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# Interdisciplinary Research in a Dense Summer Bridge: The Role of a Writing Intensive Chemistry Seminar

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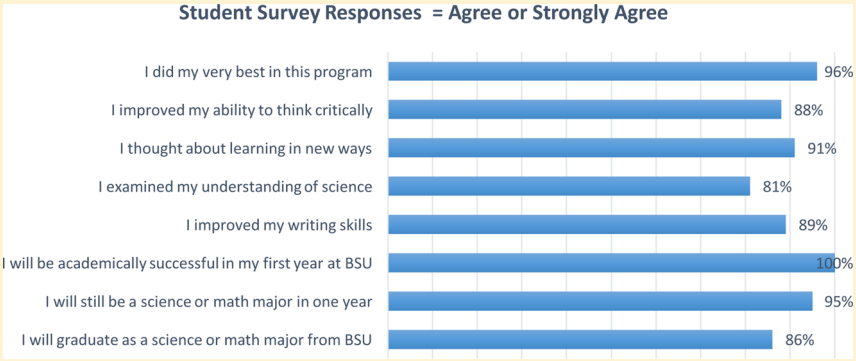
Supporting Information




**ABSTRACT:** We describe the structure of a writing-intensive, chemistry first year seminar designed to support a three week, research focused summer bridge program. Writing assignments in the seminar helped students understand their research activities, learn to conduct themselves as scientists, and reflect upon their lab work. The writing intensive seminar helped to maintain order and cohesion across multiple research groups. The participants in the program have experienced higher rates of retention and graduation in STEM fields as well as higher rates of participation in high impact practices than their peers.

**KEYWORDS:** *Communication, Writing, Undergraduate Research, Collaborative, Cooperative Learning, Inquiry-Based, Discovery Learning*

## INTRODUCTION

Summer bridge programs have the potential to greatly enhance the prospects of incoming college STEM majors. Effective programs include opportunities for students to work with peers and faculty engaged in impactful research projects. The transformational aspect of exposing college students early on to research is well documented in the literature.[1−6] Both the Writing Across the Curriculum and STEM literature indicate that connecting scientific and reflective writing to these research experiences enhances the experience and learning of the students, creates opportunities for critical thinking, and sets expectations for college level scientific inquiry.[7−10] The inclusion of community building and peer-led team learning are known to be critical support mechanisms for accelerated student programs.[11−14] Combining these aspects with common intellectual experiences and collaborative assignments enhances retention particularly within underserved groups.[15−17]

However well-known these results are, summer bridge programs remain uncommon, in large part because they are challenging to design due to their complexity and cost. At Bridgewater State University (BSU) we have been able to design and implement an effective summer bridge program that has resulted in the success of the student participants and positive responses.

### The NSF STEP (STREAMS) Grant

In 2010, BSU was the recipient of a 5-year, $1 million NSF STEP grant (STREAMS) which sought to increase the number of BSU's graduates in science and mathematics by increasing STEM retention. The summer bridge was a core feature of the grant and mirrored the other STREAMS programs which were the revision of introductory STEM courses, use of peer mentoring, residential learning communities, and project based research activities.[18] The STREAMS programs offered during the academic year benefited significantly from the leadership and strong participation of students that completed the summer bridge.

### The STREAMS Summer Bridge Program

The summer bridge was a three week NSF funded residential program for incoming science and math majors. The program was structured for 16 incoming freshman STEM majors to engage in activities and acclimate to college level work prior to their first year. The summer bridge program was designed to retain more students in STEM through its programming and to

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encourage the academic careers of a diverse group of students who would become leaders at BSU.

Table 1 describes the students enrolled in the STREAMS summer bridge program and how these students compared with their peers of first-time, full-time (FT-FT) freshmen during the five years that the program ran. At BSU, most FT-FT freshmen have declared majors, and BSU STEM majors are defined as students majoring in biology, chemistry, computer science, geology, mathematics, or physics. BSU has no engineering programs. We see that BSU STEM majors are slightly more diverse ethnically compared to the overall student body, and that the summer bridge program was slightly more diverse than the STEM majors. Summer housing arrangements promoted an equal balance of women and men in the program. Summer bridge participants were not on average better prepared for college based on SAT scores than the incoming STEM classes. The summer bridge students enrolled in a summer math course to prepare them for their fall precalculus and calculus courses. As a result, the summer bridge students had to place into these courses to be considered and this pool had slightly higher SAT scores than their nonparticipant peers.

**Table 1. Demographic and Preparatory Factors of BSU First-Time, Full-Time First Year Students**[a]

| BSU Student Categories | All BSU FT-FT Students | All STEM FT-FT Students | Summer Bridge Students |
|---|---|---|---|
| Av annual *N* | 1453 | 191 | 15 |
| Students of color | 20% | 27% | 35% |
| Women | 59% | 53% | 55% |
| Av SAT | | | |
| Math | 508 ± 71 | 529 ± 78 | 548 ± 79 |
| Verbal | 499 ± 76 | 501 ± 83 | 522 ± 92 |

[a]Although the summer bridge program was slightly more diverse than the BSU average, there are no statistically significant differences in the demographic or preparatory factors of the summer bridge participants.

Students were enrolled in a math course designed explicitly for the summer bridge program to strengthen their quantitative reasoning skills. Students were also enrolled in a chemistry first year seminar (FYS), Scientists at Work (see Supporting Information), that was connected to both their residential experience and their research activity. Each summer, students worked in small teams conducting research in departments ranging from biology to chemistry, computer science, geology, math, and physics. The research work was a highlight of the program in which students were mentored by faculty and senior undergraduates. The residential component fostered group work and growth by the participants as they benefited from having peer mentoring in their classes, research laboratory, evening study sessions, and their residence hall. The residential programming was designed to accelerate socialization, build leadership abilities, and develop their abilities for group work. Students were paid for their participation, earned grades in their two courses, and earned 6 credits toward graduation. The general schedule included two courses in the morning, research in the afternoon, and work with mentors in a peer cooperative-learning format on assignments in the evenings. An overview of the summer bridge program structure, a description of the chemistry seminar's core role in supporting students writing about their research, and the retention and graduation rates of participants are detailed in this paper.

## Selection of Students

Each spring, we worked with the Dean of Science and Mathematics to send e-mails and arrange information sessions for the declared incoming science and math majors. Additional phone calls and e-mails were used to explain the summer bridge program in greater detail. At the start of each summer, interested students were encouraged to take their mathematics placement and writing skills tests in an early orientation session which is required of each BSU student. Interested candidates were asked to participate in an interview with the summer bridge coordinator and write two essays. In the essays, students were asked to write about their strengths, weaknesses, goals, and what they hoped to gain from participating in the summer bridge program. Their placement scores, essays, and interviews were used as criteria to select candidates.

The selection of the student participants, student mentors, and faculty advisors was critical due to the short length and rigor of the summer bridge program. Key requirements of any student or mentor involved in the summer bridge was placing a high value on the opportunity and a willingness to fully engage with their peers to meet the program requirements.

We actively tried to recruit students that had one barrier to their success. For example a student that just made the cut into precalculus, a student that did not excel in writing, or a student that was not accustomed to working with others on projects would be a potential candidate. However, we avoided the recruitment of students that might have multiple barriers or very low math scores, or were not earnestly interested in the program. Additionally, an emphasis was placed on having a strong representation of traditionally underserved groups including students of color, low income students, and first generation students. As a result, each year we were able to recruit an inclusive cohort with a range of abilities that were eager to participate in the program and support their peers.

## Summer Bridge Program Staff

The bridge program was organized by a summer coordinator working with the FYS and math course instructors. This team of three faculty members oversaw the recruitment of student participants, upper class student mentors, and faculty lab advisors. Typically, the program had 4−5 student lab mentors and 4−5 faculty lab advisors, and 2−3 peer mentors to assist with student writing, the FYS class, and the math class. There were two residential assistants that worked closely with the coordinator and course instructors to assist the students. Over the five years that the program was offered, the support staff once reached a 1:1 ratio of staff to student participants, but was usually lower due to a person filling several roles. Many of the student and faculty staff mentors were involved in some way in a prior summer bridge program, which was a key support strategy.

## The Integrated Science and Mathematics Course

Prior to grant implementation, precalculus and calculus courses at BSU had high rates of students earning D, F, or W grades over 30% for STEM majors enrolling in precalculus or calculus as a cognate or introductory major course. With this in mind, the STREAMS summer bridge program wanted to create a course that would support students in their fall mathematics course but also improve quantitative reasoning skills in a way relevant to the introductory courses in the nonmathematics majors. Math 125, Integrated Science and Mathematics, or ISM, was created to serve this purpose.


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ISM met daily throughout the program, with a heavy emphasis on homework. The course was neither precalculus, nor calculus, nor a math "boot camp". Rather, topics were drawn from introductory biology, chemistry, geology, computer science, and physics assignments and laboratories, as well as from the research projects of the summer bridge. This connected a higher level of mathematical sophistication directly to the courses students would be taking in the fall and supported the research projects.

### The Chemistry FYS and Research Experience

All BSU freshman students take a writing intensive first year seminar (FYS) with a focus on writing within a discipline. The rationale for these courses is that, by writing, one learns to organize thoughts, find and present evidence, and compose a thesis. FYS courses satisfy area distribution requirements in BSU's core curriculum. The bridge students met this requirement with the chemistry FYS, which directly supported the students' 40 h of research work on projects designed by a faculty member and co-led by an upper-class peer mentor.

Our model involved students attending FYS classes at least four times per week for 90 min per session, resulting in 20 h of formal class time. Students regularly met with their peer research mentors over lunch and had discussions about their progress. In the afternoons, students worked on their research with the peer mentors and faculty. The research projects that worked the best were "side projects" created by the lead faculty member that were part of larger undergraduate research projects.

A key benefit of this model was the smooth transition from class based work to informal discussion, to research activity. The chemistry FYS combined online writing activities, in-class instruction, and actual hands-on research experiences during the official "class" time. The seminar supported the research with writing assignments that enabled students to think about what they understood, what they needed to learn, and how best to continue their research. Assignments were reviewed by the course instructor, peer research mentors, and the faculty member who led the research group. In this way, all stakeholders in the student research projects were able to ascertain student understanding on a daily basis. The 3 weeks of the FYS systematically introduced students to the activities required to be a scientist. The ultimate program goal was to change the mind-set of the participants from a "passive" to an "active" view, where the students began to see themselves as scientists at work.

### The Chemistry FYS Online Writing Blogs

Blog prompts came in three varieties, ranging from reflective writing which focused on student metacognition regarding what they were learning, less formal writing where students could write somewhat freely about their research work, and pieces designed to add up to formal sections of a paper or poster presentation. The early prompts encouraged a combination of reflective writing on their expectations and their understanding of the lab work. Students were required to write about the significance of their work, and later about the equipment and techniques they employed. By explicitly making students write about what they were trying to learn, their learning was accelerated and they were able to make meaningful progress in the laboratory. Because the blogs were public, they provided instant feedback to the lab mentors so that misunderstandings could be corrected the next day. As the summer program progressed, the FYS course served to scaffold the blog writing, the peer reviewed short essays, and the individual writing for the final product posters and papers.

### The FYS Classroom: Preview Day

Five weeks prior to the summer bridge program, a preview day was held for the students, student mentors, and faculty advisors to attend and learn about the program requirements, schedule, and resources. The courses were explained, and students were given the assignment to create their own blog site, respond to several writing prompts, and comment on their peers' blog entries. These blogs were the primary place that student writing was collected, and using public blogs enabled them to both receive and provide feedback with their peers prior to the summer bridge. The public writing choice was intentional as the first year writing literature indicates that student writing improves when the writing has real stakes and these stakes are made public.[19] The student mentors gave presentations about the available research projects in the summer bridge. The student mentors and faculty conducted lab tours and further discussed the projects to assist students in ranking their group choice. Afterward, the research groups were created and participants were provided with background information.

### The FYS Classroom: Week 1

The first class session was spent reading and annotating scientific papers written by some of their upper-class lab mentors. The bridge students learned how their more experienced peers were able to compose an informative background, structure a scientific paper, and write in a direct manner. The bridge students began to brainstorm about hot topics to write their first hot topic paper and wrote drafts, engaged in peer review, and revised their papers. We did not presume that the incoming students understood anything about the conduct of research, either in a lab or in a research paper. We found that students arrived with different levels of confidence and capability to independently start their writing projects. First year students often have a poor understanding of the academic expectations of citation and how to effectively write about science.[20] Therefore, the first "hot topic" paper explicitly described ways to cite evidence from sources in the manner of communication in scientific papers. They also began to blog regularly about their initial goals for the program, the residential experience, and mainly their research activities.

Each day, students were immersed in their collaborative undergraduate research, which led to rich nightly blog writing. Students began to explain their research projects, methods and equipment they were using, and overall project in a general manner. In this way, the students were moving at the same pace toward shared goals and they were able to incrementally refine their understanding of their research work through their writing. The students' blogs were responses to specific prompts designed to help them think about where they were in their research and how their work would eventually form the formal sections of a scientific paper and their research poster. The student and faculty lab mentors would provide resources and support to help the students write their blog entries and feedback on their understanding of the projects after reading their blogs.

### The FYS Classroom: Week 2

The continued in-class activities of reading student research papers and participation in peer feedback helped students see the structure of research writing in different STEM disciplines and learn more about their own projects.[9] The second hot topic



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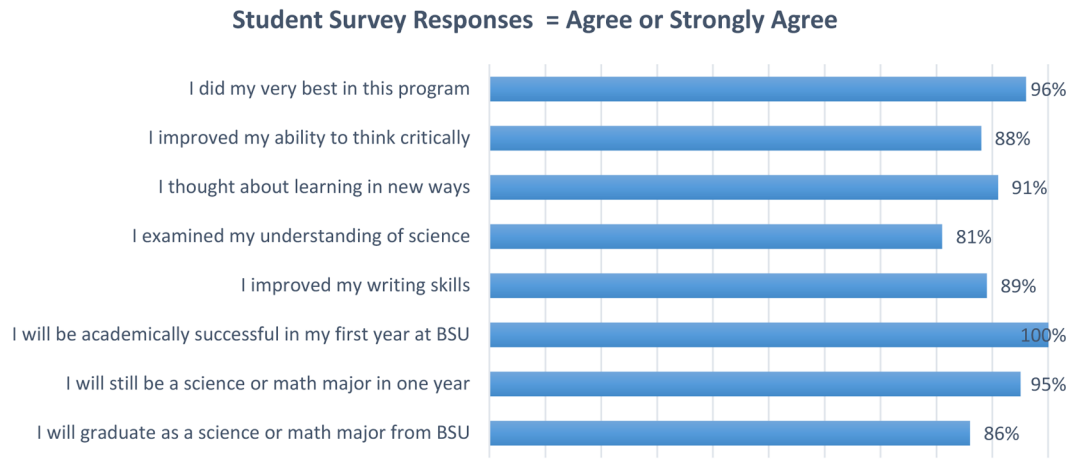


**Figure 1.** BSU STREAMS Summer Bridge Assessment Survey results for 2010−2014 participants. Summer bridge participants reported high levels of agreement (either agree or strongly agree) on 5-point Likert scale survey items given at the conclusion of the summer program on items showing an increase in perception of skills and STEM success.

paper was expected to be longer and possess greater detail, and it was evaluated more critically. Students were encouraged to use technical papers as sources in support of their hot topic paper and make more convincing arguments. Students worked to make their blog writing more precise and technical as they began to collect data. Their blog entries began to model the scientific papers read in class as they revised their earlier blogs into more technical versions. This was the start of their abstract, introduction, methods, data, discussion, and significance sections for their posters.

### The FYS Classroom: Week 3

The third week involved less time in the research lab, but enlisted the peer mentors to help students with their writing and understanding of their research activities. Students worked in their teams to fine-tune their contributions and construct the early sections of a joint poster for the team. The group then refined their writing, practiced presenting, and revised their poster content. Ultimately, peer leaders helped the students construct professional posters at the level of sophistication one would expect to see at an undergraduate research conference. Students then focused on how to present the scientific work on their posters to a broad audience to prepare for their formal presentations at a closing banquet. The third week's blog assignments were reflective assignments or metacognition assignments that enabled the students to reflect upon their accomplishments and growth during the bridge program. Most students worked very hard during the 3 weeks of this program to meet all of the requirements in a balanced manner.

### Summer Bridge Program Assessment

The STREAMS summer bridge program had both long-term and intermediate outcomes. As a long-term outcome, we hoped to directly assist a core group of about 10% of the incoming first year science and mathematics majors in their studies and increase the retention and graduation rates of this group. As more-intermediate outcomes, we hoped that the students in the summer bridge program would make gains in academic and social self-confidence. In addition, we hoped that summer bridge participants would become leaders in other grant components and participate in higher numbers in high-impact practices available at BSU to junior and senior level students.

All 74 summer bridge students participated in exit surveys in the weeks after completing their summer program. BSU's Office of Assessment generated reports each year detailing the student responses. In addition, concluding blog entries asked students to reflect on their initial goals for the program. These final reflective assignments helped students become aware of just how much they had learned, and how hard they were actually capable of working. The surveys and reflective blog entries were all used throughout the five years for continuous program improvement and were intended from the start to be part of the STREAMS summer bridge assessment plan.

While the research accomplishments of the students during the summer bridge program were modest, the process of learning how to conduct research using sophisticated equipment, beginning to write scientifically, and making a professional public presentation was transformative. Figure 1 reports the students' feedback regarding their perceptions of the program and their prospects as STEM majors at BSU over the five years of the program. The vast majority of bridge participants believed that they were exiting the program with stronger writing and critical thinking skills. They also reported significant levels of confidence that they would be successful in STEM studies, that they had learned to think about science in new ways, and that they had done their best in the program.

Annual surveys given at the conclusion of the program also indicate that students felt a strong sense of community and bonding to the university, both of which are key elements correlated to student retention. Open ended survey responses from students included the following:

- "The student and faculty mentors were extremely supportive and I cannot imagine going through this program without them. They were genuinely interested in our success."
- "This program taught me a lot about myself and helped me realize that there is a community at BSU that I want to be involved with."
- "The program made me realize how important science is and how to deal with an intense workload. I want to come back next year as a lab mentor or peer leader."
- "This experience and the people I have met has helped me to realize that there is more than just what I have seen out there and more to learn about college."


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In addition, many students felt more confident in their ability to be successful given their experiences in the summer bridge. They reported increases in academic confidence (see Figure 1), and some students phrased this increase in confidence in very concrete terms.

- "When I first came here I felt stupid. I felt that my high school did not prepare me and now I feel more confident."

The following excerpts were taken from the last blog entries of several students from our last summer bridge program and represent the significant impact of this short program on the students:

- "Looking back from the first day to now, I have learned so much over the course of 3 weeks. I have made a lot of new friendships that will go beyond STREAMS. My favorite part about this program was getting the chance to work on a research project in the lab. Every day I looked forward to spending time in the lab, I always left with some new piece of information."
- "Overall, I have had a fantastic 3 weeks here. I have made friendships that I know will last for a long time, and I have learned more than I could have even imagined. I learned basic biology, some chemistry, refreshed my mathematics skills, and I learned about Alzheimer's disease, I learned about my peers, and met so many people along the way, and through all of this, I have grown as a person."

Bridge students went on to become leaders on campus at BSU as 41 of the 74 participants (55%) participated in other high impact practices as STEM majors. This includes 23 students who received a semester or summer undergraduate research grant through BSU programs for Undergraduate Research, 18 students have who served as peer leaders for the introductory STEM courses, and 28 students who have been involved in outreach work through BSU's Center for the Advancement of Science Education.

### Student Retention and Graduation Rates

It is important to note that the summer bridge was not composed of only top students, but instead was broadly representative of our incoming STEM freshman class in regard to their gender, average SAT scores, and placement exams. Although the summer bridge was more inclusive of students of color than the incoming class, the overall combined number of students of color, first generation, and low income students broadly matched our incoming STEM freshman class each year.

The summer bridge participants performed better than their peers in their initial semester in college, which the literature shows is strongly correlated with student retention in STEM fields.[21−23] The average DFW rate of STEM majors in the major's gateway course was 16.6% while the summer bridge participants had a DFW rate of 9% from 2010 to 2014. Because of this better course performance, over 90% of the program participants were retained at the university for a second year of studies, which is above the 80% rate for the university in general. More significantly, 72% of program participants were retained into their junior year of STEM studies, compared with 60% of STEM majors overall during this time period. This difference is significant at the $p < 0.01$ level.

Figure 2 shows the percentage of each cohort who have graduated or are still pursuing studies at BSU. Each bar represents the percentages of students from that year's summer bridge cohort who graduated or are still enrolled at the university, either in STEM or generally. Because of the small numbers of students in each cohort, we provide these percentages as descriptive statistics and do not test for statistical significance.

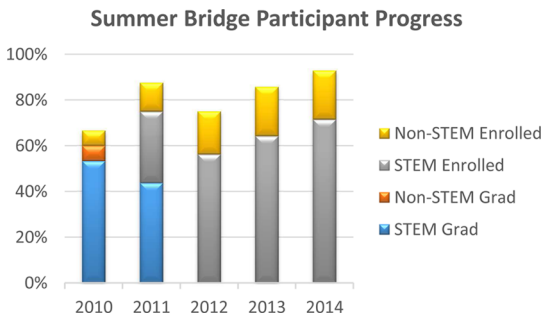


**Figure 2.** The overall academic progress of summer bridge participants as of the end of the fall 2015 semester. In blue and red bars, we show the number of students who have graduated with STEM and non-STEM degrees, respectively. In gray and yellow, we show the percentage of students still enrolled at BSU in the fall 2015 semester in either STEM or non-STEM majors. Summer bridge participants exceed the university average in retention in science and math fields at all years, and will likely exceed the overall six-year BSU graduation rate of 59%.

We note that the four year graduation rate of the 2010 cohort for the university as a whole was 29%, but 60% of the participants in the 2010 cohort graduated in four years, with 8 graduates in STEM. For the 2011 cohort, over 40% of participants graduated with STEM degrees in four years, and over 80% are still on track to graduate within six years. More recent cohorts remain enrolled at BSU in very strong numbers exceeding 75%, with over 50% of students likely to graduate in STEM annually.

## SUMMARY

The structure of Scientists at Work is based on research that connects early research experiences and other high impact practices with student retention within STEM, particularly for traditionally underserved students. We find that the writing intensive, chemistry first year seminar described in this paper was key in providing a structure for students to succeed in this program in a number of ways. First, the writing assignments concretely taught students how to go from a rough, basic idea of what is going on in their research project to a technical description following standard formats within the discipline. Second, the FYS structure enabled multiple research groups to equally progress toward program goals in an abbreviated time period. Finally, the reflective writing was important in helping the summer bridge participants understand and appreciate how much they had learned in a short time, and how high they could reach while at Bridgewater State University.

## ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b01019.

Specific course assignments and rubrics for grading blogs and reflective work (PDF)



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### Notes

The authors declare no competing financial interest.

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