

Science Bootcamp Goes Virtual: A Compressed, Interdisciplinary Online CURE Promotes Psychosocial Gains in STEM Transfer Students[†]

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Course-based undergraduate research experiences (CUREs) are well-documented as high-impact practices that can broaden participation and success in STEM. Drawing primarily from a community of practice theoretical framework, we previously developed an interdisciplinary CURE course (Science Bootcamp) for STEM majors focused entirely on the scientific process. Among first-year students, Science Bootcamp leads to psychosocial gains and increased retention. In the current study, we test whether an online Science Bootcamp also improved outcomes for STEM transfer students—a group that faces “transfer shock,” which can negatively impact GPA, psychosocial outcomes, and retention. To this end, we redesigned Science Bootcamp to a 2-week course for STEM transfer students to complete prior to beginning the fall semester at our 4-year institution. Due to the COVID-19 pandemic, the course was conducted in an entirely virtual format, using primarily synchronous instruction. Despite the course being virtual, the diverse group of STEM majors worked in small groups to conduct rigorous, novel empirical research projects from start to finish, even presenting their results in a poster symposium. Assessment data confirmed the compressed, online Science Bootcamp contained key CURE components—opportunities for collaboration, discovery and relevance, and iteration—and that students were highly satisfied with the course. Moreover, in line with our hypothesis, STEM transfer students who participated in the online Science Bootcamp experienced a range of psychosocial gains (e.g., belonging to STEM). In sum, these findings suggest our online Science Bootcamp promotes positive STEM outcomes, representing a highly flexible and affordable CURE that can be scaled for use at institutions of any size.

INTRODUCTION

Efforts to broaden participation and success in STEM have identified research experiences as essential to improving outcomes for STEM undergraduates. Course-based undergraduate research experiences (CUREs) have become recognized as an efficient, cost-effective, and logistically feasible means to deliver research experiences to a wide range of students (1, 2). These courses mean that more students can take advantage of the benefits of engaging in research experiences, which are well documented (3–7). For example, by participating in CUREs, students can experience cognitive, behavioral, affective, and/or psychosocial gains (8), many of which predict persistence in STEM (9–11).

Typically, CUREs include the following components: use of scientific practices, collaboration with a research team, investigation of broadly relevant or important work containing elements of discovery, and opportunities for iterative thinking and behaviors (12). Yet, CURE design has not been standardized, taking on different forms at various institutions: CUREs can vary in level of project ownership (13), duration (14), assessment (15), and target audience (e.g., nonmajors, introductory students, upper-level majors) (8), to name a few. This variability in CURE design is simultaneously a strength, as CUREs are maximally flexible, and a weakness, as CURE outcomes are difficult to synthesize and model (12, 16, 17).

We previously developed a CURE model (Science Bootcamp) in response to institutional needs demanding greater support of first-year STEM majors (18, 19). The Science Bootcamp CURE is one piece in a series of interventions within the KEYSTONE (KEYs to Success Through year ONE) Program. In developing this CURE, we sought to concurrently support first-year STEM students and address limitations present in the bulk of existing CURE models, including a lack of a guiding theoretical framework (8, 20), a tendency to focus on discipline-specific projects

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in the context of a majors course (14, 21), and a failure to include appropriate assessment measures and/or optimal research design features (22–24). To this end, we developed our Science Bootcamp CURE for first-year STEM majors to meet key CURE criteria while drawing on community of practice theorizing (20, 25, 26), social cognitive theory (27), and self-determination theory (28, 29). We deliberately designed the Science Bootcamp as an interdisciplinary course focused on broad training in the scientific method, with the CURE uncoupled from discipline-specific content. Finally, we assessed the Science Bootcamp using valid and reliable measures and used a rigorous research design to test hypotheses. Our results show that this 4-week, face-to-face Science Bootcamp meets CURE criteria, promotes psychosocial gains, and is associated with significantly greater retention and graduation rates in STEM majors (19, 30).

Given the success of the Science Bootcamp among first-year STEM majors, we recently redesigned the CURE to support another type of first-year student we saw struggling at our institution—STEM transfer students. “Transfer shock” is a well-researched phenomenon among undergraduate students who begin their academic career at one institution and transfer to another institution, where they encounter unanticipated academic and adjustment difficulties (31–33). Although a temporary adjustment period is normal for all undergraduate students, the impact of transfer students’ lack of a sense of belonging, especially when it leads to a lower GPA, can have lasting consequences, including an increased likelihood of withdrawal from the institution (34). Studies have shown that transfer students benefit from personalized supports for social interaction and community connectedness, academic credit guidance, and campus resource connections (31, 35, 36). Research experiences can also provide such supports. Indeed, participation in research experiences can facilitate inclusion at 4-year institutions for transfer students (37). We expected that a modified version of our Science Bootcamp CURE course—which establishes a STEM community of practice and promotes psychosocial gains (19)—would be an ideal mechanism to support STEM transfer students’ transition to our 4-year university. Thus, we designed the CURE course for a 2-week timeframe just prior to STEM transfer students beginning their first semester at our institution.

The first cohort of STEM transfer Science Bootcamp students was slotted for August 2020—during the height of the COVID-19 pandemic. As a result, we had to pivot quickly to adapt the 2-week Science Bootcamp to an online environment while still maintaining the pedagogical integrity of the CURE. We offered primarily synchronous online instruction, and data collection was entirely virtual (38). Here, we describe the full details of our online interdisciplinary Science Bootcamp CURE for STEM transfer students and offer assessment data that validate the CURE course design. We also test the hypothesis that students who participate in an online, compressed, authentic interdisciplinary CURE will experience psychosocial gains.

METHODS

Participants

STEM transfer students majoring in biology, biochemistry, chemistry, computer science, environmental studies (B.S. degree), information systems, mathematics, or physics were invited to participate in the online Science Bootcamp. The final cohort ($n = 13$) was diverse with respect to gender (7 females, 6 males), race (7 white, 3 Hispanic, 2 Black, 1 Hispanic/Black), age (19 to 30 years, mean = 21.77, SD = 3.27), and STEM major (7 biology, 4 computer science, 1 chemistry, 1 math). Most students (76.9%) demonstrated significant financial need, and 46.2% of the students identified as first-generation college students.

Course design and logistics

The online Science Bootcamp was co-taught by three STEM faculty from different disciplines or subdisciplines (the co-authors), with occasional project support from peer mentors (upper-level STEM majors), providing breadth to the project mentoring (39). Peer mentor selection occurred as previously described, specifically focusing on junior and senior STEM transfer students who showed an “ambassador skill set” (18). The Bootcamp was held in August 2020, 2 weeks prior to the STEM transfer students’ first semester at our 4-year university. The timing of the course was intentional, to use a CURE as a transitional experience for STEM majors. Although it took place before the semester began, it was loaded as a fall semester course so that students avoided paying additional summer tuition.

The online Science Bootcamp course learning outcomes were focused on scientific practices, such as experimental design and presenting findings. The “behind-the-scenes” objectives of the course—and the foundation of our research hypothesis—were to create a STEM community of practice and promote psychosocial gains, including STEM belonging, science self-efficacy, and science identity. To this end, the three-credit hour course was conducted online synchronously using the course management system Blackboard Collaborate Ultra. The course met for 36 contact hours over a 2-week period. The first week was a true “bootcamp” experience in which students were in class from 9 a.m. to 4 p.m. Monday through Friday. The second week students were in class for one full day (9 a.m. to 4 p.m.) and one half-day (9 a.m. to 12 p.m.) to accommodate orientation and move-in schedules on campus. The final poster presentation to the campus community occurred during a “common hour” the first week of the fall semester (see Appendix 1 for Course Syllabus and Schedule).

At the beginning of each class session in the morning and after lunch, students participated in 5- to 10-minute getting-to-know-you “ice-breakers.” These activities—polls, fun science facts, and games—enabled discussion among students and faculty and provided opportunities for faculty

to share narratives of their own journeys in STEM. During the first week we also invited a panel of guest visitors from the Counseling Center, Learning Center, and Office of Diversity and Inclusion. The goal of these activities was to build community among the diverse STEM transfer students, a critical component of a community of practice (40). The effects of these activities were best seen when students broke into research groups and already had a sense of community between members, which encouraged more effective group work. The remainder of synchronous class sessions was dedicated to mini-lectures and group discussions with the entire class. Significant blocks of time were provided for students to work in their CURE project groups, with faculty and peer mentors intermittently present to support students. When students worked in their research groups, there was more flexibility in activity and scheduling. Outside of class, students engaged asynchronously with faculty-recorded videos relevant to the CURE project steps, such as how to search for articles, preparing an oral or written proposal, using statistics to analyze data, and preparing a poster. Students also completed readings and course assignments outside of class.

At the heart of the online Science Bootcamp was the interdisciplinary CURE, which enabled students to engage in collaboration, discovery and relevance, and iteration—the key components of CUREs (12, 16, 22). To begin the research project, students took part in a “meet and greet” using breakout rooms in Blackboard Collaborate. First, students were asked to simply discuss their broad interests in science, with groups shuffled periodically so students could mingle with the entire class. Second, faculty project mentors visited groups of students and shared potential themes and virtual methods that could be used during the course (see Appendix 2 for a detailed description of research projects). The faculty used information gathered from an online student preference survey to create three CURE project groups. Once formed, groups met in breakout rooms to discuss provided topics and methods and were later joined by their faculty mentor. The students’ first CURE assignment was to read an empirical paper assigned by the instructor, selected based on student interests, to maximize students’ sense of autonomy (13). They were also instructed to find and read an additional empirical paper that seemed related and interesting. In the next group meeting, CURE groups discussed their “literature base,” developed a novel hypothesis, and designed an experiment to test their hypothesis using virtual methods. Each of these steps was supported by faculty and peer mentors.

After finalizing their research designs, students used PowerPoint to orally present their project proposal to the entire class. The oral proposal was designed to be an opportunity to give and receive feedback prior to data collection and to expose students to “lab culture.” Based on the feedback obtained during oral presentations, groups drafted a written project proposal. After receiving feedback on their written proposals and modifying their research

design, CURE groups obtained data from an online database, museum collections, or collected online experimental data from a human sample via an online marketplace. Students then analyzed their data, constructed graphs, and drafted posters with the support of their faculty and peer mentors. Finally, CURE groups presented their posters at a virtual symposium open to the campus community during “common hour” the first week of fall semester. At the completion of the Bootcamp, all students received an Elmhurst University t-shirt adorned with the campus mascot dressed as a scientist and the phrase “I Survived Science Bootcamp.”

Course assessment measures

Lab Course Assessment Survey (LCAS). To ensure the online Science Bootcamp contained key CURE components, an online version of the LCAS was administered on the last day of class. The LCAS assesses course design of lab courses on three key dimensions: collaboration, discovery and relevance, and iteration (22). Previous research demonstrated that the LCAS differentiates between traditional biology lab courses and CUREs, with CURE students scoring higher on the discovery and relevance and the iteration subscales. All items were assessed on a 1 to 5 (strongly disagree to strongly agree) scale. For scale items, alphas, percentage agreement, and descriptive statistics are shown in Table 1.

Course feedback survey. To assess a range of course objectives, an online course feedback survey was administered on the last day of class. To collect quantitative data, the course feedback survey assessed satisfaction with the overall course and class activities, helpfulness of faculty project mentors and peer mentors, and gains from the poster symposium. These items were all assessed on a five-point scale. Additional items were included with a yes/no response format, such as “Would you recommend the course to future incoming STEM transfer students?” To collect qualitative data, the course survey asked, “What was the most valuable aspect of the Science Bootcamp?” and “Any last comments, questions, concerns?” For quantitative survey items, percentage agreement, and descriptive statistics, see Table 2. For sample responses to qualitative questions, see Table 3.

Psychosocial outcomes. To assess psychosocial gains, students responded online to a comprehensive set of psychosocial measures pre-CURE (2 weeks before class) and post-CURE (after the poster symposium). These were all reliable and valid scales adapted from previous research and included: “STEM Community of Practice Index” (19), belonging to university (29), belonging to STEM (29), academic self-efficacy for STEM (29), science self-efficacy (29), science identity (29), intent to leave STEM (29), expectancy for STEM career (29), and life satisfaction (41). All items were measured on seven-point scales constructed using means, with higher scores representing higher values of the construct. For Cronbach’s alphas at pre-CURE and post-CURE, see Table 4.

Informed consent and institutional review board protocols

Students signed an informed consent form prior to participating in surveys. The university's Institutional Review Board determined the protocol fulfilled the necessary requirements for human subject research.

RESULTS

The online KEYSTONE Science Bootcamp contains key CURE components

We first sought to verify that the online Science Bootcamp contained key CURE components as theorized by the CURE literature (12, 16) and assessed by the LCAS (22). As can be seen in Table 1, STEM transfer students overwhelmingly agreed that the course promoted opportunities for collaboration and for discovery and relevance. A majority of students also agreed that the course promoted opportunities for iterative thinking and behaviors, but the results were more varied, which was not surprising given the timeframe of the course. We noted that the means for each of the LCAS subscales for our sample of Science Bootcamp STEM transfer students are comparable with the scores reported in the LCAS validation paper (22) and are actually higher than scores from our January 2020 cohort of Science Bootcamp first-year students who took the course face-to-face over a 4-week timeframe (19). These data confirm that our online, compressed Science Bootcamp for STEM transfer students meets the criteria of a CURE. Verifying that a CURE contains the elements of a CURE (12, 16, 22) is often not addressed by published CURE studies and yet is important to establish before drawing conclusions from study findings.

STEM transfer students in the online Science Bootcamp reported an overwhelmingly positive experience

We next examined student feedback about the online, compressed Science Bootcamp course. As can be seen in Table 2, the quantitative data revealed STEM transfer students were highly satisfied with the overall course and course activities; they found the faculty project mentors and peer mentors helpful; and they endorsed a range of benefits from taking part in the poster symposium. Particularly noteworthy is that 92.31% of students said they “would recommend the course to future incoming STEM transfer students” and “if they could go back in time, they would take the course again.” As can be seen in Table 3, the qualitative comments were also extremely favorable, with students commenting primarily on aspects of the course relevant to collaboration and to discovery and relevance. Their comments also speak to many psychosocial outcomes, including belonging and self-efficacy. Together, these data provide clear evidence

that STEM transfer students perceived the online Science Bootcamp as a positive experience, an important outcome relevant to students and faculty alike.

STEM transfer students show psychosocial gains after participating in the online Science Bootcamp

Finally, we tested our hypothesis that STEM transfer students who participated in the online Science Bootcamp would experience psychosocial gains. To do so, we conducted a series of Wilcoxon signed rank tests (given non-normal distribution of data) for each of the individual psychosocial outcomes, comparing pre-CURE scores with post-CURE scores. As can be seen in Table 4, the online Science Bootcamp promoted gains on most of the outcome measures. As predicted—from pre-CURE to post-CURE—STEM transfer students reported feeling more connected to a STEM community of practice and a greater sense of belonging to the university and STEM community. They also reported higher levels of science self-efficacy, science identity, and life satisfaction (Table 4). Although trending in the predicted direction, results were not significant from pre- to post-CURE for academic self-efficacy ($p = 0.061$) or expectancy for a STEM career ($p = 0.068$). The Science Bootcamp also had no impact on STEM transfer students' intent to leave their STEM major ($p = 0.32$). However, it should be noted that students were “at the floor” for this item pre-CURE (mean = 1.00, SD = 1.08), attesting to their commitment to pursuing a STEM major at their four-year institution. In conclusion, these data provide support for our hypothesis that the online Science Bootcamp promotes psychosocial gains in STEM transfer students, a significant predictor of STEM persistence (8).

DISCUSSION

Participation in learning communities has demonstrated benefits, but there are also challenges in implementation, particularly when trying to serve the needs of unique student populations, such as transfer students (42). Here, we have described our online, compressed Science Bootcamp CURE—an effective, accessible mechanism to build a community of practice to support STEM transfer students. Other institutions have offered condensed bootcamp-style discipline-specific labs (43) or condensed, online STEM bridge experiences (29). Yet, to our knowledge, our online, compressed Science Bootcamp represents the first fully online, interdisciplinary CURE to date. Our CURE is also among the first to specifically target transfer students.

Consistent with our original Science Bootcamp (19), the online, compressed Science Bootcamp meets the CURE goals of collaboration, discovery and relevance, and iteration (Table 1) (22). STEM transfer students who participated were highly satisfied with the course (Tables 2 and 3) and, consistent with our hypothesis, reported gains on a wide

TABLE I.
LCAS scores for online Science Bootcamp students ($n = 13$).

LCAS Subscale and Individual Items	Strongly Agree or Agree ^a	Mean (SD)
Collaboration Subscale^b “In this course I was encouraged to...”		
discuss elements of my investigation with classmates or instructors.	100%	4.92 (0.28)
reflect on what I was learning.	100%	4.92 (0.28)
contribute my ideas and suggestions during class discussions.	100%	4.92 (0.28)
help other students collect or analyze data.	100%	4.92 (0.28)
provide constructive criticism to classmates and challenge each other’s interpretations.	100%	4.77 (0.44)
share the problems I encountered during my investigation and seek input on how to address them.	100%	4.92 (0.28)
Discovery and Relevance Subscale “In this course I was expected to...”		
generate novel results that are unknown to the instructor and that could be of interest to the broader scientific community or others outside of class.	84.62%	4.23 (1.17)
conduct an investigation to find something previously unknown to myself, other students, and the instructor.	100%	4.85 (0.38)
formulate my own research question or hypothesis to guide an investigation.	100%	4.85 (0.38)
develop new arguments based on data.	100%	4.69 (0.48)
explain how my work has results in new scientific knowledge.	100%	4.92 (0.28)
Iteration Subscale “In this course I had time to...”		
revise or repeat work to account for errors or fix problems. ^c	92.31%	4.54 (0.66)
change the methods of the investigation if it was not unfolding as predicted.	53.85%	3.69 (1.25)
share and compare data with other students.	100%	4.85 (0.38)
collect and analyze additional data to address new questions or further test hypotheses that arose during the investigation.	69.23%	3.92 (1.32)
review or repeat analyses based on feedback.	76.92%	4.23 (0.83)
revise drafts of paper or presentation about my investigation based on feedback.	100%	4.85 (0.38)
Overall Subscale Comparisons		
Collaboration Subscale (Cronbach’s $\alpha = 0.95$)	n/a	4.90 (0.28)
Discovery/Relevance Subscale (Cronbach’s $\alpha = 0.77$) ^d	n/a	4.35 (0.57)
Iteration Subscale (Cronbach’s $\alpha = 0.71$)	n/a	4.83 (0.30)
LCAS Total Score	n/a	4.69 (0.30)

^aAll responses were made on a 1 (strongly disagree) to 5 (strongly agree) scale.

^bResponse format was modified from the original LCAS given the timeframe of the online Science Bootcamp.

^cUsed the same question stem as discovery and relevance subscale.

^dThe first item in the discovery and relevance subscale was not included in the scale creation due to a low alpha.

range of psychosocial outcomes (Table 4). These effects are consistent with psychosocial gains observed by other CURE models (8, 16) and join a growing body of literature demonstrating that transfer students uniquely benefit from research experiences (44). In many ways, these results are stunning: students never met each other or the faculty face-

to-face, nor had they spent significant time on the campus. For most of the participants, the Bootcamp represented the only student experience they were able to engage in at Elmhurst University before starting fall semester classes. Nevertheless, students reported significant increases in their sense of belonging to Elmhurst University, their sense

TABLE 2.
Course feedback survey results from online Science Bootcamp students (n = 13).

Course Feedback Survey Item	Strongly Satisfied or Somewhat Satisfied (4 or 5 on scale) ^a	Mean (SD)
Overall Course Satisfaction “To what extent were you satisfied with...?”		
knowledge of the instructors	100%	5.00 (0.00)
helpfulness of course resources for learning how to conduct scientific research	100%	5.00 (0.00)
usefulness of course learning activities to help you complete a research project	100%	5.00 (0.00)
technical support to successfully complete course activities and address technical errors	84.62%	4.62 (0.77)
Course Activities “Please describe your satisfaction with the following bootcamp activities...”		
“ice breakers” and in-class warm-up activities	100%	4.92 (0.28)
Guest visit by representative from the Counseling Center ^b	100%	5.00 (0.00)
Guest visit by representative from the Learning Center ^b	100%	5.00 (0.00)
Guest visit by representative from Office of Diversity ^b	100%	5.00 (0.00)
Faculty Project Mentor “How helpful was your faculty project mentor for...?”		
increasing your sense of belonging to Elmhurst University	100%	4.92 (0.28)
letting you know about campus resources	100%	4.92 (0.28)
supporting you to complete course assignments	100%	4.92 (0.28)
answering your questions about the course	100%	5.00 (0.00)
assisting you to complete your group research	100%	5.00 (0.00)
Peer Mentor(s) “How helpful was your Peer Mentor for ...”		
increasing your sense of belonging to Elmhurst University	92.31%	4.62 (0.87)
letting you know about campus resources	84.62%	4.31 (0.95)
supporting you to complete course assignments	92.31%	4.54 (0.88)
answering your questions about the course	92.31%	4.54 (0.88)
assisting you to complete your group research	84.62%	4.38 (0.96)
Poster Symposium “I have gained the following benefits from my poster symposium experience...”		
understanding of the research process	100%	4.92 (0.28)
ability to read and understand primary literature (journal articles)	92.31%	4.69 (0.86)
skill in how to give an effective presentation	100%	4.85 (0.38)
learning to work in a team	100%	4.92 (0.28)
To what extent do you consider the following to be ways your behavior has changed after your poster experience?	Large Change or Very Large Change	Mean (SD)
I feel that I have become better able to think independently and formulate my own ideas.	76.92%	4.31 (0.86)
I feel that I have become more motivated to learn.	76.92%	4.31 (1.03)
I feel that I have become a more effective team member.	92.31%	4.62 (0.65)
Additional Items		
Would you recommend the poster symposium remain a part of the bootcamp course?	100% Yes	
Would you recommend this course to future STEM transfer students?	92.31% Yes	
If you could go back in time, would you take the course again?	92.31% Yes	

^aAll items were asked on a 5-point scale except for yes/no items.

^bOne student had missing data for these items

TABLE 3.
Course feedback survey comments from online Science Bootcamp students ($n = 13$).

What was the most valuable aspect of the Science Bootcamp?	Any last comments, questions, concerns?
Doing the research project with a group.	This was an amazing experience. I would love to continue to be part of this group in the future.
Being in a research type environment for the first time. Even if it was virtually.	THANK YOU! BEST BOOTCAMP EVER
Changing my impression of scientific research and making it more accessible. Also, being able to connect with other transfer students before class starts.	Thank you all! Hope to see you on campus :D
[Learning] step by step how to conduct research. Learned how to work in groups.	It was a really great experience and I am so glad I got to meet everyone!
The most valuable aspect of Science Bootcamp is that we had the opportunity to work so closely in groups which allowed us to meet new people and step out of our comfort zones.	Thank you for allowing me to be a part of the Keystone program. It was something new and out of my comfort zone, but I am glad I did it. It was an enjoyable experiment.
Seeing how research is actually put together and how it becomes reality.	I really loved this class!
The idea of teamwork, collaboration, effective researching, and presenting our ideas.	This is my first course at Elmhurst and I already feel like this was the best University to transfer too. Thank you so much for making us welcomed to the Bluejay family. I feel so much better starting a new semester at Elmhurst while also making new friends. This course is a MUST for new incoming STEM transfer students. I really felt a part of something important. Thank you very much! ♥
Meeting other transfer students while deepening our understanding of the scientific method.	
It helped me better prepare for my upcoming courses at Elmhurst and gave me the opportunity to do actual research.	
It made me feel as a part of the Elmhurst University and science community.	It was both an honor and pleasure to be in this course with our great instructors and other boot camp participants. I learned a lot in the last two weeks and my feeling of confidence about my abilities in science received a huge boost, too. I know for sure, I will use the skills and knowledge received in the Keystone in future. Having completed this course, I feel better prepared for the Fall semester and for being a science student, in general. The course also helped be meet fellow students and faculty and made me feel like I belong at Elmhurst University.
Working in a group and getting to know everyone. Also building an experiment from scratch instead of having instruction already given to me.	
I was able to learn more about cancer, and the keystone program helped me have a recap of research and create a science experiment.	
I think the most valuable aspect was the use of groups and the process of going through the research. I initially thought this class would be going over different research methods and doing "mock" research. It turned out to be so much more exciting and hands-on, which I really loved!	

TABLE 4.
Pre- and post-CURE psychosocial outcome scores for online Science Bootcamp students ($N = 12$).

Psychosocial Outcomes	Pre-CURE Mean (SD) ^a	Post-CURE Mean (SD) ^a	Wilcoxon test p value
"STEM Community of Practice Index" ($\alpha = 0.75, 0.93$)	5.81 (0.73)	6.73 (0.48)	0.002
Belonging to university ($\alpha = 0.96, 0.90$)	5.25 (1.57)	6.33 (0.56)	0.011
Belonging to STEM ($\alpha = 0.96, 0.94$)	5.45 (1.00)	6.54 (0.35)	0.002
Academic self-efficacy for STEM ($\alpha = 0.96, 0.97$)	6.29 (0.98)	6.83 (0.34)	0.061
Science self-efficacy ($\alpha = 0.89, 0.94$)	5.54 (1.04)	6.75 (0.43)	0.003
Science identity ($\alpha = 0.83, 0.83$)	5.85 (0.84)	6.43 (0.52)	0.024
Intent to leave STEM (switch to non-STEM major)	1.08 (0.29)	1.00 (0.00)	0.317
Expectancy for STEM career ($\alpha = 0.79, 0.69$)	6.60 (0.70)	6.92 (0.16)	0.068
Life Satisfaction ($\alpha = 0.93, 0.82$)	5.11 (1.63)	5.78 (1.00)	0.042

^aAll responses were made on a seven-point scale, with varying response scale language.

Alphas represent the Cronbach's alpha at pre-CURE and post-CURE.

of belonging to the STEM community, their confidence in carrying out scientific practices, and the extent to which they feel like a scientist. It is particularly noteworthy that these effects emerged amidst the uncertain backdrop of the COVID-19 pandemic, which exacerbated the academic and social conditions that can isolate transfer students and stifle their successful transition to a 4-year university.

Our online Science Bootcamp is unique in that it promoted gains on a wide range of psychosocial outcomes among a diverse group of transfer students across STEM majors. We see this broad impact as a testament to our CURE model establishing a strong community of practice (19, 45). STEM transfer students will continue to participate in the STEM community of practice in various ways as the academic year unfolds, utilizing other components of the KEYSTONE Program, including the career exploration “STEMinar” and peer mentors. Our goal is for KEYSTONE intervention activities to buffer STEM transfer students against “transfer shock” (31, 32), enabling them to academically thrive. We are optimistic for the future of this Science Bootcamp cohort, since psychosocial gains are associated with increased persistence in STEM (9–11).

The findings we observed are consistent with the hypothesis that our online, compressed Science Bootcamp CURE leads to psychosocial gains. However, as is common with science education research at smaller institutions, our study suffered from a small sample size and a potential volunteer bias, which can threaten internal validity (23, 24). To our credit, our CURE activities were guided by theory and our outcome measures represent reliable and valid instruments, a major strength of a CURE model (8, 20, 22). A future, ideal test of our hypothesis would include a larger sample size and a comparison group, as we have done in assessing our face-to-face Science Bootcamp (19), revealing that the Bootcamp leads to psychosocial gains. We did assess a comparison group who provided data at the post-CURE time point. However, low transfer enrollments due to COVID-19-related issues provided us with data from only seven STEM transfer students. Nevertheless, these analyses did reveal that students who participated in the online Science Bootcamp scored higher on virtually all of the psychosocial measures than students in the comparison group (data not shown). Moreover, it should be emphasized that no students (Bootcamp or comparison group students) participated in any other university curricular or extracurricular activities during the timing of the bootcamp, which bolsters the possibility of the bootcamp being responsible for students’ psychosocial gains. Nevertheless, to make claims of causality, future studies that employ random assignment to a bootcamp and non-bootcamp control condition are needed.

The KEYSTONE Science Bootcamp, both in its original format (19) and in its online, compressed format, serves as a cost-effective, versatile interdisciplinary CURE model that can be adapted to meet diverse institutional needs (19). In both formats, the Science Bootcamp’s CURE focuses on the scientific method rather than course content, allowing

flexibility in both the staffing and the student populations served. Guiding projects to utilize free online data collection tools means that research costs become negligible. Furthermore, the lack of capacity limits specific to a laboratory setting allows for classes of any size to participate virtually. Indeed, the largest limitation to size and cost of the course is ensuring there are enough faculty and/or peer mentors to help guide research projects throughout the Bootcamp. More importantly, the Bootcamp’s emphasis on practice, rather than content, mirrors broader curricular trends in STEM, such as those outlined in *Vision and Change* (46, 47). Our CURE model can support and integrate with STEM curricular modifications across disciplines. In fact, at Elmhurst University, the Science Bootcamp represents the most significant and most successful intervention in place to support STEM student success across all STEM majors (18).

Although online instruction is not without its challenges, the success of our online Science Bootcamp has resulted in some unexpected and important insights: an online CURE model is (i) cost-effective; (ii) scalable; (iii) inclusive, in that students can participate from a distance; and (iv) amenable to guest visitors. Thus, this compressed, online, interdisciplinary CURE model further delivers on the promise of CUREs to expand access to the proven benefits of undergraduate research experiences and is a feasible option for schools and departments of all sizes.

SUPPLEMENTAL MATERIALS

Appendix 1: Course syllabus and schedule

Appendix 2: Detailed description of research projects

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