department of the Navy. https://www.navy.mil/Press-Office/News-Stories/Article/2264000/stem-students-dream-big-with-naval-aviation/

Wasserstein, R. L., & Lazar, N. A. (2016). The ASA's statement on p-values: Context, process, and purpose. *The American Statistician*, *70*(2), 129–133. https://doi.org/10.1080/00031305.2016.1154108

Wasserstein, R. L., Schirm, A. L., & Lazar, N. A. (2019). Moving to a World Beyond "p < 0.05." *The American Statistician*, *73*(sup1), 1–19. https://doi.org/10/gfw9bz

Wei-Cheng, M., Chen, S.-J., & Chi-Chau, L. (2019). Assessing high school student's STEM career interests using a social cognitive framework. *Education Sciences*, *9*(2). https://doi.org/10.3390/educsci9020151

Wiebe, E., Unfried, A., & Faber, M. (2018). The relationship of STEM attitudes and career interest. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(10). https://doi.org/10.29333/ejmste/92286

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Wilkerson, S. B., & Haden, C. M. (2014). Effective practices for evaluating STEM out-of-school time programs. *Afterschool Matters*, *19*, 10–19.

Young, J. L., Young, J. R., & Ford, D. Y. (2019). Culturally relevant STEM out-of-school time: A rationale to support gifted girls of color. *Roeper Review*, *41*(1), 8–19. https://doi.org/10/ghstnz

Young, J. R., Ortiz, N., & Young, J. L. (2016). STEMulating interest: A meta-analysis of the effects of out-of-school time on student STEM interest. *International Journal of Education in Mathematics, Science and Technology*, *5*(1), 62. https://doi.org/10.18404/ijemst.61149

Appendix A: Permission to Conduct Research

Embry-Riddle Aeronautical University
Application for IRB Approval
EXEMPT Determination Form

Principal Investigator: Andrew Koch

Other Investigators: Haydee M. Cuevas

Role: Student **Campus:** Worldwide **College:** Aviation/Aeronautics

Project Title: Role of Out-of-School Time STEM Programs on Aviation Workforce Recruitment and Retention

Review Board Use Only

Initial Reviewer: Teri Gabriel **Date:** 11/18/2021 **Approval #:** 22-054

Determination: Exempt

Beth Blickensderfer
IRB Chair Signature: Elizabeth L. Blickensderfer Digitally signed by Elizabeth L. Blickensderfer Date: 2021.11.23 13:54:26 -05'00'

Brief Description:

The purpose of this exploratory study is to examine the self-perceived effect of out-of-school time (OST) science, technology, engineering, and math (STEM) experiences, as compared to in-school-time (IST) STEM experiences, on the career path of current aviation employees. Participants will be asked to participate in an interview using the method of their choice; in-person, online meeting software, or phone conversation.

This research falls under the **EXEMPT** category as per 45 CFR 46.104:

☑ (2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (Applies to Subpart B [Pregnant Women, Human Fetuses and Neonates] and does not apply for Subpart C [Prisoners] except for research aimed at involving a broader subject population that only incidentally includes prisoners.)

Embry-Riddle Aeronautical University
Application for IRB Approval
EXEMPT Determination Form

Principal Investigator: Andrew Koch

Other Investigators: Haydee M. Cuevas

Role: Student **Campus:** Worldwide **College:** Aviation/Aeronautics

Project Title: Role of Out-of-School Time STEM Programs on Aviation Workforce Recruitment and Retention

Review Board Use Only

Initial Reviewer: Teri Gabriel **Date:** 03/30/2022 **Approval #:** 22-120

Determination: Exempt

Dr. Beth Blickensderfer
IRB Chair Signature: Elizabeth L. Blickensderfer Digitally signed by Elizabeth L. Blickensderfer Date: 2022.04.05 11:54:10 -04'00'

Brief Description:

The purpose of this exploratory study is to examine the self-perceived effect of out-of-school time (OST) science, technology, engineering, and math (STEM) experiences, as compared to in-school-time (IST) STEM experiences, on the career path of current aviation employees. Participants will be asked to complete a survey via Google Forms.

This research falls under the **EXEMPT** category as per 45 CFR 46.104:

☑ (2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (Applies to Subpart B [Pregnant Women, Human Fetuses and Neonates] and does not apply for Subpart C [Prisoners] except for research aimed at involving a broader subject population that only incidentally includes prisoners.)

Appendix B: Data Collection Device

STEM Survey

* Required

Purpose of this Research

You are being asked to participate in a research study to investigate the role that out-of-school time science, technology, engineering, and math (STEM) programs have on the recruitment and retention of the aviation workforce. During this study, you will be asked to reflect on your prior STEM experiences, the impact that those STEM experiences had on shaping your career, and how your prior STEM experiences affect your career in the aviation field. The total time of your participation in the study is estimated to be no more than 10 minutes.

Risks or Discomforts

The risks of participating in this study are no more than what is experienced in daily life. You may experience discomfort from reflecting on past experiences. If you experience any discomfort, you may discontinue your participation with no negative repercussions.

Benefits

While there are no benefits to you as a participant, your participation in this study may help us to better understand the benefits of STEM education on aviation workforce recruitment and retention.

Confidentiality of Records:

Your participation in this study will be anonymous. No identifying information will be collected.

Voluntary Participation

Your participation in this study is completely voluntary. You may discontinue your participation at any time without penalty. To discontinue your participation, exit out of the survey before submitting your data.

Contact

If you have any questions or would like additional information about this study, please contact Andrew Koch, at kocha4@my.erau.edu, or the faculty member overseeing this project, Dr. Haydee Cuevas, at cuevash1@erau.edu. For any concerns or questions as a participant in this research, contact the Institutional Review Board (IRB) at 386-226-7179 or via email at teri.gabriel@erau.edu.

Consent

By checking AGREE below, I certify that I am 18 years or older, located in the U.S., have participated in a STEM program during my K-12 education, and have at some point been employed in the field of aviation. I further verify that I understand the information on this form and that I voluntarily agree to participate in the study.

1. I agree to the informed consent *

Mark only one oval.

- ◯ Yes
- ◯ No *Skip to section 4 (Debriefing)*

Demographics

2. My participation in STEM primarily took place:

Mark only one oval.

- ◯ Within the school day (e.g., through a STEM academy or accelerated program).
- ◯ Outside the school day or unrelated to school (e.g., after-school club, summer camp).
- ◯ Equally within and outside the school day.

3. My current age is:

Mark only one oval.

- ◯ 18-24 years
- ◯ 25-34 years
- ◯ 35-44 years
- ◯ 45-54 years
- ◯ 55-64 years
- ◯ 65+ years

4. My gender is:

Mark only one oval.

- Male
- Female
- Non-binary
- Prefer not to say
- Other: ______________________

5. I have ___ years of experience in the aviation field

Mark only one oval.

- 0-4
- 5-9
- 10-14
- 15-19
- 20+

6. I am best described as a:

Mark only one oval.

- Pilot
- Aircrew
- Flight attendant
- Mechanic/maintainer
- Air traffic controller
- Engineer
- Scientist
- Logistician
- Management
- Aviation educator
- Other: ______________________

Career Development

Indicate the extent to which the following positively influenced your career development:

7. Interacting with industry professionals through my STEM program participation.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree						Strongly Agree

8. Interacting with mentors through my STEM program participation.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

9. Working in a community of individuals with similar interests.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

10. Learning more about aviation during my STEM program participation.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

11. Participating in hands-on learning and practical application of knowledge, related to my career field, in the STEM program.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

12. Learning more about the financial and career prospects of the aviation field.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

My STEM program participation

13. Taught me skills related to my aviation career.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

14. Positively influenced my career focus and interest.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

15. Positively influenced my career development.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	⬭	⬭	⬭	⬭	⬭	Strongly Agree

16. Made me more confident in my career goals.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

17. Provided me with skills, such as leadership and time management, to help me succeed in my career.

Mark only one oval.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Debriefing

Thank you for participating in this research study about the role that out-of-school time science, technology, engineering, and math (STEM) programs have on the recruitment and retention of the aviation workforce. If you have any questions or would like additional information about this study, please contact Andrew Koch, at kocha4@my.erau.edu, or the faculty member overseeing this project, Dr. Haydee Cuevas, at cuevash1@erau.edu. For any concerns or questions as a participant in this research, contact the Institutional Review Board (IRB) at 386-226-7179 or via email at teri.gabriel@erau.edu.

Appendix C: Tables

Table C1

	PK	EW	CB	DM	BC	RF	ES	JR	ZB	AB	MA	Total
Alternate Careers Considered	0	0	0	0	0	0	0	0	0	0	0	0
Considered auto mechanic as a career	0	0	1	0	0	0	0	0	1	0	0	2
Considered biomedical engineering	0	0	0	0	0	0	0	2	0	0	0	2
Considered engineering as a career	0	0	0	0	0	0	0	0	1	0	0	1
Considered law as a career	0	1	0	0	0	0	0	0	0	0	0	1
Considered medicine as a career	1	1	0	0	0	0	0	1	0	2	1	6
Considered music as a career	0	0	0	0	0	0	1	0	0	0	0	1
Considered sports as a career	0	1	0	0	0	0	0	0	0	0	0	1
STEM Entry	0	0	0	0	0	0	0	0	0	0	0	0
A positive outcome expectation of the STEM field influenced entry into the STEM field	0	0	0	0	0	0	0	0	0	0	1	1
Exposure to STEM at home positively influenced STEM career entry	0	0	0	0	0	0	1	1	0	0	0	2
Exposure to engineering knowledge positively influenced entry into a STEM career	0	0	1	1	0	0	0	0	0	0	0	2
Family did not influence STEM entry	0	0	2	0	0	0	0	0	0	0	0	2
Hands-on exposure to STEM concepts positively influenced STEM career entry	0	0	0	1	0	0	1	0	0	0	0	2
Having family in STEM positively influenced entry into a STEM career	0	0	0	1	0	0	2	0	0	0	0	3
Internship positively influenced entry into a STEM career	0	0	0	0	0	0	0	0	0	0	0	0
Mentors in STEM positively influenced entry into the STEM field	0	0	0	1	0	0	0	0	0	0	0	1
Parents/family had an expectation of entering the STEM field	0	1	0	0	0	1	0	3	0	0	2	7
Participation in STEM programs improved self-efficacy	0	0	0	0	0	0	0	0	0	0	1	1
Participation in STEM programs provided a negative experience	0	0	0	0	0	0	0	2	0	0	0	2

	PK	EW	CB	DM	BC	RF	ES	JR	ZB	AB	MA	Total
Participation in STEM programs provided an exposure to engineering concepts	0	0	0	0	0	0	0	0	0	0	1	1
Peer influence positively influenced entry into a STEM career	1	0	1	0	0	0	0	0	0	0	1	3
School culture positively influenced entry into a STEM career	0	0	0	0	0	0	0	0	0	0	2	2
School had little impact on entry into a STEM career	0	0	0	0	0	0	0	1	0	0	0	1
School provided negative feedback about STEM careers	0	1	0	0	0	0	0	0	0	0	0	1
Self-reported aviation career influences	0	0	0	0	0	0	0	0	0	0	0	0
Aviation mentors positively influenced aviation career entry	1	0	0	0	0	0	1	2	2	1	3	10
Community influence positively influenced aviation career entry	0	0	1	0	1	0	0	0	0	0	3	5
Exposure to aviation at home positively influenced aviation career entry	0	0	0	0	1	1	1	1	0	3	3	10
Exposure to aviation during school activities/courses positively influenced aviation career entry	0	0	0	0	0	0	0	1	0	1	2	4
Exposure to aviation research positively influenced aviation entry	0	0	0	0	0	0	0	0	0	0	1	1
Exposure to hands-on aviation positively influenced aviation career entry	0	0	0	1	1	0	2	0	0	0	0	4
Exposure to information about the aviation field positively influenced entry into aviation	0	0	0	0	1	0	2	0	0	0	0	3
Family in aviation positively influenced aviation career entry	0	1	0	0	1	3	4	1	1	0	3	14
Financial prospects of the aviation field positively influenced aviation career entry	0	0	1	0	0	0	0	0	3	0	0	4
Participation in an IST STEM program positively influenced aviation career entry	0	0	0	0	0	0	0	0	2	0	0	2
Participation in an OST STEM program positively influenced aviation career entry	0	1	1	0	0	0	1	1	1	0	4	9
Reports to have always been interested in aviation	0	1	0	0	1	0	1	1	0	0	0	4
The military guided entry into the aviation field	0	0	0	1	0	0	0	0	0	0	0	1

	PK	EW	CB	DM	BC	RF	ES	JR	ZB	AB	MA	Total
Self-reported influence of STEM programs on career	0	0	0	0	0	0	0	0	0	0	0	0
STEM programs built leadership skills	3	0	0	0	0	0	0	0	0	0	0	3
STEM programs facilitated hands-on learning and practical application of knowledge	0	1	2	0	1	0	0	0	2	0	0	6
STEM programs facilitated interaction with peers with similar interests	0	1	0	0	0	0	0	0	1	0	0	2
STEM programs positively influence time management and study skills	0	0	0	0	0	0	0	2	1	0	0	3
STEM programs positively influenced career focus and interest	2	1	0	0	2	0	1	0	0	0	1	7
STEM programs positively influenced self-efficacy	1	0	0	1	1	0	1	0	1	0	1	6
STEM programs provided exposure to knowledge and skills	1	0	0	0	0	1	2	0	3	0	0	7
Types of STEM Participation	0	0	0	0	0	0	0	0	0	0	0	0
IST Programs	0	0	0	0	0	0	0	0	0	0	0	0
Participated in a formal IST STEM curriculum/program	0	0	0	0	0	1	2	0	0	1	1	5
Participated in an IST aviation/aerospace program	0	0	0	0	0	0	0	0	1	0	0	1
Participated in experiential engineer activities	0	0	0	0	0	0	0	0	0	0	1	1
Took a high number of STEM classes outside a formal program	0	1	0	0	0	0	0	1	0	1	0	3
OST Programs	0	0	0	0	0	0	0	0	0	0	0	0
Participated in a competitive OST STEM team	0	1	2	2	0	0	0	2	1	0	2	10
Participated in a generic STEM program	0	0	1	0	0	1	0	2	0	0	0	4
Participated in a robotics program	0	1	1	1	0	0	0	0	1	0	2	6
Participated in a work-experience program	0	0	0	0	0	0	0	0	0	0	1	1
Participated in an OST aviation/aerospace program	1	0	1	2	1	0	1	1	0	0	0	7
Participated in an engineering STEM program	0	0	0	1	0	0	1	0	0	0	0	2
Participated in an environmental based STEM program	0	1	0	1	0	0	0	0	0	0	1	3
Totals	11	15	15	14	11	8	25	25	22	9	38	0

Table C2

Question	Short Name	Response	Variable type	Initial Construct	Revised Construct
My participation in STEM primarily took place:	Participation type	- Within the school day (e.g., through a STEM academy or accelerated program). - Outside the school day or unrelated to school (e.g., after-school club, summer camp). - Equally within and outside the school day.	Independent		
My current age is:	Age	- 18-24 years - 25-34 years - 35-44 years - 45-54 years - 55-64 years - 65+ years	Covariate		
My gender is:	Gender	- Man - Woman - Non-binary - Prefer not to say - Other	Covariate		
I have ___ years in the aviation field.	Years of experience	- 0-4 - 5-9	Covariate		

Question	Short Name	Response	Variable type	Initial Construct	Revised Construct
		- 10-14 - 15-19 - 20+			
I can best be described as a:	Role	- Pilot - Aircrew - Flight attendant - Mechanic/maintainer - Air traffic controller - Engineer - Scientist - Logistician - Management	Covariate		
Indicate the extent to which the following positively influenced your career development:		Likert scale (1 to 5) Strongly disagree to Strongly agree			
Interacting with industry professionals through my STEM program participation.	Industry interaction	Likert scale (1 to 5)	Dependent	Environmental	Professional Interaction
Interacting with mentors through my STEM program participation.	Mentor interaction	Likert scale (1 to 5)	Dependent	Environmental	Professional Interaction
Working in a community of individuals with similar interests.	Community interaction	Likert scale (1 to 5)	Dependent	Environmental	Professional Interaction
Learning more about aviation during my STEM program participation.	Aviation exposure	Likert scale (1 to 5)	Dependent	Exposure	Career Knowledge

Question	Short Name	Response	Variable type	Initial Construct	Revised Construct
Participating in hands-on learning and practical application of knowledge, related to my career field, in the STEM program.	Hands-on education	Likert scale (1 to 5)	Dependent	Outcomes	Career Knowledge
Learning more about the financial and career prospects of the aviation field.	Financial knowledge	Likert scale (1 to 5)	Dependent	Outcomes	N/A
My STEM program participation:					
Taught me skills related to my aviation career.	Aviation skills	Likert scale (1 to 5)	Dependent	Exposure	Career Knowledge
Positively influenced my career focus and interest.	Career focus	Likert scale (1 to 5)	Dependent	Exposure	Career Knowledge
Positively influenced my career development.	Career development	Likert scale (1 to 5)	Dependent	Outcomes	Career Knowledge
Made me more confident in my career goals.	Career confidence	Likert scale (1 to 5)	Dependent	Outcomes	Career Knowledge
Provided me with skills, such as leadership and time management, to help me succeed in my career.	Skills development	Likert scale (1 to 5)	Dependent	Outcomes	Career Knowledge

Table C3

Variable	**Mean**	**SD**	**Median**	**Trimmed**	**MAD**	**Min**	**Max**	**Range**	**Skew**	**Kurtosis**	**SE**
Participation type	2.07	0.84	2	2.09	1.48	1	3	2	-0.14	-1.57	0.08
Age	2.89	1.38	3	2.84	1.48	1	6	5	0.20	-1.07	0.13
Gender	1.72	0.47	2	1.76	0.00	1	3	2	-0.72	-0.79	0.04
Years of experience	3.02	1.47	4	3.02	1.48	1	5	4	-0.22	-1.48	0.14
Role	12.12	4.51	13	12.46	5.93	1	19	18	-0.54	-0.65	0.43
Industry interaction	3.64	1.24	4	3.79	1.48	1	5	4	-0.76	-0.38	0.12
Mentor interaction	3.73	1.30	4	3.90	1.48	1	5	4	-0.82	-0.50	0.12
Community interaction	4.22	1.05	5	4.42	0.00	1	5	4	-1.35	1.09	0.10
Aviation exposure	3.70	1.37	4	3.85	1.48	1	5	4	-0.73	-0.77	0.13
Hands-on education	4.24	1.19	5	4.48	0.00	1	5	4	-1.53	1.26	0.11
Financial knowledge	3.21	1.31	3	3.26	1.48	1	5	4	-0.34	-1.01	0.13
Aviation skills	3.95	1.13	4	4.10	1.48	1	5	4	-0.89	-0.11	0.11
Career focus	4.30	0.98	5	4.48	0.00	1	5	4	-1.69	2.80	0.09
Career development	4.31	0.88	5	4.45	0.00	1	5	4	-1.61	3.30	0.08
Career confidence	4.29	0.96	5	4.45	0.00	1	5	4	-1.49	2.09	0.09
Skills development	4.00	1.13	4	4.17	1.48	1	5	4	-1.03	0.27	0.11

Note. N = 109

Table C4

Variable	H value	P value	η2	Group 1	Group 2	Z value	P-Value	P-Value Adjusted
Industry Interaction	6.0019	0.04974	0.0378	Both	OST	-1.00845	0.31324	0.31324
				Both	IST	1.37862	0.16801	0.25202
				OST	IST	-2.42658	0.01524	0.04573
Mentor Interaction	7.9285	0.01898	0.0559	Both	OST	1.31642	0.18803	0.18803
				Both	IST	2.81028	0.00495	0.01485
				OST	IST	-1.40415	0.16027	0.24041
Community Interaction	2.4867	0.2884	0.00459	Both	OST	-0.56612	0.57131	0.57131
				Both	IST	0.96028	0.33692	0.50538
				OST	IST	-1.54704	0.12185	0.36556
Aviation Exposure	0.27718	0.8706	-0.0163	Both	OST	-0.2921	0.77021	1.00000
				Both	IST	0.22129	0.82487	0.82487
				OST	IST	-0.5263	0.59868	1.00000
Aviation Skills	1.2812	0.527	-0.00678	Both	OST	0.97715	0.32849	0.49274
				Both	IST	0.99717	0.31868	0.95604
				OST	IST	0.03756	0.97004	0.97004
Hands-On Education	2.2131	0.3307	0.00201	Both	OST	0.2457	0.80591	0.80591
				Both	IST	1.37989	0.16762	0.50286
				OST	IST	-1.11037	0.26684	0.40026
Skills Development	2.8047	0.246	0.00759	Both	OST	0.63927	0.52265	0.52265
				Both	IST	1.65406	0.09811	0.29434
				OST	IST	-0.96884	0.33263	0.49894
Career Development	3.4667	0.1767	0.0138	Both	OST	0.02319	0.9815	0.9815

				Both	IST	1.6004	0.10951	0.32853
				OST	IST	-1.5628	0.1181	0.17715
				Both	OST	1.56052	0.11864	0.17796
Career Confidence	9.4561	0.00884	0.0703	Both	IST	3.07465	0.00211	0.00632
				OST	IST	-1.40992	0.15856	0.15856
				Both	OST	0.40717	0.68388	0.68389
Career Focus	5.9265	0.05165	0.037	Both	IST	2.26004	0.02382	0.07146
				OST	IST	-1.81362	0.06974	0.1046

Note. DF is two for all variables.

Table C5

Variable	DF (den)	F value	Pr(>F)	η2	ηp2	Group 1	Group 2	Estimate	CI (low)	CI (high)	SE	T-value	DF	P-Value (adj)
Professional Interaction	70.28	3.87	.03	.08	.08	Both	OST	-0.04	-0.50	0.43	0.14	0.19	63.71	.98
						Both	IST	-0.57	-1.09	-0.05	0.15	2.64	71.34	.03
						OST	IST	-0.54	-1.08	0.01	0.16	2.35	72.76	.06
Industry Interaction	69.52	3.05	.05	.06	.06	Both	OST	0.18	-0.46	0.81	0.19	0.67	61.15	.78
						Both	IST	-0.53	-1.18	0.11	0.19	1.97	71.93	.13
						OST	IST	-0.71	-1.42	0.01	0.21	2.37	72.54	.05
Mentor Interaction	70.42	4.40	.02	.08	.08	Both	OST	-0.36	-1.00	0.28	0.19	1.34	64.40	.38
						Both	IST	-0.87	-1.56	-0.17	0.21	2.98	73.05	.01
						OST	IST	-0.51	-1.23	0.21	0.21	1.69	72.97	.22
Community Interaction	70.45	1.35	.27	.03	.03	Both	OST	0.07	-0.46	0.60	0.16	0.32	64.46	.95
						Both	IST	-0.32	-0.90	0.26	0.17	1.34	72.95	.38
						OST	IST	-0.39	-0.99	0.20	0.18	1.58	72.93	.26
Career Knowledge	66.64	3.58	.03	.06	.06	Both	OST	-0.16	-0.52	0.20	0.11	1.09	54.79	.53
						Both	IST	-0.47	-0.90	-0.04	0.13	2.65	60.25	.03
						OST	IST	-0.31	-0.79	0.18	0.14	1.52	72.31	.29
Aviation Exposure	69.10	0.11	.90	.00	.00	Both	OST	0.02	-0.77	0.82	0.23	0.07	63.41	1.00
						Both	IST	-0.12	-0.86	0.62	0.22	0.38	73.41	.93
						OST	IST	-0.14	-0.94	0.66	0.24	0.42	68.72	.91
Aviation Skills	69.62	0.79	.46	.01	.01	Both	OST	-0.27	-0.90	0.37	0.19	1.02	63.73	.57
						Both	IST	-0.29	-0.90	0.32	0.18	1.13	73.92	.50
						OST	IST	-0.02	-0.68	0.63	0.19	0.08	70.82	1.00
Hands-On Education	67.88	2.90	.06	.06	.06	Both	OST	-0.14	-0.63	0.36	0.15	0.65	58.54	.79
						Both	IST	-0.65	-1.29	0.00	0.19	2.42	59.86	.05

Variable	DF (den)	F value	Pr(>F)	η2	ηp2	Group 1	Group 2	Estimate	CI (low)	CI (high)	SE	T-value	DF	P-Value (adj)
						OST	IST	-0.51	-1.21	0.19	0.21	1.75	69.74	.19
						Both	OST	-0.24	-0.88	0.41	0.19	0.88	60.50	.66
Skills Development	68.72	1.52	.23	.02	.02	Both	IST	-0.43	-1.01	0.16	0.17	1.74	73.99	.20
						OST	IST	-0.19	-0.86	0.48	0.20	0.68	67.44	.78
						Both	OST	-0.05	-0.42	0.33	0.11	0.29	60.97	.96
Career Development	68.99	2.65	.08	.06	.06	Both	IST	-0.45	-0.93	0.02	0.14	2.28	62.88	.07
						OST	IST	-0.41	-0.92	0.10	0.15	1.91	70.08	.14
						Both	OST	-0.31	-0.71	0.08	0.12	1.90	56.33	.15
Career Confidence	67.04	7.04	.00	.11	.11	Both	IST	-0.75	-1.24	-0.25	0.15	3.63	59.23	.00
						OST	IST	-0.44	-0.98	0.11	0.16	1.89	70.88	.15
						Both	OST	-0.16	-0.61	0.28	0.13	0.89	53.01	.65
Career Focus	66.01	4.29	.02	.08	.08	Both	IST	-0.61	-1.11	-0.11	0.15	2.94	60.42	.01
						OST	IST	-0.45	-1.03	0.13	0.17	1.85	72.89	.16

Note. DF numerator is two for all variables.

Table C6

Variable	Models	P(M|data)	BF_M	BF_{10}	error %	Group 1	Group 2	Posterior Odds	$BF_{10,U}$	error %
Professional Interaction	Participation type	0.772	3.378	3.378	0.026	Both	OST	0.15	0.255	0.013
	Null model	0.228	0.296	1		Both	IST	2.1	3.576	0.008
						OST	IST	1.249	2.127	0.009
Industry Interaction	Participation type	0.611	1.573	1.573	0.023	Both	OST	0.178	0.304	0.012
	Null model	0.389	0.636	1		Both	IST	0.649	1.105	0.011
						OST	IST	1.387	2.361	0.009
Mentor Interaction	Participation type	0.782	3.586	3.586	0.027	Both	OST	0.315	0.536	0.011
	Null model	0.218	0.279	1		Both	IST	4.532	7.716	4.85E-07
						OST	IST	0.445	0.758	0.012
Community Interaction	Participation type	0.237	0.31	0.31	0.03	Both	OST	0.154	0.262	0.013
	Null model	0.763	3.226	1		Both	IST	0.287	0.488	0.013
						OST	IST	0.383	0.651	0.012
Career Knowledge	Participation type	0.592	1.451	1.451	0.023	Both	OST	0.244	0.416	0.012
	Null model	0.408	0.689	1		Both	IST	1.87	3.183	0.008
						OST	IST	0.353	0.602	0.012
Aviation Exposure	Participation type	0.086	0.094	0.094	0.024	Both	OST	0.147	0.251	0.013
	Null model	0.914	10.587	1		Both	IST	0.149	0.253	0.015
						OST	IST	0.152	0.259	0.015
Aviation Skills	Participation type	0.133	0.154	0.154	0.026	Both	OST	0.228	0.389	0.012
	Null model	0.867	6.499	1		Both	IST	0.238	0.404	0.014
						OST	IST	0.142	0.241	0.015
Hands-On Education	Participation type	0.563	1.288	1.288	0.022	Both	OST	0.177	0.301	0.012
	Null model	0.437	0.776	1		Both	IST	1.215	2.068	0.009
						OST	IST	0.461	0.784	0.012

Variable	**Models**	**P(M|data)**	**BF_M**	**BF_{10}**	**error %**	**Group 1**	**Group 2**	**Posterior Odds**	**$BF_{10, U}$**	**error %**
Skills Development	Participation type	0.205	0.258	0.258	0.029	Both	OST	0.204	0.348	0.012
	Null model	0.795	3.878	1		Both	IST	0.487	0.829	0.012
						OST	IST	0.173	0.294	0.015
Career Development	Participation type	0.549	1.219	1.219	0.022	Both	OST	0.153	0.26	0.013
	Null model	0.451	0.82	1		Both	IST	0.974	1.658	0.01
						OST	IST	0.572	0.974	0.011
Career Confidence	Participation type	0.941	15.992	15.992	0.024	Both	OST	0.687	1.169	0.01
	Null model	0.059	0.063	1		Both	IST	15.626	26.601	1.15E-07
						OST	IST	0.566	0.964	0.011
Career Focus	Participation type	0.741	2.861	2.861	0.026	Both	OST	0.207	0.353	0.012
	Null model	0.259	0.35	1		Both	IST	3.31	5.635	7.35E-07
						OST	IST	0.549	0.935	0.011

Note. The posterior odds have been corrected for multiple testing by fixing to 0.5 the prior probability that the null hypothesis holds across all comparisons (Westfall et al., 1997). Individual comparisons are based on the default t-test with a Cauchy (0, r = 1/sqrt(2)) prior. The "U" in the Bayes factor denotes that it is uncorrected. The prior odds for all rows is 0.587 and that column is omitted for brevity. The posterior odds are equal to the prior odds multiplied by the Bayes Factors.

Appendix D: Figures

Figure D1

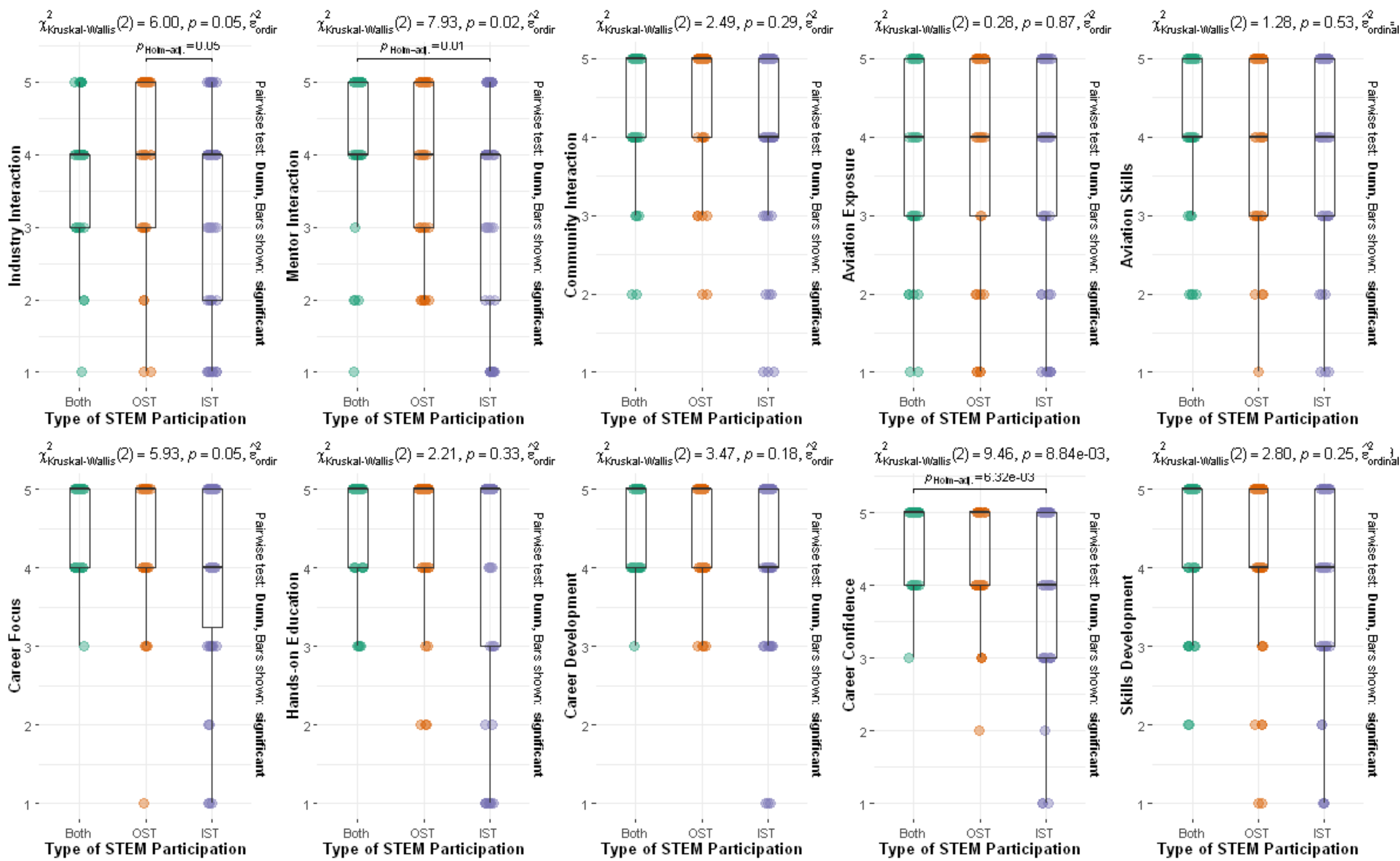
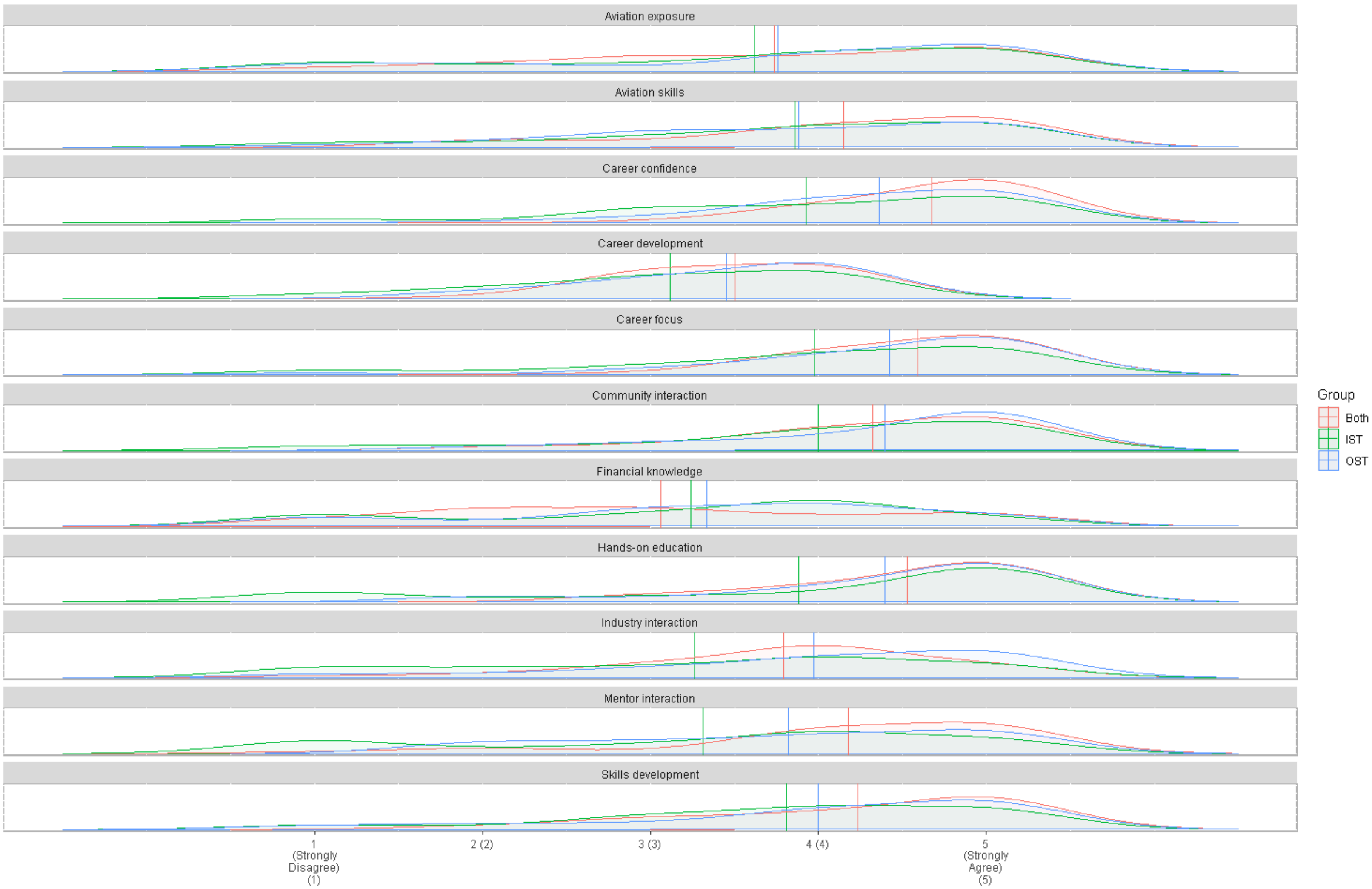

χ²Kruskal-Wallis(2) = 6.00, p = 0.05, ε²ordir
pHolm-adj. = 0.05
Industry Interaction
χ²Kruskal-Wallis(2) = 7.93, p = 0.02, ε²ordir
pHolm-adj. = 0.01
Mentor Interaction
χ²Kruskal-Wallis(2) = 2.49, p = 0.29, ε²ordir
Community Interaction
χ²Kruskal-Wallis(2) = 0.28, p = 0.87, ε²ordir
Aviation Exposure
χ²Kruskal-Wallis(2) = 1.28, p = 0.53, ε²ordinal
Aviation Skills
χ²Kruskal-Wallis(2) = 5.93, p = 0.05, ε²ordir
Career Focus
χ²Kruskal-Wallis(2) = 2.21, p = 0.33, ε²ordir
Hands-on Education
χ²Kruskal-Wallis(2) = 3.47, p = 0.18, ε²ordir
Career Development
χ²Kruskal-Wallis(2) = 9.46, p = 8.84e-03,
pHolm-adj. = 6.32e-03
Career Confidence
χ²Kruskal-Wallis(2) = 2.80, p = 0.25, ε²ordinal
Skills Development
Both
OST
IST
Type of STEM Participation
Pairwise test: Dunn, Bars shown: significant

Figure D2


Aviation exposure
Aviation skills
Career confidence
Career development
Career focus
Community interaction
Financial knowledge
Hands-on education
Industry interaction
Mentor interaction
Skills development
1 (Strongly Disagree) (1)
2 (2)
3 (3)
4 (4)
5 (Strongly Agree) (5)
Group
Both
IST
OST