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Rising to the challenge: adult student perceptions of institutional supports to increase access to careers in biotechnology

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Abstract

Purpose – Amidst continued calls for the democratization of access to higher education for historically underrepresented populations alongside the first global health crisis in a century lies the opportunity to address persistent societal needs: increasing access for underrepresented minority students to educational pathways that lead to careers in lucrative fields of science, technology, engineering and math (STEM).

Design/methodology/approach – Student participants enrolled in the biotechnology pathway Associates, Bachelors and Masters programs share programmatic experience in an accelerated biotechnology program through a bi-annual survey grounded in the central tenets of social-cognitive career theory aimed at understanding requisite academic, social and financial support for student success.

Findings – The pathway program described in this paper emerged to address the need to support underrepresented students in degree attainment and taking on roles in the growing field of biotechnology through a novel, multi-degree, multi-institutional pathway to STEM degree attainment and career success.

Social implications – This work has advanced understanding about how to effectively align higher education institutions with each other and with evolving STEM labor market demands while documenting the impact of essential academic, career and social supports recognized in the literature as high impact practices in broadening participation and increasing retention of underrepresented minority students in lucrative STEM careers.

Originality/value – Pathway programs which best support student success include robust mentoring, experiential learning and robust student scholarship support, part of the design of this unique pathway program. The authors share how this program utilizes high impact practices to provide low-income, underrepresented minority students with supportive, accelerated biotechnology degrees in preparation for success in the job market. What's more, of all our BS-level graduates thus far, 100% are employed and 93% within the biotechnology field. For many, the opportunity to raise their family out of poverty via a stable, high paying job is directly tied to their successes within this program.

Keywords Widening access and participation, Social mobility, Employer–University collaboration, Access to higher education, Career advancement, Academic support

Paper type Research paper

Introduction

The nationwide unemployment rate of 3.8% belies a persistent gap in economic mobility in our society. The share of jobs that require postsecondary education has doubled over the last 40 years (Carnevale *et al.*, 2010), leaving behind those that lack this new "entry-level credential." Economic mobility gaps persist across generations as well. We know, for

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example, that fully half of individuals from high-income families have a bachelor's degree by age 25, while just 10% of those from low-income families do (Bailey and Dynarski, 2011). Post-secondary education remains one of the best ways to close this opportunity gap. According to a Brookings Institution report, when children born into the bottom quintile of the income distribution get a college degree, their chances of making it to the top nearly quadruple and their chances of making it out of the bottom increase by more than 50% (Isaacs *et al.*, 2008).

There is no dearth of evidence to illustrate the detrimental impact of the pandemic on both the education gap and global health. From the deleterious toll on health, including decreases in life expectancy (Aburto *et al.*, 2022; Islam *et al.*, 2021), to the negative impact on education enrollment as dropout rates of global learners' soar (Dee and Murphy, 2021; Kose *et al.*, 2022; World Bank, 2020), the number of traditionally underrepresented populations in higher education in the United States continue to falter at an alarming rate (Salmi and D'Addio, 2021; Whitcomb and Singh, 2021). While financial disparities between classes grow (Mertz *et al.*, 2016), so too do calls for an increased focus on growing the next generation of scientists ahead of future pandemics (Oppenheim *et al.*, 2019). What's more, a persistent representation problem exists in lucrative Science, Technology, Engineering and Math (STEM) fields where underrepresented minority students (URM) and adult learners find themselves continuously pushed out of some of the fastest growing and most urgently needed fields, including the field of biotechnology (Howard *et al.*, 2021).

The dual concern around education and global health highlights an urgent need to prepare for future global health crises while simultaneously opening access to lucrative fields such as biotechnology, specifically for historically underrepresented populations. One way to do this is to focus on "adult" learners, average age is 29, from local community colleges, who are mainly taking classes at night and online while working during the day. The pathway program described in this paper emerged to address the need to both support underrepresented students in degree attainment and to grow talent for the booming biotechnology field through a novel, multi-degree, multi-institutional pathway to STEM degree attainment and career success. We share how the pathway program utilizes high impact practices to provide low-income, adult, underrepresented minority students (URM) with supportive, accelerated Associates, Bachelors and Master's degrees in preparation for success in the biotechnology job market. The networked approach ensures adult and URM learners acquire requisite skills and competencies to enter and/or grow careers in the biotechnology field including post-graduation employment opportunities from industry partners.

The level of post-secondary credential required by the local biotechnology industry served by this pathway program has also been changing. According to a 2021 Pew Research study (Fry *et al.*, 2021), "roughly two-thirds of STEM workers (67%) have completed a bachelor's or postgraduate education." Between 2011 and 2016, job listings for four core biotechnology occupations requiring at least a four-year degree grew by 44%, while job listings requiring an Associate degree or less grew by only 16% (Bruso, 2018, p. 12). The pathway program in this study responds directly to this trend. The holistic, systems-based approach taken by this pathway program works to bridge the needs of science to the needs of historically underrepresented, adult students to gain entry into the STEM field of biotechnology by providing social and financial capital required for all students to thrive.

Background

Institutions often focus on retention or increased graduation rates to increase URM and adult student access to higher education in STEM (Stohs and Schutte, 2019), which may have unintended consequences in increasing the already prevalent social-class achievement gap (Stephens *et al.*, 2014). This inherently flawed focus on retention also fails to consider the reasons why students leave programs and often lacks a focus on the student experiences

most valuable in supporting historically underrepresented students, including women (Dennehy and Dasgupta, 2017; Griffith and Dasgupta, 2018), enrolled in STEM programs (Kricorian *et al.*, 2020; Mishra, 2020). Some research evidences a failure to consider the environmental-person fit, requisite for a student's sense of belonging, which may set students up for an increased risk of failure (Ajayi *et al.*, 2021). Similarly, institutions which do not explicitly leverage existing networks to industry partners in supporting learners to see the utility of coursework to the world beyond their degree, also miss an opportunity to support and later employ students post-graduation (Donald *et al.*, 2018). Ultimately, attempts to increase graduation rates without establishing adequate support fail to sustain enrolled students from coursework to career (Khan *et al.*, 2019; Stohs and Schutte, 2019).

If we are to address the growing gap in economic mobility, we must attend to local and regional job supply/demand gaps and provide pathways to credentials tied to entry-level jobs that are in demand in a particular area. This pathway program addresses just such an effort: A novel, accelerated pathway spanning three credentials from Associates to Master's degrees in biotechnology in a large city in the Northeast with a flourishing biotechnology industry and one of the top biotech job markets in the country. This program brings together a set of committed partners including a leading producer of biotechnology Associates degrees, a top 40 ranked Carnegie research intensive institution, two biotech industry consortia, and leading biotech employers to ensure students have academic, social and financial resources to support their learning experience. If we aim to ensure historically underrepresented minority and adult students not only access higher education but acquire lucrative careers in STEM, we must focus on growing our students' sense of belonging, purpose for learning and ways to continuously support the social and financial capital students need to thrive.

Program design

The program was structured to provide scholarships to support low-income, adult and underrepresented students through the entire pathway from Associates to Master's degree while also providing tailored academic, career and social supports all recognized in the literature as high impact practices in broadening participation and increasing retention. The articulation agreement between the community college partner and the university partner ensured wraparound for students in providing academic, career and social support during the biotechnology pathway program. Academic supports include career and academic coach/advisor during all stages of the pathway (Heisserer and Parette, 2002; Miltenberger, 2007) and research experiences shown to increase persistence for underrepresented minorities in STEM (Hathaway *et al.*, 2002; Hernandez *et al.*, 2013; Hurtado *et al.*, 2009; Seymour *et al.*, 2004). A "Biotech Navigator" serves as a career coach for scholars throughout the pathway program as a persistent mentor and guide throughout students' journey, building the student community and ensuring student success (Bassett, 2021; Heisserer and Parette, 2002; Peter *et al.*, 2021; Miltenberger, 2007) and academic tutors are provided for STEM courses, aligning with and expanding the strong practices within literature (Scrivener *et al.*, 2015).

To build a welcoming environment and social support within the cohort that is key to student success, a variety of social programming is provided to support students in field specific professional development and industry connection (Swail, 2003; Wyatt, 2011; Younger *et al.*, 2019). Biotechnology clubs at each campus are an additional way to support learners in networking and socializing with others in their cohort (Swail, 2003; Thayer, 2000), as are mentorship, including near peer, alumni and industry mentors, a well-documented in the research as a tool to bridge the gap between science in a classroom and science in a lab. These mentorships and social supports, research-based high impact practices, are a mechanism to increase access to careers for historically underrepresented students (Gibau *et al.*, 2010; Haeger and Fresquez, 2016; Prunuske *et al.*, 2016).

Financial capital is essential to retain students in higher education when many students are simultaneously caring for aging family members or children while also responsible for financially sustaining households (e.g. keeping food on the table, gas in the tanks, health insurance to care for family members and maintaining mortgage payments). By ensuring our low-income students have access to these critical financial resources, we remove what could otherwise be a barrier to student success and potential large financial stressor (Scrivener *et al.*, 2015).

Designing the pathway program, the goal was to address the social and financial capital needs of students while providing meaningful learning experiences that readily apply to work in the field of biotechnology. The purpose of this study, therefore, is to assess the efficacy of these academic, social and financial supports throughout the program as indicated by students currently enrolled in the Associate, Bachelors and Masters pathway program at different developmental points in their program. Regular check-ins with students serve as a litmus to continual programmatic improvement and helps assess the research question driving this study which asks by cohort: How do students enrolled in Associates, Bachelors and Masters levels of biotechnology pathway program view academic, career-related, social inclusion and connectedness, and stress reduction supports embedded within the program? Moreover, which of the career-related, social inclusion and connectedness and financial stress reduction supports embedded within the program are most impactful to students at different levels of the biotechnology pathway program?

Methodology

Researchers acquired IRB approval from partner institutions and acquired informed consent from all participants prior to beginning the study. Student participants enrolled in the Associates, Bachelors and Masters biotechnology pathway programs were invited to complete a bi-annual survey about their programmatic experience. Students received an email invitation from the Biotechnology Navigator to participate in the survey in the middle of the term and the survey remained open for two weeks. Students self-reported gender and race as part of the survey. Cumulative GPA and first-generation status were collected through student records by program staff.

The survey was developed in partnership with a third-party researcher and is grounded in the central tenets of social-cognitive career theory (SCCT; Lent *et al.*, 1994) which suggest students' academic, and career-related interests are moderated by access to career-related experiences alongside relevant and timely knowledge acquisition and further enhanced by positive performance outcomes in those careers, often called self-efficacy (Bandura, 1986). This survey builds upon SCCT to include extant work which assesses specific academic, financial and social capital necessary to support historically underrepresented and adult students in career readiness (Gibbons and Shoffner, 2004; Ma and Shea, 2021).

The student survey included 64 items in total, beginning with 30 questions drawn from social-cognitive career theory (SCCT) to assess student perceptions across six categories: general self-efficacy, course specific outcome expectations, external anxiety, programmatic support and personal goals. Students responded to the 30 SCCT questions on a 6-point Likert scale ranging from strongly disagree (1) to strongly agree (6). The following 34 items asked students to rank academic, career-related, financial stress reduction, and social inclusion and connectedness from most (1) to least helpful.

Findings

The student-survey was sent to all 85 students currently enrolled in the Associate's to Master's degree program. This number includes a total of 32 students in the Associates, 44

students in the Bachelors and 9 students in the Masters pathway programs. Of the possible 85 student respondents, a total of 77 students completed the survey and were included in data analysis including 25 students enrolled in the Associates program, 43 students enrolled in the Bachelors program and 9 students enrolled in the Masters program. One of the 25 students enrolled in the Associate pathway cohort did not respond to the five force-ranked questions and were removed from that analysis and 2 students from the Bachelors program did not report their age in the self-reported survey.

Across all three cohorts, student respondents skewed female (60 of 77 respondents), with a mean age of 31 years old, a mean cumulative GPA of 3.31 with 71% of respondents identifying as first-generation students. The mean age of students enrolled in the Associates program was slightly, but not significantly, higher ($N = 25$, $M = 32.5$, $SD = 9.26$) than the mean age of students enrolled in the Masters ($N = 9$, $M = 30.6$, $SD = 6.04$) or Bachelors ($N = 41$, $M = 29.8$, $SD = 6.04$) program. The mean cumulative GPA was slightly, but not significantly, higher within the Masters program ($N = 9$, $M = 3.38$, SD = 0.55) than within the Bachelors ($N = 43$, $M = 3.30$, SD = 0.47), or Associates program ($N = 25$, $M = 3.25$, SD = 0.51).

Additionally, within each sample, more respondents identified as first-generation students across Bachelors ($N = 33$, $M = 1.23$, SD = 0.43), Associates ($N = 14$, $M = 1.44$, SD = 0.51) and Masters programs ($N = 7$, $M = 1.44$, SD = 0.51). Descriptive statistics for gender, race, age, GPA and first-generation status of students by program are presented in Table 1.

The social cognitive career theory aligned survey included 30 items with six subscales. The general self-efficacy subscale consisted of five items ($\alpha = 0.89$), the course-specific outcome expectation subscale consisted of five items ($\alpha = 0.91$), the external anxiety subscale consisted of five items ($\alpha = 0.80$), the programmatic supports subscale consisted of five items ($\alpha = 0.82$) and the personal goals subscale consisted of five items ($\alpha = 0.89$).

Student perceptions of academic ability across three cohorts: Associates, Bachelors and Masters pathways

To determine how student perceptions of pathway support vary by cohort (Associates, Bachelors or Masters), a one-way ANOVA was performed with cohort as the factor and student self-reported responses for each of the five areas of programmatic support. A Bonferroni adjustment (Armstrong, 2014) was made to account for multiple comparison tests ($\alpha_{new} = 0.97$).

Table 1. Descriptive statistics for Associate, Bachelors and Masters pathway students

Variable	Associates pathway	Bachelors pathway	Masters pathway
Gender (N)			
Female	19	35	6
Male	6	8	3
Race (N)			
Black	3	9	2
Asian	15	12	3
White	4	10	1
Latinx/Hispanic	4	10	1
2 or more	–	2	2
Age (*M*)	32.5	29.8	30.6
First-generation student (*N*)	14	33	7
Non-first-generation student (*N*)	11	10	2
Cumulative GPA (*M*)	3.25	3.30	3.38

The first five questions of the inventory provide data to explain student perceptions of academic work on a programmatic level (Table 2) and course-specific work (Table 3) within and across the pathway program. Statistically significant differences in student responses by cohort were found for two of the programmatic-level questions where strongly disagree is 1 and strongly agree is 6 (Table 2). A statistically significant response was found between at least two groups for the statement "I feel confident I can do well next semester" varied F (2, 74) = 3.87, p = 0.03. Students in the Associates cohort reported a mean score of 5.24 (N = 25, SD = 0.78), students in the Bachelors cohort reported a mean score of 5.00 (N = 43, SD = 1.00) and students in the Masters cohort reported a mean score of 5.89 (N = 9, SD = 0.33).

The second significant difference in student responses by cohort was found in response to the statement "I have clear ideas about what I need to work on over the next month," F (2, 74) = 3.70, p = 0.03. Students in the Associates cohort reported a mean score of 5.24 (N = 25, SD = 0.60), students in the Bachelors cohort reported a mean score of 4.95 (N = 43, SD = 1.02) and students in the Masters cohort reported a mean score of 5.78 (N = 9, SD = 0.44). Taken together, student responses about perception of academic ability on a programmatic level indicate that Bachelors-level students hold a lower level of confidence in their current and future work in the biotechnology program than those students in the Associates or Masters cohorts.

Thinking about your academic work in the program	Associates			Bachelors			Masters		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
I feel like I have a good understanding of the academic challenges I am facing	25	5.20	1.04	43	5.21	1.06	9	5.22	1.64
I feel like I can be successful at meeting these challenges	25	5.16	0.75	43	4.98	1.12	9	5.00	1.66
I feel confident I can do well next semester*	25	5.24	0.78	43	5.00	1.00	9	5.89	0.33
I have clear ideas about what I need to work on over the next month*	25	5.24	0.60	43	4.95	1.02	9	5.78	0.44
I feel like the academic choices I am making are the best ones for me	25	5.36	0.76	43	5.00	1.00	9	5.67	0.50

Note(s): *p < 0.05 **p < 0.01 ***p < 0.001

Table 2. Student general self-efficacy across three cohorts

Thinking about what you are learning in your courses	Associates			Bachelors			Masters		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
When I am learning about biotechnology, I like to think about how this will be useful	25	5.60	0.50	43	5.40	0.88	9	5.78	0.44
The biotechnology classes I am taking give me enough guidance to master the material	25	5.40	0.58	43	5.00	1.11	9	5.56	0.53
I feel like if I apply myself in biotechnology classes, I will learn valuable skills	25	5.60	0.58	43	5.26	1.03	9	5.89	0.33
By the end of this semester my technical skills will have improved a lot***	25	5.64	0.49	43	4.67	1.25	9	5.67	0.50
Each of the biotechnology classes has taught me the best ways to work in the field**	25	5.52	0.59	43	4.79	1.26	9	5.44	0.73

Note(s): *p < 0.05 **p < 0.01 ***p < 0.001

Table 3. Student course-specific outcomes expectation across three cohorts

Student perceptions of academic work by course across three cohorts

To determine if student perceptions of learning in coursework varied by cohort, a second one-way ANOVA was performed with cohort (Associates, Bachelors and Masters) as the factor and student self-reported responses to course specific perception of learning where strongly disagree is 1 and strongly agree is 6 (Table 3). The results of this analysis revealed a statistically significant difference between at least two groups to two items beginning with the statement, "By the end of this semester my technical skills will have improved a lot" between at least two groups, $F(2, 74) = 9.08$, $p = 0.000$. Students across all cohorts reported a mean score of 5.10 ($N = 77$, SD = 1.10) in response to the growth of their technical skills, where strongly disagree is 1 and strongly agree is 6. However, students in the Associates cohort reported a mean score of 5.64 ($N = 25$, SD = 0.49), whereas students in the Bachelors cohort reported a mean score of 4.67 ($N = 43$, SD = 1.25), and students in the Masters cohort reported a mean score of 5.67 ($N = 9$, SD = 0.50). These results suggest that students in the Associates and Masters cohorts report a stronger belief that their technical skills will improve by the end of the term as compared to students in the Bachelors cohort.

Similarly, results indicate a significant difference between two groups ($F(2, 74) = 4.80$, $p = 0.02$) for the statement "Each of the biotechnology classes has taught me the best ways to work in the field." The mean score across all three cohorts was 5.10 ($N = 77$, $SD = 108$), where 1 is the lowest and 6 is the highest degree of agreement. Within these findings, students in the Associates reported a mean score of 5.52 ($N = 25$, $SD = 0.59$), while students in the Bachelors cohort reported a mean score of 4.79 ($N = 43$, $SD = 1.26$), and those in the Masters cohort reported a mean score of 5.44 ($N = 9$, $SD = 0.73$). These results further indicate Bachelors cohort appear less confident that their current coursework will impact their work in the field of biotechnology compared to peers in the Associates and Masters cohort.

Students level of personal and financial concern while enrolled in biotechnology programs across three cohorts

To explore the impact of financial and external stressors while enrolled in the pathway program, questions about financial and personal distractions such as "I often worry about how I am going to pay for things" were assessed (Table 4) where strongly disagree is 1 and strongly agree is 6. A one-way ANOVA was performed where degree (Associate, Bachelors, Masters) was the factor and student self-reported responses to level of personal and financial concern while enrolled in the program were the dependent variable.

Results of this one-way ANOVA revealed a statistically significant difference between at least two groups ($F(2, 74) = 3.65$, $p = 0.03$) to only one statement, "I sometimes think about

Table 4. Students external anxiety across three cohorts

How you feel while enrolled in the program	Associates			Bachelors			Masters		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
I am often distracted in class by things that are happening in my personal life	25	3.52	1.53	43	3.86	1.51	9	3.00	1.73
I often worry about how I am going to pay for things	25	4.32	1.35	43	3.93	1.67	9	3.56	1.67
I am concerned that I am spending too much money on getting this degree	25	3.20	1.63	43	2.67	1.41	9	2.33	1.41
I think the other students in my classes are better off than me financially	25	3.20	1.44	43	3.56	1.55	9	3.11	1.27
I sometimes think about quitting and getting a job*	25	3.44	1.53	43	3.14	1.74	9	1.78	0.83

Note(s): *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

quitting and getting a job." Students across all cohorts reported a mean score of 3.08 ($N = 77$, SD = 1.65), where strongly disagree is 1 and strongly agree is 6. Students in the Associates cohort reported a mean score of 3.44 ($N = 25$, SD = 1.53), students in the Bachelors cohort reported a mean score of 3.14 ($N = 43$, SD = 1.74) and students in the Masters cohort reported a mean score of 1.78 ($N = 9$, SD = 0.83).

Whereas previous differences by cohort enrollment indicated lower levels of agreement from Bachelors students, these results indicate that Masters-level students hold lower levels of agreement to the item "I sometimes think about quitting and getting a job." These results indicate that students toward the end of their program are less likely to feel the urge to leave the pathway to biotechnology program, perhaps seeing the end of the degree and a future career in clearer focus than those in the Associates- and Bachelors-level cohorts.

Student perceptions of programmatic supports across three cohorts

To explore students' general perceptions of relational support embedded within the program, questions such as "The faculty are very supportive at helping us learn difficult material" were assessed where strongly disagree is 1 and strongly agree is 6 (Table 5). A one-way ANOVA to determine if responses varied by cohort (Associates, Bachelors and Masters), revealed a statistically significant difference in responses to three of the five statements around relational supports intentionally embedded within the biotechnology pathway program.

Students reported significantly different responses between at least two groups to the statement "The faculty are very supportive at helping us learn difficult material," F (2, 74) = 3.96, $p = 0.02$. While students across all cohorts reported a mean score of 5.13 ($N = 77$, SD = 1.07), students enrolled in the Associates ($N = 25$, $M = 5.52$, $SD = 0.71$) and Masters ($N = 9$, $M = 5.44$, $SD = 1.33$) cohorts reported higher mean scores than students in the Bachelors cohort ($N = 43$, $M = 4.84$, $SD = 1.11$).

The one-way ANOVA also revealed statistically significant differences in response to the statement "I feel like I can approach faculty and staff with important questions about careers," between at least two groups, F (2, 74) = 3.81, $p = 0.03$. Students across all cohorts reported a mean score of 5.04 ($N = 77$, $SD = 1.09$), where strongly disagree is 1 and strongly agree is 6, with students in the Bachelors ($N = 43$, $M = 4.84$, $SD = 1.11$) cohort reporting a lower mean score than students in the Associates ($N = 25$, $M = 5.40$, $SD = 0.65$) or Masters ($N = 9$, $M = 5.44$, $SD = 1.33$) cohorts.

Results indicate statistically significant different responses to the statement, "I have made valuable industry connections through my biotechnology program" between at least two groups, F (2, 74) = 5.88, $p = 00$. Responses to this statement were lower for students in the

	Associates			Bachelors			Masters		
Thinking about your supports within the program	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
The faculty are very supportive at helping us learn difficult material*	25	5.52	0.71	43	4.84	1.11	9	5.44	1.33
I feel like I can approach faculty and staff with important questions about careers*	25	5.40	0.65	43	4.74	1.18	9	5.44	1.33
I have made valuable industry connections through my biotechnology program**	25	5.20	0.96	43	4.35	1.02	9	5.00	1.23
I know some websites that are especially helpful for lab-related information	25	4.64	1.25	43	4.26	1.36	9	4.89	1.27
The other students in my classes often share valuable career information with me	25	4.84	1.11	43	4.40	1.24	9	4.78	1.20

Note(s): *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

Table 5. Student perceptions of programmatic supports across three cohorts

Bachelors cohort ($N = 43$, $M = 4.35$, $SD = 1.02$) than for students in either the Associates ($N = 25$, $M = 5.20$, $SD = 0.96$) or Masters ($N = 9$, $M = 5.00$, $SD = 1.23$) cohorts. These results suggest that students in the Associates and Masters cohorts appear more confident in the programmatic support they receive around acquisition of difficult material, ability to seek answers to career related questions or can make valuable connections with industry professionals while enrolled in the program.

Student reflections on personal goals for their respective programs across three cohorts

Student responses to questions about their goals such as "The lab skills I am learning will be the ones I will actually be using in my future job" where strongly disagree is 1 and strongly agree is 6 (Table 6) provide additional insight into student perceptions of personal goals within and throughout the biotechnology program. A one-way ANOVA was performed to determine if differences in student responses varied by cohort and revealed a statistically significant difference in student responses to three of the five statements.

In response to the question "The lab skills I am learning will be the ones I will actually be using in my future job," significant differences were revealed between at least two groups, $F(2, 74) = 6.17$, $p = 0.01$. Students across all cohorts reported a mean score of 5.14 ($N = 77$, $SD = 1.12$), closer to strongly agree (6) than strongly disagree (1). Students enrolled in the Associates ($N = 25$, $M = 5.64$, $SD = 0.76$) and Masters ($N = 9$, $M = 5.44$, $SD = 0.88$) cohorts reported higher mean scores than students enrolled in the Bachelors ($N = 43$, $M = 4.79$, $SD = 1.23$) cohort. These results indicate students seem more confident that knowledge acquired through their biotechnology program will apply to their future work when students are at the beginning and end of their program.

The one-way ANOVA also revealed a statistically significant difference in responses to "I feel like the math we do in classes is just what I will need to do in my career" between at least two groups, $F(2, 74) = 7.38$, $p = 0.000$. Students across all cohorts reported a mean score of 4.78 ($N = 77$, SD = 1.20), where strongly disagree is 1 and strongly agree is 6. Higher mean scores were reported by students in the Associates ($N = 25$, $M = 5.36$, $SD = 0.81$) and Masters ($N = 9$, $M = 5.22$, $SD = 0.97$) cohort than in the Bachelors ($N = 43$, $M = 4.35$, $SD = 1.27$) cohort. These results suggest that students at the beginning and end of the biotechnology pathway program are more confident that the math they cover in their coursework is what they will need to succeed in their biotechnology careers.

Significant differences between at least two groups ($F(2, 74) = 4.68$, $p = 0.01$) were discovered for the statement, "I feel like I am 'learning how to learn' in a way that will continue

Thinking about your goals within the program	Associates			Bachelors			Masters		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
The analytical skills I am learning will transfer into whatever career I choose	25	5.52	0.77	43	5.00	0.93	9	5.33	0.87
The lab skills I am learning will be the ones I will actually be using in my future job**	25	5.64	0.76	43	4.79	1.23	9	5.44	0.88
I feel like the math we do in classes is just what I will need to do in my career***	25	5.36	0.81	43	4.35	1.27	9	5.22	0.97
I feel like the "soft skills" such as communication and collaboration get enough emphasis in my classes	25	5.16	1.03	43	4.72	1.20	9	5.33	0.71
I feel like I am "learning how to learn" in a way that will continue throughout my career*	25	5.52	0.65	43	4.81	1.22	9	5.56	0.73

Note(s): *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

Table 6.
Student reflections on personal goals for their respective programs across three cohorts

throughout my career." While the mean score from students across all cohorts was 5.13 ($N = 77$, SD = 1.07), higher scores were reported by Associates ($N = 25$, $M = 5.52$, SD = 0.65) and Masters ($N = 9$, $M = 5.56$, SD = 0.73) students as compared to scores reported by the Bachelors ($N = 43$, $M = 4.81$, SD = 1.22) students. Results indicate that students in the pathway program have a greater sense of efficacy in their ability to learn relevant material that will serve them throughout their career in biotechnology at the beginning and end of the biotechnology program.

Academic supports indicated as most (1) to least (4) important across cohorts

The second research question aims to understand the value students place on specific academic, career, financial reduction and social inclusion supports at different places within their pathway program (Associates, Bachelors and Masters). Students were asked to rank specific supports within each of the five categories, as most (1) to least (4) supportive (Table 7).

Within the category of academic supports, the one-way ANOVA performed to determine differences in student responses by Associates-, Bachelors- and Masters-level students revealed a statistically significant difference to three of the four supports: Biotech Navigator, Tutoring Support and Textbook Loaners.

Significant differences between at least two groups (F (2, 73) = 5.78, $p = 0.01$) were revealed regarding the importance of the Biotech Navigator, a dedicated staff member unique to the pathway program who guides students throughout the program from reaching out to prospective students to supporting enrolled students in course registration as well as many smaller level supports such as parking passes while students are on campus. Student reported perceptions of the Biotechnology Navigator across all cohorts was 1.63 ($N = 76$, SD = 0.99) indicating that this role is of greater importance to students than other supports. Moreover, students in the Bachelors ($N = 43$, $M = 1.40$, $SD = 0.79$) and Masters ($N = 9$, $M = 1.33$, $SD = 0.71$) cohorts reported the Biotech Navigator to be of greater importance than those students enrolled in the Associates ($N = 24$, $M = 2.17$, $SD = 1.20$) cohort.

Student response data also revealed significant differences between at least two groups (F (2, 73) = 5.30, $p = 0.01$) around the impact of academic tutoring support. Across cohorts, students reported a mean score of 2.96 ($N = 76$, $SD = 0.96$) for the impact of academic tutoring support as compared to the other three academic supports, indicating a lesser importance to students overall than other academic supports. Students in the Bachelors cohort reported less value in the tutoring support ($N = 43$, $M = 3.26$, $SD = 0.79$) than did their peers in the Associates ($N = 24$, $M = 2.54$, $SD = 1.14$) or Masters ($N = 9$, $M = 2.67$, $SD = 0.71$) cohorts. This finding suggests that students in the Associates and Masters Program see greater value in access to tutoring support than those in the Bachelors cohort.

Lastly, significant differences between at least two groups were revealed for the academic support, textbook loaners, F (2, 73) = 6.17, $p = 0.00$. Overall, students ranked textbook loaners at 2.76 ($N = 76$, $SD = 1.03$), with students in the Masters cohort ($N = 9$, $M = 3.78$, $SD = 0.44$) ranking textbook loaners as less important than students in the Associates

	Associates			Bachelors			Masters		
Academic supports	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Biotech Navigator**	24	2.17	1.20	43	1.40	0.79	9	1.33	0.71
Faculty Mentoring	24	2.50	1.02	43	2.81	1.01	9	2.22	0.97
Free Tutoring Support**	24	2.54	1.14	43	3.26	0.79	9	2.67	0.71
Textbook Loaners**	24	2.79	1.10	43	2.53	0.96	9	3.78	0.44

Note(s): *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

Table 7. Academic supports indicated as most (1) to least (4) important across cohorts

($N = 24$, $M = 2.79$, $SD = 1.10$) and Bachelors ($N = 43$, $M = 2.53$, $SD = 0.96$) cohorts. This finding reveals students further along in the program appear to value textbook loaners less than those earlier on in the program. Results will be discussed within the discussion section.

Career-related supports indicated as most (1) to least (8) important across cohorts

The second set of force ranked data required students to place eight career-related supports (Biotech Navigator, Faculty Mentoring, Industry Mentoring, Peer Mentoring, Industry Site Visits, Internships/Co-ops, Industry Seminars, Soft Skills Development) in order from most (1) to least (8) important (Table 8).

A one-way ANOVA was performed to determine if differences in student responses varied by cohort to reveal a statistically significant difference between groups for the career-related support of faculty mentoring, $F(2, 73) = 5.52$, $p = 0.01$. The overall means across cohorts for faculty mentoring was 3.45 ($N = 76$, SD = 1.88), with students in the Bachelors cohort ($N = 43$, $M = 4.00$, $SD = 2.04$) ranking faculty mentoring as less important than students in either the Bachelors ($N = 24$, $M = 2.50$, $SD = 1.02$) or Masters ($N = 9$, $M = 3.33$, $SD = 2.00$) cohort.

Financial supports indicated as most (1) to least (6) important across cohorts

The third set of force rankings asked students to place six financial stress reduction supports (Conference Travel, Tutoring, Loaner Laptops, Internships/Co-ops, Scholarships, Textbook Loaners) in order from most (1) to least (6) important (Table 9). A one-way ANOVA performed to determine if differences in student responses to financial support varied by cohort, a statistically significant difference between at least two groups was identified for the financial support "paid internships/co-ops," ($F(2, 73) = 13.36$, $p = 0.00$). While the overall means across

Table 8. Career-related supports indicated as most (1) to least (8) important across cohorts

	Associates			Bachelors			Masters		
Career-related supports	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Biotech navigator	24	2.79	2.06	43	1.86	1.64	9	2.67	2.50
Faculty mentoring**	24	2.50	1.02	43	4.00	2.04	9	3.33	2.00
Industry mentoring	24	3.13	1.57	43	4.02	1.57	9	3.44	1.59
Peer mentoring	24	4.42	1.61	43	5.05	1.83	9	5.00	1.23
Industry site visits	24	3.13	1.57	43	4.02	1.57	9	3.44	1.59
Internships/co-ops	24	–	–	43	4.65	2.43	9	3.67	2.50
Industry Seminars	24	5.04	1.94	43	5.44	2.26	9	6.44	1.59
Soft skills Development	24	4.46	1.53	43	5.30	2.05	9	5.22	2.68

Note(s): *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

Table 9. Financial supports indicated as most (1) to least (6) important across cohorts

	Associates			Bachelors			Masters		
Financial-related supports	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Conference travel	24	5.08	1.02	43	5.74	1.51	9	6.11	1.17
Free Tutoring	24	3.63	1.28	43	4.47	1.53	9	4.22	1.39
Loaner laptops	24	4.92	1.06	43	5.12	1.64	9	5.11	1.69
Paid internships/co-ops***	24	2.54	1.32	43	4.44	1.59	9	3.00	1.50
Scholarships	24	1.58	1.28	43	1.21	0.83	9	1.11	0.33
Textbook loaners	24	3.25	1.23	43	3.70	1.64	9	4.56	1.59

Note(s): *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

cohorts for internships/co-ops was 3.67 (N = 76, SD = 1.73), students enrolled in the Bachelors (N = 43, M = 4.44, SD = 1.59) cohort found the paid internships and co-ops less important than their peers in the Associates (N = 24, M = 2.54, SD = 1.32) or Masters (N = 9, M = 3.00, SD = 1.50) cohorts.

Social inclusion and connectedness supports indicated as most (1) to least (7) important across cohorts

The fourth set of force ranked data asked students to place seven social inclusion and connectedness supports (Biotech Navigator, Faculty Mentoring, Family Events, Monthly Seminars, Peer Mentoring, Social Outings, Student Groups/Clubs) in order from most (1) to least (7) important (Table 10).

A one-way ANOVA performed to identify differences in student responses to social inclusion and connectedness supported by cohorts revealed a statistically significant difference in responses between at least two groups for the support, "faculty mentoring," (F (2, 73) = 3.50, p = 0.04). Overall mean across cohorts for faculty mentoring support was 3.16 (N = 76, SD = 1.59), indicating faculty mentoring is seen as moderately important to students. However, students in both the Associates (N = 24, M = 2.54, SD = 1.35) and Masters (N = 9, M = 2.11, SD = 1.83) cohorts indicated that faculty supports were more important than did their peers in the Bachelors cohort (N = 43, M = 3.56, SD = 1.53).

Discussion

The current study sought to explore historically underrepresented minority and adult student's perceptions of themselves as learners, as well as perceptions of institutional support, while enrolled in a biotechnology pathway program at three distinct points (Associates, Bachelors and Masters) in their degree program. The biotechnology program was intentionally designed to address key academic, social and financial needs which are often barriers to student success in STEM pathway programs (McAlexander *et al.*, 2022; Millea *et al.*, 2018; Skvoretz *et al.*, 2020; Thomas, 2000). Using a bi-annual survey aligned to social-cognitive career theory (SCCT; Lent *et al.*, 1994), our goal was to delineate student reported self-efficacy beliefs, course specific outcome expectations, external anxieties, programmatic supports and personal goals while enrolled in the program. Additionally, student perceptions of specific academic, career-related, financial stress reduction and social inclusion embedded within the pathway program to provide tailored support for students were evaluated to identify patterns in student perceptions for the purpose of continually iterating on the biotechnology pathway program to best serve student needs.

There were several limitations to the current study including the social desirability bias of self-reported inventories and sample size within each cohort across programs. Additionally, as the data were not drawn from a random sample but from a self-selected sample of students

Social inclusion and connectedness supports	Associates			Bachelors			Masters		
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*
Biotech navigator	24	2.13	1.62	43	1.95	1.69	9	2.11	1.83
Faculty mentoring*	24	2.54	1.35	43	3.56	1.53	9	2.89	2.03
Family events	24	4.67	1.74	43	5.05	1.70	9	4.44	1.81
Monthly Seminars	24	3.63	1.56	43	3.44	1.87	9	4.11	1.97
Peer mentoring	24	4.42	1.56	43	4.63	1.42	9	4.44	1.67
Social outings	24	5.58	1.59	43	4.84	1.80	9	5.11	1.83
Student groups/clubs	24	5.04	1.99	43	4.53	2.12	9	4.89	1.62

Note(s): *p < 0.05 **p < 0.01 ***p < 0.001

Table 10. Social inclusion and connectedness supports indicated as most (1) to least (7) important across cohorts

enrolled in the pathway program, the inferences are not as strong as they might be if the sample was entirely random. Furthermore, as a pioneering program which has seen only one graduating class move into industry, longitudinal data was not accessed for the current study. However, the purpose of this research was to understand student perception within a specific pathway program making the statistical data essential when utilized as descriptive. In this way, the data illustrate student perceptions about self-efficacy, outcome expectations, external anxieties, programmatic supports and personal goals alongside student perceptions of specific programmatic support embedded within the program. Taken together, the statistical data is a means to understand the impact of programmatic support for students toward continual iteration of the pathway program and moreover to support other institutions creating high impact pathway programs to support students in academic- and career-related success.

Students' perceptions of academic ability were evaluated on a programmatic and course level with students reporting an overall high level of agreement (1 is strongly disagree and 6 is strongly agree) to statements about their "understanding of academic challenges" programmatically but also on a course level that students perceive biotechnology classes "give enough guidance to master the material." Results of the study indicate an overall positive sense of student perceptions across all three cohorts (Associates, Bachelors and Masters). What's more, overwhelmingly positive responses were reported by students in response to the academic, career-related, financial stress reduction and social inclusion support. While students across cohorts hold relatively high perceptions of each category of support, students in the Associates- and Masters-level students hold higher perceptions of academic, career-related, financial stress reduction and social inclusion support than Bachelors cohort students. Similarly, student perception of the Biotechnology Navigator as a support uniquely tailored for underrepresented minority and adult students' success in STEM learning pathways (Bassett, 2021; Heisserer and Parette, 2002; Miltenberger, 2007) was met with overwhelmingly positive responses across cohorts of students.

Findings from the current study indicate a consistent shift in student perceptions mid-program is an important indicator for the biotechnology program with implications for the field. Across each of the five categories of supports, Bachelors cohort students reported lower levels of agreement with academic, career-related, financial stress reduction and social inclusion support statements than those in the Associates- or Masters-level cohort. Students in the Bachelors cohort consistently reported lower mean scores than their Associates- and Masters-level peers when thinking about how their coursework will be useful in their biotech careers (e.g. "Each of the biotechnology classes has taught me the best ways to work in the field"), considering course specific skills in service of future work (e.g. "I feel like the math we do in classes is just what I will need to do in my career"), and even as they perceive themselves as lifelong learners (e.g. "I feel like I am 'learning how to learn' in a way that will continue throughout my career"). This finding reinforces work by Tasgin and Coskun (2018) who report that students at the end of a program are driven less by extrinsic motivation as they near the end of their coursework.

Future work will explore the dip in student perceptions mid-program and follow students longitudinally to determine programmatic impact over time. More specifically, we aim to explore how perceptual shifts mid-program is related to the program, the learning or external stressors on historically underrepresented minority and adult students enrolled in STEM programs (Aruguete, 2017; Bassett, 2021; Mishra, 2020). These findings must be evaluated within the current biotechnology pathway program and extended to similar STEM pathway programs if we are to identify which wraparound services support career success of historically underrepresented minority and adult students (Prunuske *et al.*, 2016). However, we hope the insights provide additional possibilities to those designing programs for widening participation.

In all, this data makes it clear that a pathway beyond an Associates degree to a Bachelors and Master's degree paired with wraparound support throughout coursework and into industry is a valuable asset for current and future success of job seekers in the biotech labor market. And an abundance of research indicates increasing URM students' access to lucrative careers in STEM fields (Kricorian *et al.*, 2020; Lambert *et al.*, 2020) such as biotechnology requires deliberate efforts by institutions beyond simply offering coursework to satisfy degree requirements (Bassett, 2021; Grim *et al.*, 2021). The networked approach of this Associates to Masters biotechnology program addresses financial and social capital needs of students to ensure they thrive academically in coursework and also in industry. Many new pathway programs have been implemented nationwide and those which have the best support for student success typically include robust mentoring, experiential learning and robust student scholarship support.

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