Breaking Down Barriers: A Bridge Program Helps First-Year Biology Students Connect With Faculty

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Summer bridge programs often aim to build social connections for first-year students to ease their transition into college, yet few studies have reported on bridge programs successfully leading to these outcomes. We backward designed a summer bridge program for incoming biology majors to increase the comfort and connections among students and between students and faculty. We found that first-year students who participated in the bridge program had greater comfort and connections with faculty compared with matched students who did not participate in the bridge program. However, there were no differences in the comfort and connections with peers for students who participated in the bridge program compared with matched students who did not participate in the program. Bridge students reported specific elements of the bridge program that they perceived led to greater comfort and connections with faculty, which can help guide bridge developers in the design of their programs aimed to enhance student relationships with faculty. This study adds to the growing literature on bridge programs and demonstrates how a bridge program can be designed to lead to increased comfort and social connections with faculty.

First-year students' transition into college can be challenging, particularly adapting to a new environment without their normal social support system (Mounts, Valentiner, Anderson, & Boswell, 2006). Students have a higher likelihood of persisting in college if they are more involved in the social system of college and interact more with other students and faculty (Tinto, 1975, 1987). This is particularly important for students who are entering majors in science because these disciplines are often demanding, and faculty members are perceived as unapproachable (Seymour & Hewitt, 1997). One way to enhance students' social integration in college is to engage students in a summer bridge program before they enter college.

Summer bridge programs are typically multiday intensive experiences that occur just before a student's first year in college. Bridge programs are varied in length, scope, and outcomes; however, a common goal of many bridge programs is to improve the social experiences of students in college (Ashley, Cooper, Cala, & Brownell, 2017). Opportunities to network with peers and faculty are often integrated into bridge programs because the relationships that students build with peers and faculty during a bridge program are thought to be leverageable into social and academic benefits that can help students persist in college (Tinto, 1975, 1987). In a review of 30 STEM bridge programs implemented over the past 25 years, we found that 11 programs aimed to help students enhance their relationships with faculty; however, only seven programs measured this outcome and reported that the bridge program successfully enhanced students' relationships with other students or faculty (Ashley et al., 2017). One study exploring the impact of a bridge program for students in STEM majors found that students attributed faculty mentors in the bridge program as being particularly important to their academic success (Maton, Hrabowski, & Schmitt, 2000). Similarly, another study exploring the impact of a bridge program for nursing students showed that students ranked the social aspects of the bridge program as the most important part of the experience (Pritchard et al., 2016). However, no study has explored student comfort levels and the number of connections students make with peers and faculty. Thus, building relationships with peers and faculty is an understudied, yet potentially important, outcome of bridge programs.

We have previously called for the use of backward design (Wiggins & McTighe, 1998) in the development of bridge programs so that program activities can be designed to meet specific outcomes (Ashley et al., 2017). However, studies that probe into what specific aspects of bridge programs lead to students forming relationships with students and faculty are currently

missing from the literature on bridge programs. To address this gap in the literature, we explored student experiences in a biology bridge program that was backward designed to increase student comfort and connections with first-year biology students and biology faculty. The developers of this bridge program integrated elements into the program that they proposed would increase bridge students' comfort and connections with peers and faculty. To measure the impact of the program on students, we compared students who participated in the program (Bridge students) to students who were eligible to participate in the bridge program but did not enroll (non-Bridge students). Our research questions were:

1. To what extent are there differences between Bridge and non-Bridge students' comfort and connections with biology peers?
2. To what extent are there differences between Bridge and non-Bridge students' comfort and connections with biology faculty?
3. If there are differences between Bridge and non-Bridge students' comfort and connections with biology peers and/or biology faculty, what elements of the bridge program contributed to this difference?

Methods

Bridge program description

A 2-week intensive summer bridge program was designed for incoming first-year biology students who were academically underprepared. The bridge program was implemented two and a half weeks before the students' first day of college classes. A student is considered academically underprepared if his or her college index (CI) score is in the lowest quartile of students admitted into the biology major at this institution. CI score is calculated by the university using a combination of high school GPA and SAT/ACT, however the specific formula is not released by the university. We have previously shown that CI score is a strong predictor for student success in introductory biology (Cooper, Ashley, & Brownell, 2017). Students' academic preparation is a strong predictor of their performance and persistence in biology, so the institution implemented this bridge program to increase retention of these low CI students in college. The bridge program was backward designed; bridge developers started with program goals, then articulated how to measure those goals, and finally integrated specific elements that they thought would lead to those goals (Allen & Tanner, 2007; Cooper, Soneral, & Brownell, 2017). The three main goals of the bridge program were to: (a) improve student biology content knowledge, (b) provide students with knowledge about how to navigate college, and (c) build community among students and between students and faculty. The bridge program has been implemented and iteratively revised a total of three times; this manuscript reports on the third iteration of the bridge program and focuses on the goal of building community among students and between students and faculty.

The bridge program focused on teaching biology content that would be covered in the students' introductory biology course to give students an opportunity to engage with the material before beginning their introductory biology course. The biology content of the bridge program was taught in an active learning way (Freeman et al., 2014), and students frequently worked in groups with other students to solve problems (Cooper, Ashley, & Brownell, 2017). At the end of the program, students applied the biology that they learned by working in partner pairs to create a poster about a genetic disease and presented the poster in a conference-style poster session.

Two biology faculty members and a graduate student taught the bridge program. Fifteen biology faculty members joined students for a casual lunch discussion during the program; a faculty member sat with five to six bridge students during lunch. The faculty members who came to lunch included all introductory biology instructors as well as faculty who teach upper level biology courses and have active research labs. Therefore, it is likely that students in the bridge program would interact with these faculty again during their undergraduate experiences. All students in the bridge program were required to have a lunch with at least two faculty members during the program. Biology faculty also attended the poster session and asked students questions about their posters. During the bridge program, students were taught how to e-mail faculty through a structured activity of writing and sending an e-mail to faculty about their research. For a more detailed description of the bridge program, see Cooper, Ashley, and Brownell, 2017.

Two-day summer camp

After the bridge program ended, immediately before students' first semester of college, all students who participated in the bridge program joined nearly all incoming first-year biology students at a 2-day summer camp that was exclusively

focused on building social connections among students and between students and faculty. At this camp, first-year students were randomly assigned to teams of seven to eight and engaged in team-building activities. A small subset of biology faculty attended camp and interacted with students, but in a brief way such as giving advice to large groups of students or participating in the camp talent show.

Participants and propensity-score matching

One hundred and five students were eligible to participate in the bridge program on the basis of their CI score, and 35 students chose to participate in the program. Of the 35 students who participated in the bridge program, 26 students completed all surveys and had a complete set of demographic data, so these bridge students were included in the analyses (Bridge students). Propensity-score matching was used to identify 26 students who were eligible for the program but did not participate and who were most similar to the 26 bridge participants (non-Bridge students). All Bridge and non-Bridge students attended the two-day summer camp and were enrolled in the same introductory biology course during their first semester in college.

To identify non-Bridge students, we used propensity-score matching using the MatchIt software program in R (Ho, Imai, King, & Stuart, 2007). Students were matched using the following variables: CI score, gender, race/ethnicity, native language, college generation status, and whether a student lives on campus. The demographics of the Bridge and non-Bridge students are described in Table 1.

Survey measures

To measure students' comfort and connections with biology peers and faculty, we administered an online survey to Bridge students at the beginning of the bridge program and then to both Bridge and non-Bridge students at the beginning and end of their first-semester in college. We asked students "How comfortable are you talking to biology first-year students?" and "How comfortable are you talking to biology faculty?" which students answered on a 6-point Likert scale (ranging from 1 = *extremely uncomfortable* to 6 = *extremely comfortable*). We also asked students to "Please name all biology first-year students who you feel comfortable talking to for help or advice" and "Please name all biology faculty who you feel comfortable talking to for help or advice," and each student recorded student and faculty names in response to these questions.

Analyzing students' comfort and connections

To assess student comfort with peers and faculty, we analyzed the question "How comfortable are you talking to biology (first-year students/faculty)?" using Mann–Whitney U-tests. To assess student connections with biology peers and faculty, we analyzed the question "Please name all biology (first-year students/faculty) who you feel comfortable talking to for help or advice" and tallied both the number of students and the number of faculty that each student named. The Mann–Whitney U-test was used to test for differences between the number of students and faculty that Bridge and non-Bridge students felt comfortable talking to for help or advice.

We compared Bridge and non-Bridge student responses at the beginning of their first semester in college to see whether Bridge students felt more comfortable and established more connections with peers and faculty than non-

TABLE 1

Demographics of Bridge and non-Bridge students.

	n	Average CI score	Female students	Underrepresented minority students	First-generation student	Students living on campus
Bridge students	26	100	77%	38%	27%	69%
Non-Bridge students	26	101	80%	42%	38%	79%

TABLE 2

Demographics of the Bridge students who participated in semistructured interviews.

	n	Average CI score	Female students	Underrepresented minority students	First-generation student	Students living on campus
Interviewed Bridge students	12	100	66%	33%	25%	83%

Bridge students. We also compared Bridge and non-Bridge student responses at the end of their first semester in college to see if any differences sustained over students' first semester in college. Last, we compared Bridge student responses at the beginning of the bridge program to non-Bridge student responses at the beginning of their first semester in college to ensure that Bridge students were not different from non-Bridge students when they first arrived at college.

Exploring elements of the bridge program

To probe what specific elements of the bridge program may have led to differences between Bridge and non-Bridge students' comfort and connections with faculty, we conducted semistructured interviews with a subset of 12 Bridge students at the end of their first semester in college (see Table 2 for the demographics of the interviewed Bridge students and Table 3 for the interview questions). The interviews were transcribed, and students were given pseudonyms to protect their identity. Deductive coding

TABLE 3

Questions from semistructured interviews with Bridge students that were analyzed using inductive and deductive coding to explore what elements of the bridge program may have led to Bridge students' increased comfort and connections with biology faculty.

Interview questions
Think back to the beginning of the bridge program. How comfortable were you talking to biology faculty at the end of bridge, compared to the beginning of bridge? Please explain. **If student is more comfortable:** • How did you become more comfortable with faculty during the bridge program? • How do you think becoming more comfortable with biology faculty during bridge has influenced your experience in the School of Life Sciences? **If student comfort level has not changed:** • How do you think your unchanged comfort level with biology faculty during bridge has influenced your experience in the School of Life Sciences? **If student is less comfortable:** • How did you become less comfortable with faculty during the bridge program? • How do you think becoming less comfortable with biology faculty during bridge has influenced your experience in the School of Life Sciences?
Think back to the first day of [introductory biology]. Compared to the first day of [introductory biology], how comfortable are you talking to biology faculty now? Please explain. **If student is more comfortable:** • How did you become more comfortable with faculty during the semester? • How do you think becoming more comfortable with biology faculty since the first day of class has influenced your experience in the School of Life Sciences? **If student comfort level has not changed:** • How do you think your unchanged comfort level with biology faculty since the first day of class has influenced your experience in the School of Life Sciences? **If student is less comfortable:** • How did you become less comfortable with biology faculty during the semester? • How do you think becoming less comfortable with biology faculty since the first day of class has influenced your experience in the School of Life Sciences?
Talk to me about whether you feel it is important or not important to talk with biology faculty? Please explain. • If student believes that talking to biology faculty is important: When and how did you learn that?
Have you talked with any biology faculty for help or advice? Please explain. **Why did you/why did you not talk to them?** **If student talked with faculty:** • When and how did you get to know them? • How did this interaction influence your experience in the School of Life Sciences?

(Hsieh & Shannon, 2005) was done using a list of elements that were purposefully implemented in the bridge program to help students develop comfort and connections with faculty. The interviews were also analyzed using inductive coding (Creswell, 1994) to identify unexpected aspects of the program that at least 25% of students perceived led to enhanced comfort and connections with faculty. All three authors reviewed a subset of four different interviews and together created a rubric that was used to code elements of the program that were perceived to influence student comfort and connections with faculty. Subsequently, two authors (KMC and MA) independently coded every interview using the rubric and compared their results. Their consensus estimate was 96% (Stemler, 2004), and they came to consensus about any discrepancies. This study was done in accordance with an approved IRB protocol.

Results

Finding 1: Compared with non-Bridge students, Bridge students have increased comfort and a greater number of connections with biology faculty, but not with biology peers at the beginning and end of their first semester in college.

Comfort and connections with biology peers

To explore whether the bridge program increased Bridge students' comfort and connections with biology peers over the 2-week program, we compared Bridge and non-Bridge students' comfort and connections with peers at the beginning of their first semester in college. We found that there was no difference between Bridge and non-Bridge students' comfort talking with biology peers (5.31 vs. 5.11; $p = .11$, Mann–Whitney *U*-test; Figure 1a) or between the number of biology peers that Bridge and non-Bridge students felt comfortable talking to for help or advice at the beginning of their first semester in college (1.58 vs. 2.00; $p = .50$, Mann–Whitney *U*-test; Figure 1b).

We also compared Bridge and non-Bridge students' comfort and connections with biology peers at the end of their first semester and found that there was no difference between Bridge and non-Bridge students' comfort with biology peers (4.96 vs. 4.92; $p = .65$, Mann–Whitney *U*-test; Figure 1a) or between the number of biology peers that Bridge and non-Bridge students felt comfortable talking to for help or advice (1.77 vs. 1.81; $p = .87$, Mann–Whitney *U*-test; Figure 1b).

Bridge students self-selected into the bridge program. Thus, to make sure that Bridge students were not more comfortable or had more connections with biology peers than non-Bridge students when each group first arrived at college, we compared Bridge students' comfort and connections with peers at the beginning of the bridge program to non-Bridge students' comfort and connections with peers at the beginning of their first semester in college. We found that there was no difference between Bridge and non-Bridge students' comfort talking with peers (4.50 vs. 5.11; $p = .24$, Mann–Whitney *U*-test; Figure 1a), and, in fact, non-Bridge students knew significantly more peers that they felt comfortable talking to for help or advice at the beginning of their first semester than Bridge students knew at the beginning of the bridge program (0.65 vs. 2.00; $p = .03$, Mann–Whitney *U*-test; Figure 1b).

Comfort and connections with biology faculty

We explored whether the bridge program increased Bridge students' comfort and connections with biology faculty over the 2-week program by comparing Bridge and non-Bridge students' comfort and connections with biology faculty at the beginning of their first semester. We found that Bridge students were significantly more comfortable talking with biology faculty than non-Bridge students (5.04 vs. 3.81; $p = .03$, Mann–Whitney *U*-test; Figure 1c). Bridge students also knew significantly more biology faculty whom they felt comfortable talking to for help or advice than non-Bridge students at the beginning of their first semester (1.73 vs. 0.54; $p < .0001$, Mann–Whitney *U*-test; Figure 1d).

To probe whether the differences between Bridge and non-Bridge students' comfort and connections with faculty were sustained over their first semester, we compared Bridge and non-Bridge students' comfort and connections with faculty at the end of their first semester and found that Bridge students continued to be significantly more comfortable talking with faculty than non-Bridge students (4.5 vs. 4.0; $p = .04$, Mann–Whitney *U*-test; Figure 1c). Bridge students also knew significantly more faculty whom they felt comfortable talking to for help or advice than non-Bridge students at the end of their first semester (1.15 vs. 0.08, $p = .0005$, Mann–Whitney *U*-test; Figure 1d).

To explore whether Bridge students knew more faculty than non-Bridge students when they first arrived at college, we compared Bridge students' comfort and connections with faculty at the beginning of the bridge program to non-Bridge students' comfort and connections with faculty at the beginning of their first semester in college. We found that there was no difference between Bridge and non-Bridge students' comfort talking with faculty (4.15 vs. 3.81, $p = .36$, Mann–Whit-

ney *U*-test; Figure 1c) or between the number of biology faculty that Bridge and non-Bridge students felt comfortable talking to for help or advice when each group of students first arrived at college (0.42 vs. 0.54, $p = .56$, Mann–Whitney *U*-test; Figure 1d).

Finding 2: Bridge students perceived that specific elements of the bridge program led to knowing more biology faculty and feeling more comfortable approaching biology faculty.

Because Bridge students were significantly more comfortable and had more connections with biology faculty than non-Bridge students, we explored Bridge student perceptions of what elements of the bridge program helped them to feel comfortable and helped them connect with faculty.

At least 25% of Bridge students mentioned all but one of the elements that were integrated into the bridge program to increase student comfort and connections with faculty (Table 4). Interacting with the faculty instructors of the bridge program was the

FIGURE 1

Bridge student comfort and connections with biology peers and biology faculty at the beginning of the bridge program and Bridge and non-Bridge student comfort and connections with biology peers and biology faculty at the beginning and end of their first semester in college (*M* ± *SE*). (A) There is no difference between Bridge and non-Bridge students' comfort talking with biology peers at the beginning or the end of their first semester in college. (B) Non-bridge students knew a significantly greater number of peers whom they felt comfortable talking to for help or advice at the beginning of their first semester in college than did Bridge students when they first started the bridge program. (C) Bridge students were significantly more comfortable talking to biology faculty both at the beginning and end of their first semester in college. (D) Bridge students knew a significantly greater number of biology faculty who they felt comfortable talking to for help or advice than did non-Bridge students both at the beginning and end of their first semester in college. *$p < .05$, **$p < .01$, ***$p < .001$, **** $p < .0001$, Mann–Whitney *U*-tests.

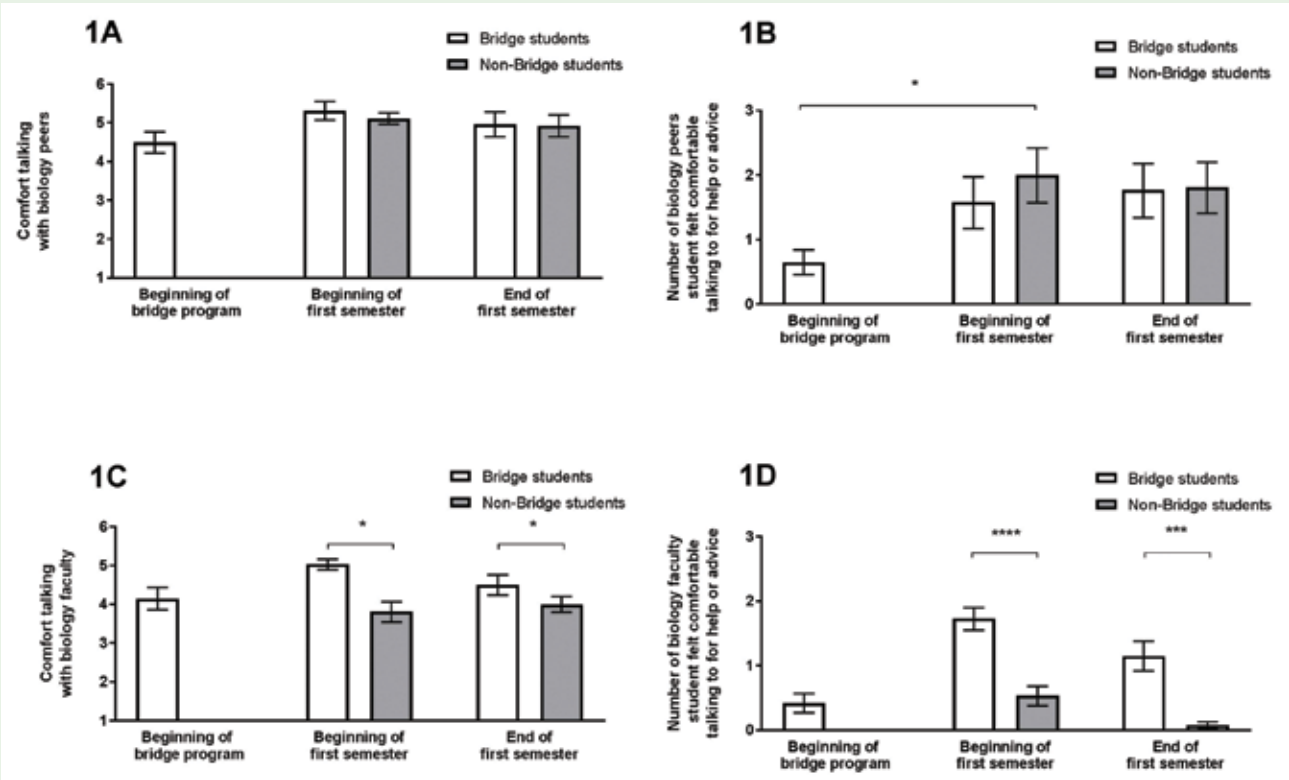

TABLE 4

Elements of the bridge program that program developers expected would influence student comfort and connections with biology faculty or elements of the bridge program that at least 25% of Bridge students mentioned influenced their comfort and connections with biology faculty.

Element of the bridge program	Description	Expected/ unexpected by bridge developers	% of Bridge students who mentioned each element	Example student quote
Interacting with bridge faculty who taught biology during the program	Two of the three primary bridge instructors are biology faculty.	Expected	83%	Simon: The bridge program helped you become more friendly with [faculty] just because you don't feel like it's them just lecturing you. It's more of like we're all interacting together and they're helping us and teaching us.
Subtheme: Interacting with bridge faculty who taught biology during the program: Bridge faculty immediacy	Students describe that they felt particularly comfortable with the faculty instructors of the bridge program because they were more immediate, or increased the physical and psychological distance between faculty and students. Examples of immediate instructor behaviors include learning student names, talking with students about things other than school, smiling at students, and using "we" language (Richmond, 1987; O'Sullivan, Hunt and Lippert, 2004).	Unexpected	67%	Daisy: I was definitely a lot more comfortable talking to faculty just because of them showing that they care about us. It definitely made me feel like, "Okay, I can talk to them. I feel more comfortable approaching them, in talking to them about things." They were calling us by name when we'd walk in like, "Hi, Daisy, how are you?" and they would talk to us during the class. They would walk around while we are doing our work and ask us how we are doing. They really made it feel like they cared about us learning.
Subtheme: Interacting with bridge faculty who taught biology during the program: Bridge faculty conversations with students during active learning activities	Students explain that interacting with faculty during active learning made them feel more comfortable with biology faculty. Students described that the practice of articulating their thoughts in front of bridge faculty made them more comfortable talking with other faculty. Further, many students indicated that because the bridge faculty responded positively to their wrong ideas, they felt more comfortable talking with other biology faculty.	Unexpected	33%	Nyla: When I came to university, you have a picture in your head that a professor is scary and they expect everything out of you and you need to know everything all the time (...) During bridge the faculty asked what we know and that made their teaching what it was. Just being around that more made me more comfortable and telling them what I didn't know and what I needed help on. (...) Even if you weren't correct, they were like, "OK, I understand why you're seeing this," and they could kind of work it out. It was more comfortable knowing, "Oh yeah, you're wrong," and people understand and accept your errors. They're not just there to correct you.
Explicit talk during the bridge program about why it is important to form relationships with faculty	Throughout the bridge program instructors talked explicitly about why forming relationships with faculty is important. For example, instructors referenced that faculty could connect students with helpful people such as other faculty or advisors, and that the faculty teaching their biology courses could help them with their content knowledge or help them get into a research lab.	Expected	67%	Simon: [During the bridge program] we went through what the benefits of reaching out to faculty are. We talked about the benefits it can bring and how there are almost no negatives at all to reaching out and discussing stuff with faculty.

TABLE 4 (CONTINUED)

Element of the bridge program	Description	Expected/ unexpected by bridge developers	% of Bridge students who mentioned each element	Example student quote
Having lunch with faculty during the bridge program	Three to six biology faculty came to eat lunch in the dorm cafeteria with the Bridge students nearly every day of the program. Students signed up to eat with at least two faculty members over the course of the program. Six students were assigned to eat with each faculty member during lunch but any student was welcome to sit with the group.	Expected	58%	Delilah: I remember that [the bridge instructors] were helping us break ice with some of the other biology faculty members by asking us to have lunch with them (…) One of the professors insisted on being called [by her first name]. I was like, "not Professor or Doctor or anything like that?" It felt very casual.
Learning how to write emails to faculty and sending emails to faculty	Bridge instructors taught Bridge students about how to construct emails to faculty. Bridge instructors reviewed e-mail etiquette and explicitly referenced how to address faculty, the importance of keeping e-mails concise, and the tone of an e-mail. Students then formed groups of two and used the university website to search for faculty whose research they were interested in. Students constructed e-mails to faculty asking to meet with them to talk about their research. Each e-mail was reviewed by a bridge instructor and then students sent the e-mail to faculty.	Expected	33%	Carmen: When they taught us how to write an email to a professor they told us different ways, different methods of writing the email. Interviewer: Why does knowing how to email faculty make you feel more comfortable with faculty? Carmen: I can collect my thoughts easier when I'm writing. I'm not just saying it out of the blue. I can compose my thoughts in my head as I write it down, and then prepare myself. I guess that helps me talk to professors easier, because I know what I'm trying to say.
Interacting with faculty during the poster symposium	During the bridge program students applied what they have learned about genetics by researching a genetic disease in groups of two. Students created a poster about their assigned disease, which they present on the last day of the program in a conference-style poster symposium. About 15 biology faculty attended and asked students questions about their poster.	Expected	25%	Sophia: Well I know for one thing when we did the posters and we had a bunch of different people view it, I think, coming in as a freshman, I was more comfortable talking to faculty so I think that really helped too.
The small class size of the bridge program	The size of the bridge program is limited to 40 students to allow for more one-on-one interactions with faculty.	Expected	25%	Sophia: I was definitely a lot more comfortable after bridge because I had those weeks with [the bridge faculty] before college started and it was a lot smaller classroom compared to going into a bigger classroom where [the intro bio instructor] has a lot of people to interact with.
Touring faculty research labs	Bridge students were split into three groups and toured four faculty research labs for 10 minutes each. Students had the potential to interact with faculty, graduate students, or undergraduate researchers.	Expected	0%	NA

most frequently mentioned element of the program (83%). Interestingly, two subthemes emerged from the interviews about specific aspects of students' interactions with faculty that helped students feel more comfortable with faculty broadly; the bridge developers did not specifically design these elements into the program. Sixty-seven percent of students described the bridge instructors as immediate instructors or instructors who increase the physical and psychological closeness between themselves and students (Mehrabian, 1971). Students gave specific examples of immediate instructor behaviors practiced by bridge faculty instructors such as using students' names or asking students questions (Cooper, Haney, Krieg, & Brownell, 2017; Freitas, Myers, & Avtgis, 1998) that helped students realize that biology faculty were approachable and willing to help students. Bridge students (33%) also cited that their interactions with faculty during active learning helped them feel more comfortable with biology faculty. Students explained that at the beginning of the bridge program, they expected to be lectured at and did not expect faculty to interact with students during class. Once students realized that the program was taught in an active learning way and that they were expected to talk with faculty about their understanding of biology, they assumed that the bridge faculty would be upset or disappointed with them if they shared incorrect thoughts. Students explained how their interactions with bridge faculty helped them to understand that it is OK to be wrong and that the instructors were there to support them.

The majority of students whom we interviewed (67%) mentioned that the instructors of the bridge program explicitly talked about how important it is to interact with faculty, which positively influenced their level of comfort. Specifically, bridge instructors talked about why it is important to develop relationships with faculty, which made students more comfortable and more likely to connect with faculty during the semester. Having lunch with biology faculty during the bridge program helped 58% of Bridge students realize that faculty were "real people" and caused them to feel more comfortable talking with faculty during the semester. Additionally, 33% of Bridge students discussed that learning how to write e-mails to faculty helped them to connect with faculty. A subset of students (25%) also acknowledged that the small size of the program was important because it meant that the bridge faculty were more likely to interact with them, which took the pressure off of the student to establish the relationship with the faculty member. Last, 25% of students highlighted that interacting with faculty during the poster symposium helped them feel more comfortable talking about biology with faculty, and surprisingly, none of the Bridge students mentioned that touring faculty labs increased their comfort and connections with biology faculty. It is possible that the student–faculty interactions during the lab tours were so brief that they had little influence on students' comfort with faculty.

Discussion

In this study, we found that Bridge students were no more comfortable and had no more connections with their biology peers than non-Bridge students. However, the bridge program appeared to have an impact on Bridge students' comfort and connections with biology faculty; Bridge students were more comfortable approaching biology faculty and knew more biology faculty who they could talk to for help or advice than non-Bridge students at the beginning and end of their first semester of college. We suspect that the summer camp, which occurred after the bridge program but before students' first semester in college, positively affected both Bridge and non-Bridge students' comfort and connections with biology peers. However, the summer camp did not seem to have the same effect on students' relationships with biology faculty, which may be because the camp provided many opportunities for students to form connections with each other but fewer opportunities for students to interact closely with faculty.

We found that specific elements of the program that had been designed to lead to greater student comfort and connections with faculty were perceived by Bridge students to lead to these outcomes. We also discovered unintended elements of the program that enhanced student relationships with faculty. The developers of this bridge program did not initially consider how immediate faculty behaviors or student–faculty interactions during active learning would positively affect students. However, more than half of the Bridge students highlighted that the bridge faculty practiced immediate instructor behaviors, which made them feel more comfortable with biology faculty. This is consistent with literature that suggests that instructor immediacy positively influences student comfort in the classroom (Chesebro & McCroskey, 2001; Cooper, Haney, et al., 2017). The bridge developers also did not design the bridge program in an active learning way

to increase student comfort with faculty, but one-third of the Bridge students explained that interacting with bridge faculty during active learning helped them feel more comfortable with biology faculty. Specifically, students described how bridge instructors practiced error framing or framed student mistakes as natural or useful, which has been shown to decrease student anxiety about making mistakes (Bell & Koz-lowski, 2008) and increase student motivation (Steele-Johnson & Kalinoski, 2014), but to our knowledge it has not been directly linked to student comfort with faculty.

Even though Bridge students reported a significantly greater number of faculty connections than non-Bridge students, the absolute number of faculty members whom students said that they felt they could go to for help or advice was low. Bridge students are only forming strong relationships with one or two biology faculty members, yet they had the opportunity to interact with over 17 different faculty members. Their interactions with these faculty members may not have been substantial enough for them to feel as though they could go to them for help. Alternatively, many of the faculty whom bridge students interacted with during the program taught upper level biology courses, and Bridge students may have not felt comfortable with or recognized the value of establishing relationships with faculty who are not teaching introductory biology. Interestingly, although Bridge students were more comfortable with faculty than non-Bridge students at the beginning and end of the program, Bridge students' comfort with faculty decreases slightly over the course of their first semester. We suspect that this could be because Bridge students encountered biology faculty during the semester who were less immediate than the bridge faculty.

Limitations

This study explored the impact of one bridge program at one institution, so broad generalizations should not be made. A limitation of this work is that we relied on student self-report about which aspects of the bridge program contributed to their increased comfort with faculty. It is possible that students may not have an accurate memory of which aspects were most helpful. However, self-report is often perceived as the most accurate way to glean information about student affective experiences such as their comfort with faculty.

Conclusion

A bridge program that was backward designed to increase student comfort and connections with biology peers and biology faculty increased students' comfort and connections with faculty, but not with peers. We identified aspects of the bridge program that students reported led to their increased comfort and connections with faculty members. We propose that bridge programs can be intentionally designed to help students feel more comfortable and build connections with faculty. ■

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References

Allen, D., & Tanner, K. (2007). Putting the horse back in front of the cart: Using visions and decisions about high-quality learning experiences to drive course design. *CBE—Life Sciences Education*, *6*(2), 85–89.

Ashley, M., Cooper, K. M., Cala, J. M., & Brownell, S. E. (2017). Building better bridges into STEM: A synthesis of 25 years of literature on STEM Summer Bridge Programs. *CBE—Life Sciences Education*, *16*(4), es3.

Bell, B. S., & Kozlowski, S. W. (2008). Active learning: Effects of core training design element on self-regulatory processes, learning, and adaptability. *Journal of Applied psychology*, *93*, 296–316.

Cooper, K. M., Ashley, M., & Brownell, S. E. (2017). A bridge to active learning: A summer bridge program helps students maximize their active-learning experiences and the active-learning experiences of others. *CBE—Life Sciences Education*, *16*(1), ar17.

Cooper, K. M., Haney, B., Krieg, A., & Brownell, S. E. (2017). What's in a name? The importance of students perceiving that an instructor knows their names in a high-enrollment biology classroom. *CBE—Life Sciences Education*, *16*(1), ar8.

Cooper, K. M., Soneral, P. A., & Brownell, S. E. (2017). Define your goals before you design a CURE: A call to use backward design in planning course-based undergraduate research experiences. *Journal of Microbiology & Biology Education*, *18*(2).

Chesebro, J. L., & McCroskey, J. C. (2001). The relationship of teacher clarity and immediacy with student state receiver apprehension, affect, and cognitive learning.

Communication Education, *50*, 59–68.

Creswell, J. (1994). *Research design: Qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *USA, 111*, 8410–8415.

Freitas, F. A., Myers, S. A., & Avtgis, T. A. (1998). Student perceptions of instructor immediacy in conventional and distributed learning classrooms. *Communication Education*, *47*, 366–372.

Ho, D. E., Imai, K., King, G., & Stuart, E. A. (2007). Matching as Nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis*, *15*, 199–236.

Hsieh, H.-F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*, 1277–1288.

Maton, K. I., Hrabowski, F. A., & Schmitt, C. L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching*, *37*, 629–654.

Mehrabian, A. (1971). *Silent messages* (Vol. 8). Belmont, CA: Wadsworth.

Mounts, N. S., Valentiner, D. P., Anderson, K. L., & Boswell, M. K. (2006). Shyness, sociability, and parental support for the college transition: Relation to adolescents' adjustment. *Journal of Youth and Adolescence*, *35*, 68–77.

O'Sullivan, P. B., Hunt, S. K., & Lippert, L. R. (2004). Mediated immediacy: A language of a liation in a technological age. *Journal of Language and Social Psychology, 23,* 464–490.

Pritchard, T. J., Perazzo, J. D., Holt, J. A., Fishback, B. P., McLaughlin, M., Bankston, K. D., & Glazer, G. (2016). Evaluation of a summer bridge: Critical component of the Leadership 2.0 Program. *Journal of Nursing Education*, *55*, 196–202.

Seymour, E., and N. Hewitt. (1997). *Talking about leaving: Why undergraduates leave science*. Boulder, CO: Westview.

Steele-Johnson, D., & Kalinoski, Z. T. (2014). Error framing effects on performance: Cognitive, motivational, and affective pathways. *Journal of Psychology*, *148*, 93–111.

Stemler, S. E. (2004). A comparison of consensus, consistency, and measurement approaches to estimating interrater reliability. *Practical Assessment, Research & Evaluation*, *9*(4), 1–19.

Richmond, V. P. (1987). The relationship between selected immediacy behaviors and cognitive learning. *Communication Yearbook, 10,* 574–590.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research*, *45*, 89–125.

Tinto, V. (1987). *Leaving college: Rethinking the causes and cures of student attrition*. Chicago, IL: University of Chicago Press.

Wiggins, G., & McTighe, J. (1998). *Understanding by design.* Alexandria, VA: Association for Supervision and Curriculum Development.

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