Board 188: A Legacy of Success: The High Achievers in STEM

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A Legacy of Success: The High Achievers in STEM

Abstract - There are well-known and widespread issues that come with recruiting and retaining a diverse group of students into STEM majors. Financial strain for students, course workload, and institutional quality are highlighted in the literature [1], [2], [3], [4]. Our program, The High Achievers in STEM (HAIS), utilizes the concept of a learning community as the central nexus for providing services to students in order to recruit and retain students in STEM majors. Along with full academic scholarships, HAIS scholars are members of a learning community that extends into various aspects of life on campus. The learning community concept has been shown to facilitate the development of relationships between students by combining their academic and social interests [4], [6]. Learning communities have also been shown to increase student retention, especially for students in STEM majors who may be faced with some of the challenges noted above [6], [7]. During the COVID-19 pandemic, connection to the HAIS learning community sustained the Sense of Community (SOC) experienced by our scholars, enabling them to persist [15][19]. By empowering and sustaining the SOC within our learning community throughout the life of the HAIS program, we have successfully recruited and retained a diverse group of STEM scholars. One hundred percent of HAIS scholars across all five years came from economically disadvantaged backgrounds. On average, 46.34% of HAIS scholars were non-White, which is more than double the percentage of racial or ethnic diversity in our overall student population (19%). Overall retention rates for the five STEM majors who participated in HAIS ranged from 96.0% to 100%. Graduation rates ranged from 89.7% to 95.7%. Non-HAIS students in the same five STEM majors had retention rates that were 22-23% lower than HAIS scholars across time. From the beginning of HAIS (fall 2018) until the end of the last academic year (spring 2023), the program has served a total of 63 students, with 54 students graduating with either an undergraduate or a graduate degree to date. HAIS programming consists of a three-pronged approach, including a weekly seminar, a research team led by a faculty mentor, and a study hall. Research teams comprised students in the same major or a diverse group of students from various complementary disciplines. At the beginning of each academic year, social events were hosted to help new HAIS students assimilate into the learning community. At the end of each semester, research teams met to present progress and findings for their projects in a mini research conference-style session. HAIS scholars across all five years of data reported high levels of satisfaction with the HAIS program in general, with the research team and mentoring rated higher than study halls. SOC was consistently rated as high, and STEM Affinity as measured by the STEM Affinity Scale, was also consistently high.

I. Introduction

There are well-known and widespread issues that come with recruiting and retaining a diverse group of students into STEM (science, technology, mathematics, and engineering) majors. Financial strain for students, course workload, and institutional quality are some of the reasons highlighted in the literature [1], [2], [3], [4]. Our program, The High Achievers in STEM (HAIS), utilized the concept of a learning community as the central nexus for providing services to students in order to recruit and retain students in five STEM degree programs. The HAIS program was funded by a 5-year National Science Foundation S-STEM grant. A longitudinal mixed methods study took place from fall 2018 to spring 2023 to examine the effectiveness of

the HAIS program. The purpose of this study was to examine the extent to which the S-STEM program met the following goals:

1. Increase opportunities for students from the Appalachian region to pursue a degree in the five participating STEM disciplines,
2. Increase the retention rate of students in these five STEM disciplines,
3. Improve recruitment, particularly of underrepresented students,
4. Increase the overall number of graduates in the five STEM disciplines coming from economically disadvantaged backgrounds,
5. Encourage students to seek advanced degrees,
6. Improve the student support infrastructure available to *all* STEM students, and
7. Establish a learning environment that mimics an interdisciplinary "real world" experience.

A. Study Context

This study took place at a large, regional-serving 4-year institution located in the southeastern United States. In 2022-2023, the institution awarded 16.1% (n = 855) of its degrees to STEM majors. Currently, STEM degree programs comprise 13.1% (n = 2,775) of the total enrollment for fall 2023 [5].

The HAIS program was a structured learning community that operated during the academic years from 2018 to 2023. Support for HAIS scholars included: weekly seminars, study halls, research experiences, faculty mentorship, and social activities. Students in the HAIS program were in one of five degree areas: Chemistry, Computer Science, Geology, Mathematics, and Physics.

II. Review of Literature

Learning communities, like the HAIS program, have been shown to be effective for retaining students within STEM degree programs [6], [7]. These types of communities allow students with similar interests and abilities to form relationships where they might not otherwise, which can have positive implications for low income, first generation, and minority students [3], [4], [7], [8]. Salomone and Kling [9] found that requiring peer-cooperative learning in introductory courses increased retention of STEM majors in their program. Many other studies have linked specific STEM-focused programming or communities of practice to increased retention and increased Sense of Community (SOC) [10], [11], [12], [13], [14]. SOC is linked to mental health issues such as loneliness and alienation, thus it is important to consider when targeting measures for supporting student success [4], [12], [15].

III. Methods

This longitudinal study employed an explanatory mixed methods approach [16]. Mixing methods is appropriate for this type of study as it allows the collection of contextual data along with quantitative data. Doing so allowed for qualitative data to support findings from quantitative data. As part of the evaluation of the HAIS program, data were collected systematically to serve both formative and summative purposes on an annual basis.

A. Study Participants

From the beginning of HAIS in fall 2018 until the end of spring 2023 the program has served a total of 63 students. Fifty-four students graduated with either an undergraduate or a graduate degree to date. Students were recruited into HAIS if they first qualified for additional financial aid due to the amount of need and also if they showed high academic potential. Scholars were recruited into HAIS during their freshman year or at any point in their undergraduate career. The scholarship was available to qualifying students for four years, allowing some students to complete both an undergraduate degree and a Master's degree as an HAIS student. Each of the five degree programs nominated students for HAIS based on these qualifications, with specific attention paid to scholars from the mountain counties surrounding the university.

B. Data Collection

Surveys were administered to scholars during each academic semester (fall and spring) from fall 2018 to spring 2023. The surveys included evaluative questions regarding the components of HAIS along with the Sense of Community Index -2 (SCI-2) and questions regarding STEM identity [17, [18]. The surveys also included open-ended items which allowed for free response.

In addition, three focus groups were held in order to collect qualitative data from participants. Focus groups occurred in person during April 2019, February 2020 (prior to the COVID-19 pandemic), and April 2022.

Program records were collected by the Primary Investigator and shared with the evaluation team and the educational researcher. Program records for each participant were used to track retention, graduation, and future plans.

C. Data Analysis

Quantitative data were analyzed descriptively for this study using both SPSS (version 29) and Microsoft Excel. As the HAIS scholars were not admitted in cohorts, but could be admitted into and out of the program at any time, data were not examined inferentially due to small sample size. To support descriptive findings, qualitative data were analyzed holistically, with participant statements used to support descriptive findings in this study.

IV. Results

A summary of major findings relevant to the goals of the HAIS program will be detailed below. This study is concerned with the investigation of the following concepts related to the program goals outlined above: recruitment, diversity, retention, graduation, advanced degrees, careers, infrastructure, learning environment, and overall impact.

A. Recruitment and Diversity

Of the 63 HAIS scholars that were admitted into the program across all five years, 25 (40%) came from the 10-county Appalachian region surrounding our institution. A large portion of the scholars were from the county (n = 11, 18.3%), where our main campus is located, and its neighboring county (n = 6, 10%). The percentage of scholars coming from the 10-county Appalachian region varied each semester, from 8.0% (fall 2021) to 40.0% (fall 2018), with average annual percentages decreasing each year. In total, this is a higher percentage of students originating from this region than the general population on our campus (source blinded for review).

One hundred percent of HAIS scholars across all five years came from economically disadvantaged backgrounds. On average in any given academic year, over 40% of HAIS scholars were non-White, which is more than double the percentage of racial or ethnic diversity in our overall student population, which is 19% (source blinded for review). See Table I below for a breakdown of HAIS scholars by academic semester and designation.

Table I
Percentage of HAIS Scholars by Academic Semester and Designation

	Yr 1		Yr 2		Yr 3		Yr 4		Yr 5	
	F18	S19	F19	S20	F20	S21	F21	S22	F22	S23
	%	%	%	%	%	%	%	%	%	%
Economically Disadvantaged	100	100	100	100	100	100	100	100	100	100
Non-White	45.0	47.8	59.3	58.6	46.7	44.8	44.0	39.1	41.7	36.4
Coming from 10-county Appalachian Region	40.0	30.4	22.2	20.7	16.7	17.2	8.0	8.7	8.3	13.6

Of the 63 HAIS scholars across all five years, 12% of HAIS scholars were Hispanic and 11% were Black. In total, 44.4% scholars were non-white, which makes the program significantly more racially diverse than the institution overall (see Table II).

In fall 2023 the institution's population of enrolled students was 57% female and 43% male. An examination of HAIS data by degree program shows that there were higher numbers of males in HAIS, which is on trend for STEM degree programs. Chemistry, however, had substantially more female HAIS scholars (86.71%) and Mathematics had nearly 50% female scholars (42.86%). See Table III for more information.

Table II

Ethnic Diversity Across all Five Years of the HAIS Program as Compared to the institution

	HAIS Scholars (n = 63)		Student Body in fall 2023 (n = 21,253)	
Ethnic Group	*f*	*%*	*f*	*%*
Asian	3	4.76%	781	3.67%
Black/ African American	11	17.46%	1,222	5.75%
Foreign National	0	0%	116	0.55%
Hispanic/ Latino	12	19.05%	1, 818	8.55%
American Indian/ Alaskan Native	2	3.17%	434	2.04%
White	35	55.56%	17,245	81.14%

Note. source blinded for review

Table III

Gender Diversity by Major Across all Five Years of the HAIS Program (n = 63)

Major	Total	Female (n = 23)		Male (n = 40)	
	n	*f*	*%*	*f*	*%*
Chemistry	7	6	86.71%	1	13.29%
Computer Science	24	7	29.17%	17	70.83%
Geology	7	2	28.57%	5	71.43%
Mathematics	14	6	42.86%	8	57.14%
Physics	11	2	18.18%	9	81.82%
Total	63	23	36.51%	40	63.49%

The breakout of HAIS scholars per each degree program, across all five years, can be seen in Figure 1.

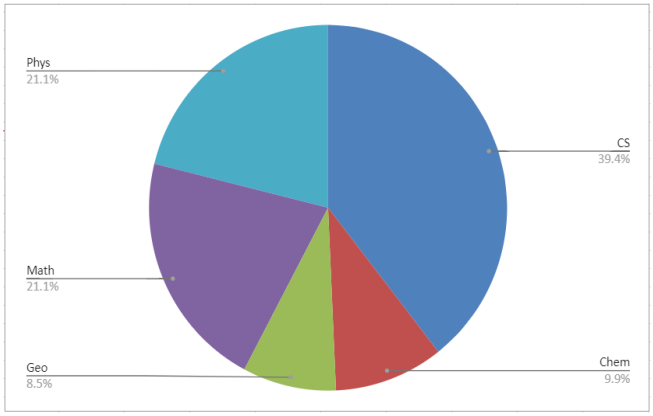

Figure 1. Percentage of HAIS scholars by STEM degree program.

B. Retention and Graduation

Overall retention rates for the five STEM majors who participated in the HAIS program are over 88% for undergraduate scholars and about 95% for graduate scholars. The retention and graduation rates for HAIS Scholars were quite high. In comparison, retention rates were around 22-23% lower among non-HAIS students in the same majors. It is worth noting that out of 63 unduplicated HAIS scholars, only eight undergraduate scholars and one graduate scholar left the program.

There were 19 graduate students who were HAIS scholars; 10 were Computer Science majors (one female, nine male), five were Physics majors (all were male), and four were Mathematics majors (three female, one male). One Computer Science graduate student completed the HAIS program with his undergraduate degree but left during the first semester of his graduate Computer Science program in order to take a job in NC.

Table IV
Overall HAIS Scholar Status by Major as of Fall 2023

	Total	*Active Fall 2023*	*Graduated Prior to Fall 2023*	*Left Prior to Fall 2023*
	n	*f*	*f*	*f*
Chemistry	7	2	3	2
Computer Science	24	2	20	2
Geology	7	1	5	1
Mathematics	14	3	9	2
Physics	11	5	4	2
Total	63	13	42	9

By the end of the program, HAIS supported 54 scholars to earn bachelor's degrees and 19 scholars to earn master's degrees. Seven scholars earned both a bachelor's and a master's degree with support from HAIS. HAIS resulted in more than 88% overall retention, with more than 84% of the 43 graduates remaining in NC to join the workforce or attend graduate programs.

When HAIS Scholars were disaggregated by whether they were transfer students or not, analyses revealed that transfer students had a 100% retention rate. Non-transfer HAIS Scholars' retention rates were slightly lower at about 98%. Regardless of these differences, rates for both these S-STEM groups for retention and graduation are exceptional.

C. Infrastructure

In order to support STEM majors both within and outside of the HAIS program, the HAIS program created the STEM Seminar. This seminar took place each Friday at 3:00 p.m. during all 5 academic years. The STEM Seminar was a required one hour course where students in the HAIS program, along with selected other STEM majors, would gather to learn about different STEM fields along with engaging in leadership training. Examples of workshops included:

- Forum on Election Security (Dr. Jones [pseudonym])
- From Modeling To Meta-Modeling: Going From A Student Of Data Science To A Professional (Dr. Wright [pseudonym])
- The Role of Adventure, Exploration, and Discovery in the Environmental Studies: Why We Do It and Why It's Good for You Too! (Dr. Thomas [pseudonym])
- Biotechnology: How Viruses Can be Used for Good (Dr. Andrews [pseudonym])
- Smashing Pumpkins (Dr. Cox [pseudonym])

During the COVID-19 pandemic, when the institution held classes 100% online, the STEM Seminar continued to meet virtually using Zoom. This continuation of the community aspect of the HAIS program through these weekly seminars during COVID-19 supported HAIS scholars' Sense of Community (SOC) [17], [19]. Students shared comments during this time such as:

- "It has been very helpful as a support system especially being at home so much during quarantine."
- "I love having a group of people that care for me!"
- "Every time we meet up, it feels like meeting with family and friends so it is very nice to have in times when I can't visit my family and friends."

Scholars were asked to rate how engaging they found the STEM Seminar each semester on a scale of 1 (Not at all engaging) to 5 (Very engaging). As is shown below, ratings ranged from 3.61 to 4.35, with an average rating of 3.93.

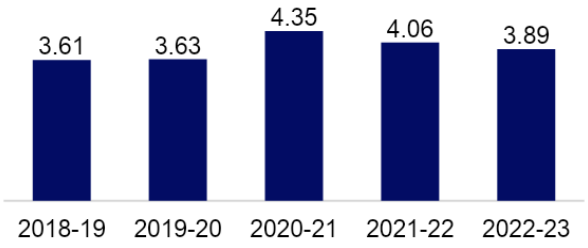

Figure 2. Ratings of amount of engagement for the STEM seminar.

Student survey responses indicated that students liked these seminars immensely. Students noted that the STEM seminars provided them with new information about career fields or topics in their career or helped them learn about something they knew nothing about. Comments across the years about these seminars included:

- "Helped clarify my plans for the future."
- "It was really helpful to see professors who went through similar struggles and took time to get into their field. They gave advice that meant a lot as well."
- "They introduced interesting new concepts that are beneficial to my career."
- "Being able to create connections with people outside of my major. In the pumpkin demo, we were able to interact with our presenter and learn some cool stuff at the same time."

Students who indicated that the various seminars were useful noted that they were interactive, helped participants be more outgoing, allowed participants to meet other students,

and supported participants' overall teamwork and team building.

As part of the HAIS program, scholars were required to attend two study halls each week. Study halls were monitored by junior or senior scholars who were available to help students, as needed, with homework. As all HAIS scholars were required to attend, it also provided a way for scholars to get to know each other better. The figure below includes the ratings scholars provided when asked to rate the benefits of participating in the study halls, on a scale of 1 (Not At All Beneficial) to 5 (Extremely Beneficial). As can be seen, ratings ranged from 2.21 to 4.00 indicating that, on average, scholars found study halls to have benefits.

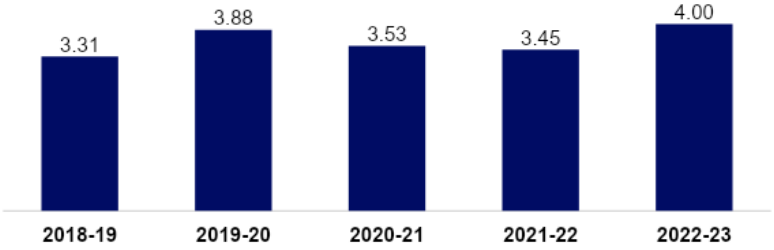

Figure 3. Ratings of the benefits of study halls.

Study halls became virtual while the institution was fully online during the COVID-19 pandemic, which has some implications for student ratings during these academic semesters. In addition, scholars shared feedback as a part of the formative evaluation process that helped the PI's to reconsider requirements for time and location of the study halls. Scholars were able to have some flexibility with study hall time if they needed it due to conflicting schedules and they also helped to craft policies and procedures around study halls.

D. Learning Environment

The final goal of the HAIS program was to create learning environments that mimicked interdisciplinary, real-world experiences. As such, all HAIS scholars participated in faculty-led research teams. Most teams consisted of students from the same degree program, often combining graduate and undergraduate students. Topics were either designed by the faculty mentor or originated from the students. Research projects in most cases spanned the entire academic year, with a conference type meeting held at the end of the academic year where teams presented their work.

HAIS Scholars identified the main benefit of working with a research mentor as the knowledge and guidance/direction they receive from him or her related to their research. Many also noted personal and professional mentoring they received as well. Select comments about the benefits of the research experience and mentoring they have received include:

- "Dr. Smith [pseudonym] is amazing! She is understanding and really cares about us and wants us to succeed. She really is preparing [us] for a research lab."
- "My research mentor has been extremely patient and helpful throughout the research process. My mentor has given me a lot of advice and has helped me a lot throughout the semester."
- "There is no longer an imaginary wall between you and the faculty here at (blinded).

My mentor is always able to help me in the lab and with professional development."

- "Getting research experience in my field has really prepared me for life after graduation at graduate school pursuing more intensive research."
- "It has allowed me to see what research in my field actually looks like. I have gotten to experience both the theoretical side of my major and the applied side of my major and how each research experience differs from the other and how they are both equally cool and engaging."

Scholars responding to the annual survey in Years 3, 4, and 5 of the program also rated their agreement to positively worded statements about the benefits of participating in research and receiving mentoring. As is shown below, across all years, scholars' agreement ratings were at or above 4.38 on a 5-points scale of 1 (Strongly Disagree) to 5 (Strongly Agree). These ratings (see Figure 4) indicated that HAIS scholars found the mentoring they received beneficial to them professionally and personally and that it positively influenced their intention to remain in their degree programs.

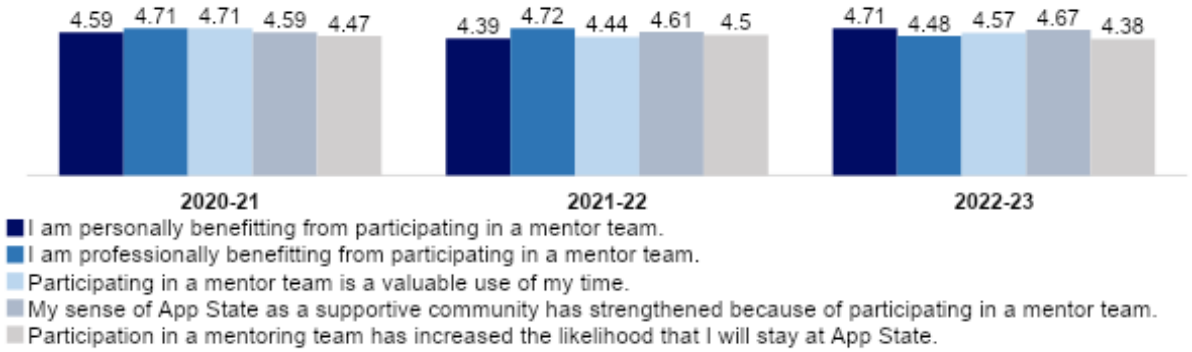

Figure 4. Agreement ratings regarding the benefits of research teams led by faculty mentors.

E. Sense of Community and STEM Identity

HAIS Scholars, as part of end-of-year surveys, rated their Sense of Community (SOC) using the SCI-2 [17]. The SCI-2 has a reported alpha of 0.94, with subscale alpha coefficients of 0.79 to 0.86. Due to the limitations of small sample sizes only descriptive statistics will be reported by item. As part of this scale, Scholars were asked to rate how true certain things were related to the S-STEM community using a scale of: 1 = Not at all, 2 = Somewhat, 3 = Mostly, and 4 = Completely. Scholars ' ratings were generally high over the three years that this construct was measured. Table V contains the SCI-2 ratings. Figure 5 shows one example of team-building activities that occurred during some of the STEM seminars.

Table V
Item Ratings: Sense of Community

	SP21	SP22	SP23
	M	*M*	*M*
a. I get important needs of mine met because I am part of this community.	3.53	3.22	4.00
b. Community members and I value the same things.	3.12	3.33	3.35

c.	This community has been successful in getting the needs of its members met.	3.29	3.50	3.30
d.	Being a member of this community makes me feel good.	3.47	3.61	3.50
e.	When I have a problem, I can talk about it with members of this community.	3.59	3.39	3.75
f.	People in this community have similar needs, priorities, and goals.	3.47	3.39	3.55
g.	I can trust people in this community.	3.41	3.61	3.70
h.	I can recognize most of the members of this community.	3.53	3.44	3.60
i.	Most community members know me.	3.35	2.94	3.55
j.	This community has symbols and expressions of membership such as clothes, signs, art, architecture, logos, landmarks, and flags that people can recognize.	3.00	2.06	3.15
k.	I put a lot of time and effort into being part of this community.	2.65	2.88	2.20
l.	Being a member of this community is a part of my identity.	3.29	2.56	3.40
m.	Fitting into this community is important to me.	2.88	2.78	2.75
n.	This community can influence other communities.	3.29	3.11	2.90
o.	I care about what other community members think of me.	3.47	2.78	3.30
p.	I have influence over what this community is like.	3.12	2.67	3.15
q.	If there is a problem in this community, members can get it solved.	3.00	3.61	2.80
r.	This community has good leaders.	3.65	3.72	3.55
s.	It is very important to me to be a part of this community.	3.88	3.33	3.80
t.	I am with other community members a lot and enjoy being with them.	3.53	3.06	3.45
u.	I expect to be a part of this community for a long time.	3.53	3.22	3.10
v.	Members of this community have shared important events together, such as holidays, celebrations, or disasters.	3.53	2.94	3.30
w.	I feel hopeful about the future of this community.	3.06	3.67	2.85
x.	Members of this community care about each other.	3.88	3.61	3.70

Scholars were also asked to respond to questions regarding their STEM identity [18]. Responses indicated that S-STEM participants were well suited as STEM majors as they found STEM interesting, were curious and enjoyed learning about it, and were viewed by others as “STEM” people.

Figure 5. Team building activity during one of the STEM Seminars

Table VI
Item Ratings: STEM Identity

	SP21	SP22	SP23
	M	*M*	*M*
a. I am interested in learning more about STEM.	4.59	4.78	4.75
b. Topics in STEM excite my curiosity.	4.82	4.78	4.75
c. I enjoy learning about STEM.	4.82	4.78	4.74
d. My STEM teacher sees me as a STEM person.	4.65	4.50	4.50
e. Others ask me for help in STEM.	4.35	4.44	4.45
f. My friends/classmates see me as a STEM person.	4.59	4.56	4.60

F. Overall Impact

At the end of each semester, HAIS scholars rated the degree to which being a part of the HAIS program affected various plans. As is shown in Figure 6, impacts of HAIS were meaningful as it related to making participants more interested in pursuing a career in their major and continuing in their major. This was especially true in Years 2-5 where the majority of S-STEM Scholars responded to the survey.

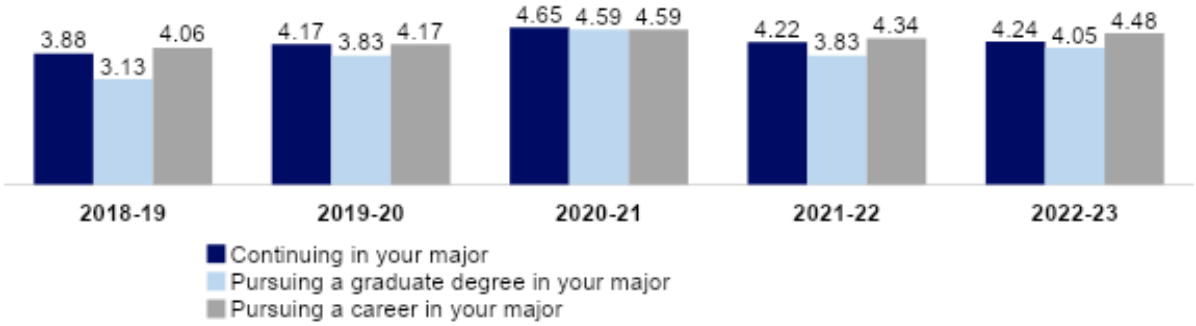

Figure 6. Ratings for HAIS impacts on future plans.

Additional comments by students about their experiences in HAIS across the years included:

- "Great program with wonderful support, mentors, and colleagues to learn from!"
- "I have really enjoyed being a part of a tight-knit community at (blinded). I have a stronger sense of belonging in the community."
- "I have been able to improve my ability to work in a team and as a team leader because of this program."
- "Because of HAIS, I feel like I better belong in my major."
- "I think this program has been essential to my continuation in studying STEM and has encouraged me in pursuing a graduate degree because of my research experience."

V. Conclusions

The first person comments from HAIS scholars throughout the collection of data over the five year program cemented the importance of the program to each individual scholar. The combination of the infrastructure created by HAIS and the mentoring support from dedicated faculty supported students in their pursuit of degrees in STEM, but also in factors such as sense of community and STEM identity. The retention of diverse students in the HAIS program serves as a model of innovation for other types of learning communities both at our institution and in other fields.

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