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Investigating the Experiences, Beliefs, and Career Intentions of Historically Underrepresented Science and Engineering Undergraduates Engaged in an Academic and Internship Program

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Abstract: Women and students of marginalized race/ethnicity continue to be underrepresented in many science and engineering fields, and access to special programs, mentors, and internships may influence awareness, intention, and persistence in STEM fields. This mixed-methods case study investigated the experiences, beliefs, and career intentions of thirteen undergraduate students from historically underrepresented groups in the United States as they engaged in a federally funded grant program, "Sustainable Futures". The program consisted of online courses, workshops, and a summer internship, intended to increase awareness, interest, and diverse participation in bioeconomy-related industries. The expectancy-value theory of achievement motivation theoretical framework guided this investigation of students' changes in beliefs about bioproducts, bioenergy, the bioeconomy, and their career intentions. Program courses helped students develop skills and knowledge and program internships inspired and reinforced their career directions. Following program activities, students expressed greater intention to pursue bioproduct/bioenergy-related careers and articulated their career intentions with greater specificity. This study provides insight into the viability of focused academic and professional development programs as a practical method to promote students' awareness, beliefs, and intentions to participate in careers in a sustainable bioeconomy, particularly across diverse populations.

Keywords: undergraduate; bioeconomy; bioproducts; careers; diverse workforce; internship

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1. Introduction

1.1. Background

Our use and reliance on fossil fuels and other non-renewable resources undermines global environmental resilience [1,2]. Replacing fossil-fuel-based products and energy with bioproducts and bioenergy is a promising way to reduce greenhouse gas emissions and mitigate climate change, as well as contribute to increased energy independence for nations around the world [3,4]. The sectors whose activities support a transition away from a fossil-fuel dependent society, such as some sustainable practices in forestry, agriculture, and biotechnology, are collectively called the "bioeconomy" [5]. The U.S. federal government describes the bioeconomy as "the global industrial transition of sustainably utilizing renewable aquatic and terrestrial resources in energy, intermediate and final products for economic, environmental, social and national security benefits" [6] (p. 201). The bioproducts and bioenergy sectors of the bioeconomy grew 17% from 2014 to 2016, and are expecting continued growth [6]. The federal National Bioeconomy Blueprint [7] report recognized workforce development and academic student training as a "strategic imperative"; yet student and public awareness remain low [3].

Currently, many sectors of the STEM workforce lack the diverse perspectives of underrepresented minorities and females [8] and the same challenges exist for bioproducts and bioenergy industries and occupations [9]. Denson et al. [10] attributed a lack of diversity in STEM professions to the failure of formal learning environments to introduce students to STEM careers. One way to help build professional networks with increased racial/ethnic diversity is to recruit from outside the immediate membership and networks of organizations [11].

A number of undergraduate and graduate-level bioeconomy education programs have received federal support to bolster interest and awareness in bioproducts and bioenergy careers, and to diversify participation in the bioeconomy, most notably through United States Department of Agriculture's (USDA) granting programs, which funded the research reported in the current study and similar education efforts [12]. While these programs address the calls from government and corporate entities looking to expand participation within the U.S. bioeconomy workforce [3,6,7,12,13], there is a dearth of research regarding student beliefs and interest in working in the bioeconomy. Research into specific sectors of the bioeconomy, such as forestry, can offer some insight into developing undergraduate awareness and interest in related careers. O'Herrin et al. [14], surveying more than one-thousand undergraduate students in the U.S., found that increased awareness about a career field, such as urban forestry, can improve students' perceptions of related careers. A study from Sharik and Frisk [15] also focused on undergraduates in the United States. Students expressed a preference in natural resources degrees over forestry degrees, because they believed that natural resources careers were more sustainability-focused, aligning with their environmental orientation better than forestry. These findings led us to wonder if and how students would associate bioproducts and bioenergy with sustainability, and if this would influence their intention to pursue careers in related fields.

1.2. Theoretical Framework

This study is informed by the expectancy-value theory of achievement motivation (EVT) [16,17], a framework often used to discuss career interest and motivation. EVT asserts that students' prior experiences, expectancies, abilities, beliefs, and values directly motivate their choices, performance, effort, and achievement.

The two key constructs applied to this study are expectancy and value. Expectancy is operationally defined as the student's belief that they can succeed in the given task. Value is the student's belief that there are direct or indirect benefits to the task. Eccles has shown that both expectancies and values predict career choices [17]. The task value described in the framework has four major components: attainment value, intrinsic value, utility value, and cost. Attainment value is defined as the importance of doing well on a given task, and is related to how well a certain choice fits with an individual's identity. For example, a student who identifies themselves as an environmentalist may be more likely to value learning about bioproducts/bioenergy, or to select a career related to the environment, because it aligns with their identity. Intrinsic value is the enjoyment one anticipates gaining from performing the activity, such as a student who anticipates enjoyment from their career activities. Utility value, or usefulness, refers to how helpful a certain task is in reaching current and future goals, such as future career objectives, whether the individual is or is not interested in the task for its own sake.

Research into career interest using the EVT framework was initially driven by quantitative analyses of survey data [18]. Other applications of the EVT are more qualitative in nature, in which student interviews and written work have been analyzed based on EVT constructs to better understand students' science and STEM career interests in relation to who they are and their future goals [19–25]. In the qualitative work of Matusovich et al., a longitudinal study investigated beliefs of engineering undergraduate students using EVT constructs [21]. Their findings illustrated the importance for academic and internship programs to expose students to a range of engineering careers, and provide experiences for students to observe what engineers do, the necessary skills, and how these

relate to their own abilities. In subsequent research, Matusovich et al. investigated the beliefs of U.S. career center employees and academic advisors regarding the influence of internships on engineering students [22]. The researchers again employed EVT, considering the influence of the advisors' beliefs on their students' career choices. They identified three main ways that internships influenced students' career interests and intentions: "enabling career discovery, providing opportunities for development of career skills, and helping students with full-time job acquisition" (p. 651). McCormick et al. measured engineering undergraduate students' attitudes and influences on attitudes about sustainable engineering using an instrument based on the EVT framework [23]. In their quantitative survey, students who participated in internship or co-op experiences had higher Sustainable Engineering self-efficacy scores, and had more positive feelings about the value of Sustainable Engineering concepts and careers. Related work by Linnenbrink-Garcia et al. found that when undergraduate students engaged in STEM-related research programs, they expressed higher task value for pursuing STEM-related research careers [24].

1.3. Purpose and Research Questions

This study aimed to measure the impacts of a two-year undergraduate academic and professional development program, the Sustainable Futures Program (all names as pseudonyms) on undergraduate participants. Specifically, this study investigated the influence of program activities and supports on students from historically underrepresented groups in science and engineering.

These research questions guided this study:

1. How did student career interests and intentions change during their participation in the Sustainable Futures Program?
2. How did student beliefs about bioproducts/bioenergy and the bioeconomy change during their participation in the Sustainable Futures Program?

2. Methods

2.1. Study Design

This mixed-methods study used a single embedded case study [26] to investigate changes in thirteen undergraduate students' beliefs about bioproducts/bioenergy and career interest. The case was bounded by studying the participants from a single academic and internship program. Qualitative and quantitative data were collected in parallel [26].

2.2. Study Context

The context for the study is a USDA-funded grant program, the Sustainable Futures Program, which was intended to diversify participation in the bioeconomy. Students were recruited into the program from regional community colleges, four-year colleges, and universities in a southeastern state in the US. Participant selection was guided by the program's goal to provide opportunities to students from historically underrepresented groups in science and engineering careers (i.e., females, minorities, first-generation college students). Program activities included three funded, online courses at a major research university in the state and a funded summer internship hosted by a bioproducts or bioenergy company or organization in the US.

2.3. Program Components

Students were first introduced to bioproducts and bioenergy concepts and careers through a one-day, on-campus orientation session featuring discussions and hands-on laboratory activities. Next, they enrolled in two 3-credit, asynchronous online courses, "The Sustainable Bioeconomy", and "Converting Biomass to Bioenergy and Bioproducts", which were provided for college credit at no charge and allowed to be transferred back to their home institutions for credit hours. After successful completion of the courses, students were invited to apply for a 10–12 week funded summer internship and had the opportunity to take an additional online course.

The first course surveyed bioeconomy-related science, technology, and the three pillars of sustainability: economic, social and environmental factors. The second course introduced students to engineering concepts used in the generation of products and fuels. Both courses consisted of video lectures, analyses of current bioproducts literature, written reflections, and forum discussions. Of the twenty-one students who started the program, thirteen students successfully completed both courses (with a grade of C or better) and therefore were eligible for the summer internship opportunity.

For the internship portion of the program, 40 bioproducts/bioenergy organizations who were contacted expressed interest in hosting interns. Students participated in a two-way selection process through resume reviews and interviews and were matched with companies and organizations. Stipends for summer training, travel, and housing were provided. Summer internships lasted 10–12 weeks and typically entailed self-directed projects and training under the guidance of a mentor. Internship hosts represented a range of sectors, including microalgae technology applications, biopharmaceuticals research, gasification research, enzyme manufacturing, paper additive research, biorefining research, and plant protection and regulation.

The focus of this study was on those undergraduate students who participated in the program and those who completed a summer internship through the program. Adhering to accepted policies regarding participants' rights and welfare and research ethics, the study protocol and data collection instruments were approved by the university's Institutional Review Board (IRB 14030).

2.4. Participants

The demographics of the thirteen research participants were: female (71%), male (29%); White (57%), Black Latino (14%), Middle Eastern (14%), Black (7%), and Latina (7%); and first-generation college students (36%). To allow for greater sample size, race/ethnicities were combined into Underrepresented Minorities (URM) for groups that are historically underrepresented in STEM fields (Black/African American, Hispanic/Latino, Native American, Middle Eastern, and Multi-racial) and non-URM (White, non-Hispanic; Asian; Indian) [27]. The authors realize that not all URM students (or non-URM students) have parallel experiences and that intersectional identities, including but not limited to age, gender, race/ethnicity, sexuality, and disability, are vast and complicated and are not fully addressed by this study. Seven students (50%) started the program while enrolled full-time at a regional community college, and six of these students transferred to four-year institutions during their participation in the Sustainable Futures Program.

2.5. Quantitative Data Collection & Analyses

Qualitative and quantitative data (N = 13) were collected in parallel at multiple time points over an 18-month period.

To address students' career interest in bioproducts and bioenergy, the Career Interest in Bioproducts and Bioenergy Survey (CIBB) was used. The CIBB survey was co-developed and validated by the authors [28]. It consists of four Likert-type questions with scores ranging from 1 (strongly disagree) to 5 (strongly agree). To address students' beliefs about bioproducts and bioenergy, the Beliefs about Bioproducts and Bioenergy Survey (BABB) was used [28]. The BABB survey, similarly developed and validated by the authors, consists of seventeen Likert-type questions with scores ranging from 1 (strongly disagree) to 5 (strongly agree). Items are organized into two related subscales based on personal (BABB-P) and societal orientation (BABB-S).

The BABB and CIBB instruments were developed, administered, and validated in a parallel and concurrent process [28] of item generation, questionnaire administration, item reduction by Exploratory Factor Analysis (EFA), and finally validation by Confirmatory Factor Analysis (CFA) [29].

Most items were adapted from existing validated surveys, The Colorado Learning Attitudes about Science Survey [30] and the Student Interest in Technology and Science

Survey [31], respectively. A few new items were created to address specific career settings. Items underwent review for content validity by a faculty team of subject matter experts. Additionally, three undergraduate students provided feedback regarding item clarity. To administer the surveys, faculty members teaching courses in the College of Natural Resources at a University in the southeastern United States were asked to share Qualtrics survey links with their undergraduate students (N_{BABB}= 168; N_{CIBB} = 203).

Sample Items

- CIBB Q1. I would enjoy working in a research setting to develop new bioproducts or bioenergies;
- CIBB Q2. I would like to work in a biorefinery (a production site for bioproducts or bioenergy);
- BABB-S Q1. Bioproducts/bioenergy help maintain a healthy environment;
- BABB-P Q8. I think about the bioproducts/bioenergy that I encounter in everyday life.

After data collection and cleaning, SPSS software was used for Exploratory Factor Analysis (EFA), a process that calculates the number of factors that best explain the latent variables of interest. For the BABB, three factors were identified, but only factor focused on beliefs about bioproducts/bioenergy and it had an acceptable Cronbach's α = 0.88. For the CIBB, three factors were identified, but only factor was found relevant to the study, and it had an acceptable reliability with a Cronbach's α = 0.91. All other items were removed from future analyses.

Confirmatory Factor Analysis (CFA) was used to confirm that all the items in each factor were related and measured the same latent variable. For the BABB, initial chi-square tests and indices indicated a weak model fit. Observing that each remaining item referenced either a personal or societal orientation, items were organized into two subscales, BABB-personal (9 items) and BABB-societal (8 items) revealing an improved model fit and internal reliability. For the CIBB, removing one item improved the model fit, resulting in a sufficient Cronbach's alpha α = 0.86.

The validated CIBB and BABB surveys were administered to Sustainable Futures Program participants at four times: during the program orientation, at the completion of Course 1, at the completion of Course 2, and following the internship experience. To analyze changes in CIBB and BABB scores, SPSS (IBM, 2019) was used to compare matched samples. Student surveys were compiled and matched for nonparametric analysis.

2.6. Qualitative Data Collection and Analysis

To further address research question 1, relevant student writings and interview transcripts were reviewed for mention of career intention and the influence of program activities on student career goals. One student in the study was unable to complete the post-internship interview. Interview audio data were transcribed. All data were de-identified, names were assigned pseudonyms, and data were matched for all research participants.

Open coding [32] of student writings and interview transcripts allowed the production of a table of student career intentions at multiple timepoints during their program participation. Two co-coders developed a codebook to analyze each stated career intention for specificity and bioproduct/bioenergy relatedness (BB-relatedness), assigning scores of 3, 2, or 1 for high, medium, and low, respectively. Interrater reliability (IRR) was calculated at 78% using simple percentage agreement [33] from an independent analysis of 30% of the transcript data. All differences between co-coders were discussed and negotiated until 100% consensus was reached [34].

To address research question 2, relevant student writings and transcripts were reviewed for student comments regarding beliefs about bioproducts/bioenergy or the bioeconomy. Open coding was conducted by two co-coders to examine the ways in which students discussed their beliefs about bioproducts/bioenergy. Initial open coding revealed reoccurring themes, including student motivations for wanting to learn about bioproducts/bioenergy, the potential impact of bioproducts on the environment, and how using

bioproducts to support sustainable lifestyles was part of students' values. Researchers noted that some student beliefs focused on the student's personal relationship or role, and others focused on more general and societal aspects. From these observations, the authors applied *a priori* codes based on EVT motivational constructs [16,17]. The "attainment value" code was applied when students discussed bioproducts/bioenergy/bioeconomy beliefs in relation to their identity. The "intrinsic value" code was applied when students discussed bioproducts/bioenergy/bioeconomy beliefs in relation to their personal interest or enjoyment. The "utility value" code was applied when students discussed bioproducts/bioenergy/bioeconomy beliefs in relation to their usefulness in reaching current and future goals. Each coded task value was also analyzed for student orientation: was the bioeconomy belief related to the students' personal connection to the bioeconomy or to the relationship between the bioeconomy and society? Lastly, transcripts were open coded for the ways in which students described their role in the bioeconomy (consumers of bioproducts who promoted the use of sustainably made goods; advocates of bioproducts/bioenergy and the bioeconomy to their friends, family, or the public at large; and scientists or engineers employed in bioproducts, bioenergy, or bioeconomy sectors). These codes were organized and described into the codebook and then used in a second round of coding to identify themes. These codes were included in the aforementioned 78% IRR calculation. All differences between co-coders were discussed and negotiated until 100% consensus was reached.

3. Results

3.1. Students' Career Intentions

Students described ways in which the Sustainable Futures courses and internship influenced their career intentions (Table 1). When commenting on the influence of the Program courses, comments were organized thematically into developing of technical knowledge/skills, inspiring or reinforcing career intentions, and developing personal interest. Students most frequently credited participation in the Program internship as inspiring or reinforcing career intentions, influencing job setting preference (e.g., office, laboratory, fieldwork), and increasing exposure to career options. (See frequency of codes in Table 2.)

Table 1. Example quotes and themes for student perceptions of the influence of Sustainable Futures Program courses and internship on their career intentions.

Name	Source	Exemplar Quote with Theme
Mary	Course influence	"[The courses] *got me really interested in the energy side of Environmental Science. Especially that first course . . . I think the algae fuel— I got real interested in that. And the second course, I learned more about the . . . business side of it. I like business more than . . . the lab stuff . . . [I like] building connections with other organizations".* (developed interest, inspired/reinforced career direction)
	Internship influence	*It just showed me that I don't really want to work in a lab setting . . . I definitely gained more confidence in myself networking, and I've gained a lot of more mentors. I learned . . . I met a lot people in the company that were really helpful and stuff for preparing me for a career . . . "* (influenced job setting, inspired confidence, gained mentors)
Carolina	Course influence	*"The program classes, I would say they more informed me about what was out there* [referring to potential jobs]". (exposure to career options)
	Internship influence	*"The internship more was hands-on and taught me what I could actually do . . . I don't think I could be on the super chemistry side of things, just because I would find it a bit boring . . . they more like analyze graphs and stuff and develop it into spreadsheets . . . . And the biology side of things . . . I loved to see strains of yeast . . . I'm more of like a hands-on person . . . so I think process development was a lot of fun".* (exposed to career options)

Table 1. *Cont.*

Name	Source	Exemplar Quote with Theme
April	Course influence	"[T]*he first course probably had the most influence on my career interests. I knew I wanted to work in environmental engineering, but at the time I still had no idea what I wanted to do with it . . . . I think really just opening my eyes to all you can do. And it kind of helped keep me on track of focusing on sustainability. At* [home university], *we take a lot of basic engineering classes before we get into any of the major classes. So I think having these classes to keep my mind on sustainability".* (inspired/reinforced career direction)
	Internship influence	*"So I think it definitely influenced . . . I love [bioenergy research internship-host company]. I would totally go back there for a job. I think they're a wonderful company as far as what I got to see for the summer. And I love the team I worked on. It made me very, very interested in R&D. So I think that's definitely where my heart is right now, anyway, would be in research and development".* (inspired/reinforced career direction)
Amber	Course influence	*"I didn't really know a lot about biofuels and stuff before this. I definitely learned a lot more about how plants specifically are related to biofuels and bioenergy".* (provided technical knowledge/skills)
	Internship influence	*"I think I learned a lot about the different types of jobs . . . I'm working in R&D, but then there are other people who I need to work with, like a chemical analyst or something like that who works on the chromatography machines . . . there's probably a million different jobs that you could do specifically. Everyone has a different title at the end of their email—it'd be like Research Analyst I, Research Associate V".* (exposed to career options)

Table 2. Frequency of coded themes for how students described the influence of Program courses and internship experiences on their career intentions.

Career Intention Themes	Code Frequency (% of Students)	
	Course Influence	Internship Influence
Inspired/reinforced career direction	4 (33%)	7 (58%)
Developed technical knowledge/skills	6 (50%)	2 (17%)
Exposed to career options	2 (17%)	3 (25%)
Influenced job setting preference	1 (8%)	3 (25%)
Developed personal interest	3 (25%)	0
Developed confidence	1 (8%)	1 (8%)
Developed career focus	0	1 (8%)
Provided competitive advantage	0	1 (8%)

To examine changes in student career intentions, the authors compared student comments from the middle of course 1, the end of course 1, and following the internship (Table 3). By the end of the program, seven of the remaining twelve students, (Alex, Amanda, Caleb, April, Fisher, Tony, Amber, and Ann) intended to pursue bioproducts/bioenergy-related careers. Caleb and April expressed career goals specific to bioproducts/bioenergy careers early in the program, and their interest remained high. Mary, Alex, Amanda, and Tony's career intentions became more related to bioproducts/bioenergy over time. Simone was the only student of the group whose career intention following the internship was less related to bioproducts/bioenergy (civil engineer was coded low for BB-relatedness) than her career intention prior to the internship (environmental engineering field was coded medium for BB-relatedness). As Simone honed her passion for engineering by exploring various engineering fields, such as industrial and civil engineering, she recognized that these careers may involve building bioproducts/bioenergy facilities or infrastructure, but that BB-relatedness was not a priority for her.

Student career intentions were also examined for specificity to determine if students had honed their science/engineering career focus during their participation in the program and exposure to numerous career options through the course curriculum and work experience during the internships. Students sometimes indicated both their intended career field (e.g., biopharmaceuticals) and/or their intended occupations (e.g., Research and Development scientist). All twelve students who shared their career intentions after the internship were able to articulate their career goals with far more specificity than in the program application and early course writings, even if they had a couple of fields/occupations in mind.

Table 3. Example student career intentions indicated during program participation.

Name	Career Intention		
	Program Application	**End of Course 1**	**Post-Internship**
Simone	Biomedical engineer	Environmental engineering field	Structural designer for civil projects
Mary	Fieldwork	Park Ranger	CEO of environmental non-profit
Lilly	US Forestry Service; alternative fuels	Forestry; working with reclaimed wood for bioplastics	Environmental conservation; biological monitoring.
Carolina	Biological Engineer; sustainable energy researcher	Medical researcher; pediatrician	STEM field; "helping career" with Hispanic populations
Alex	Biochemist	No data	Pharma R&D; vaccine manufacturing; medical liaison
Amanda	Science	Environmental sustainability industry; bioproduct inventor	Chemistry and sustainability; Marketing or creating sustainable makeup products or biofuel/bioenergy
Caleb	Biopharmaceutical researcher; develop methods of utilizing biomass	Enzyme and protein researcher; drug manufacturing	R&D for drug development or biofuels/bioenergy
April	Develop clean energy	Biopolymer research; Bioproduct/biomaterials research	R&D and fieldwork in water pollution management/remediation
Tony	Physician; founder of a GMO product company	Physician; business owner; MD/PHD	MD/PhD in genetics and oncology; founder of a biopharma company
Angie	Air or water pollution control	mid-level sustainability field; bioproducts job; jobs outside of lab work	Environmental risk assessment for nonprofit or government

Statistical analysis was conducted with data from the twelve students who completed surveys at all four time points. For CIBB data, student scores remained positive across time points, with means ranging from 3.00 to 5.00. Skewness and Kurtosis were outside the normal bounds of plus or minus one, and therefore, non-parametric tests were used to account for non-normal distribution of the data. The means for each time point were compared by Friedman Test followed by Wilcoxon post hoc test ($U_{T1} = 4.46$, $U_{T2} = 4.16$, $U_{T3} = 4.34$, $U_{T4} = 4.17$) and there were no significant differences between time points.

To examine demographic differences on the CIBB (4-item factor), Mann–Whitney U tests were used. Prior to the internship (time point 3) male students had statistically higher scores, (U ($N_{\text{males}} = 4$, $N_{\text{females}} = 10$) = 4.5, $z = -2.22$, $p = 0.02$). Students who transferred from community colleges to four-year institutions demonstrated higher CIBB factor scores both during orientation (time point 1, U ($N_{\text{transfer}} = 6$, $N_{\text{non-transfer}} = 7$) = 6.5, $z = -2.13$, $p = 0.04$) and at the start of course 1 (time point 2, U ($N_{\text{transfer}} = 7$, $N_{\text{non-transfer}} = 7$) = 8.0, $z = -2.14$, $p = 0.04$), but there was no significant difference for the last two time points. There were no significant differences by URM status or first-generation college student status at any time point.

Further statistical tests were conducted to check for a relationship between CIBB scores and the BB-relatedness (high/med/low) of student career intentions. A Kruskal–Wallis test indicated a relationship between CIBB scores (quantitative data) and BB-relatedness (qualitative data given scores of 1, 2, or 3 for relatedness). Post hoc Mann–Whitney U tests indicated that BB-relatedness based on student writings were associated with higher CIBB factor scores. Early program writing BB-relatedness scores were associated with CIBB time point 3 scores (U = 0.5, z = −2.23, $p = 0.03$). Late program writing BB-relatedness scores were also correlated with CIBB time point 3 scores (time point 3, U = 8) = 3.0, z = −2.24, $p = 0.03$). These findings indicate a positive relationship between the quantitative and qualitative findings.

3.2. Students' Beliefs about Bioproducts, Bioenergy, and the Bioeconomy

Student beliefs about bioproducts, bioenergy, and bioeconomy were analyzed using EVT task value codes (attainment value, intrinsic value, and utility value) and considering

whether the task value was oriented to the student's role (personal) or society's role (societal). Sample statements and coding are provided in Table 4.

Table 4. Sample quotes and coding for student beliefs about bioproducts/bioenergy and the bioeconomy.

Name	Program Application	End of Course 1	Post-Internship (Bioeconomy Role)
Simone	*"I hope to broaden my college experience by learning about . . . renewable bio products"* (attainment-p) . . . *"I have always had an interest in all sustainable products such as renewable energy".* (intrinsic-p)	*"Learning about sustainability, the bio-economy, bio-energy, bioproducts . . . I never expected it to be so enjoyable"* (intrinsic-p) . . . *"I have discovered that working in the bioproducts or bioenergy field is something I would love.* (attainment-p)	*"I feel like taking on the role of improving the bioeconomy and setting it up for future generations".* (working in the bioeconomy)
Lily	*"I always wanted to be a part of the massive change that would take place to help save our planet. Working with biofuels truly is the first step in beginning to make a change".* (attainment-p)	"[A]*lgae can be used to create a biofuel to replace fossil fuels. I have always been interested in algae, so it was very interesting to learn it can have this use".* (utility-s)	*"As a consumer . . . I feel like I have more of a choice, because I have a little more education than most people do on what hurts the environment. I feel like I have a bigger role because I'm working in this field".* (consumer, working in the bioeconomy)
Carolina	*"The challenge of clean, renewable, and sustainable resources is one that must be tackled with hard work and passion . . . I can eventually be part of the team advancing clean, renewable, and sustainable resources".* (attainment-p)	*"Being able to live and reside in a state that has such a large influence in this industry allows for more opportunities available for us.* [Our state] *has many different feet in the bioindustry from lumber to algae".* (utility-s)	*"I see my role as helping companies make the link between product and consumer".* (working in the bioeconomy, public advocate)
Amber	*"I am interested in the bioeconomy because I believe it is a way to include large corporations, the largest polluters and waste producers in the world, in decreasing their effect on the environment".* (utility-p)	*"The bioeconomy has a much larger impact in my current life and society than I thought it did" . . . ".There are thousands of sustainable products on the market . . . begin making a shift towards a sustainable future".* (utility-personal, utility-s)	*"I want to be a developer of biofuels . . . even if we were to find a way to incorporate biofuels and bioenergy more into our everyday system and become mostly renewable".* (working in the bioeconomy)

Note: Each EVT task value code was designated as either personal (p) or societal (s) orientation.

In Program Application statements regarding beliefs about bioproducts and bioenergy, students' statements were most frequently coded as "attainment value with a personal orientation", and "utility value with a societal orientation". That is, students began their participation in the program thinking that bioproducts were personally relevant, and they extended those beliefs in recognition of the usefulness of bioproducts to society.

Following their participation in Course 1, student comments were most frequently coded as "utility value with a societal orientation", "intrinsic value with a personal orientation", and "attainment value with a personal orientation". That is, students maintained their beliefs that bioproducts, bioenergy, and bioeconomy played a critical role in environmental sustainability, and they valued and enjoyed thinking and learning about these topics. In their Program Applications, students focused more on the usefulness of studying or exploring bioproducts/bioenergy for their personal goals (utility-p) than they did in their end of Course 1 writings, which were more often coded as being useful to society (utility-s).

Following their participation in the internship, students described how they saw their own role in the bioeconomy. Student descriptions were organized into three themes: consumers of bioproducts who promoted the use of sustainably made goods (consumer, 42% of students); advocates of bioproducts/bioenergy and the bioeconomy to their friends, family, or the public at large (advocate, 33%); and scientists or engineers employed in bioproduct, bioenergy, or bioeconomy sectors (working in the bioeconomy, 67%). (See sample quotes and codes in the fourth column of Table 4.)

Analysis was conducted with the data from the twelve students who completed surveys at all four time points (two students were missing one data point). For BABB (17-items) student scores remained highly positive across time points, with means ranging from 3.74 to 5.00 (U_{T1} = 4.46, U_{T2} = 4.46, U_{T3} = 4.49, U_{T4} = 4.49). Due to the non-normality of the sample, nonparametric repeated measures ANOVAs were used (see McAlexander, 2020 [35] for more detail on all statistical analyses). No significant differences were determined between any of the time points ($\chi 2 = 0.622$, df = 3, $p = 0.891$).

For the BABB-Personal factor, student scores remained positive across time points with means ranging from 3.44 to 5.00 (U_{T1} = 4.41, U_{T2} = 4.37, U_{T3} = 4.41, U_{T4} = 4.35). Although students' personal beliefs about bioproducts and bioenergy were high, no significant differences were found between time points ($\chi 2 = 1.917$, df = 3, $p = 0.590$). For the BABB-Societal factor, student scores remained highly positive across time points, with means ranging from 3.58 to 5.00 (U_{T1} = 4.52, U_{T2} = 4.56, U_{T3} = 4.57, U_{T4} =4.61). No significant differences were found between time points ($\chi 2 = 1.917$, df = 3, $p = 0.579$).

To examine demographic differences on the BABB (17-items) and BABB-P (9-item factor) and BABB-S (8-item factor), Mann–Whitney U tests were used. There were no significant differences by gender, URM status, first-generation college student status, or between transfer students and non-transfer students for any factor at any time point.

Further Mann–Whitney U tests were conducted to check for a relationship between BABB, BABB-P, and BABB-S scores, and whether the students' early- and late-program career intentions were bioproduct/bioenergy-related. There were no significant differences between students who intended to pursue bioproduct/bioenergy-related careers and those who did not.

3.3. Limitations

These findings should be viewed in light of several limitations. First, the number of participants in this study was relatively small, and the nature of their experiences with the courses and internships may have been influenced by some factors that were not captured in the interviews and instruments that were used in this study. By combining racial and ethnic groups, due to sample size, the authors were not able to parse out specific differences as they related to race or ethnicity. The authors realize that not all URM students (or non-URM students) have parallel experiences and that intersectional identities, including but not limited to age, gender, race/ethnicity, sexuality, and disability, are vast and complicated and are not fully addressed by this study. Due to the program's explicit focus on URM students and first-generation college students, this research did not investigate the potential influence on the program for non-URM groups.

4. Discussion

The first research question investigated how student career interest and intentions changed during the Sustainable Bioproducts Program. The findings of this study led to a number of assertions.

Assertion 1: Student awareness of existing bioproducts/bioenergy careers increased due to their course work and internship experiences. The Sustainable Futures Program courses were designed to introduce students to various fields and roles related to bioproducts and bioenergy through career exploration assignments, guest speakers, and virtual company tours. Students were encouraged to learn about various roles within the organization in which they interned. Findings demonstrated that both the courses and the internship gave students exposure to careers they had not known existed beforehand. Consistent with the beliefs asserted from career counselors and advisors [22], the undergraduate students in this study highlighted career discovery as a central benefit of the internship experience.

Assertion 2: Students in the Sustainable Futures Program refined their career goals during program experiences. The Sustainable Futures Program intended to support student career development even if students were interested in fields outside of bioproducts and bioenergy. All students maintained their intention to pursue careers in science or engineering. Previous

work has addressed STEM-related interventions and their influence on task values for career intention and STEM persistence [24,25]. Student experiences with the program, along with other academic and professional activities, led students to refine their career goals.

Assertion 3: Student intention to pursue bioproduct/bioenergy-related careers increased during their program participation. Students explored various careers and job roles during their participation in the program, and 58% of the students who completed post-internship interviews expressed an intention to pursue a bioproduct/bioenergy-related career. Student CIBB scores were consistently highly positive. Participating students had group mean CIBB factor scores ranging from 4.16 to 4.46 across time points, compared to mean scores of 3.92 and 4.02 for "Paper Science and Engineering" and "Sustainable Materials and Technology" respectively, the two highest scoring majors of undergraduates at a state university [28]. The quantitative findings align with the qualitative findings, as high BB-relatedness was associated with high CIBB scores for individual students for multiple time points, further validating the CIBB as a measure of intention to pursue careers in bioproducts and bioenergy. Similar to the work of McCormick et al. [23] regarding student attitudes toward sustainable engineering careers, exposure to in-school and out-of-school experiences related to the bioproduct/bioenergy careers increased student interest in pursuing work in these fields.

Assertion 4: Students felt more prepared to pursue their career intentions following the course and internship experience. Students identified the program courses and internship as influential for developing their technical knowledge and skills. The internship provided further advantages: confidence building, access to professional networks, and great competitive advantage when applying for future opportunities. Whereas some students considered pursuing full-time employment with their internship host company, all students recognized additional benefits of the internship in helping them develop career skills and preparing them for full-time job acquisition, again consistent with the beliefs of career counselors [22].

The second research question investigated how student beliefs about bioproducts/bioenergy changed. The findings of this study led to the following assertions:

Assertion 5: Students participating in the Sustainable Futures Program maintained positive personal and societal beliefs about bioproducts/bioenergy. Students in the Sustainable Future Program expressed highly positive beliefs about the personal and societal benefits of bioproducts and bioenergy within a bioeconomy. These qualitative findings align with the quantitative findings on BABB-P and BABB-S factors. Participating students had group mean BABB-P factor scores ranging from 4.35 to 4.41 across time points, compared to mean scores of 3.96 and 4.14 for "Paper Science and Engineering (PSE)" and "Sustainable Materials and Technology (SMT)" respectively, the two highest scoring majors of undergraduates at a state university [28]. BABB-S factor scores, ranging from 4.52 to 4.61 across time points, were greater than the mean scores of SMT and PSE majors (4.34 and 4.51, respectively). This study's findings were also consistent with previous studies in that group mean scores for BABB-S were higher than BABB-P [28].

Assertion 6: Students described themselves as advocates of bioproducts/bioenergy within the bioeconomy through various roles: consumer, public communicator, and working in related industries. In keeping with the goals of the Sustainable Futures Program, participating students saw themselves participating in the bioeconomy in several roles. These findings resonate with the authors' previous work [28], in which undergraduate students who had regular exposure to sustainability concepts within their program curriculum held more positive personal and societal beliefs about the bioeconomy. Many students intended to work in fields related to the bioeconomy, but students also recognized personal roles and responsibilities as consumers of sustainably produced bioproducts and bioenergy, and as public advocates of a sustainable bioeconomy.

5. Conclusions

The combination of focused course work and supported internships contributed to changes in these students' beliefs about the benefits of bioproducts and bioenergy in

their own lives and in society, addressing calls for workforce development and academic training [7], particularly for individuals who are underrepresented in the field [9].

Drawing from our understanding of previous research, we recognize that students bring with them varied backgrounds and worldviews, influenced by socioeconomic factors, geographic region, racial background, and gender, which influence their persistence and career pathways [36]. The science and engineering undergraduates in the Sustainable Futures Program, over a two-year period, were able to explore numerous fields and occupations related to the bioeconomy in their course work, and then selected a funded internship where they could apply the new technical skills and knowledge obtained in the courses, demonstrating the potential of financial support. From the internships, students developed more specific intentions about their desired career directions, many of them pursing bioproduct/bioenergy jobs. Additionally, students expanded their professional networks and gained confidence in pursuing future job opportunities, consistent with recommendations within the research literature [11].

Expectancy value theory [16,17] was applied to qualitative data in two ways: as a theoretical framework to understand these students' motivations, and also as a coding protocol to understand nuances in students' career interests and intentions. The students who participated in this study were from at least one historically underrepresented group in science and engineering. Therefore, the findings of this study demonstrate the potential of a targeted academic and internship program to address underrepresentation [8,9] of women, minorities, and first-generation college students in STEM and the bioeconomy workforce. It is hoped that the details of the Sustainable Futures Program [37] will provide a model for others in related fields who wish to increase the diversity of their programs.

To further develop our understanding of career interest in bioeconomy sectors, we propose future work that addresses barriers and supports that students face as they pursue various careers. We intend to examine the impact of recruiting interns and early-career professionals from historically underrepresented groups on overall company diversity. To continue to develop awareness, positive beliefs, and participation in the U.S. bioeconomy, further work is needed to study and implement training experiences for diverse student populations.

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