Work in Progress: Transformation Course-Based Undergraduate Research Experience (T-CURE)

Dr. Heather Dillon, University of Washington

Dr. Heather Dillon is Professor and Chair of Mechanical Engineering at the University of Washington Tacoma. Her research team is working on energy efficiency, renewable energy, fundamental heat transfer, and engineering education.

EC Cline, University of Washington Tacoma

Associate Professor in Sciences and Mathematics, and Director of ACCESS in STEM, an NSF S-STEM supported program that supports students in natural science, mathematics, and engineering at UW Tacoma.

Dr. Emese Hadnagy, University of Washington Tacoma

Dr. Emese Hadnagy is an associate professor and chair of the BS Civil Engineering program at the University of Washington Tacoma. Dr. Hadnagy received her Ph.D. at the University of New Hampshire. Her work falls in the broad areas of surface water quality assessment, physicochemical treatment technology development, and engineering education research.

Dr. Sarah L Rodriguez, Virginia Polytechnic Institute and State University

Sarah L. Rodriguez is an Associate Professor of Engineering Education and an affiliate faculty member with the Higher Education Program at Virginia Tech. Her engineering education research agenda centers upon engineering and computing identity development of historically marginalized populations at higher education institutions. Currently, Dr. Rodriguez is involved with several large-scale interdisciplinary research projects focused on institutional environments and STEM identity development are sponsored by the National Science Foundation (NSF) and the Kapor Center. In recent years, she was selected as an Early Career Awardee and Faculty Fellow with the American Association of Hispanics in Higher Education (AAHHE) and a NASPA Emerging Faculty Leader. She also received the Barbara Townsend Early Career Scholar Award by the Council for the Study of Community Colleges (CSCC) and gave the distinguished ASHE-CAHEP Barbara Townsend Lecture. To learn more about her current projects, visit http://sarahlrodriguez.com/

Amanda K Sesko, University of Washington Tacoma

Dr. Sesko received her PhD in Social Psychology from the University of Kansas in 2011 and is now an Assistant Professor at the University of Washington Tacoma. Dr. Sesko is a stereotyping, prejudice, and discrimination researcher. Her work focuses on how stereotypes guide judgments of, memory for, and behavior directed at individuals belonging to stereotyped groups. For example, in her primary line of research Dr. Sesko examines the processes and outcomes of intersectional invisibility—a form of discrimination characterized by not being attended to, remembered, represented, differentiated from others, or given recognition for contributions—experienced by individual's with multiple stigmatized identities (e.g., Black women; Sesko & Biernat, 2010, 2018).

Dr. Rebecca N Sliger, Tacoma Community College
Noelle Wilson

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Abstract

Undergraduate research experiences are well-established as a high impact practice for students. Transitions, including those from community colleges, are often challenging for students to navigate and may lead to retention issues. In this project, we designed a summer bridge course to leverage undergraduate research as a mechanism for supporting students during programmatic and campus transitions. We recruited from dual credit (e.g., "Running Start") programs, incoming transfer students from local two-year institutions, and pre-major STEM students. In the course, we included transformational experiences and personal artifacts as a way to enhance research identity and build community. The personal artifacts were used as a tool to allow students to share an aspect of themselves with the research class.

Student worksheets and reflective essays were collected to assess identity related tasks and reflections in the course. Students completed a survey about the class experience, with 100% of students reporting agreement that the class had a positive sense of community and collaboration.

Introduction

The transition from a two year institution to a four year institution is a well documented challenge for STEM students [1]. Engineering is a difficult major, and full of systemic barriers for students from historically excluded groups [2,3]. High impact practices have been shown to support students in engineering and STEM disciplines to persist in the major [4,5].

Undergraduate research experiences are a type of high impact practice that have consistently been shown to offer benefits to students, including retention. Research experiences for undergraduates are a well established method to support underrepresented students [6–8]. A CURE is a research experience that is included in an undergraduate class with the goal of providing an authentic research journey to students [9].

Our research team explored using a new type of summer research experience to help students transition between a two year institution and a four year institution as shown in Figure 1 and Table 1. The Transformation Course-Based Undergraduate Research Experience (T-CURE) was designed to support students during the summer between a community college and STEM program. The course included several features focused on helping students develop a STEM research identity [10], build community, and settle into the new institution.

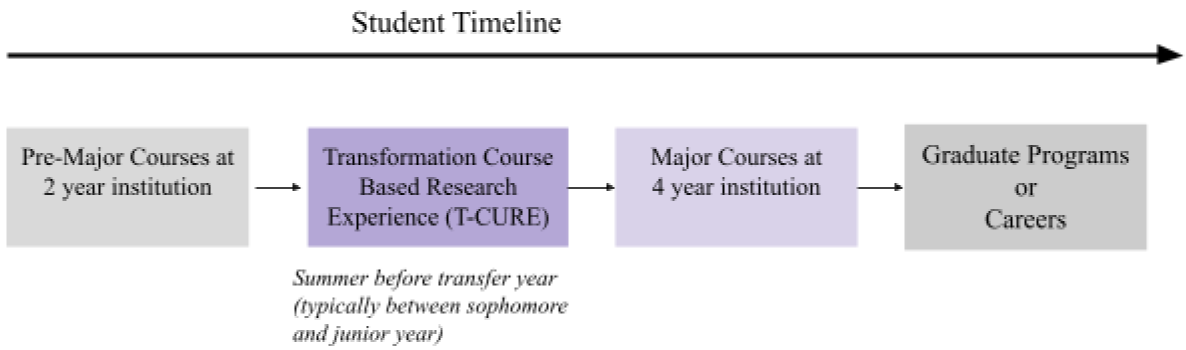

Figure 1. Overview of the research experience we designed for transfer students.

Table 1. Summary of the project and T-CURE course details.

	Description
Who	Undergraduate students in STEM majors who are in the process of transferring from a 2 year institution to a 4 year institution.
What	2-credit class focused on a research topic in energy and the environment.
Where	The course occurred at the 4-year institution in the engineering program.
When	Late summer, one month before classes start in fall term. The timing of the class was organized to allow students to take the course at no cost.
How	Faculty from both institutions worked together to design the curriculum, project, and tasks.
Why	The team goal is to increase retention and success of STEM transfer students.

The university and community college faculty involved in the T-CURE project were able to meet through the Washington Council for Engineering and Related Technology Education (WCERTE). WCERTE is a state-wide organization of all of the universities and community colleges that offer engineering coursework. WCERTE created the Associate of Science pre-major engineering transfer degrees on the state level to streamline transfer. At WCERTE, we talk about curriculum and engineering education. The universities tell community colleges about upcoming degree changes, and the community colleges give insight as to how these changes will affect community college students. WCERTE members also provide mentoring to new engineering faculty, since there are often only one or two engineering professors at a community college. The organization goes back to the 1970s. The organization is considered a national best practice, in part because of its collaborative round-table approach [11]. The chair position rotates between people at universities and community colleges. The executive committee has specific representation based on the type of institution. The close relationships at WCERTE lead to the partnerships that formed this T-CURE project.

To understand the impact of the T-CURE course, we developed the following research questions.

1. How does a course-based undergraduate research course focused on student transformation (T-CURE) support transfer students in STEM fields?
2. How do activities focused on research identity support transfer students in STEM fields?

Background

Prior research has shown that few (16%) of community college students complete bachelor's degrees at four year institutions. The rates are even lower for low-income (11%) and historically marginalized groups [12]. Tinto's framework for student retention has become a foundation for understanding student persistence [13], with an emphasis on student community formation. Townsend and Wilson found that student success was influenced primarily by university size, university clubs in major, and the opportunity to conduct research [14]. Barnett found that faculty validation is important to student persistence, particularly caring instruction, appreciation for diversity, and mentoring [15].

Undergraduate research in science and engineering with faculty mentors is well recognized as a high impact practice [4,16] that supports persistence [17]. The research programs have been shown to increase student engagement, academic confidence, and performance [4]. Research experiences may also be scaffolded to provide pathways to graduate programs [8,18].

STEM identity has been associated with enhanced persistence and quality of experience during the community college to four-year institution transfer process [19,20]. Engineering identity refers to the ability of a student to both recognize themselves as well as be recognized by others as the kind of individual who engages in the type of work typical of an engineer [21]. Community college students experience a wide range of benefits from activities that are meant to develop STEM or engineering identity, including activities that speak to nurturing engineering identity interests and competence as well as providing spaces for developing a sense of belonging, demonstrating their abilities to perform and be recognized as engineers [20,22,23].

Table 2. Summary of prior work relevant to transfer students and research.

Author/Citation	Year	Student Population	Intervention	Data Collection
Townsend and Wilson [14]	2009	Transfer students	NA	Interviews (n=12)
Laanan et al [24]	2010	Engineering Transfer Students	NA	Mixed Methods
Ford et al [25]	2023	Engineering Transfer Students	Community of Practice for Faculty Partners	Data Sharing
Present Work	**2024**	**STEM Transfer Students**	**Research Experience with Identity focus**	**Surveys, reflections, and student artifacts**

A recent related effort that focused on creating stronger partnerships between faculty and staff at a 2 year and 4 year institution supporting engineering transfer students found that faculty and mentors played a major influence on students' decision to choose an engineering major [25]. Students also reported on the challenges that they faced finding detailed and locally relevant information on engineering career pathways outside the classroom environment and several of them were struggling with issues related to engineering identity development and sense of belonging. Furthermore, students articulated that what drew them to engineering was their desire to develop their quantitative and critical thinking skills, and their love of innovation and design, all of which are closely aligned with research. The aforementioned underscore the importance of building stronger and lasting connections between 2 year and 4 year institutions in support of transfer students and the potential for significant impact in terms of both student recruitment and retention into STEM majors via faculty lead structured research courses such as the present work.

Methods

Course Structures

To recruit students, we connected with faculty and advisors at the community colleges to share information to students who had been admitted as fall transfer students. Transfer students who were admitted for fall quarter had the opportunity to participate in undergraduate research during the summer. This was a unique workaround to provide students to take the research course in the summer but have it paid for with their fall tuition. Students were then able to attend the class and begin research as a transition into their university careers.

The class was structured as an intensive research experience. Students met three times per week for multiple hours per day over a three week period in late summer. The technical theme for the class was water quality and wave energy and the main goal was for students to develop an engineering solution/prototype to address a problem in their selected research area. The transformation theme of the class was STEM research identity formation. Our choice of technical topics was intentional with the goal of selecting projects that were tied to issues that were of interest to a wide array of local stakeholders, including the public, to ensure that students would find their research tasks to be highly relatable on multiple levels (i.e. both professionally and personally) and therefore further aiding their research identity formation.

The focus of the first week was getting to know the basics of the project, team formation, and learning how to use equipment. Activities included doing a SWOT analysis for the team and reflective journal prompts. Basic instruction about wave energy and renewable energy was provided to the students. This included an overview of the typical types of wave energy conversion systems.

Students were also provided with basic instruction on surface water quality monitoring with a special focus on a local saltwater estuarine system that is a defining feature of our region economically, socially and culturally. Traditional and innovative sensor-based water quality monitoring techniques were both discussed and students were provided with links to additional resources, such as relevant local agency and organization websites, to help launch their independent exploration of the technical literature on the topic. In addition, students engaged in a hands-on activity, exploring the use of a low-cost, simple conductivity, temperature and depth (CTD) sensor node in a laboratory setting to provide a bridge between theory and their independent design brainstorming task.

As the students became familiar with the technical aspects of the projects and tasks, they were asked to bring a personal artifact to share with the class that connected with their research identity in some way. The instructor provided a few examples of the types of artifacts that connected with their own research identity. The instructor examples were deliberately personal in nature (a music box that was a gift from a supportive grandparent) to allow students to understand that a technical response was not expected. During the class period at the end of the first week students brought their own artifacts to class and shared them with one another. They completed a worksheet that encouraged them to reflect on what interesting things they had learned about one or two classmates.

Student Artifacts and Reflections

The student artifact activities were designed to connect student culture with the research experience based on the prior work of Rodriguez [26]. The activity was done near the beginning of the term as a way to build community with many students new to campus. Each student was asked to share an artifact that connected with their STEM research identity in some way (e.g. headphones, journals, etc). To help the students get started, the instructor shared a small music box and a story about how her grandmother had supported her curiosity and research identity over time. A few days later the students brought in small objects and stories of their own.

During the class session, students were asked to reflect on objects shared by new classmates. **What aspect of this artifact or this person's journey did you connect with? Why? What makes this artifact significant for them?** After the class activity, students were asked to reflect on the artifact they shared. **Write a bit about why you choose your artifact. What makes your artifact significant? How does the artifact connect to your identity and lived experience?**

Student Survey

Students filled out an anonymous survey online assessing evaluations of the class activities and structure and sense of trust and belonging in the class. Specifically, to measure students' perceptions of outcomes gained from class activities they filled out five questions on a 1-strongly disagree to 5-strongly agree scale including: "The research project helped me learn something new about myself", "The research project helped me learn something new about others", "The class projects and activities helped me feel connected to others in the class", "The research project helped me explore my own culture", and "The research and artifact project allowed me to bring my own life experiences into this class." Students were then asked to provide a written example of how they felt the research project contributed to their learning in the course.

To measure students' evaluations of the class structure, they responded to the following five questions (on a 1-strongly disagree, to 5-strongly agree scale): "The class had a positive sense of community and collaboration,” “The class had a clear, co-constructed understanding of what we are trying to achieve,” “The class provided opportunities to build meaningful relationships with students and educators,” “The class structure (like grading) were designed to avoid doing me harm,” and “The class seemed different than traditional STEM classes I have taken.” They were then asked to share a written example of how the class provided opportunities to build relationships, collaborations, and community.

To measure trust and belonging, students rated their agreement (on a 1-strongly disagree, to 5-strongly agree scale) with four questions adapted from Pietri et al. [27] and prior work [28–30]: “I trust that my instructor is committed to helping me learn,” “I feel like I belong at the university,” “I feel that my contributions are valued by my instructor in this class,” and “I feel connected to the community I developed in this class.” Students also shared a written example of who or why they had a sense of belonging or trust in the class. Finally, we asked students to indicate if they considered themselves to be part of a traditionally underrepresented group in computer science or engineering (female/non-binary, LGBTQ+, or person of color).

Results

Course Structures

The class was taken by nine STEM students, most engineering transfer students in mechanical and electrical engineering. The number of students was consistent with the research team expectations, since we advertised the course to incoming students in several groups (~80 students total).

Near the start of the class, students were broken into three teams each with a specific research and design focus. Each team was given an open-ended challenge and provided with tools and resources to begin research. The first week focused on data gathering and basic literature searches. The second week focused on technical skills needed like 3D printing, Arduinos, and environmental monitoring tools. The third week of the class focused on documentation and presenting the findings in a poster. Over the full course students were encouraged to use rapid prototyping with simple materials like cardboard whenever possible. An example of one of the simple prototypes made with an aluminum can is shown in Figure 2.

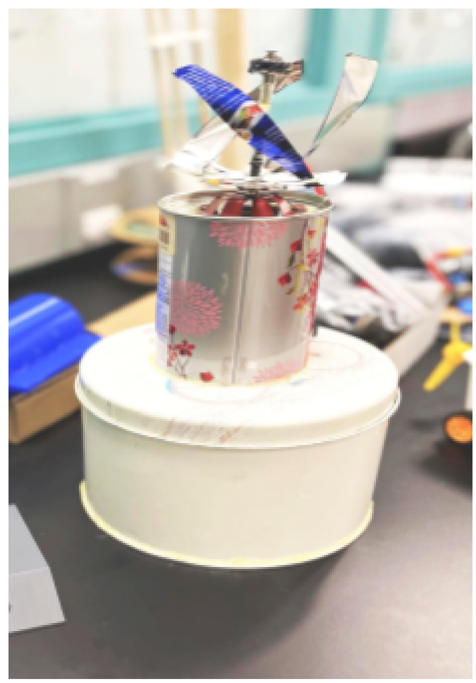

Figure 2. Example of rapid prototyping from students taking the T-CURE course.

Early in the class students participated in the identity artifact project to build community. Examples of student artifacts included:

- A journal. An international transfer student shared a journal where he wrote down challenges and goals. He talked about his own journey and challenges in moving to the US and how hard the pre-engineering courses had been for him as his language skills improved.
- Headphones. One student shared headphones and talked about his deep love of music and how music helps him concentrate when doing difficult tasks.
- Models. One student shared a small model they had built and talked about how they connected this joyful pursuit with deciding to become an engineer.

Many student objects had a playful theme that connected to childhood or memories they cherished. The artifact sharing was by far the most powerful and emotional day of the course. The artifacts also foreshadowed roles the students would then adopt over the course of the research. For example, the student who enjoyed modeling took on the 3D printing tasks for their team.

Student Survey

The survey was completed by eight students out of nine the last week of the class, creating a small sample size but a good response rate. 50% of the students self-reported that they belonged to a traditionally underrepresented group including female/non-binary, LGBTQ+, or a person of color. 25% of the students indicated they preferred not to respond to this question.

Students made mostly positive statements about the course structures as shown in Figure 3. In particular, all the students indicated the class had a positive sense of community and collaboration. This was an important goal for the research team in developing the T-CURE class, so the student feedback is helpful.

The students were asked an open-ended question, “Give an example of how you felt the research project contributed to your learning in this course.” A few insightful student responses are below.

- It helped me understand the way a team functions, by showing us how a project and coordination.
- The research project contributed to my learning in this course because the more questions I asked the more answers I got out of it and the more detailed answer I got. Finding different ways to use natural and renewable energy creates more ideas to have a model.
- It helped me learn how to quickly prototype and research a topic within a short period of time.

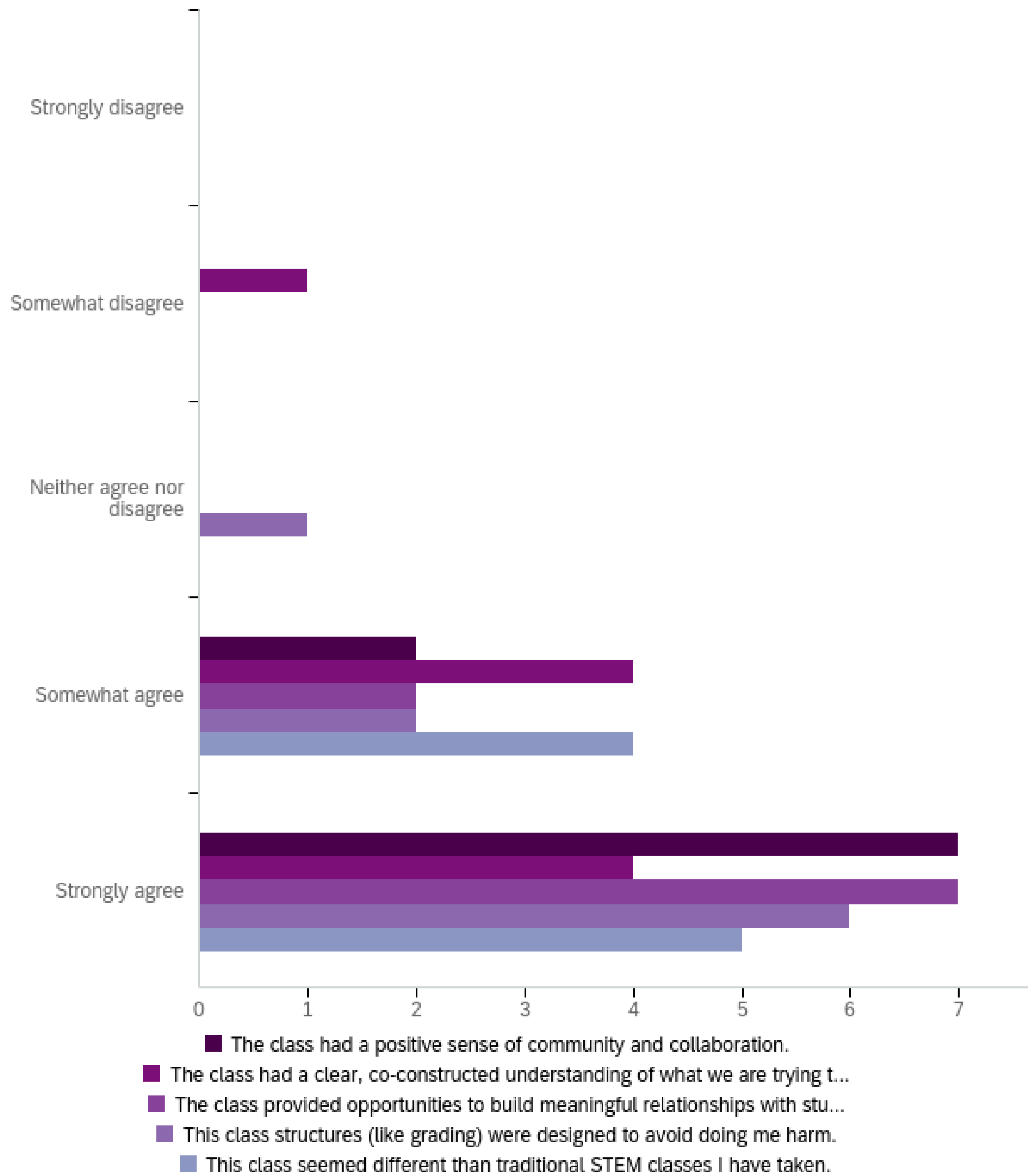

Figure 3. Student responses to the survey question, "Select your agreement with the following statements related to class structures."

The students were asked an open-ended question, "Share an example of how this class provided opportunities to build relationships, collaborations, and community." A few insightful student responses are below.

- This class provided me with great opportunities to build relationships and collaborate with others. The activities we did in order to divide into our groups really helped me get comfortable with talking to others in my group and others in the other different groups. After everybody tested the prototypes the groups collaborated more which built relationships.
- Working on group every day help me to interact with my classmates and they make me feel that I belong to this class, the project and the entire [university] community. The support and

comprehensive Interaction with Dr. [instructor] helps me to improve my skills in this amazing research.

- I got put into a small group that allowed me to form positive relationships with my team. The teamwork required for the class also caused me to work on my collaboration skills.

The survey results confirmed the course was mostly successful in creating a sense of belonging and building trust. Figure 4 shows that only one student disagreed with the statement, "I feel like I belong at the university". All other statements were "agree" or "strongly agree" for the students. It is interesting that all the students did agree with the related statement, "I feel connected to the community I developed in this course," which may indicate that the students had a different relationship with the course than the university. Increasing student sense of belonging is challenging and may be a focus of future iterations of the T-CURE class.

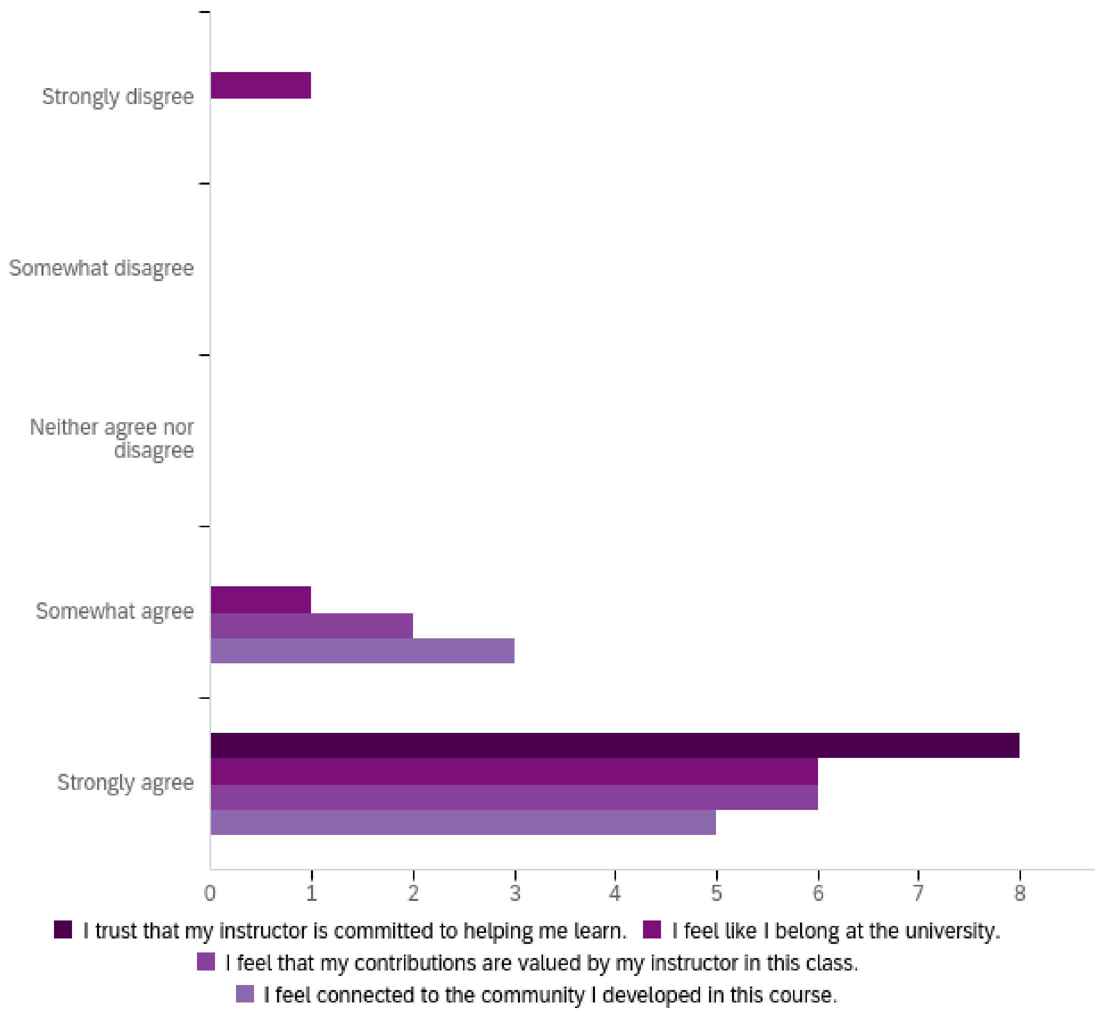

Figure 4. Student responses to the survey question, "Select your agreement with the following statements related to trust and belonging in the context of this class."

The students were asked an open-ended question, “Share an example of how or why you had a sense of belonging or trust in this class.” A few insightful student responses are below.

- We went to pizza as a team
- The environment in the class was amazing and all my classmates are awesome.
- Working with people of the same or similar majors in a team allowed me to see how similar other people are at [my university].

The course overall was academically very successful for the students. At the end of the class, students were given the option to continue the research project over the next part of the school year. Four of the nine students opted to do so and joined paid research projects or continued for additional course credit. Two students have now drafted research papers about two of the three topics and several students have expressed interest in possibly attending graduate programs.

Conclusions

The research team has developed a specific and carefully designed intervention to support transfer students moving from a 2-year institution to a 4-year institution. The T-CURE class was designed to help students adapt to a new campus while building community and research identities.

RQ1: How does a course based undergraduate research course focused on student transformation (T-CURE) support transfer students in STEM fields?

The course structures and the artifact activity supported the students in developing a research identity and building community over the course. Students survey responses indicated all had a strong sense of community in the course even if one student did not have a strong sense of belonging at the institution yet. In future course offerings we may focus additional activities on building a sense of belonging with the new institution, perhaps a scavenger hunt to learn more about the history of the campus and other students in their majors. Preliminary results reinforce prior STEM literature which emphasizes the important connections between the development of identity and elements of sense of belonging [23].

RQ2: How do activities focused on research identity support transfer students in STEM fields?

Our preliminary results indicate the artifact activity was a wonderful way to help students develop a research identity in the class. Sharing the artifacts with other students empowered some students to adopt specific roles in the class over time. The student insights are consistent with prior findings by Rodriguez et al about STEM identity [26].

Based on our work in progress results with a small initial offering we plan to continue offering this course in the future as a bridge for students joining a 4-year institution. We also plan to continue conversations with our students about identity and artifacts as they move through the programs to reinforce the identities they have started to develop.

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