

Recruiting STEM Students with Brief Summer Research Experiences: An Opportunity for Colleges and Their Alumni

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Abstract

In 2000, several STEM faculty at Bethel College in Kansas designed and began offering a one-week intensive residential summer research experience for high school students – the Bethel College Summer Science Institute. The core idea underlying the design was to motivate students through the excitement of discovery. This event has been offered annually since that time and emphasizes collaboration with others during the research process, learning laboratory techniques, systematic data recording, data analysis methods, formal oral presentation of research results, exposure to cutting-edge STEM topics, and a residential experience with recreational activities mentored by college STEM students. Research topics have varied across STEM disciplines, including biology, psychology, chemistry, neuroscience, computer science, engineering, mathematics, and astronomy. Instruction involves a bare minimum of didactic presentation with emphasis on active involvement in laboratory or field activities. Instructional groups of 12 or fewer students, taught by 1 or 2 faculty with 1 or 2 undergraduate assistants, are further divided into groups of 2 to 4 students for individual projects, of which the results are presented in an afternoon symposium at the conclusion of the institute. The institute was funded primarily with student fees for the first decade of its existence, though enrollment, especially of underserved students, appeared to be limited by the \$325 fee. In 2009, STEM alumni of the college were offered the opportunity to support individual students through donations, and fees were set at \$50 in 2010. Enrollment tripled in 2010 and has remained at this level to the present; alumni donations have been adequate to cover expenses. Many students report that this support was crucial to their attendance and that the experience increased their desire to pursue study and careers in STEM fields (mean greater than 4 on a 1-to-5 scale for both attendance and desire). Approximately 17% of institute attendees have eventually matriculated to Bethel College, greatly enhancing the financial sustainability of the event. STEM alumni have responded very favorably to this opportunity for a significant impact on the development of young STEM students and on STEM enrollment at their alma mater. The approach described here can be replicated at other institutions as a

strategy to build STEM enrollments and to engage STEM alumni in this effort.

Introduction

There is widespread concern that the US is not preparing a sufficient number of students for the workforce in STEM-related disciplines and occupations, and the numbers are particularly low among underserved populations and, for some areas of STEM, among women. Thus, the development of successful strategies to recruit and retain students to college and university STEM programs is regarded as a national priority (President's Council of Advisors on Science and Technology, 2012). The large proportion of students who express interest in STEM majors on the one hand (National Academies of Sciences, Engineering, and Medicine, 2016, Figure 2-2) and the prominence of STEM careers among emerging employment opportunities on the other (Langdon, McKittrick, Beede, Khan, & Doms, 2011) suggest that such strategies could be valuable enrollment management tools for many 2-year and 4-year colleges and universities. This report gives an example of one such strategy at a small private liberal arts college, describing the 16-year history of a program that provides a brief summer research experience for high school students.

The importance of STEM in the US economy is indicated by a recent report of the US Department of Commerce (Langdon et al., 2011) showing that the recent and projected growth of STEM-related employment is much greater than that in other fields, although there is a lack of consensus on whether there is truly an impending shortage in the STEM workforce (Salzman, 2013). High school students' interest in STEM majors and careers suggests an awareness of these employment trends. Assessment of this interest depends on how broadly or narrowly one defines "STEM-related" (e.g., whether to include psychology, social science, and health fields). While the National Science Foundation has at times defined STEM to include these fields (National Academies of Sciences, Engineering, and Medicine, 2016, pp. 9-10), they have been excluded in some studies of the STEM workforce (Salzman & Van Noy, 2014). The ACT (2015a, 2015b)

found that among the 1.9 million high school seniors who took the ACT test (59% of the US graduating class), 49% of high school seniors report interest in a STEM major and career (excluding psychology and social sciences, which would represent several additional percentage points). According to a recent report by Chen (2013, Table 2), a more modest percentage of students actually complete a bachelor's degree in a STEM field – about 48% of those who enter college with STEM majors (not including psychology, social sciences, health sciences) do not complete them. Although this attrition rate is actually lower than that in some non-STEM fields, a higher STEM attrition rate is characteristic of African-American (65%) and low-income (58%) students as well as of students whose parents did not attend college (59%). These percentages suggest the need for strategies to motivate students to recruit and retain them in STEM programs at the bachelor's degree level and beyond (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013; Hossain & Robinson, 2012).

Thus, one major argument for the investment in high school STEM education by colleges and universities is based upon evidence that a competent STEM workforce is crucial to the economic needs and interests of the country. However, the somewhat conflicting assessments of workforce demand suggests that a more compelling argument for investment in STEM education at all levels is the need of students and the society for a high quality STEM education (National Academies of Sciences, Engineering, and Medicine, 2016, pp. 7-9). Indeed, the claims that STEM education is a national economic priority are not without detractors. Uncritical acceptance of the idea that having a more STEM-educated workforce is economically beneficial ignores the often-unacknowledged environmental cost that may accompany such an education (Donovan, Moreno Mateos, Osborne, & Bisaccio, 2014). The need for STEM graduates who are critical thinkers and appreciative of the broader consequences of their actions (e.g., resource use and environmental quality) raises the question of the nature of the STEM education that we are providing. Is it focus on factual knowledge that enhances test scores, or is it providing the kind of broader perspective needed to move beyond concerns with one's own employment and

advancement? Understanding the critical role of scientific thinking in addressing contemporary health, environmental, or other societal problems (Gawande, 2016) suggests a much more fundamental rationale for investing in high school STEM education – preparing a scientifically literate citizenry.

These latter considerations support the view that STEM education should involve students in the process of science at a fundamental level so that they can critically evaluate scientific work and its implications. Fortunately, it appears that the goal of motivating students for STEM study and careers and that of educating critical scientific thinkers can both be addressed by engaging students in scientific research, at undergraduate (Eagan, Hurtado, Chang, Garcia, Herrera, & Garibay, 2013; Graham et al., 2013) as well as high school levels (Hammond, Karlin, & Thimonier, 2010). Engagement of undergraduates in research in various ways is now widely accepted as an effective strategy in STEM teaching (Karukstis & Elgren, 2007; Lopatto & Tobias, 2010), both among advanced students and, more recently, at the introductory level (Piper & Krehbiel, 2015). A number of efforts to extend this approach to high school students have been reported (Eeds et al., 2014; Hammond et al., 2010; Kabacoff, Srivastava, & Robinson, 2013; Niemann, Miller, & Davis, 2004; Rohrbaugh & Corces, 2011; VanMeter-Adams, Frankenfeld, Bases, Espina, & Liotta, 2014). The promise of such efforts and the issues encountered in pursuing them are the subject of the remainder of this article.

Numerous colleges, universities, and other institutions concerned with STEM education now offer programs for high school students, many of them outside regular high school classrooms. The Pathways to Science site (Institute for Broadening Participation, 2016) lists over 230 programs for high school students. These programs vary in duration, from a few days to months or years, and in approach, from courses designed to enhance preparation for college to intensive research experiences. The programs providing research experiences vary in the types of mentorship they provide (e.g., in the degree to which students can work with doctorally trained scientists) and in the role that students play in the research process. Here we describe one such program that, because of its small size (30–36 students per year), allows extensive direct mentoring by Ph. D. faculty. Because of its short duration (~5 days) it is focused more on motivation for study and careers in STEM through engagement in discovery than on acquisition of specific laboratory skills. It is also an attempt to provide the necessary social support for scholarly endeavor through a residential experience and through counseling and assistance by undergraduate STEM students in both laboratories and residence halls. These characteristics together with its multidisciplinary nature are intended to create a community of collaboration and exploration of issues and careers in STEM, similar to what we strive to achieve during the academic year with under-

graduates (Piper & Krehbiel, 2015). The program is made accessible to all, including underserved students, through sponsorship of students by STEM alumni donors, permitting a registration fee of only \$50. The remainder of this report describes this program in further detail, providing a rationale for the approach, along with evaluation data demonstrating some effects of the program.

Description and Evaluation of the Bethel College Summer Science Institute

The Summer Science Institute at Bethel College began in 2000 as an effort to attract high school students to the study of science at Bethel by giving them an opportunity to experience a discovery-learning environment in the laboratory and field. This environment was created by having a small student-faculty ratio, with additional assistance from undergraduate science students. Areas of study that were offered were generally close to the research and teaching interests of faculty. Thus, in our first institute in 2000 we offered studies in neuroscience and environmental science, principal interests of the co-authors. Areas of study have shifted over the years but have always provided options in biology, chemistry, and psychology, which also constitute our largest undergraduate student clientele in STEM (see the Appendix for a sample of student project presentation titles). The institute runs for approximately the duration of a work week, beginning on a Sunday afternoon in early June and ending on the following Friday afternoon. Another aspect of our approach has been for students to experience a college-like campus life by having them live in college residence halls with undergraduate STEM student counselors.

Our pedagogical approach has placed primary emphasis on empirical inquiry along with minimal lecturing and reading to provide background for investigations. Measurement methods and techniques are introduced to provide students with the tools for conducting their own studies. Then students are encouraged, with the assistance of undergraduates, to generate hypotheses and a methodology for testing them. Students are encouraged to work in groups of 2 to 4 in order to be able to exchange ideas and receive assistance in carrying out their studies. The formal data gathering is typically underway by the first or second full day of the institute.

We strive to lead students through all phases of a scientific investigation, culminating in a presentation of their results at a symposium on the final afternoon of the institute. Students are assisted in entering data into computer files and in preparing graphs to display their findings. They also learn to create descriptive statistical summaries of their data, and some are able to conduct inferential statistical tests. We provide 1 hour of college credit for all students who complete the week's work (granted to 303 of 306 attendees through 2015). Thus, students have essentially taken the first step of their college STEM education upon completing the institute.

An important part of the institute has been an evaluation questionnaire administered to students at the conclusion of the week. The results have been used primarily to guide program improvements, especially in the early years when enrollments were small, and the questionnaire has evolved somewhat as the program has been modified. Fairly complete data have been gathered for the past five years as enrollments have been larger (total n for this 5-year period = 164). High response rates (ranging from 90.6 to 100%, i.e., effective n = 156) have been obtained by requiring questionnaire completion prior to the award of achievement certificates. Some of the data from these last five years are summarized in the present report.

Attendance and funding. The institute began with enrollments of roughly 10 students per year, funded by occasional donations of alumni and by student fees of \$300 per student (increased to \$325 in 2002). While these funds were generally inadequate to cover costs, we often heard from prospective attendees or their parents that they were unable to afford this fee. Note that the institute was not selective throughout the period described here – all applicants were accepted if they met deadlines and paid

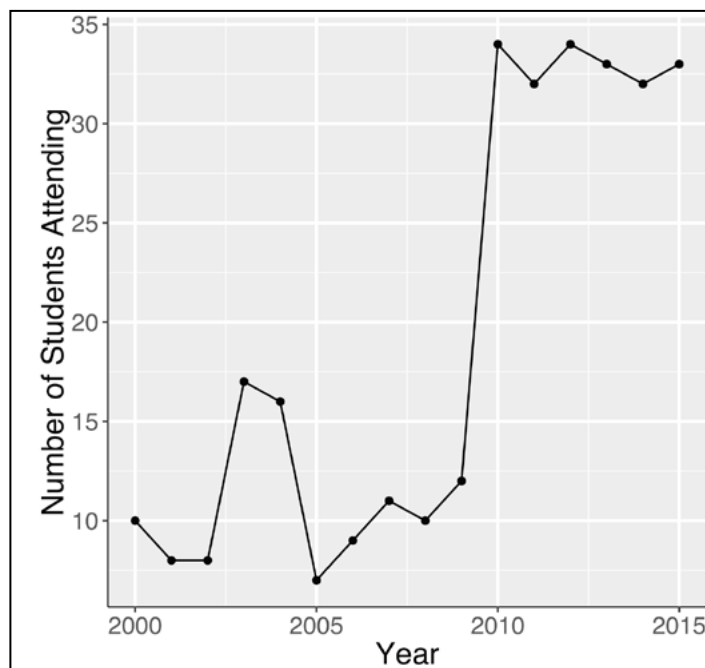


Figure 1. Yearly attendance at the Bethel College Summer Science Institute. Student fees were reduced from \$325 to \$50 in 2010.

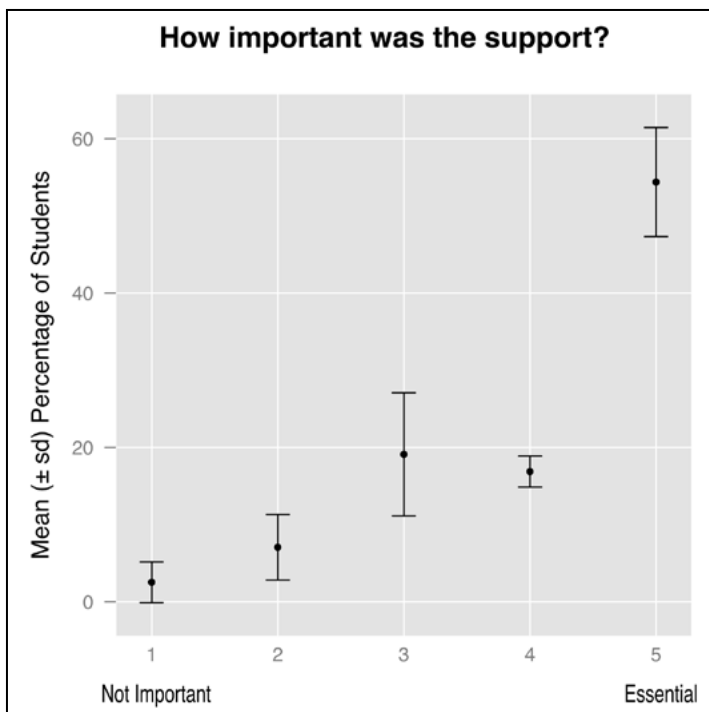


Figure 2. Percentage of students indicating each degree of importance of the support provided by alumni, averaged across the past five years.

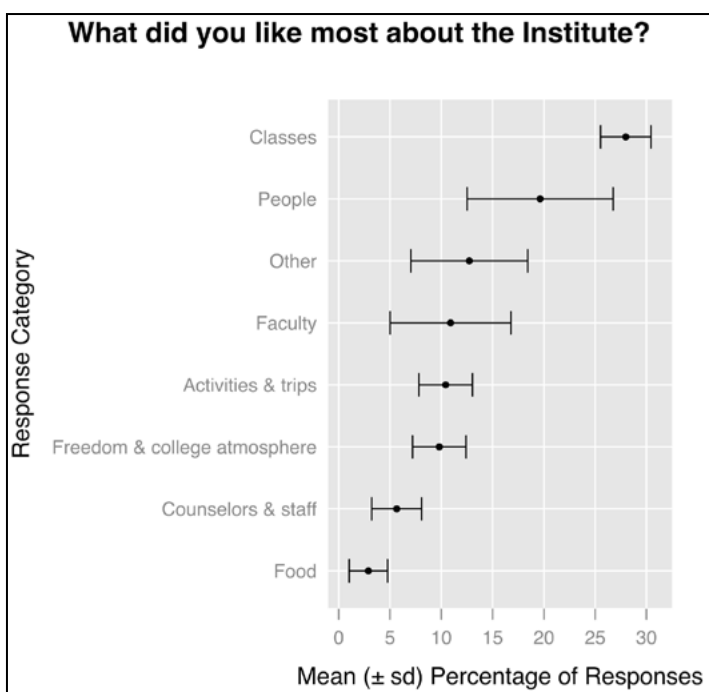


Figure 3. Preferences of students who attend the Summer Science Institute. Responses to the open-ended question at the top of the figure were categorized in each year from 2011–2015. Some students provided more than one response, but all respondents provided at least one response. Percentages of the total number of responses were calculated separately for each year, and then means and standard deviations across years were determined.

and possible STEM career choice for a promising young student. We began using this funding mechanism in 2009. After some initial difficulties with lack of commitment by a few students to follow through on their stated intention to attend, we adopted a student fee of \$50 as a token demonstration of the student's intention. Alumni sponsorship of enrollment fees had an immediate and dramatic effect on participation (Figure 1). Mean annual enrollment prior to 2010 was 10.8; in the period beginning in 2010 enrollment tripled to 33.0. Of the total number of attendees during these 16 years, 14.4% chose to attend more than once, a few of them 3 times. The percentage of enrollees who were female varied considerably from year to year but was not markedly different between these two periods (prior to 2010: 47.2%; after 2010: 51.6%). Minority enrollments (African American, Asian, Hispanic) also increased dramatically – a mean annual percentage minority of 7.5% from 2000–2009, whereas that percentage from 2010–2015 was 36.9%. Thus, the lower fees were accompanied by larger overall enrollments as well as by disproportionately larger minority enrollments.

After the change in funding mechanism, we added a question pertaining to the importance of this alumni support to the evaluation questionnaire: "We are fortunate to be able to subsidize the Summer Science Institute through the generosity of several Bethel College alumni scientists and physicians who care deeply about science education. As a result, the institute was provided at very low cost to you. How important was this support in making it possible for you to attend? Please rate 1–5 where 1 = Not important, I would have attended anyway; 5 = Essential, I could not have paid the full cost (about \$450) to attend." The five-year mean

and standard deviation of the scores on this 1 to 5 scale are 4.13 ± 0.10 (Figure 2). These results provide strong evidence that donor funding has played an important role in attracting students, and that minority and perhaps other underserved students especially benefited.

Content and student preferences. A primary goal of the discovery-oriented approach of the institute has been to motivate students for college-level study of STEM. There are numerous advocates of such an exposure to research (e.g., Karukstis & Elgren, 2007; VanMeter-Adams et al., 2014), both to motivate students and to provide opportunities for STEM learning needed by students to fulfill important roles in the society at large. To address the motivational question, evidence that students enjoy the activities would be valuable in the short term, although such evidence obviously does not ensure improved long-term outcomes. Student preferences and enjoyment of the institute's activities were studied through four questions on the evaluation questionnaire administered at the conclusion of the week:

1. What did you like most about the institute?
2. What do you wish you could have done more of?
3. What did you like least about the institute?
4. What do you wish you could have done less of?

Responses for the first two of these questions showed enough commonalities to allow a rough categorization of responses. In responses to question 1, both academic and social aspects of the institute received endorsement by a substantial proportion of students, with the fundamental teaching and learning activities ("classes") being the most frequently mentioned (Figure 3).

Question 2 provides another glimpse into the likes and preferences of students. While social activities are the single most frequently mentioned category of responses (Figure 4), it is clear that there was considerable interest in more opportunities for the main teaching/learning activities of the institute (experiments and projects, learning, classes, presentations). The strategy of keeping lectures to a minimum in an event designed to motivate students for STEM is also suggested by these results.

Questions 3 and 4 produced few common themes and were thus very difficult to summarize. There were recreational activities in some years that were unpopular (e.g., a getting-to-know-you game). The teaching/learning activity that elicited the most negative response was the student presentations (5-year mean of 10.4%), especially the limited time to prepare them. These responses may be partly attributable to the fact that the questionnaires were completed shortly after the presentations, i.e., while these concerns remained a focus of their attention.

Taken together, these results raise the question whether the overall allotment of time to various kinds of activities during the week was appropriate. This question was posed directly to students in another item on the evaluation questionnaire: "The mix of activities within the

required fees. An idea generated by an advisory council of STEM alumni of the College was to fund the institute by asking STEM alumni to support individual students, i.e., to pay their registration fees. The rationale for this approach was that alumni might be especially motivated by the opportunity to facilitate and support STEM education

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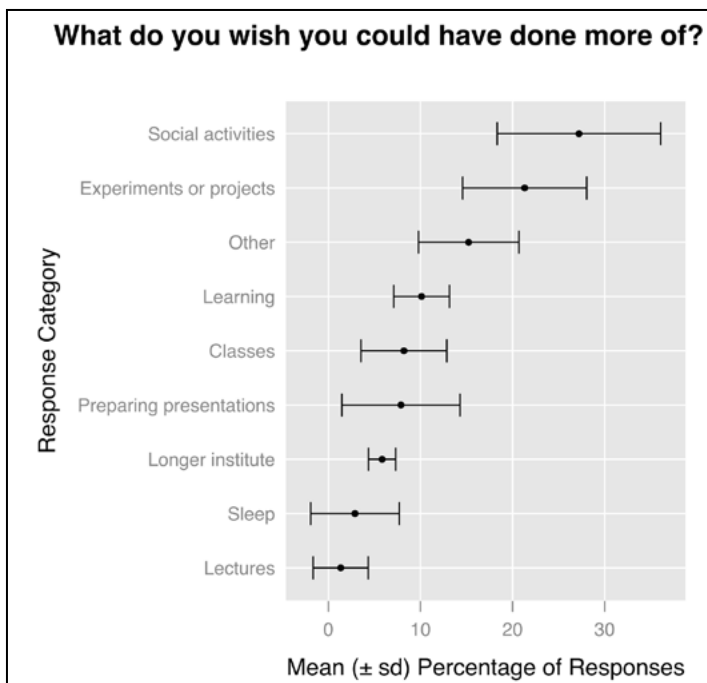


Figure 4. Preferences as indicated by what students would have liked to increase. Data were analyzed as described for Figure 3. There were two respondents who did not offer a response on this question.

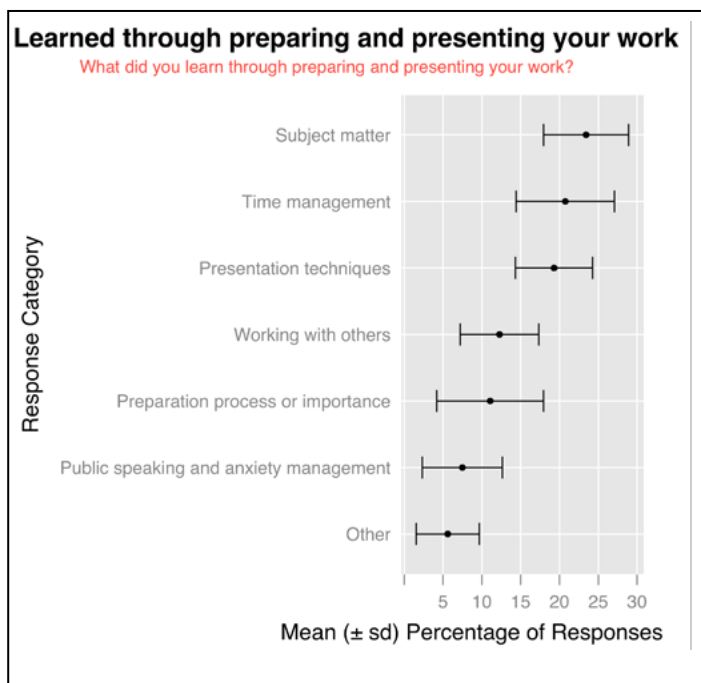


Figure 5. Student responses regarding the learning arising from formal presentation of their work at a symposium at the end of the week. Data are summarized as described for Figure 3.

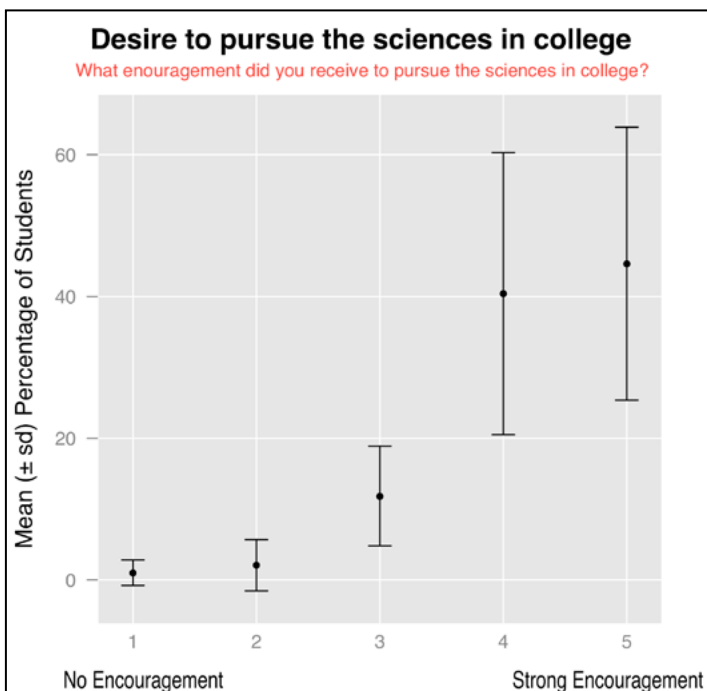


Figure 6. Student responses to the question on whether the institute encouraged them to pursue the study of science. Means and standard deviations of percentages for each response are calculated across the three years that this item has been administered.

Science Institute (i.e., laboratory or field work, reading, lecture, data analysis, symposium preparation, recreation) was a) balanced or b) unbalanced” (students could indicate in what way it was unbalanced). On this question from 2011 to 2015, 78.1% to 96.6% of students chose the alternative “balanced,” with a mean of 86.7%. Thus, most students appear to have been satisfied with the choices of activities

made available to them. In fact, some were so pleased with the institute that they wished it could have been longer (see the response category “Longer institute,” Figure 4).

Although the institute was concerned with motivation for the study of STEM fields, it also appears unwise to allow the program to be driven simply by students’ expressed likes and dislikes. The evidence for some dislike of presentations, mentioned above, may raise the question of the value of this activity. That issue was addressed in the evaluation questionnaire at week’s end by another question: “Regarding the Friday afternoon symposium, list one or two things you learned through preparing and presenting your work during this event.” There was considerable agreement

about several types of learning that occurred as a result of this requirement (Figure 5), each of them important and desirable learning outcomes on a path toward becoming a more independent scholar in a STEM (or other) field. The learning of subject matter included both their own topics and those of other students in the institute. Thus, even though some students reported disliking the presenta-

tions or the time pressure to do them, most students were readily able to list substantive examples of what they had learned by having to prepare and deliver presentations about their research.

Longer-term outcomes. Whereas student preferences regarding the content of the institute provide valuable information about its effect on their motivation for the pursuit of STEM knowledge and skills, it would be of even greater interest to know what the long-term influence of these experiences might be. At present, we have limited information about the studies and careers our students have eventually pursued. However, one question added to the evaluation questionnaire in 2013 gives us a measure of students’ judgment regarding the effects of the institute on their own inclination to study and work in a STEM field: “A main purpose of the Summer Science Institute is to encourage pre-college students to study and pursue careers in science. Rate (using a 1 to 5 scale) the degree to which the SSI increased or reinforced your desire to pursue the sciences in college. Please circle along the scale where 1 = No encouragement to study science; 5 = Strong encouragement (or reinforcement) to study science.” The results show that most student responded with a 4 or 5 on this scale (Figure 6). Another way to summarize these results is the mean and standard deviation of the mean annual score: 4.26 ± 0.26 . Thus, most students clearly believe that this experience has encouraged them to study the sciences at a more advanced level.

Another aspect of these longer-term outcomes is matriculation to college, and possibly to STEM fields. We do not have such data on all students who have attended the institute. However, we do know that 17.2% of those

attending (45 students) have matriculated to Bethel College. About two-thirds of these matriculants have chosen to study in STEM fields. Slightly more than half of them had actually graduated from Bethel by the end of the 2016–17 academic year, of whom over 70% graduated in STEM fields. Another 22% of these students are currently enrolled at Bethel College. In addition, at least 7 of the 18 STEM graduates have pursued advanced STEM-related studies at the Master's degree level or beyond.

Discussion

The program described in this article is an example of a STEM out-of-school program. These programs, along with classroom settings, digital learning resources, naturalistic environments, family, friends, etc. constitute the complex ecosystem in which STEM learning occurs, as summarized in a recent book prepared for the National Research Council (2015). The important contribution of such programs to the STEM learning of young people is now becoming well documented, affecting both their interest and their understanding of STEM and reducing achievement differences along the income scale. Such programs have been studied sufficiently to allow the Committee on Successful Out-of-School Learning (CSOL) of the National Research Council to identify several major characteristics of productive programs (National Research Council, 2015, p. 2):

1. "Engage young people intellectually, academically, socially, and emotionally"
2. "Respond to young people's interests, experiences, and cultural practices"
3. "Connect STEM learning in out-of-school, home, and other settings"

Although as designers of the Summer Science Institute 16 years ago we were largely unaware of much of the research literature reviewed in this CSOL book, our colleagues and we appear to have created a program that exemplifies many of these characteristics.

Student engagement. In elaborating on the meaning of "engagement," the CSOL reviews the powerful effect of first-hand experiences that provide "... direct engagement with questions, contexts, and data in all of its relevant forms" (National Research Council, 2015, p. 16). The discovery-learning environment that we describe above (see "Description and Evaluation of the Bethel College Summer Science Institute") is designed to foster exactly this sort of engagement. The evidence from our questionnaire indicates that students indeed find these experiences engaging (Figures 3 and 4), often wishing for more of the main teaching and learning activities of the institute. Since our approach was designed somewhat independently of the programs reviewed by the CSOL, our data also provide independent corroboration of the framework they propose.

We note that engagement is partly social and emo-

tional in nature. "Supportive learning communities" are described by the CSOL as an important component of productive, engaging STEM out-of-school programs (National Research Council, 2015, p. 19). Encouraging students to ask and answer their own scientific questions and to share the results of their inquiry are important parts of the support that is needed. In the absence of such support, the inevitable failures in some phase of the inquiry or the intimidation of sharing one's results publicly may overwhelm students and discourage future study of STEM. Students at our institute appear to have felt such support, as evidenced by the high frequency with which they mentioned people and faculty as institute features that they liked most (Figure 3). Describing what he or she liked most about the institute, one student wrote, "I liked the classes and the hands-on learning. The people were really nice as well." Best liked by another student was the "friendly accepting environment plus creative experience as it applies to the labs." Even though some complained of the presentation requirement, they provided many examples of what they had learned through the preparation and delivery (Figure 5), as though the support had helped them overcome the challenges. As one student said, "I learned to be calm when speaking in a friendly environment for learning." Another student elaborated further: "It feels wonderful when strangers compliment you on your speaking capability and say how successful they think you will be without even knowing you; it is a huge confidence booster overall."

Student interests, experiences, and cultural practices. Evidence regarding the other major characteristics identified by the CSOL is less directly reflected in our evaluation questionnaire. Nevertheless, our choice of study areas has been made with the interests of young people in mind. For example, considering students' enjoyment of the outdoors and of the variety of life in the natural world has led to frequently offering a section of the institute entitled "Biology in the Wild." Study topics offered in neuroscience and psychology include sleep and dreams, the experience of persons with schizophrenia, and concussions (summer, 2016). Offerings in chemistry have focused on analysis of nutrients or contaminants in common foods, chosen by students. Popular offerings in computer science and engineering have involved programming robots. The molecular biology sessions use cutting-edge DNA technologies that help prepare students for the 21st century world of work.

An aspect of the "interests, experiences, and cultural practices" identified by the CSOL (National Research Council, 2015, p. 22) is the opportunity to work, learn, and lead in collaboration with other students. Collaborative work is integral to our approach, as our "Description and Evaluation" above indicates. Although there is limited time for collaborative relationships to develop in a one-week event, student responses indicate an appreciation for this feature of the institute (e.g., see Figure 5). In response to

the question "What did you like best," one student wrote "I loved the nutritional chemistry as well as bonding with the other students." Asked about learning from the presentations, another wrote "I learned that team work is important to work together and make their research the best."

Connections across settings. Our efforts to connect STEM learning across settings (#3 in the above list of the CSOL) have had several components. Perhaps the most significant is related to the funding mechanism for the institute. Alumni donors sponsor specific students, and we provide e-mail addresses of sponsors to students. During the institute, students compose and send messages of thanks to their sponsors, who often respond with encouraging messages to the students. Since the sponsors are STEM alumni and most are or have been in STEM-related professions, these exchanges become opportunities to highlight STEM career options and provide encouragement for further studies in STEM. In some instances, biographical sketches of donors have been posted on a bulletin board near an area where students congregate during the institute. A few donors have even attended the institute symposium. In 2015, the institute added an evening session involving exploration and discussion of STEM-related careers, which was reported to be helpful by over three-fourths of the students.

Another kind of connection is with a nearby Upward Bound program in Wichita that provides an intensive six-week summer residential program of instruction, research experience, and other activities focused on STEM disciplines (Upward Bound Math Science, 2016). The program serves students whose parents do not have a bachelor's degree. Our institute provides an additional week of such experiences for some of these students, including an exposure to the environment of a small campus and intensive engagement with a research topic together with supportive college faculty members. Family members sometimes attend the symposium at the end of the week. Institute faculty and assistants have in turn attended several Upward Bound events. This relationship has created a more diverse student clientele for the institute and offered more opportunities to reflect on the learning that occurs in different school and out-of-school settings. Of course, this relationship is made possible by our funding mechanism that permits low student fees.

Comparison to other summer STEM learning programs. The Bethel College Summer Science Institute is one of many STEM learning events for high school students (Institute for Broadening Participation, 2016), including numerous summer programs. Published reports about such programs (Eeds et al., 2014; Hammond et al., 2010; Kabacoff, Srivastava, & Robinson, 2013; Niemann, Miller, & Davis, 2004; Rohrbaugh & Corces, 2011; VanMeter-Adams, Frankenfeld, Bases, Espina, & Liotta, 2014) indicate a considerable variety of approaches. Some involve partnership with a high school (e.g., Eeds et al., 2014) and

thus may not meet a strict definition of “out-of-school programs.” Some involve an extensive time period ranging from several weeks to several years (Eeds et al., 2014; Niemann et al., 2004; Rohrbaugh & Corces, 2011; VanMeter-Adams et al., 2014). These latter programs are based at large, research-oriented universities, and involve as many as 100 or more students at a time. Mentorship of students may thus entail a complex structure with several levels – undergraduate students, graduate students, post-doctoral staff, and faculty. Fees range from negative (i.e., stipends paid to the student) to several thousand dollars for a summer experience. Many include considerable course-based instruction along with laboratory experience that appears focused on specific STEM knowledge and skill development.

It is unclear how closely these programs align with the recently published National Research Council (2015) recommendations for out-of-school STEM programs. However, in general, they appear somewhat less oriented toward inquiry and more oriented toward directed experiences (courses, lectures, tutoring) than is our Summer Science Institute. An example of a program with a similar approach and duration as ours is that of Hammond et al. (2010), based in France and emphasizing student collaboration, engagement in all phases of experimentation, and absence of grades or penalties for mistakes. Our program has a similar emphasis, provided in a residential liberal arts college setting and with very low fees so that it is accessible to all. Our funding mechanism makes the approach sustainable since it is incorporated into the development plan of the College. In fact, it provides a means for our institutional development staff to reach prospective donors who are likely to support other college programs as well. The matriculation to the college of students from the summer program provides tuition income that is easily several fold greater than the amount invested in the program, further enhancing sustainability.

Conclusion. Our description, evaluation data, and comparison to other STEM out-of-school programs indicate success of the Bethel College Summer Science Institute in (1) motivating students for STEM learning, (2) recruiting students to STEM programs, and (3) engaging STEM alumni in STEM program support. Since most of the features of the institute appear readily replicable, our success suggests that comparable efforts at other institutions would lead to similar benefits.

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Appendix

Example Titles of Summer Science Institute Student Research Presentations

- "Isolation of DNA from Human Hair and Oral Cavity"
- "Transformation of E. Coli Cells with Plasmid GFP"
- "Restriction of Lambda DNA with HindIII and BamH1"
- "Forebrain Development"
- "Biodiversity of Wheat Field vs. Forest Area"
- "Arthropod Biodiversity"
- "Analysis of Arthropods Caught by Sweep Netting"
- "Got Milk? Comparing Calcium Levels in Milk Using Atomic Absorption Spectroscopy"
- "Iron Concentrations in Peanuts vs. Almonds"
- "Two Combinatorics Problems"
- "Analyzing the Game of Craps"
- "Recognition of Words vs. Images"
- "Measuring Bias Towards Gay Couples: You May be More Prejudiced than You Think"
- "Engineering: Making YOUR Life Easier!"
- "The Cricket Has Nerve: The Effect of Monosodium Glutamate on the Ventral Nerve Cord of the Cricket"
- "Human to Human Interface: How to Control Someone Else's Arm 101"