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A Causal Comparative Study of STEM Persistence Between Supported and Non-Supported STEM Interested Students

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A Causal Comparative Study of STEM Persistence Between Supported and Non-Supported STEM Interested Students

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by

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ABSTRACT

A Causal Comparative Study of STEM Persistence Between Supported and Non-Supported STEM Interested Students

by

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Many students who enter a STEM track in college move out of that track before graduation (National Science Foundation, 2018). The purpose of this study was to assess whether there was a difference in STEM-related major persistence for population proportions of students actively involved in the Science Scholars program and those who were STEM-interested but not program participants. This program oriented students to the STEM program, facilitated engagement with peers and faculty, exposed students to research opportunities, and filled in potential learning gaps (Gibson et al., 2019).

The questions guiding the current research included:

Q1. Was there a statistically significant difference in STEM science persistence at College A when comparing Science Scholars students to STEM students who were not Science Scholars Program members?

Q2. Was added support needed to encourage STEM persistence for College A STEM students?

Q3. Is there a STEM persistence advantage to being in Science Scholars versus being a STEM-interested student outside of the program?

The researcher used disaggregated tally sheets to quantify the proportion of students who persisted in a STEM-related major in low, medium, and high ACT score ranges on the overall ACT Composite, as well as on the Math and Science portions of the ACT in both the STEM Scholars group and the STEM-interested group. The analysis of the program derived from the engagement theory framework that related social and academic involvement as a driver for student persistence. The basis for relationships analysis was the score ranges of each group and persistence in a STEM major after the second and third semesters of college.

The results revealed that the proportion of students persisting in a STEM-related major to the second and third semesters of college was greater for those high achieving ACT test groups when they were members of the STEM Scholars program. Students who scored in the mid and low ranges of ACT test takers were not more likely to persist in the STEM Scholars group than those in the STEM-interested group. The support and engagement themes emerged from the analysis of data. Students who were socially and academically engaged and supported academically were more likely to persist in STEM-related majors.

DEDICATION

This work is dedicated to my partner in life's journey, my husband, Richard Bernardi. He has supported and encouraged my pursuits while keeping me grounded and focused. Our next adventure awaits us.

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Chapter 1. Introduction

According to the National Science Foundation (2018), fifty thousand jobs in science, technology, engineering, and math (STEM) fields have been unfilled. Too few students are prepared for the scientific performance jobs that must be filled (USDOE, 2011), and the STEM-trained worker deficit could exceed one million (President's Council of Advisors on Science and Technology, 2012). Studies predicted the demography of the United States would continue to shift toward underrepresented groups such as persons of color, women, and low-income students in higher education and there needs to be a plan to recruit those students into STEM fields. How can STEM career preparation be increased in East Tennessee and throughout the United States for all groups of students?

Secondary school courses often do not prepare students for the rigors of college STEM coursework. School systems often abandon inquiry-based learning and mathematical integration for rote memorization with low emphasis on critical thinking skills. For example, physics, as the foundation for understanding the world, is a critical component of secondary science education; however, there is a severe shortage of secondary physics teachers, which leads to a smaller number of students taking a high school physics course. The basic math skills integrated into a physics course allow students to make STEM applications to the real world and build their STEM efficacy. Engaging with a physics course in high school is the largest determining factor of whether students will declare a STEM major in college (Bottia et al., 2015; Tyson et al., 2007). At the time of this study, the highest number of STEM-prepared individuals was primarily white males; educators need to broaden the STEM appeal to diverse groups of students to increase the number of trained professionals. Students must gain STEM efficacy in high school courses to build confidence in their abilities to tackle post-secondary challenges (Bottia et al., 2015; Mathewson, 2020).

Many students who enter a STEM track in college move out of that track before graduation. In 2012, 60% of students who entered post-secondary school with the intent of majoring in a STEM topic changed their projection. The most common reasons students gave for changing course related to lack of preparation for or lack of inspiration from the introductory courses. Further impetus for a major change for minority or underserved students related to the lack of a belonging within STEM departments (National Science Foundation, 2018; Wilson et al., 2012;). Espinosa et al. (2019) found several key indicators of STEM success for minority-serving institutions. A cohesive community with easily accessible academic and research supports and access to undergraduate research experiences were strong predictors of success. First-generation college students and other underrepresented groups are often not exposed to STEM career role models. It is difficult for students to envision a career in a field of which they are unaware. Students must view themselves as being capable of achieving in STEM before they pursue a program of study (Herr et al., 2004).

The current study evaluated the effectiveness of the Science Scholars program supports for increasing STEM persistence. This program was designed to orient students to the STEM program, facilitate engagement with peers and faculty, expose students to research opportunities, and fill potential learning gaps (Gibson et al., 2019).

The questions guiding the research were:

RQ1. Was there a statistically significant difference in STEM science persistence at College A when comparing Science Scholars students to STEM students who were not Science Scholars Program members?

RQ2. Was added support needed to encourage STEM persistence for College A STEM students?

RQ3. Is there a STEM persistence advantage to being in Science Scholars versus being a STEM-interested student outside of the program?

Once students enter college, persistence in a STEM major between their first and second year can be low. Various programs have mitigated this low persistence, including STEM-specific first year seminar courses, peer mentoring, a summer bridge program, living-learning communities, career seminars, STEM-specific scholarships, recruitment of underrepresented groups, and early research opportunities (Bottia et al., 2015; Cuseo, 2015; Espinosa et al., 2019; Guenther et al., 2019; Gibson et al., 2019; Nagda et al., 1998; Spaulding et al., 2020; Wilson-Kennedy et al., 2019). Jenkins and Cho (2012) suggested that the earlier students declared a major, the more likely they were to complete their degree.

Science Scholars Program

STEM leaders at College A established the Science Scholars program to support STEM students in their journey to a bachelor's degree and improved STEM persistence. The Science Scholars program provided financial and academic support for selected students beginning in the summer before their first year of college. In addition, academic support was available to non-Science Scholars who were STEM-interested students during the school year. An intensive two-week summer experience allowed first-year Science Scholars students the opportunity to immerse in laboratory, computing, math, and teamwork skills necessary for STEM college success. First-year Science Scholars also worked with various STEM professionals other than their college professors who exposed them to a variety of job opportunities available to STEM majors. Throughout the first year, students maintained required tutoring hours in the STEM student support center. However, once the students established study habits, tutoring became optional beginning with their sophomore year. Finally, students who participated in the Science Scholars program could obtain additional scholarship money through a National Science Foundation grant.

Participation in the program was not required to major in a STEM field at College A and the support center was open to non-Science Scholars STEM students. The college maintained a group of students who were STEM majors but not Science Scholars participants available for control group comparison purposes (Maryville College, 2020a).

Problem Statement

Many students who enter a STEM track in college move out of that track before graduation. In 2012, 60% of students who entered post-secondary school with the intent of majoring in a STEM subject changed their projection. The most common reasons students gave for changing course related to lack of preparation for or lack of inspiration from the introductory courses. Further impetus for a major change for minority or underserved students related to their lack of a belonging within STEM departments (National Science Foundation, 2018; Wilson et al., 2012). Espinosa et al. (2019) found several key indicators of STEM success for minority serving institutions, including a cohesive community with easily accessible academic and research supports and access to undergraduate research experiences. First-generation college students and other underrepresented groups are often not exposed to STEM career role models. It is difficult for a student to envision a career in a field of which they are unaware. Students must view themselves as being capable of achieving in STEM before they pursue a program of study (Herr et al., 2004).

The current study evaluated the effective supports of the Science Scholars program for increasing STEM persistence. The purpose of the study was to assess whether there was a difference in the proportions of STEM-related persistence for students actively involved in the Science Scholars program and those who were STEM-interested but not program participants. Analysis of student proportions were on the low, medium, and high score ranges of the overall ACT Composite, Math, and Science tests.

Theoretical Framework

Cuseo (2015) discussed several support strategies employed to retain students beyond the first year of college. Active academic supports, such as learning communities or cohorts, peer study groups, peer mentoring, peer tutoring, and summer bridge programs, increase retention to the second year of college. Other supports, such as required supplemental learning sessions, have also been effective retention strategies for all students. Supports, such as required participation in academic tutoring, should be intrusive and intentional (Cuseo, 2015) to make complete use of the supports and develop the skills necessary for success. Often, students do not realize that they need academic support until they are struggling significantly (Cuseo, 2015; Tinto, 1994). Cohen and Kelly (2018) referenced the seminal work of Seymour and Hewitt (1997) in their discussion of the introductory STEM courses as weed-out courses and the need for a culture change at the institutional level in STEM courses. The need is greater for support services and activities to help students find success in the early STEM coursework, to make their foundation firm, and to encourage their remaining a STEM major.

Bandura’s (1990) Social Cognitive Career Theory stated that early exposure to career possibilities generated interest. Students needed role models in and genuine engagement with STEM professionals to gain self-efficacy in STEM. Luttenberger et al. (2019) and Wilson-

Kennedy et al. (2019) in relation to the Social Cognitive Career Theory also discussed the concept of having self-efficacy in STEM fields. Bandura (1990) cited the key factors for choosing a career as self-efficacy in the field and the individual's perception of career prospects. Lent and Brown (2002) purported that social constructs often determined self-efficacy for underserved populations, such as women and minorities. There is evidence that individuals who have ample social supports, such as parent and teacher role models, that align with their interest areas have less difficulty translating their interests into career possibilities and eventually career goals. Exposure to a variety of career options will impact a student's career choice because they can only choose from careers they know exist. School counselors and role models play a role in exposing underserved students to STEM career paths (Herr et al., 2004).

Bandura (1990) elucidated the physiological response to stress and the ability of self-efficacy to exert control over that response. Students should build self-efficacy through challenges supported by others. Students must conquer increasingly more difficult academic experiences as they navigate their educational endeavors.

Tinto's (1994) Engagement Theory addressed the idea that a student's engagement with the school, both socially and academically, contributed to persistence in post-secondary education. He discussed the role of the institution in creating learning communities to enable students to form an attachment to the institution and develop socially and academically. The National Survey of Student Engagement (NSSE) (2010) analyzed the area of active, collaborative learning in which students would engage while working in small learning communities, such as College A's Science Scholars program. The student support center encouraged upper class students to tutor first-year students and to engage in the *each-one-teach-one* practice to reinforce concepts learned in prior courses. The engagement of the tutors further cemented their investment both in their own learning and in the college by helping others. The engagement of both tutors and first-year students could lead to embeddedness within the STEM major and within the college.

Morganson et al. (2015) discussed the application of the Embeddedness Theory to STEM persistence. Previously, the Embeddedness Theory related to retention of employees, but recently it applied to retention of STEM majors in college. The three major themes within the theory were: fit, links, and sacrifice. Businesses addressed these themes when assessing what kept employees in their jobs. For the application of the theory to students, fit applied to whether students' abilities were appropriate for the requirements they expected in their major. Fit could be reinforced within the student learning center when students fill in learning gaps in the gatekeeper courses. Links were connections between others in the program or identification of self in the major reinforced through learning communities or seminar sessions. Finally, sacrifice applied to the potential losses that the student could suffer if they were to leave the program or the school. The National Science Foundation scholarships as well as the opportunity to engage in authentic research could be examples of a sacrifice that would be a deterrent to changing a STEM major (Maryville College, 2020a).

Purpose Statement

The purpose of this quantitative study was to assess whether a difference existed in STEM-related major persistence for students actively involved in the Science Scholars program and those who were STEM-interested but not program participants. Analysis of the proportions of students based on low, medium, and high score ranges of the overall ACT Composite as well as Math, and Science subtests.

Controlling questions for the study were:

Q1. Was there a statistically significant difference in STEM science persistence at College A when comparing Science Scholars students to STEM students who were not Science Scholars Program members?

Q2. Was added support needed to encourage STEM persistence for College A STEM students?

Q3. Is there a STEM persistence advantage to being in Science Scholars versus being a STEM-interested student outside of the program?

Method Statement

The current study was a factorial designed quasi-experimental/causal comparative analysis (Fraenkel & Wallen, 2009) of STEM persistence differences between College A students who participated in in the Science Scholars program and those who did not take part in the program. College A is a small liberal arts college in the southeastern United States. The control group consisted of STEM-interested students at College A who were not enrolled in the Science Scholars program. A comparison of the proportion of students who persisted in a STEM-related major in each of the ACT score ranges and sections was measured for both groups of students in the second and third semesters of college (Fraenkel & Wallen, 2009).

Controlling questions for the study were:

Q1. Was there a statistically significant difference in STEM science persistence at College A when comparing Science Scholars students to STEM students who were not Science Scholars Program members?

Q2. Was added support needed to encourage STEM persistence for College A STEM students?

Q3. Is there a STEM persistence advantage to being in Science Scholars versus being a STEM-interested student outside of the program?

Significance and Relevance

The fact that many STEM jobs remained unfilled in the United States delineated the need for an increase in a STEM-trained workforce (Morganson et al., 2015). College A experimented with various methods to increase STEM persistence. In response, College A and the National Science Foundation developed financial and educational support strategies to achieve this goal. However, the question remained whether these supports were statistically sufficient to increase STEM persistence?

Delimitations

The study included only students attending College A in the 2020-2021 first-year cohort. Due to the issues involved in that year, the complications of learning in a pandemic might have impacted student persistence. Students could select a pass/fail option, which might have mitigated the impact of a poor grade on GPA (Grade Point Average) and persistence.

Students in this study were disaggregated groups of STEM-interested students who did and did not take part in the Science Scholars program, which mandated approved STEM success activities (tutoring and career seminars) of at least six hours per week and a summer bridge program before the first year.

Definition of Terms

The following terms will apply for the purposes of this study.

STEM: Science, technology, engineering, or math fields.

STEM persistence: Continuation of degree pursuit in STEM by declaring a STEM major before the third semester of post-secondary experience (Gibson et al., 2019) applied to College A in the southeastern United States.

STEM retention: Persistence through graduation with a STEM-related degree (Sithole et al., 2017) at any college.

Science Scholars: Science Scholars Program at College A. The program encourages STEM major persistence and retention to graduation (Maryville College, 2020a).

STEM-interested: Students who expressed interest in a STEM-related major but were not Science Scholars (A. Gibson, personal communication, 2021).

Summary

The purpose of this quantitative study was to assess whether there was a difference in STEM or STEM-related major persistence for proportions of students actively involved in the Science Scholars program compared to those who were STEM interested but not program participants. Analysis of the proportions of students was based on low, medium, and high score ranges of the overall ACT Composite as well as Math and Science ACT subtests.

Several limitations existed in this study due to the lowered amount of data available based on the occurrence of a global pandemic. This study highlights the need for further research and evaluation into STEM persistence, particularly as it applies to the Science Scholars program at College A.

Chapter 2. Review of the Literature

Of the students who began with a college major in science and engineering, fewer than half graduated in the field. Only 32% of White students, 20% of Black and Hispanic students, and 42% of Asian American students who entered with STEM aspirations graduated with a STEM degree (Hrabowski, 2013). Women earn most of their STEM degrees in biological fields (National Science Foundation, 2018). If the field needs an increase in engineering, computer sciences, mathematics, statistics, and physics jobs, there must be policies in place to motivate more individuals in minority, women, and other underserved populations to embark upon and complete those degrees.

According to the President's Council of Advisors on Science and Technology (PCAST), as of 2012, there would be a shortage of one million STEM professionals. The report cited the need to increase the number of undergraduate STEM matriculations. Sixty percent of students who begin college with the intent to major in a STEM field change their projection. Various recommendations to better those numbers included the improvement of the climate within STEM departments to welcome underserved and nontraditional students. The report also discussed the need to increase undergraduate research experiences during the first two years of post-secondary education to inspire STEM-interested students. Finally, the report addressed mathematics deficits with recommendations to improve support for STEM-specific math skills (President's Council of Advisors on Science and Technology, 2012). The integration of STEM communities, implementation of required tutoring during the first year, and incorporation of early undergraduate research opportunities fulfilled the recommendations made in this executive report to President Obama.

Persistence versus Retention

When students make an early decision of college major early, they are more likely to complete their degree (Jenkins & Cho, 2012). Students in the first two years of postsecondary education have the greatest risks of attrition (Ikuma et al., 2017; Krause et al., 2015). The College Board (2012) recommended that an increase in persistence would increase college completion rates. The National Center for Education Statistics (2021) measured the first- to second-year persistence rates at colleges and universities for first-time, full-time, degree seeking students at 76% in 2013. Sixty-three percent of those measured completed their degree within six years at the same institution (retention). This statistic demonstrated that student persistence to the second year of college was an important metric to assess. Persistence rates implied that students persisted in degree-seeking status at any institution. Retention indicated that students returned to the same institution the next school year.

Hossler and Bontrager (2015) began their discussion of persistence and retention with the definition of retention established by Tinto in 2006. They defined postsecondary retention as "remaining enrolled where students began" (p. 255). The basis of this definition was primarily on the evaluation structure of higher education. As students' needs and projections changed, persistence to a degree might involve more than one institution. The authors discussed the evolving definition of the measure of retention as being focused on the institution of origin rather than on the students' degree completion, which might involve more than one institution. "Institutions retain students and students persist" (Hagedorn, 2005, p. 92). The National Student Clearinghouse Research Center (2020) agreed with persistence as measured by students who persisted in any institution to their second year of postsecondary education, while retention indicated students returning to the same institution their second year. Graham et al. (2013)

focused on persistence as a student-centered concept instead of an institutional focus. Students must build their confidence in STEM through early undergraduate research and interaction with peers in learning communities. Institutional leaders could implement programs that allowed students to develop their confidence as a scientist and motivation to persist in a STEM program (Graham et al., 2013).

This study evaluated a STEM persistence program at one institution. Data were available from the 2020-2021 cohort of first-year students at College A. The researcher narrowed the definition of persistence in separate statistical tests to that of declaring a STEM or STEM-related major before the second and then the third semester of postsecondary education. STEM major retention-to-graduation at College A data had limitations due to the short duration of the program's existence.

Underrepresented Students in STEM

The long-term economic health of the population of United States was in jeopardy due to the low completion of STEM education programs. Participation of underrepresented groups in STEM fields was especially critical as diversity in the country increased (Wilson-Kennedy et al., 2019). The undergraduate student body was no longer composed of majority White 18–22-year-olds with no responsibilities other than attending school. A more diverse student body in terms of age, economic status, and ethnicity had become the norm (Terenzini & Pascarella, 1998).

Nestor-Baker and Kerka (2009) detailed seven challenges faced in recruiting and retaining underrepresented students in STEM programs. Those seven challenges included: "lack of academic preparation, low confidence levels, the imposter syndrome (e.g., everyone understands but me), unrealistic expectations (e.g., passing with little effort), lack of community, environmental alienation, and financial need" (cited by Kendricks & Arment, 2011, p. 22). One characteristic of STEM programs able to dissuade imposter syndrome (*everyone understands but me*) was a balanced representation of peers and role models for women and minority students (Tao & Gloria, 2018).

Wesley College in Dover, Delaware addressed the high financial need and lack of academic preparation with the Cannon STEM Scholarship program funded by the National Science Foundation (D'Souza et al., 2018). Students were invited to apply for the scholarship program and given the opportunity to participate in tutoring and mentoring sessions, undergraduate research, leadership training, and community service to maintain the scholarship. The retention rate in STEM programs increased significantly for students in the Cannon STEM scholar program over other STEM-interested but non-program participants (D'Souza et al., 2018).

Kendricks and Arment (2011) proposed adopting a K-12 Family Model to recruit and maintain minority students in a STEM program. Central State University in Wilberforce, Ohio, implemented a Scholar's Program that included several practices from the K-12 Family Model to address the seven challenges faced by underrepresented minority students. To establish a sense of belonging they recommended establishing a supportive family environment with caring teachers who set high expectations for their students. This support enabled an increase in academic rigor (Howard, 2001; Ladson-Billings, 1994). In addition, the Scholar's Program at Central State University incorporated undergraduate research experiences and scholarship funding with the academic and social support indicated in the K-12 Family Model to establish a successful retention program for underrepresented minorities in STEM fields. The program included an academic learning community, an honor's dormitory, mentoring meetings, honors credit, graduate school and professional development workshops, and research experiences. Scholarships were contingent on fulfillment of the requirements (Kendricks & Arment, 2011).

Often researchers did not consider the implications of sex and gender in studies and used men as the standard for testing. Women had significant physiological differences that treatments and interventions could affect in varying manners (del Giudice, 2015), however not only was gender diversity a physiological aspect but a social aspect as well. Women bring an underrepresented perspective to the design process in engineering designs, construction, and scientific conversations. According to a 2015 UNESCO study cited by Bert (2018), “only 28 percent of researchers around the world are women” (n.p.). While the numbers of bachelor’s and master’s degrees in science were equal with respect to gender, significantly fewer women pursued doctorate degrees. Bert (2018) referred to this factor as a *leaky pipeline*. An important tactic to combat this underrepresentation of women in higher degree programs was to invest in the battle against gender bias in children.

Cited by Atkinson-Bonasio (2017), Sterling, Provost of Imperial College London, detailed the beginning of gender bias at a young age in the *Gender in the Global Research Landscape Report*. Interest in science should be fostered at a young age in all children. According to the *Gender in the Global Research Landscape Report*, as cited by Atkinson-Bonasio (2017), women tended to be more interdisciplinary in the scientific fields than men did. This interdisciplinary approach became an important facet of research to solve more challenging problems in science and engineering. The report also noted that the number of patents issued to women climbed steadily over the past 20 years which indicated that women were breaking through and becoming more recognized in research (Atkinson-Bonasio, 2017).

Luttenberger et al. (2019) and Wilson-Kennedy et al. (2019) in relation to the Social Cognitive Career Theory also discussed the concept of having self-efficacy in STEM fields. Bandura (1990) cited the key factors for choosing a career as self-efficacy in the field and the individual's perception of career prospects. Lent and Brown (2002) purported that social constructs often determined self-efficacy for underserved populations, such as women and minorities. There is evidence that individuals who have ample social supports, such as parent and teacher role models, that align with their interest areas have less difficulty translating their interests into career possibilities and eventually career goals. Exposure to a variety of career options will impact a student's career choice because they can only choose from careers they know exist. School counselors and role models play a role in exposing underserved students to STEM career paths (Herr et al., 2004).

Bandura (1990) elucidated the physiological response to stress and the ability of self-efficacy to exert control over that response. Students should build self-efficacy through challenges that are supported by others. Students must conquer increasingly more difficult academic experiences as they navigate their educational endeavors.

Several studies discussed the effects of a learning community and social and academic integration on minority students in the STEM fields. Faculty-student interaction was a key component to establish student connections to and investment in an institution. When individuals in minority groups developed a connection with the institution early in their careers, retention rates increased (Guenther et al., 2019; Nagda et al., 1998).

Financial Need

Students with high financial need often work many hours while also taking a full course load of college classes. Many programs attempt to combat this competition for student time and focus with scholarships or increased financial aid. The National Science Foundation, The National Institutes of Health, and other organizations funded scholarships with underrepresented minorities in STEM fields as the focus (Chang et al., 2016). Terenzini et al. (1996) discussed the differences between first-generation college students and their traditional peers. First-generation students not only entered college with less academic preparation, but they also tended to work more hours, which impacted their study time. Increased financial aid could reduce the need to work additional hours and enable first-generation college students to focus on study.

Career Exposure

High school graduates and college students are often not aware of the many opportunities that are available to them with a STEM degree. Programs, such as career seminars, serve to expose students to a large variety of potential STEM careers and allow students to network with individuals at many levels in the field. This can ignite student interest by showing them possibilities they did not realize were available (Gibson et al., 2019; Guenther et al., 2019). Career seminars should include opportunities for informal interaction with professionals, such as question and answer sessions as well as presentations from a broad range of career fields related to STEM (Guenther et al., 2019).

Summer Bridge Program

Various successful programs implement a summer bridge program for incoming first-year STEM students to facilitate college transition, (Ashley et al., 2017) establish community, and begin the mentor relationship. Many programs close academic experience gaps and engage students in early research opportunities (Ikuma et al., 2017). Because math skills are important to increase a sense of self-efficacy in STEM fields, summer bridge programs often address math deficiencies to prepare students for the rigors of future coursework (Findley-Van Nostrand & Pollenz, 2017).

One of students' often-cited reasons for leaving a STEM major was their perception of lack of belonging in the program or lack of connection to the institution. Students did not necessarily leave a STEM major due to lack of talent (Findley-Van Nostrand & Pollenz, 2017); in fact, many were well positioned for success in a STEM career academically, but social and financial barriers disengaged them (Seymour & Hewitt, 1997; Sweeder et al., 2021). A summer bridge program could increase student connections to the institution by encouraging relationships with other students, faculty, and staff. Often, students view STEM programs as unsupportive and unwelcoming, thus an early opportunity to engage with a learning community may counterbalance the chilly climate of STEM by allowing first-year students to build relationships (Ikuma et al., 2017). Bradford et al. (2021), in their meta-analysis, found preliminary evidence that summer bridge programs contribute to STEM program retention for underrepresented minority students.

Motivation

According to data gathered by Miller (2015), science- and math-related activities in which students engaged outside of the regular school day were a strong predictor of college STEM major matriculation. If students had exposure to extracurricular science-related activities, they could increase their knowledge and competencies while finding a STEM major attractive and possible. Miller also studied the relationship between parental aspirations and STEM persistence and found a positive correlation. If parents aspired for their child to pursue a career in a STEM field, they would encourage the child to develop skills through extracurricular activities and academic support. The Expectancy-Value theory equated social constructs with student motivation in various fields. If peers and family members placed value on STEM subjects, the student had greater motivation to pursue those fields (Hsieh et al., 2019).

The culture of science and teaching often suggested that students did not have the tools for success beyond the high school walls. Thus, collaboration was not a strong skill that students brought to college STEM classrooms (Hrabowski, 2018), even though collaboration was how science *gets done* in the real world.

Hrabowski (2018) discussed in his TEDx MidAtlantic talk the phenomenon of students coming to college excited about a STEM career, then discovering it was more difficult than expected and losing interest. High school preparation through Advanced Placement courses, other college preparatory classes, and high-level math classes could be reliable predictors of STEM persistence in college. Regrettably, institutions tended to sort women and minority students into lower-level science and math courses. Women were more likely than their male counterparts to graduate from college, but they were less likely to pursue a STEM degree (Green & Sanderson, 2018). For students who are unprepared for the rigors of a college science class, the challenge could be daunting enough to cause the individual to lose interest. According to Hrabowski, seventy-five percent of students who came to college excited about a STEM career chose a non-STEM major before the end of the first year. On the other hand, the data for College A in the current study offered a higher rate of STEM persistence at fifty percent in 2019 (Gibson et al., 2019). Poor grades frequently equated with a decrease in interest (Cohen & Kelly, 2019; Hrabowski, 2018). Unfortunately, first-year college STEM courses were typically the *weed-out* or *barrier* courses and they do an excellent job with this task (Hrabowski, 2018). Schools that supported first-year, underrepresented students as they adjusted to the rigors of college coursework could help those less prepared students make it through the *weed-out* courses and gain valuable skills to survive the even more difficult upper-level STEM courses (Krause et al., 2015).

Instead of treating introductory level STEM courses as *weed-out* courses, students should be prepared for success in STEM careers in the introductory level courses. Supports, such as STEM focused mathematics, small learning communities, and exposure to authentic undergraduate research opportunities, could inspire STEM-interested students to persevere to matriculation in a STEM degree (President's Council of Advisors on Science and Technology, 2012). The lack of engagement in first-year introductory STEM courses has been cited as one of the biggest reasons students change majors. Along with interest in other majors, difficult coursework, and chilly climate, students claimed that poor teaching and absence of course engagement in introductory STEM courses caused them to change majors (Watkins & Mazur, 2013). Many researchers on STEM retention focused on additional supports, such as peer mentors, departmental advisement, and departmental support. Changing the culture of STEM departments to a more supportive environment for the students enrolled in the foundational courses might allow students to find success in the *weed-out* classes and enable their achievement and retention (Cohen & Kelly, 2019). College A in the current study implemented those programs into its Science Scholars program for undergraduate STEM majors.

A deficit in mathematics skills necessary for success in STEM courses was often a reason for students not pursuing STEM aspirations. Students who did not take precalculus or calculus in high school could be required to enroll remedial courses before embarking on a STEM major (Green & Sanderson, 2018). The National Academies of Science, Engineering, and Medicine (2019) recommended closing the achievement gap for underrepresented groups in STEM with one suggestion; closing the gap with summer bridge programs for post-secondary students.

Often, these bridge programs only enroll students with a demonstrated mathematics deficit, such as those who are enrolled in a precalculus course the first semester of college (Findley-Van Nostrand & Pollenz 2017; Sweeder et al., 2021). Math and technology courses taught by professors of engineering, physics, and computer science could both increase STEM interest as well as make mathematics relevant to rising college students. The site for the current study, College A, provides a summer bridge program for students who participate in the Science Scholars program. This program includes mathematics, computer science, and technology courses as well as exposure to research opportunities and career options in STEM fields (Gibson et al., 2019; Sweeder et al., 2021).

Green and Sanderson (2018) found that the likelihood of STEM persistence to graduation was higher in schools that only granted undergraduate degrees. The researchers proposed this significant increase was due to professors being more attentive to teaching than to research at these institutions. Support throughout the journey to a firm major declaration was effective in encouraging persistence (Terenzini et al., 1996).

Early Undergraduate Research Opportunities

Carter, Mandell, and Maton's (2009) *The Influence of On-Campus, Academic Year Undergraduate Research on STEM PhD Outcomes: Evidence from the Meyerhoff Scholarship Program* focused on the need for increased involvement of undergraduate students in academic year long scientific research. Students who were actively engaged in research as early as their first year of college were more likely to pursue a PhD in a STEM field. Engagement in research allowed students to apply the knowledge gained in the classroom to real world problems (Seymour et al., 2004; Summers & Hrabowski, 2006). The relationships developed between undergraduate students and faculty mentors could create a culture of academic research that would encourage students to pursue further education beyond the bachelor's degree. The researchers also discussed the need to incorporate underrepresented minorities in recruitment for academic year research projects and to build self-efficacy in STEM that could enable individuals to visualize themselves as STEM professionals.

Informal student and faculty interactions while engaged in research partnerships help establish student integration into the institution while building student confidence and interest in scientific research and professional identification with the scientific community (Graham et al., 2013; Nagda et al., 1998; Tinto, 1993). The first two years of a student's undergraduate work have the greatest risk of attrition. Programs that involve early undergraduate students in some form of research collaboration, such as conducting background research, developing research questions, analyzing data, and even co-authoring papers, decrease student attrition. The greatest effect on retention was by students involved with research during their sophomore year of undergraduate study (Nagda et al., 1998).

The successful Keystone Program at Elmhurst College in Elmhurst, Illinois, culminated with a summer research experience. The research opportunity is tied to participation in a short research course in January of the first year of college. Students applied to participate in and receive a stipend for their efforts with college faculty on the faculty member's work. Students become directly engaged in active learning and gained STEM efficacy from their contributions to ongoing research. Communication skills were further developed by a poster presentation early in the second year of college. The students presented their summer research to first-year students to encourage new participants in the program (Guenther et al., 2019).

Multiple researchers emphasized the importance of engaging high school students in STEM-associated programs. Rosenzweig et al. (2016) incorporated high school junior and senior students in a research program that included partnerships with undergraduate, master's and PhD students to investigate an environmental phenomenon. They discussed the importance of including high school students to allow for a vertical integration into the STEM learning community. Dasgupta and Stout (2014) discussed the importance of the integration of college STEM visitors to elementary, middle, and high schools to present their research in an age-appropriate manner to create interest in STEM careers at an early age. Students should be exposed to role models like themselves, such as women and minority STEM students, and to professionals.

One of the major barriers to early undergraduate student research is the lack of incentives for faculty to include undergraduates in their research. The amount of time required to train an early college student is greater than it is for a student who has taken a larger number of science courses. Faculty workload is high and mentoring students is not typically funded. Unlike liberal arts colleges that have a student-centered mission, research institutions place priority on advancing knowledge inherently linked to funding (Eagan et al., 2010; Prince et al., 2007). In addition, faculty members, particularly those seeking tenure, are under time-consuming pressure to publish and spending time training undergraduate assistants increases their already burdened workload. Support from the institution is imperative to allow for successful incorporation of undergraduates in faculty research (Prince et al., 2007).

Many of the benefits associated with undergraduate research experiences involved professional confidence gains. Students reported an increase in scientific confidence and critical thinking along with technological and communication skills (Seymour et al., 2004). Early research allows students to apply their classroom learning to solve real world issues and establish their own relevance to the field (Graham et al., 2013; Dagley et al., 2016).

Learning Communities

College clubs that focus specifically on women and minorities in STEM fields can help students find a sense of place in the institution as well as establish a professional identity (Graham et al., 2013). The College of Wooster in Wooster Ohio has a STEM Success Initiative club open to both women and underrepresented minorities to expose students to role models and STEM-related activities (STEM Success Initiative, n.d.). A sense of belonging has particular importance to underrepresented minority populations to increase persistence and graduation rates at institutions (Chang et al., 2016).

Along with motivation to succeed, teamwork skills were a requisite component of a STEM major and a successful STEM career. Students must collaborate on laboratory coursework throughout their studies and in the field. Often, students reported that their exposure to laboratory experiences in high school was poor or non-existent (National Research Council, 2006). Students enrolled in the Science Scholars program in the current study engaged in community building beginning with a two-week summer bridge program that exposed rising first-year college students to team development activities as well as science- and math-related experiences that could prepare them for the rigors of their gateway or *weed-out* science coursework. During the initial year of the Science Scholars program, students took part in a first-year seminar course to develop academic and professional skills, create learning communities, and establish relationships with faculty. Students enrolled in the Science Scholars program had a minimum number (6 hours/week) of tutoring hours and seminar sessions they must attend to remain eligible. Students who were STEM-interested but not enrolled in the program could also participate in tutoring and seminar sessions but were not required to do so (Gibson et al., 2019). If students could develop the skills needed for success in the gateway science courses, they could enrich their self-efficacy in STEM, which could lead to persistence in STEM majors (President's Council of Advisors on Science and Technology, 2012). All students at College A had to complete a senior capstone project before graduation. Some students began as early as their junior year (Maryville College, 2020b).

Johnson et al. (2020) and Graham et al. (2013) outlined the importance of a learning community on STEM retention beyond the first year, especially among underrepresented groups. They focused on creating a sense of place for students that not only involved a connection to the institution but also a social connection between students, faculty, and the natural world. Programs that clustered introductory courses around a theme and a common cohort could build connections among disciplines and among students. Johnson et al. (2020) integrated place-based education in the local region to further connections between students and the environment. The integration of individual student culture into the community allowed students to embrace diversity and to benefit from the perspective of others in the group. A community of learners with common backgrounds allowed students to understand they were not alone in their struggles and accomplishments. Those learning communities could also address the imposter syndrome (*everyone understands but me*). Students gained experience with peers and role models that increased their STEM identification and confidence (Chang et al., 2016). Students at College A participated in a one credit hour course designed to guide them through their first year. A STEM professor served as an advisor and seminar facilitator (A. Gibson, personal communication, March 11, 2021).

Tinto (1993) connected both social and academic involvement as drivers for student persistence. The literature established the concept of a living learning community as a critical component of successful STEM education programs (President's Council of Advisors on Science and Technology, 2012). Dagley et al., (2016) noted that an increase in involvement in the academic and social components of the institution correlated with persistence in STEM disciplines. The connections built and maintained in a living learning community contributed to retention in STEM disciplines due to the support and camaraderie offered by such a community. Various STEM-related activities throughout the academic year could increase connections between students and STEM faculty within the program. First-year student living learning communities could lead to a positive influence of peers on study behavior (Dagley et al, 2016). A living learning community might also further facilitate the formation of study groups. Students who participated in study groups had a higher propensity to graduate in STEM. This might relate to higher self-efficacy or sense of responsibility in students, but Green and Sanderson (2018) advised some form of study group requirement for STEM courses due to this significant effect.

A learning community could be a connection between two or more courses with a common theme and common students (Smith et al., 2009). A STEM first-year seminar that linked the common coursework of the gateway science courses would allow students to make connections and form a deeper understanding of the concepts (Klein, 2005). Johnson et al. (2020) further recommended that a first-year program should integrate place-based themes throughout its cohort courses to foster stronger connections between students, the institution, and the larger community.

Peer Mentors

The Keystone program at Elmhurst College employed peer mentors to act as a guide within the STEM community for first-year students. These mentors were academically gifted student leaders who were previous participants in the program. The mentors assumed responsibility for both academic support and STEM community integration for first-year students in any STEM course to which the mentors had ties (Guenther et al., 2019). The mentor students could help first-year students make a connection with the institution through informal study groups and interactions, while further developing their own leadership skills. Positive peer pressure from mentors could play a role in student persistence to graduation in a STEM field (Foltz et al., 2015).

Spaulding et al. (2020) conducted a large-scale study on the effect of being a peer mentor. Mentoring allowed more advanced students to contribute to the community of the institution and to develop their leadership and communication skills. Another benefit of peer mentoring involved mentors reviewing and revisiting course information as they answered questions from their mentees (Page & Hanna, 2008). The I-PERSIST mentoring program was a large-scale mentoring program at Rensselaer Polytech Institute in Troy, New York. The institution recruited and trained peer mentors extensively to aid mentees in developing the skills necessary to become successful in STEM gateway courses, such as Calculus 1, Chemistry 1, or Physics 1. The mentors not only worked with first-year students, but they also received ongoing professional development throughout the semester to improve their leadership skill set. Mentors could report information about potentially at-risk students to their supervisor who could arrange more assistance before their struggle became too difficult. The peer mentors benefitted by developing a working relationship with the faculty and staff involved in the mentoring program. The mentors also built important skills they could employ in the workforce (Spaulding et al., 2020).

Amaral and Vala (2009) found a statistically significant gain for peer mentors initially underprepared for a general chemistry course at the University of Florida. Faculty recruited student peers to mentor small groups in a classroom setting of a remedial chemistry course. The peer mentors were once students in the course themselves and discovered they could reinforce their knowledge of course content as they revisited material in peer tutoring sessions (Page & Hanna, 2008). The study demonstrated that students who participated as mentors were more likely to take subsequent chemistry courses and perform better than those who did not mentor or were not underprepared for chemistry I. The researchers argued that the success of the mentors further reinforced the need to incorporate leadership activities into a STEM retention program.

A successful peer mentoring program at Louisiana State University (LSU) in Baton Rouge, Louisiana focused on underperforming STEM undergraduates as mentees who became mentors as they progressed through the program (Wilson et al., 2012). A cooperation with Howard Hughes Medical Institute (HHMI) and LSU allowed students to participate as mentees and then as mentors with academic interventions and early research opportunities. This LSU-HHMI Professors Program impacted underperforming student retention in STEM programs and exceeded the national average of STEM program graduates. There was also evidence that students who participated in the program were more likely to earn a degree even if they were not retained in a STEM discipline due in part to the focus on learning strategies employed by the program (Wilson et al., 2012).

Page and Hanna (2008) investigated student perceptions on peer mentoring and explored the preferred means of communication as well as the types of interactions and mentor/mentee pairings that were preferred by students at Queen Margaret University in Belfast, UK. The students preferred an online means of communication as opposed to meeting their mentors in a physical location. The researchers argued that making this type of peer mentoring program available would reduce costs associated with a physical space at the institution. Many of the interactions between the mentors and mentees were social as opposed to academic in nature. A peer mentor was important in helping a new student adjust to the changes of living away from home and to a new culture. This might improve overall college retention efforts since student satisfaction with the university was a predictor of retention (Cosgrove, 1986).

Faculty Student Interaction

Cosgrove's 1986 seminal study on faculty mentoring found increased satisfaction with the institution in students who participated in faculty mentoring programs. Student-faculty interactions outside of class could contribute to student learning and retention. The extent to which students perceived that the institution was committed to their welfare was a strong determinant to student commitment. When faculty showed interest and practiced good teaching techniques and the administration acted fairly and equitably, students were more likely to develop a connection to the institution and persist (Hossler & Bontrager, 2014).

Watkins and Mazure (2013) discovered that a pedagogical modification from lecture-intensive to a more student-centered environment encouraged students to engage in discussions. Curriculum adaptation in only one introductory STEM course was enough statistically to increase STEM persistence. The researchers indicated that group problem solving activities might have decreased the *chilly* climate of STEM courses by increasing student engagement with the material.

Student engagement with faculty was connected to student loyalty to the institution (Snijders et al., 2020). Relationship building correlated with increased loyalty to the institution, which could lead to persistence and retention to graduation. Faculty and staff that showed a genuine interest in student success led to an increased sense of belonging for students (Snijders et al., 2020). Interaction with faculty on a collegial level, such as in research opportunities, could increase students' sense of confidence in their own abilities to think critically and technologically (Seymour et al., 2004).

Science Scholars Program

Designed for STEM-interested college students, the Science Scholars program at College A offered focused support for the first year. Those supports included: an intensive summer bridge program, peer mentors who were junior and senior STEM majors, access to and participation in the STEM Success Center, a STEM focused first-year curriculum, research opportunities with local organizations in STEM fields, potential for institutional and National Science Foundation scholarships, and a STEM-focused living and learning community (Scots Science Scholars Program, 2020; A. Gibson, personal communication, March 11, 2021).

The intensive two-week summer bridge program included a one-time increase in financial aid to allow for potential summer wages lost due to participation. Students must participate in the bridge program to be included in the Science Scholars cohort. The experience included skills necessary for STEM success, scientific research experience, and exposure to careers and opportunities available for STEM majors (Scot's Science Scholars Program, 2020; A. Gibson, personal communication, March 11, 2021).

The STEM Success Center is an academic support and collaboration space wherein students could participate as both learners and tutors as they progressed through the program. First-year students in the Science Scholars program had to log at least six hours per week in academic support activities. Successful upper-level science and math students participated as tutors and peer mentors at the STEM Success Center. Small learning communities encouraged collaboration for both academic and career exploration (Scot's Science Scholars Program, 2020; A. Gibson, personal communication, March 11, 2021).

The design of the STEM-focused first-year curriculum at College A included a seminar course (three credit hours) to establish and invest in study skills, research techniques, career readiness and exploration, and critical thinking and communication skills, while centering on various STEM disciplines. STEM professors facilitated the course and served as co-advisors to the students' academic advisors. Ultimately, survey data from Science Scholars alumni indicated a desire to integrate into the larger college community for first-year seminar. Thus, the program was discontinued after 2017 with a substitution of a one-credit hour portfolio class focusing primarily on issues pertinent to first year STEM students (A. Gibson, personal communication, May 12, 2021).

In the program, first-year students were exposed to and involved in research opportunities with local organizations to gain relevant experience and knowledge to make STEM curricula applicable. Exposure to ongoing research efforts allowed students to envision their inclusion in future studies, which encouraged persistence in a STEM major (Scot's Science Scholars Program, 2020; A. Gibson, personal communication, March 11, 2021). Early undergraduate research opportunities were pivotal to STEM retention for underrepresented students (Kendricks & Arment, 2011; Sweeder et al., 2021

Finally, the STEM-focused living and learning community allowed students the opportunity to become embedded within the department and the institution by including social links and generating a place of belonging (Scot's Science Scholars Program, 2020; A. Gibson, personal communication, March 11, 2021). Gibson et al. (2019) found that students who were Science Scholars members showed a higher likelihood of persistence at the college and as a STEM major than STEM-interested students in the general college population. The researcher in the current study further dissected this finding to determine whether components of the Science Scholars program had influence on persistence.

ACT Score Ranges

Various scholarships were available to students depending on their composite ACT score, which was an average of the subject area tests on the ACT exam. Qualification for the HOPE Scholarships in Tennessee was partially based on the student's ACT composite score as 21 or higher. Additional scholarship funding was available through the Tennessee General Assembly Merit scholarship with a score of 29 or higher on the overall ACT Composite. Many advisors encouraged students to aim for these score goals to increase their ability to qualify for these and other scholarships (Financial Aid Brochure, 2018).

Summary

Education and government leaders revealed concerns about STEM persistence as the number of unfilled positions in the field increased. Leaders developed various programs to increase STEM persistence. Many of those programs included interventions such as: summer bridge programs, tutoring, career seminars, learning communities, recruitment of underrepresented populations, additional funding for financial aid, early undergraduate research opportunities, and peer and faculty mentoring. The literature established that students in the first two years of college were the most at risk for attrition (Ikuma et al., 2017; Krause et al., 2015). Educational leaders at College A incorporated these interventions into their Science Scholars program to increase persistence to the third semester and ultimately to graduation in a STEM-related major. Bandura's (1990) Social Cognitive Career theory pinpointed self-efficacy and visualization of career prospects as important factors in college major choices. These interventions should enable students to view themselves as scientists and visualize future successful careers.

Chapter 3. Methodology

Introduction

The low rate of STEM persistence in post-secondary education leads to fewer prepared graduates to fill open STEM career positions. Organizations such as Johns Hopkins University in Baltimore, Maryland (Nagda, et al., 1998) and the researchers Amaral and Vala (2009) and Herr et al., (2004) proposed solutions to increasing STEM persistence in college students. Fundamental reinforcements, such as academic support, authentic research opportunities, and career seminar participation, could lead to an increase in STEM persistence beyond the first semester of college (Amaral & Vala, 2009; Herr, et.al., 2004; Nagda et al., 1998). The researcher sought to analyze the effectiveness of the Science Scholars program at College A in increasing persistence in a STEM-related major to a second year of college. This program oriented students to the STEM program, facilitated engagement with peers and faculty, exposed students to research opportunities, and filled potential learning gaps (Gibson et al., 2019). Science Scholars members attended a two-week summer bridge program, enrolled in a one-hour seminar course their first semester, and could engage with field trips and research opportunities. The following majors were considered STEM-related: Computer Science, Engineering, Math for teacher licensure, Biology, Biology for teacher licensure, Biochemistry, Biopharmaceutical Science, Biological Science (Pre-Vet), Business Analytics, Chemistry, and Chemistry for teacher licensure, Finance and Accounting, Economics, Exercise Science, and Health Care/Nursing.

The researcher conducted a quantitative, non-experimental, comparative analysis, utilizing data collected from College A. This data included ACT scores, program participations, and persistence to both the second and third semesters of college in a STEM-related major or expressed interest. The goal was to analyze the proportion of participants and non-participants who persisted in a STEM-related major or interest to the second or third semester. The groups were further categorized according to ACT score ranges and analyzed using SPSS software in a Chi-Square test. Six two-by-three contingency matrices calculate the expected frequencies (F_e).

Purpose

The purpose of this quantitative study was to assess whether a difference existed in STEM-related major persistence for students actively involved in the Science Scholars program and those who were STEM-interested but not program participants. Analysis of the proportions of students was based on low, medium, and high score ranges of the overall ACT Composite as well as Math, and Science subtests.

The controlling questions guiding the research were:

Q1. Was there a statistically significant difference in STEM science persistence at College A when comparing Science Scholars students to STEM students who were not Science Scholars Program members?

Q2. Was added support needed to encourage STEM persistence for College A STEM students?

Q3. Is there a STEM persistence advantage to being in Science Scholars versus being a STEM-interested student outside of the program?

Research Questions

RQ 1: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the second semester for all overall ACT Composite ranges statistically equal?

H_{01} The population proportion of STEM Scholars and STEM-interested students in all overall ACT Composite ranges (low, medium, high) who persisted in STEM-related majors to the second semester was statistically equal. Analysis of this research question was with SPSS using a two by three Chi- Square contingency matrix.

RQ2: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the third semester for all ACT Composite ranges statistically equal?

H_{02} The population proportion of STEM Scholars and STEM-interested students in all ACT Composite ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal. Analysis of this research question was with SPSS using a two by three Chi- Square contingency matrix.

RQ3: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the second semester for all ACT Math ranges statistically equal?

H_{03} The population proportion of STEM Scholars and STEM-interested students in all ACT Math ranges (low, medium, high) who persisted in STEM-related majors to the second semester was statistically equal. Analysis of this research question was with SPSS using a two by three Chi- Square contingency matrix.

RQ4: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the third semester for all ACT Math ranges statistically equal?

H_{04} The population proportion of STEM Scholars and STEM-interested students in all ACT Math ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal. Analysis of this research question was with SPSS using a two by three Chi- Square contingency matrix.

RQ5: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the second semester for all ACT Science ranges statistically equal?

H_{05} The population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in STEM-related majors to the second semester was statistically equal. Analysis of this research question was with SPSS using a two by three Chi- Square contingency matrix.

RQ6: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the third semester for all ACT Science ranges statistically equal?

H_{06} The population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal. Analysis of this research question was with SPSS using a two by three Chi- Square contingency matrix.

Research Design

This study employed a quantitative, non-experimental, comparative analysis to assess the effect of the Science Scholars program on STEM persistence. The study measured the interaction of the independent variable (ACT composite, math, and science scores) with the moderator variables (Science Scholars versus STEM-interested groups). The data set included approximately 119 participants who met one of the following parameters: STEM-related interest declared in their first year, reported ACT score, or declared a STEM-related major by the second or the third semester of college.

The researcher obtained disaggregated scores and persistence data from College A. The proportion of students who persisted in each ACT score group was compared between the STEM-interested and Science Scholar students in the 2020-2021 cohort. The scores that were compared were the Science and Math portions of the ACT as well as the overall ACT Composite score. Examining persistence in STEM majors to the second and third semesters of college tested the causal relationship (Fraenkel & Wallen, 2009). The Statistical Program for the Social Sciences (SPSS) software analyzed the data in a Chi Square test. Six two-by-three contingency matrices calculated the expected frequencies with a matrix addressing each research question. The Statistical Program for the Social Sciences (SPSS) software analyzed the data using a Chi Square test to compare population proportions for each test and score group. The researcher calculated the statistical equivalence for each population group tested for both semesters one and two.

College and Student Profiles at College A

College A is a bachelor's degree granting, private, non-profit, liberal arts institution with an enrollment in the Fall of 2019 of 1,143 students. The demographics in the Fall of 2019 consisted of 56.7% women and 43.3% men. The race/ethnicity breakdown consisted of a large majority (75.6%) white, 9.4% Black or African American, 5.8% Hispanic/Latino and less than 5% of other identified races. The student-to-faculty ratio was 12 to 1. Standardized test score ranges for the entering class in the Fall 2019 were: SAT Evidence-Based Reading and Writing 518-633, SAT Math 498-633, ACT Composite 21-27, ACT English 20-28, ACT Math 18-26. The retention rate at the college from first to second year (Fall 2018-Fall 2019) was 77%. The overall graduation rate for those who began their studies in Fall 2013 was 51% (Institute for Education Sciences, 2021).

Protection of Human Subjects

The researcher obtained approval from the Institutional Review Boards of both East Tennessee State University and College A to complete this study. All data were disidentified by College A before receipt by the researcher.

Population and Sample

The Science Scholars cohort population was estimated to be 112 from the inception (2013) of the program (*N*=112). One of the cohort members in 2020-2021 did not persist to the second semester. Eight of the 2020-2021 cohort members received National Science Foundation scholarship money. There was a matched cohort of STEM-interested first-year students. The college invited all entering first-year students to apply to the Science Scholars program with selection based on measured interest, academic history and science activity, gender balance, and STEM underrepresented groups to include first-generation college students, women, and those of minority populations (Gibson et al., 2019).

Sampling Procedures

The sample derived from the entering first year student cohort of Science Scholars participants and STEM-interested students at College A for the 2020-2021 school year. The data were disaggregated before receipt by the researcher.

Instrumentation

The researcher gathered data on STEM persistence, program involvement, and ACT scores from the Science Scholars program coordinators. The basis for persistence was a declaration of STEM-related major or interest before the second and then the third semester of college. Analysis of data used the Statistical Program for Social Sciences (SPSS).

Validity and Reliability Assessment

Internal Validity. Threatened by the potential variability of the groups of students in each cohort. Student cohorts were matched by educational level and STEM-interest. All students attended the same school and took courses in STEM departments. Time sampling of participation for 2020-2021 cohort persistence in STEM-related majors. Criterion-related evidence: participation predicts persistence. Construct-related evidence: participation in support activities builds STEM skills. National Science Foundation scholarships were available from 2019 to the time of the study.

External Validity. Addressed by the diversity of the groups. Threatened by the group sizes. Purposive sampling of STEM-interested participants.

Reliability. Addressed with a Chi square analysis. Statistics analyzed using the Statistical Program for the Social Sciences (SPSS).

Objectivity. Addressed with an $p < .05$ in a one variable X^2 test. Statistics analyzed using SPSS.

Data Collection Procedures

The Institutional Review Board of East Tennessee State University deemed the study exempt. The researcher received no student names or identifiable information from College A. The Institutional Review Board of College A approved adding the researcher to the pre-approved ongoing study of the Science Scholars program. The data from the 2020-2021 cohort were collected in the Fall of 2021 from records at College A.

A Chi-square analysis ($p < .05$) determined whether there was a significant difference in the proportion of students who persisted in a STEM major after the first year of college between Science Scholars participants and STEM-interested students. The groups of students were high, middle, and low scoring ranges of the overall ACT Composite as well as ACT Math, and ACT Science subtests.

The researcher used tally sheets to ascertain the ACT score ranges and the declared interest and/or major of the students in the cohort. Persistence was based on the declaration of STEM or STEM-related major before the second semester and then again in the third semester of college as verified by College A.

Data Analysis

The independent variable for this study was participation in the Science Scholars program. The dependent variables for the study included ACT Score ranges on the overall ACT Composite, as well as ACT Math and ACT Science subtests, persistence to second semester as a STEM-related major or interest, and persistence to third semester as a STEM-related major or interest.

The researcher compiled the information into a two by three contingency matrix for each research question to calculate the expected frequencies of students who persisted to each semester in each subgroup. The matrix data were then uploaded into SPSS for data analysis using a Pearson’s Chi-Square test. The results of the Chi-Square test determined whether the proportions of persistent Science Scholars (S3) were significant compared to the persistence of the non- Science Scholars STEM-interested group.

Table 1

Observed Contingency Matrix for ACT Composite to 2nd Semester

	Observed	Observed
ACT Composite	Non S3 Persisted to 2nd semester	S3 Persisted to 2nd semester
13-20	27	3
21-28	47	3
29-35	23	7
	97	13

Table 2

Observed Contingency Matrix for ACT Composite to 3rd Semester

	Observed	Observed
ACT Composite	Non S3 Persisted to 3rd semester	S3 Persisted to 3rd semester
13-20	21	3
22-28	44	2
29-35	23	7
	88	12

Table 3

Observed Contingency Matrix for ACT Math to 2nd Semester

	Observed	Observed
ACT Math	Non-S3 Persisted to 2nd semester	S3 Persisted to 2nd semester
13-20	39	1
21-28	48	7
29-35	10	5
	97	13

Table 4

Observed Contingency Matrix for ACT Math to 3rd Semester

	Observed	Observed
ACT Math	Non-S3 Persisted to 3rd semester	S3 persisted to 3rd semester
13-20	32	1
21-28	46	7
29-35	10	4
	88	12

Table 5

Observed Contingency Matrix for ACT Science to 2nd Semester

	Observed	Observed
ACT Science	Non S3 Persisted to 2nd semester	S3 Persisted to 2nd semester
13-20	30	2
21-28	51	6
29-35	14	5
	95	13

Table 6

Observed Contingency Matrix for ACT Science to 3rd Semester

	Observed	Observed
ACT Science	Non S3 Persisted to 3rd semester	S3 Persisted to 3rd semester
13-20	25	2
22-28	47	5
29-35	14	5
	86	12

Limitations

The data used in this study was derived from records kept by the Science Scholars Program coordinators at College A. There was a lack of randomization in the groups but there had been a quest for diversity in group formation.

The researcher was unable to manipulate the variables because the individuals chose their own exposure by self-selecting to participate in the Science Scholars (S3) program. Subject characteristics may be a threat to internal validity due to individual choice in groups.

The study took place during a global pandemic with the opportunity for students to select a Pass/Fail option for coursework.

Ethical Considerations

Data were disaggregated to avoid subject identification. The Institutional Review Boards of both College A and East Tennessee State University reviewed the study.

Summary

To evaluate population persistence, the researcher developed six two-by-three contingency matrices to display observed versus calculated expected persistence frequencies for each population to both the second and third semester in a STEM-related major. Six research questions and null hypotheses guided the quantitative, non-experimental, comparative analysis of persistence. The population samples were derived from records of the 2020-2021 cohort of first-year students at College A. This data were made available to the researcher in disaggregated form after approval from the Institutional Review Boards of both East Tennessee State University and College A (Appendices A and C). The matrix data were then uploaded into SPSS for data analysis using a Pearson's Chi-Square test. The results of the Chi-Square test determined whether the proportions of persistent Science Scholars (S3) were significant compared to the persistence of the non- Science Scholars STEM-interested group.

Chapter 4. Research

Many students who enter a STEM track in college move out of that track before graduation (National Science Foundation, 2018). The purpose of this study was to assess whether there was a difference in STEM-related major persistence for population proportions of students actively involved in the Science Scholars program and those who were STEM-interested but not program participants. This program design was to orient students to the STEM program, facilitate engagement with peers and faculty, expose students to research opportunities, and fill in potential learning gaps (Gibson et al., 2019).

The purpose of this chapter was to describe and summarize the data in the study using narratives, quantitative results, and tables. The chapter explained the hypothesis and tests that were conducted and revealed the answers to the research questions with statistical evidence.

Research Question 1

RQ 1: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the second semester for all overall ACT Composite ranges statistically equal?

H_1 The population proportion of STEM Scholars and STEM-interested students in all overall ACT Composite ranges (low, medium, high) who persisted in STEM-related majors to the second semester was statistically equal.

To analyze research question number one, the researcher conducted a Chi-square analysis for overall ACT Composite scores for STEM Scholars and STEM-interested students who persisted to semester two. The results were not significant at $X^2\,(2, N = 110) = 5.536, p = .063$. Science Scholars (S3) with overall ACT Composite scores in all range groups did not appear to have a more significant proportion of their population persisting to the second semester in a STEM-related major.

In conclusion, the data suggested that STEM Scholars and STEM-interested students appeared to have equal proportions persisting to the second semester when measured by overall ACT Composite scores. The null hypothesis (H_1) was not rejected.

Table 7

SPSS Outputs for ACT Composite to Second Semester

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
Compositescore * Groups	110	100.0%	0	0.0%	110	100.0%

Compositescore * Groups Crosstabulation

			Groups		
			NonS3 to 2nd semester	S3 to 2nd semester	Total
Compositescore	13-20 Composite ACT	Count	27	3	30
		Expected Count	26.5	3.5	30.0
	21-28 Composite ACT	Count	47	3	50
		Expected Count	44.1	5.9	50.0
	29-35 Composite ACT	Count	23	7	30
		Expected Count	26.5	3.5	30.0
Total		Count	97	13	110
		Expected Count	97.0	13.0	110.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.536[a]	2	.063
Likelihood Ratio	5.125	2	.077
Linear-by-Linear Association	2.536	1	.111
N of Valid Cases	110		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 3.55.

Research Question 2

RQ2: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the third semester for all overall ACT Composite ranges statistically equal?

H_{02} The population proportion of STEM Scholars and STEM-interested students in all overall ACT Composite ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal.

To analyze research question number two, the researcher conducted a Chi-square analysis for ACT composite scores for STEM Scholars and STEM-interested students who persisted to semester three. The results were significant. X^2 (2, N = 100) = 6.205, p = .045. Science Scholars (S3) with overall ACT Composite scores in the high range appeared to have a significant proportion of their population persisting to the third semester in a STEM-related major.

In conclusion, the data suggested that STEM Scholars and STEM-interested students who scored in the high range of the overall ACT Composite were more likely to benefit from participation in the Science Scholars (S3) program in relation to persistence to a STEM-related major to the third semester than those who scored in the medium and low ranges. The null hypothesis (H_{02}) was rejected.

Table 8

SPSS Outputs for ACT Composite to Third Semester

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Composite ACT Score Ranges * Groups	100	100.0%	0	0.0%	100	100.0%

Composite ACT Score Ranges * Groups Crosstabulation

			Groups		
			Non S3 to 3rd Semester	S3 to 3rd Semester	Total
Composite ACT Score Ranges	1	Count	21	3	24
		Expected Count	21.1	2.9	24.0
	2	Count	44	2	46
		Expected Count	40.5	5.5	46.0
	3	Count	23	7	30
		Expected Count	26.4	3.6	30.0
Total		Count	88	12	100
		Expected Count	88.0	12.0	100.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.205[a]	2	.045
Likelihood Ratio	6.250	2	.044
Linear-by-Linear Association	1.880	1	.170
N of Valid Cases	100		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.88.

Research Question 3

RQ3: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the second semester for all ACT Math ranges statistically equal?

H_{03} The population proportion of STEM Scholars and STEM-interested students in all ACT Math ranges (low, medium, high) who persisted in STEM-related majors to the second semester was statistically equal.

To analyze research question number three, the researcher conducted a Chi-square analysis for ACT Math scores for STEM Scholars and STEM-interested students who persisted to semester two. The results were significant. X^2 (2, N=110) = 10.039, p = .007. STEM Scholars with ACT Math scores in the high range appeared to have a significant proportion of their population persisting to the second semester in a STEM-related major.

In conclusion, the data suggested that STEM Scholars and STEM-interested students who scored in the high range of the ACT Math were more likely to benefit from participation in the STEM Scholars program in relation to persistence to a STEM-related major to the second semester than those who scored in the medium and low ranges. The null hypothesis (H_{03}) was rejected.

Table 9

SPSS Outputs for ACT Math to Semester Two

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
MathACT * Groups	110	100.0%	0	0.0%	110	100.0%

MathACT * Groups Crosstabulation

			Groups		
			NonS3 to 2nd Semester	S3 to 2nd Semester	Total
MathACT	13-20 Math ACT	Count	39	1	40
		Expected Count	35.3	4.7	40.0
	21-28 Math ACT	Count	48	7	55
		Expected Count	48.5	6.5	55.0
	29-35 Math ACT	Count	10	5	15
		Expected Count	13.2	1.8	15.0
Total		Count	97	13	110
		Expected Count	97.0	13.0	110.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.039[a]	2	.007
Likelihood Ratio	9.546	2	.008
Linear-by-Linear Association	9.325	1	.002
N of Valid Cases	110		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.77.

Research Question 4

RQ4: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the third semester for all ACT Math ranges statistically equal?

H_{04} The population proportion of STEM Scholars and STEM-interested students in all ACT Math ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal.

To analyze research question number four, the researcher conducted a Chi-square analysis for ACT Math scores for STEM Scholars and STEM-interested students who persisted to semester three. The results were significant. X^2 (2, N=100) = 6.228, p = .044. STEM Scholars who had ACT Math scores in the high range appeared to have a significantly higher proportion of their population persisting to the third semester in a STEM-related major than those in the medium and low ranges.

In conclusion, the data suggested that STEM Scholars and STEM-interested students who scored in the high range of the ACT Math were more likely to benefit from participation in the

STEM Scholars program in relation to persistence to a STEM-related major to the third semester than those who scored in the medium and low ranges. The null hypothesis (H_{04}) was rejected.

Table 10

SPSS Outputs for ACT Math to Semester Three

Case Processing Summary

	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
MathACT * Groups	100	100.0%	0	0.0%	100	100.0%

MathACT * Groups Crosstabulation

			Groups		
			Non S3 to 3rd Semester	S3 to 3rd Semester	Total
MathACT	13-20 Math ACT	Count	32	1	33
		Expected Count	29.0	4.0	33.0
	21-28 Math ACT	Count	46	7	53
		Expected Count	46.6	6.4	53.0
	29-35 Math ACT	Count	10	4	14
		Expected Count	12.3	1.7	14.0
Total		Count	88	12	100
		Expected Count	88.0	12.0	100.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.228[a]	2	.044
Likelihood Ratio	6.298	2	.043
Linear-by-Linear Association	6.024	1	.014
N of Valid Cases	100		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 1.68.

Research Question 5

RQ5: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the second semester for all ACT Science ranges statistically equal?

H_{05} The population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in STEM-related majors to the second semester was statistically equal.

To analyze research question number five, the researcher conducted a Chi-square analysis for ACT Science scores for STEM Scholars and STEM-interested students who persisted to semester two. The results were not significant. X^2 (2, N = 108) = 4.794, p = .091. The population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in STEM-related majors to the second semester was statistically equal.

In conclusion, the data suggested that the population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in

STEM-related majors to the second semester was statistically equal. The null hypothesis (H_{05}) was not rejected.

Table 11

SPSS Outputs for ACT Science to Semester Two

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
ScienceACT * Groups	108	100.0%	0	0.0%	108	100.0%

ScienceACT * Groups Crosstabulation

			Groups		
			Non S3 to 2nd Semester	S3 to 2nd Semester	Total
ScienceACT	13-20 Science ACT	Count	30	2	32
		Expected Count	28.1	3.9	32.0
	21-28 Science ACT	Count	51	6	57
		Expected Count	50.1	6.9	57.0
	29-35 Science ACT	Count	14	5	19
		Expected Count	16.7	2.3	19.0
Total		Count	95	13	108
		Expected Count	95.0	13.0	108.0

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.29.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.794[a]	2	.091
Likelihood Ratio	4.191	2	.123
Linear-by-Linear Association	3.944	1	.047
N of Valid Cases	108		

Research Question 6

RQ6: For the 2020-2021 first-year student cohort was the population proportion of STEM Scholars and STEM-interested students who persisted in STEM-related majors to the third semester for all ACT Science ranges statistically equal?

H_{06} The population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal.

To analyze research question number six, the researcher conducted a Chi-square analysis for ACT Science scores for STEM Scholars and STEM-interested students who persisted to semester three. The results were not significant. $X^2\,(2, N= 98) = 4.423$, $p = .110$. The population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal.

In conclusion, the data suggested that the population proportion of STEM Scholars and STEM-interested students in all ACT Science ranges (low, medium, high) who persisted in STEM-related majors to the third semester was statistically equal. The null hypothesis (H_{06}) was not rejected.

Table 12

SPSS Outputs for ACT Science to Semester Three

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	*N*	Percent	*N*	Percent
ScienceACT * Groups	98	100.0%	0	0.0%	98	100.0%

ScienceACT * Groups Crosstabulation

			Groups		
			Non S3 to 3rd Semester	S3 to third Semester	Total
ScienceACT	1	Count	25	2	27
		Expected Count	23.7	3.3	27.0
	2	Count	47	5	52
		Expected Count	45.6	6.4	52.0
	3	Count	14	5	19
		Expected Count	16.7	2.3	19.0
Total		Count	86	12	98
		Expected Count	86.0	12.0	98.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.423[a]	2	.110
Likelihood Ratio	3.788	2	.151
Linear-by-Linear Association	3.217	1	.073
N of Valid Cases	98		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.33.

Contingency Matrices for Research Questions Observed and Expected Proportions

Table 13

Contingency Matrix for Research Question 1 Observed and Expected Proportions (ACT Composite 2nd Semester)

ACT Composite	Observed Non- S3 Persisted to 2nd semester	Expected Non-S3 Persisted to 2nd semester	Observed S3 persisted to 2nd semester	Expected persisted to 2nd semester
13-20	27	26.5	3	3.5
21-28	47	44.1	3	5.9
29-35	23	26.5	7	3.5
	97	97.0	13	13.0

Table 14

Contingency Matrix for Research Question 2 Observed and Expected Proportions (ACT Composite 3rd Semester)

ACT Composite	Observed Non-S3 Persisted to 3rd semester	Expected Non-S3 Persisted to 3rd semester	Observed S3 persisted to 3rd semester	Expected persisted to 3rd semester
13-20	21	21.1	3	2.9
22-28	44	40.5	2	5.5
29-35	23	26.4	7	3.6
	88	88.0	12	12.0

Table 15

Contingency Matrix for Research Question 3 Observed and Expected Proportions (ACT Math 2nd Semester)

	Observed	Expected	Observed	Expected
ACT Math	Non-S3 Persisted to 2nd semester	Non-S3 Persisted to 2nd semester	S3 persisted to 2nd semester	S3 persisted to 2nd semester
13-20	39	35.3	1	4.7
21-28	48	48.5	7	6.5
29-35	10	13.2	5	1.8
	97	97.0	13	13.0

Table 16

Contingency Matrix for Research Question 4 Observed and Expected Proportions (ACT Math 3rd Semester)

	Observed	Expected	Observed	Expected
ACT Math	Non-S3 Persisted to 3rd semester	Non-S3 Persisted to 3rd semester	S3 persisted to 3rd semester	S3 persisted to 3rd semester
13-20	32	29.0	1	4.0
21-28	46	46.6	7	6.4
29-35	10	12.3	4	1.7
	88	88.0	12	12.0

Table 17

Contingency Matrix for Research Question 5 Observed and Expected Proportions (ACT Science 2nd Semester)

ACT Science	Observed Non- S3 Persisted to 2nd semester	Expected Non- S3 Persisted to 2nd semester	Observed S3 persisted to 2nd semester	Expected S3 persisted to 2nd semester
13-20	30	28.1	2	3.9
21-28	51	50.1	6	6.9
29-35	14	16.7	5	2.3
	95	95.0	13	13.0

Table 18

Contingency Matrix for Research Question 6 Observed and Expected Proportions (ACT Science 3rd Semester)

ACT Science	Observed Non S3 Persisted to 3rd semester	Expected Non S3 Persisted to 3rd semester	Observed S3 persisted to 3rd semester	Expected persisted to 3rd semester
13-20	25	23.7	2	3.3
22-28	47	45.6	5	6.4
29-35	14	16.7	5	2.3
	86	86.0	12	12.0

Summary

Student populations that scored in the highest range on the overall ACT Composite and the ACT Math subtest were statistically more likely than their STEM-interested peers in the control group to persist to the second and third semesters at College A in a STEM-related major. Populations that scored in the medium and low ranges did not show a significant difference from their STEM-interested peers in the control group in persistence to second and third semester at College A in a STEM-related major.

Chapter 5. Findings, Conclusions, and Recommendations

Problem Statement

Many students who enter a STEM track in college move out of that track before graduation. In 2012, 60% of students who entered post-secondary school with the intent of majoring a STEM field changed their projection. The most common reasons students gave for changing course related to lack of preparation or lack of inspiration in the introductory courses. Further impetus for a major change for underrepresented students noted the lack of a belonging within STEM departments (National Science Foundation, 2018; Technology, 2012). Espinosa et al. (2019) found several key indicators of STEM success for minority-serving institutions. A cohesive community with easily accessible academic and research supports and access to undergraduate research experiences were predictors of success.

First-generation college students and other underrepresented groups were often not exposed to STEM career role models. It could be difficult for a student to envision a career in a field with which they are unaware. Students must view themselves as capable of achieving in STEM before they pursue a program of study (Herr et al., 2004).

The current study evaluated the effectiveness of the Science Scholars program supports for increasing STEM persistence. The purpose of the study was to assess whether there was a difference in STEM-related major persistence for students actively involved in the Science Scholars program and those who were STEM-interested but not program participants. Analysis of proportions of students were based on low, medium, and high score ranges of the overall ACT Composite, Math, and Science tests. The score ranges indicated Tennessee benchmarks that correlate with scholarship eligibility.

The independent variable was group membership determined by participation in the Science Scholars program or STEM-interested nonparticipants. The dependent variables were persistence to second and persistence to third semesters as a STEM-related major or expressed interest.

The researcher analyzed the data with a Chi Square test to determine whether population proportions were statistically significant in persistence to second and then third semester in STEM related fields. The two-by-three contingency matrix sorted the data and calculated expected frequencies for comparison to observed persistence frequencies.

Discussion and Conclusions

The data demonstrated greatest significance in population persistence proportion differences for the higher scoring ACT ranges, particularly in the Math and the overall Composite scores. The high scoring students who were Science Scholars persisted to both second and third semester with a higher frequency than did the STEM-interested, non- Science Scholars program participants. There was no significant difference found for the Science portion of the ACT test. The observed versus expected persistence proportions were insignificant between groups in the middle range of overall ACT composite and Math scores.

Green and Sanderson (2018) suggested the impact of math skills on persistence in STEM or STEM-related fields was important. Students who completed more math courses in high school persisted longer than did those who had not engaged in at least pre-calculus in high school. This skill level was measured on the ACT Math subtest. College A supported students who have the requisite math skills by challenging them further in the gateway STEM courses. The support offered by the STEM Success Center should allow students who earned lower Math ACT scores to build their skills, while also challenging themselves in the Gateway STEM courses (Krause et al., 2015). The evidence in this study suggested that higher scoring students received the necessary support through the Science Scholars program but there might be more potential to further support the middle and low range scoring students.

STEM persistence programs focused on establishing a community of learners and supporting career exploration to help students establish connections and relevance to their futures (Gibson et al., 2019; Guenther et al., 2019; Miller, 2015). These aspects of the Science Scholars program may impact the persistence of the higher achieving students by solidifying their commitment to STEM when they can envision themselves as a productive STEM graduate. The Social Cognitive Career Theory (Bandura, 1990) supported the development of career prospects to encourage STEM persistence as students must be able to visualize themselves in a STEM career. The gateway STEM courses that students engage in early in their college careers often lead them to determine their fit in the department and in STEM fields. A community of learners helps students establish a connection with the department and the university early in their careers, which both Nagda et al. (1998) and Guenther et al. (2019) discussed as an important retention strategy. The summer bridge program that exposes first year students to the basic math and science skills requisite for success in the gateway courses, blended with application of those skills early in the introductory classes, make the connection of math and STEM-relevant courses to students’ futures. This community of learners allows students to develop self-efficacy in STEM as they work with others to develop their skills. The summer bridge and required support hours during the first year for Science Scholars may solidify connections through extracurricular activities that would be connected to a living learning community. After their first year, students can serve as peer mentors to the next cohort of Science Scholars. The research noted that serving as peer mentor not only reinforced prior learning and developed leadership skills, but also established firm connections with the university and the department (Spaulding et al., 2020).

The literature established that early undergraduate research opportunities could help students visualize their role in the scientific community. When undergraduate students engaged with professors in any portion of their research, it allowed them to apply classroom concepts to practice (Seymour et al., 2004; Summers & Hrabowski, 2006). College A requires students to complete a capstone project before graduation (Maryville College, 2020). Many students begin this project during their junior year. Nagda et al. (1998) suggested that students who contributed to ongoing research as early as their sophomore year were more likely to persist to graduation in a STEM-related major.

In conclusion, the data gathered from the 2020-2021 cohort of incoming first-year students at college A demonstrated that students who were STEM-interested and scored in the higher range of overall ACT Composite and Math subtest had a persistence benefit from being involved in the Science Scholars program. Those in the low score range of overall ACT Composite and Math subtest appeared to benefit less from participation in the program. Finally, students who scored in the medium range of overall ACT Composite and Math subtest had nearly equal proportions of persistence to those not involved in the program.

Implications for Practice

Since there is a clear significance in the higher ACT groups for those who participate in the Science Scholars program, it appears that the program is providing the necessary supports for that population. The medium and low scoring range of students could be studied further to understand the additional supports that would encourage their persistence.

The researcher suggests the following:

- Involve students early in undergraduate research. Student involvement as assistants to professors or other researchers will empower them to develop STEM self-efficacy.
- Grant-funded, volunteer, and work-study programs could allow early undergraduates to contribute to the research of others.
- Survey successful Science Scholars program participants about their perceptions of the program.
- Engage in exit interviews with students who chose a non-STEM-related major or who do not persist at the college.
- Implement viable suggestions from the surveys.
- Increase the mathematic support within the Science Scholars program such as a focused foundational math in science course.
- Recruit successful math students to serve as additional peer mentors and tutors for the success center.
- Teach gateway STEM courses in a cross-curricular, thematic manner. Students will understand the applications of previous studies when they are relevant to current endeavors.

Implications for Future Research

The researcher recommends several future studies to evaluate the effectiveness of the Science Scholars program on persistence to the second and third semester in a STEM-related field.

- This study should be repeated with future cohorts at College A to increase the population size and mitigate the effects of a pandemic on persistence.

- The number of hours students attend support sessions in relation to their persistence to the second and third semesters in a STEM-related field could be compared to analyze the effects of academic support.
- The number of career seminar sessions that persistent students attend could be examined and compared to determine the effect on persistence.
- A comparison between genders in a larger population can be examined to determine whether career seminar sessions impact the decision to persist in STEM-related fields more strongly for males or females.

Summary

The population of students who earned the higher range of ACT Composite and ACT Math subtest score were more likely to persist to the second and third semesters in a STEM-related major if they were Science Scholars program participants than if they were in the STEM-interested control group. This reveals that the program supports the highest scoring students well. The medium and low range scoring students did not persist with a higher frequency than their peers in the control group of STEM-interested students. This finding demonstrates that more research may establish support for less prepared students to maintain their STEM interest and success.

The research findings were congruent with studies that suggested that mathematics preparation was pivotal to STEM success (Green & Sanderson, 2018). The population proportion of students that demonstrated a firm mathematics foundation with a score of 29-35 on the ACT Math subtest were statistically more likely to persist than their STEM-interested peers in the control group.

Further research is needed to assess the impact of specific support afforded to STEM students at College A. Career seminar session attendance and success center (tutoring) hours can be quantified and compared for their effects on various population groups' persistence. The goal of the Science Scholars program is to increase persistence and graduation with a STEM-related degree. Gaps in persistence based on gender, race, and prior preparation are all viable areas to improve once they are assessed.

References

Amaral, K., & Vala, M. (2009). What teaching teaches: Mentoring and the performance gains of mentors. *Journal of Chemical Education*, *86*(5), 630-633. https://doi.org/10.1021/ed086p630

Ashley, M., Cooper, K. M., Cala, J. M., & Brownell, S. E. (2017). Building better bridges into STEM: A synthesis of 25 years of literature on STEM Summer Bridge Programs. *CBE Life Sciences Education*, *16*(4), 1-16. https://doi.org/10.1187/cbe.17-05-0085

Atkinson-Bonasio, A. (2017). *Gender balance in research: New analytical report reveals uneven progress*. https://www.elsevier.com/connect/gender-balance-in-research-new-analytical-report-reveals-uneven-progress

Bandura, A. (1990). Reflections on nonability determinants of competence. In R. J. Sternberg, & J. Kolligian, Jr. (Eds.), *Competence considered* (pp. 315-362). Yale University Press.

Bert, A. (2018, October 1). 3 reasons gender diversity is crucial to science. https://www.elsevier.com/connect/3-reasons-gender-diversity-is-crucial-to-science

Bottia, M. C., Stearns, E., Mickelson, R. A., Moller, S., & Parker, A. D. (2015). The relationships among high school STEM learning experiences and student's intent to declare and declaration of a STEM major in college. *Teacher's College Record*, 1-46.

Bradford, B. C., Beier, M. E., & Oswald, F. L. (2021). A meta-analysis of university STEM Summer Bridge Program effectiveness. *CBE Life Sciences Education*, *20*(2), ar21. https://doi.org/10.1187/cbe.20-03-0046

Carter, F. D., Mandell, M., & Maton, K. I. (2009). The influence of on-campus, academic year undergraduate research on STEM PhD outcomes: Evidence from the Meyerhoff Scholarship Program. *Educational evaluation and policy analysis*, *31*(4), 441-462. https://doi.org/10.3102/0162373709348584

Chang, J.-M., Kwon, C., Stevens, L., & Buonora, P. (2016). Strategies to recruit and retain students in physical sciences and mathematics on a diverse college campus. *Journal of College Science Teaching*, *45*(3), 14-22.

Cohen, R., & Kelly, A. M. (2019). Community college chemistry course taking and STEM academic persistence. *Journal of Chemical Education*, *96*, 3-11. https://doi:org/10.1021/acs.jchemed.8b00586

College Board. (2012). Recommendation nine: Dramatically increase college completion rates. *The College Completion Agenda.* http://media.collegeboard.com/digitalServices/pdf/advocacy/policycenter/college-completion-agenda-2012-progress-report.pdf

Cosgrove, T. J. (1986). The effects of participation in a mentoring-transcript program on freshmen. *Journal of College Student Personnel*, *27*. 119-124.

Cuseo, J. (2015, June). *Academic-support strategies for promoting student retention & achievement during the first-year of college & beyond*. https://www.researchgate.net/publication/277711533_academic_support_strategies_for_promoting_student_retention doi: 10.13140/RG.2.1.3230.9929

Dagley, M., Georgiopoulos, M., Reece, A., & Young, C. (2016). Increasing retention and graduation rates through a STEM learning community. *Journal of College Student Retention: Research, Theory & Practice*, *18*(2), 167–182. https://doi.org/10.1177/1521025115584746

Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights from the Behavioral and Brain Sciences*, *1*(1), 21-29. doi: 10.1177/2372732214549471

Del Giudice, M. (2015). Why it's crucial to get more women into science. *National Geographic*. https://www.nationalgeographic.com/culture/article/141107-gender-studies-women-scientific-research-feminist

Department of Education. (n.d.). *Tennessee Department of Education*. www.tn.gov

Dirmeyer, H. (2021). Black and White student achievement gaps in Tennessee *Electronic Theses and Dissertations.* Paper 3862. https://dc.etsu.edu/etd/3862

D'Souza, M. J., Shuman, K. E., Wentzien, D. E., & Roeske, K. P. (2018). Working with the Wesley College Cannon Scholar Program: Improving retention, persistence, and success. *Journal of STEM Education*, *19*(1), 31-40.

Eagan, M. K., Sharkness, J., Hurtado, S., Mosqueda, C. M., & Chang, M. J. (2010). Engaging undergraduates in science research: Not just about faculty willingness. *Research in Higher Education*, *52*(2), 151-177. https://doi.org/10.1007/s11162-010-9189-9

Espinosa, L. L., McGuire, K., & Jackson, L. M. (2019). *Minority serving institutions: America's underutilized resource for strengthening the STEM workforce*. The National Academies Press.

Financial Aid Brochure 2018_ONLINE.PDF. https://www.tn.gov/content/dam/tn/collegepays/media/print/Financial%20Aid%20Brochure%202018_ONLINE.PDF

Findley-Van Nostrand, D., & Pollenz, R. S. (2017). Evaluating psychosocial mechanisms underlying STEM persistence in undergraduates: Evidence of impact from a six-day pre-college engagement STEM academy program. *CBE-Life Sciences Education, 16(36),* 1-15.

Foltz, L. G., Foltz, C. B., & Kirschmann, S. L. (2015). Planning for science, technology, engineering, and math (STEM) retention: Understanding the implications of the theory of planned behavior. *Planning for Higher Education*, *43*(4), 17-25.

Fraenkel, J. R., & Wallen, N. E. (2009). *How to design and evaluate research in education* (7th ed.). McGraw Hill Education.

Gibson, A. D., Siopsis, M., & Beale, K. (2019). Improving persistence of STEM majors at a liberal arts college: Evaluation of the Scots Science Scholar program. *Journal of STEM Education*, *20*(2), 6-13.

Graham, M., Frederick, J., Byars-Winston, A., Hunter, A., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science*, *341*(6153), 1455-1456.

Green, A., & Sanderson, D. (2018). The Roots of STEM achievement: An analysis of persistence and attainment in STEM majors. *The American Economist*, 63(1), 79-93. doi:101177/0569434517721770.

Guenther, M. F., Johnson, J. L., & Sawyer, T. P. (2019). The Keystone Program: A model for STEM student success and retention at a small liberal arts college. *Journal of College Science Teaching*, *48*(6), 8-14.

Hagedorn, L. S. (2005). How to define retention: A new look at an old problem. In A. Seidman (Ed.), *College Student Retention: Formula for Student Success* (pp. 81-99). American Council on Education and Praeger Publishers.

Herr, E. L., Cramer, S. H., & Niles, S. G. (2004). *Career guidance and counseling through the lifespan: Systematic approaches*, Vol. 6. Pearson Education.

Hossler, D., & Bontrager, B. (2015). *Handbook of strategic enrollment management.* Jossey-Bass.

Howard, T. C. (2001). Telling their side of the story: African-American students' perceptions of culturally relevant teaching. *The Urban Review Journal*, *33,* 131-149.

Hrabowski, F. (2013, January 9). *We must change the culture of science and teaching: Freeman Hrabowski at TEDx MidAtlantic* [Video]. https://www.youtube.com/watch?v=SLYMLt4MQ0Y

Hrabowski, F. A. (2013, February). Freeman Hrabowski: TED 2013: 4 pillars of college success in science [Video]. https://www.ted.com/talks/freeman_hrabowski_4_pillars_of_college_success_in_science?language=en

Hsieh, T-y, Liu, Y. & Simpkins, S. D. (2019). Changes in United States Latino/a high school students' science motivational beliefs: Within group differences across science subjects, gender, immigrant status, and perceived support. *Frontiers in Psychology*, *10,* 380.

Ikuma, L. H., Steele, A., Dann, S., Adio, O., & Waggenspack, W. N. (2019). Large-scale student programs increase persistence in STEM fields in a public university setting. *Journal of Engineering Education*, *108*(1), 57-81. https://doi.org/10.1002/jee.20244

Institute for Education Sciences. (2021). *Search for Schools and Colleges*. National Center for Education Statistics (NCES). U.S. Department of Education. https://nces.ed.gov/globallocator/index.asp?search=1&State=TN&zipcode=37777&miles=50&sortby=name&College=1&Records=1&CS=3DAB055E

Jenkins, D., & Cho, S.-W. (2012). *Get with the program: Accelerating community college students' entry into and completion of programs of study* (CCRC working paper No. 32). Community College Research Center, Teachers College, Columbia University.

Johnson, M. D., Sprowles, A. E. Goldenberg, K. R., Margell, S. T., Castellino, L. (2020). Effect of a place-based learning community on belonging, persistence, and equity gaps for first-year STEM students. *Innovative Higher Education*, *45*, 509-553. https://doi.org/10.1007/s10755-020-09519-5

Kendricks, K., & Arment, A. (2011). Adopting a K-12 family model with undergraduate research to enhance STEM persistence and achievement in underrepresented minority students. *Journal of College Science Teaching*, 41(2), 22-27.

Klein, J. T. (2005). Integrative learning and interdisciplinary studies. *Peer Review*, *7*(4), 8-10.

Krause, S. J., Middleton, J. A., Judson, E., Ernzen, J., Beeley, K. R., & Chen, Y.-C. (2015, June). *Factors impacting retention and success of undergraduate engineering students.* Paper presented at the 122nd ASEE Annual Conference & Exposition, Seattle, WA.

Ladson-Billings, G. (1994). *The dreamkeepers: Successful teachers of African-American students.* Jossey-Bass.

Lent, R.W., & Brown, S.D. (2002). Social cognitive career theory. In D. Brown (Ed.), *Career choice and development* (4th ed) (pp. 255-311). Wiley.

Maryville College. (2020a, July 31). *Scots Science Scholars Program*. https://www.maryvillecollege.edu/academics/learn-by-experience/scots-science-scholars/

Maryville College. (2020b, July 31). *Senior studies by major*. https://www.maryvillecollege.edu/academics/learn-by-experience/research/senior-study/

Mathewson, T. G. (2020, March 30). Why aren't students prepared for STEM careers: No physics in high school. *The Hechinger Report*. https://hechingerreport.org/one-reason-students-arent-prepared-for-stem-careers-no-physics-in-high-school/

Miller, J. A. (2015). *Predictors of student persistence in the STEM pipeline: Activities outside the classroom, parent aspirations, and student self-beliefs using NELS:88 data* (Order No. 3684530). Available from Education Database ProQuest Central. (1660753267).

Morganson, V. J., Major, D. A., Streets, V. N., Litano, M. L., & Myers, D. P. (2015). Using Embeddedness Theory to understand and promote persistence in STEM majors. *Career Development Quarterly*, *63*(4), 348-362. https://doi.org/10.1002/cdq.12033

Nagda, B. A., Gregerman, S. R., Jonides, J., von Hippel, W., & Lerner, J. S. (1998). Undergraduate student-faculty research partnerships affect student retention. *The Review of Higher Education*, *22*(1), 55-72. doi:10.1353/rhe.1998.0016

National Center for Education Statistics (NCES). (n.d.). *Home Page*. U.S. Department of Education. https://nces.ed.gov/

National Research Council (NRC). (2010). *Rising above the gathering storm, revisited: Rapidly approaching category 5*. National Academies Press.

National Science Foundation. (n.d.). *National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS): Completions survey*. National Center for Science and Engineering Statistics. https://ncsesdata.nsf.gov/webcaspar/

National Science Foundation. (2018). *SEI 2018 Chapter 2* (NSB-2018-2). https://www.nsf.gov/statistics/2018/nsb20181/assets/561/higher-education-in-science-and-engineering.pdf.

National Survey of Student Engagement. (2010). *Major differences: Examining student engagement by field of study*. Annual results 2010. https://eric.ed.gov/?id=ED512590

Nestor-Baker, N., & Kerka, S. (2009). *Recruitment and retention of underrepresented students in STEM fields.* The Ohio State University Press.

National Student Clearinghouse Research Center. (2020, September 18). *Persistence & Retention.* https://nscresearchcenter.org/persistence-retention/

Page, D., & Hanna, D. (2008). Peer mentoring: The students' perspective. *Psychology Learning and Teaching*, *7*(2), 34-37.

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering and math.* https://permanent.fdlp.gov/gpo21068/pcast-engage-to-excel-final_2-25-12.pdf

Prince, M. J., Felder, R. M., & Brent, R. (2007). Does faculty research improve undergraduate teaching: An analysis of existing and potential synergies. *Journal of Engineering Education*, *96*(4), 283-294. https://doi.org/10.1002/j.2168-9830.2007.tb00939.x

Reena, I. (2018). *The effect of a STEM-specific intervention program on academic achievement, STEM retention, and graduation rate of at-risk college students in STEM majors at a Texas college* (Order No. 10929851). Available from ProQuest One Academic; Social Science Premium Collection. (2153851872). https://www.proquest.com/dissertations-theses/effect-stem-specific-intervention-program-on/docview/2153851872/se-2?accountid=10771.

Rosenzweig, J., Vrinceanu, D., Hwang, H., & Shishodia, S. (2016). Vertical alignment of educational opportunities for STEM learners: Evaluating the effects of road dust on biological systems. *The American Biology Teacher, 78*(9), 710-716.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Westview Press.

Seymour, E., Hunter, A.-B., Laursen, S. L., & DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education*, *88*(4), 493-534. https://doi.org/10.1002/sce.10131

Singer, S. R., Hilton, M. L., Schweingruber, H. A. (Eds.) & National Research Council. (2006). *America's lab report: Investigations in high school science*. The National Academies Press. https://doi.org/10.17226/11311

Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student attraction, persistence and retention in STEM programs: Successes and continuing challenges. *Higher Education Studies*, *7*(1), 46-59. doi: 10.5539/hes.v7n1p46.

Smith, B. L., MacGregor, J., Matthews, R., & Gabelnick, F. (2009). *Learning communities: Reforming undergraduate education.* Wiley Publishing.

Snijders, I., Wijnia, L., Rikers, R. M. J. P., & Loyens, S. M. M. (2020). Building bridges in higher education: Student-faculty relationship quality, student engagement, and student loyalty. *International Journal of Educational Research*, *100*, 1-14. https://doi.org/10.1016/j.ijer.2020.101538

Spaulding, D. T., Kennedy, J. A., Rozsavolgyi, A. & Colón, W. (2020). Outcomes for peer-based mentors in a university-wide STEM persistence program: A three-year analysis. *Journal of College Science Teaching*, *49*(4), 30-36.

STEM Success Initiative. The College of Wooster. (n.d.). https://wooster.edu/academics/apex/stem-success-initiative/

Summers, M., & Hrabowski, F. (2006). Preparing minority scientists and engineers. *Science, 311*(5769), 1870-1871.

Sweeder, R. D., Kursav, M. N., & Valles, S. A. (2021). A cohort scholarship program that reduces inequities in STEM retention. *Journal of STEM Education, 22*(1), 5-13.

Tao, K. W., & Gloria, A. M. (2019). Should I stay or should I go: The role of impostorism in STEM persistence. *Psychology of Women Quarterly*, 43(2), 151-164. https://doi.org/10.1177/0361684318802333

Terenzini, P.T., & Pascarella, E.T. (1998). Studying college students in the 21st century: Meeting new challenges. *The Review of Higher Education*, *21*(2), 151-165.

Terenzini, P. T., Springer, L., Yaeger, P. M., Pascarella, E. T., & Nora, A. (1996). First-generation college students: Characteristics, experiences, and cognitive development. *Research in Higher Education*, *37*(1), 1-22. https://doi.org/10.1007/BF01680039

Tinto, V. (1994). *Leaving college: Rethinking the causes and cures of student attrition*. University of Chicago Press.

Tyson, W., Lee, R. Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk, 12*(3), 243-270.

U.S. Department of Education (USDOE). (2011). *Trends in international mathematics and science study (TIMMS)*. Washington, DC: Institute of Education Sciences, National Center for Educational Statistics.

Watkins, J., & Mazur, E. (2013). Retaining students in science, technology, engineering, and mathematics (STEM) majors. *Journal of College Science Teaching*, *42*(5), 36-41.

Webber, K. L., Nelson Laird, T. F., & BrckaLorenz, A. M. (2013). Student and Faculty Member Engagement in Undergraduate Research. *Research in Higher Education*, *54*(2), 227–249. https://doi.org/10.1007/s11162-012-9280-5

Wilson-Kennedy, Z., Byrd, G., Kennedy, E., & Frierson, H. (2019). Broadening participation in STEM: Effective methods, practices, and programs. Emerald Publishing Limited.

Wilson, Z. S., Holmes, L., de Gravelles, K., Sylvain, M. R., Batiste, L., Johnson, M., Warner, I. M. (2012). Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate STEM disciplines. *Journal of Science Education and Technology*, *21*(1), 148-156. doi: http://dx.doi.org/10.1007/s10956-011-9292-5

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