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Bioengineering and Bioinformatics Summer Institutes (BBSI) Program: Results of Surveys of 2003–2006 Student and Faculty Participants and Survey of 2002 Non-Awardees

Executive Summary

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Jongwon Park was the Study Director for this project at SRI International. He was the chief interviewer of the BBSI principal investigators, helped develop the survey instruments, supervised the administration of the surveys, and presented preliminary and final results to the sponsoring agencies and others. Lori Thurgood, principal author of this report, developed the survey instruments, assisted with interviews, and analyzed the survey data for presentation in this report. John Benskin played a key role in survey administration, assisted with preparation of presentation material, and incorporated the data into the appendices of this report. Mary Hancock reviewed the survey instruments, cleaned the survey data, and produced the data tables from the survey database. Roland Bardon developed the web versions of the survey instruments and was responsible for launching the surveys, monitoring responses, and overseeing the fielding stage. Adrian Tyler assisted with interviews and also with survey administration. Prudy Brown pretested the survey instruments and reviewed and helped edit this report.

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EXECUTIVE SUMMARY

I. INTRODUCTION

The National Institute of Biomedical Imaging and Bioengineering (NIBIB) within the National Institutes of Health (NIH) and the National Science Foundation regard bioengineering and bioinformatics as essential fields for the Nation as they underpin many other areas of science, engineering, and technology in the 21st century. To increase the number of young people considering careers in bioengineering and bioinformatics at the graduate level and beyond, the two agencies established the Bioengineering and Bioinformatics Summer Institutes (BBSI) Program in 2002. The goal of this program is to provide undergraduate and early-stage graduate students majoring in the biological sciences, computer sciences, engineering, mathematics, and physical sciences with well-planned, interdisciplinary bioengineering or bioinformatics research and education experiences in active "summer institutes," thereby increasing the number of individuals pursuing careers in bioengineering and bioinformatics at the graduate level and beyond.

The first BBSI solicitation was released in fiscal year 2002, and the first nine summer institutes began in 2003. The awardees were permitted to recompete for a new award in the last year of their initial award. Each BBSI received joint NIH/NSF support of up to $200K per year for up to four years. According to NSF Fastlane data, the overall cost of funding the nine BBSIs from 2003-2006 was $6,040,000. Approximately 15 undergraduate and graduate students were trained annually in each BBSI – a total of 450 student participants in the BBSI Program during those years. Dividing the total cost by the total number of students in the program results in a cost of $13,422 per student. The total amount of direct support for each undergraduate student, including stipend, travel allowance, housing, and meals, is estimated at $6,889.[1]

The BBSI Program differs from other student research programs sponsored by NIH and NSF in its focus on formal course work and research seminars, although it shares common elements such as an emphasis on hands-on research experience and an explicit concern about students' professional growth. Another special feature of the BBSI Program is the option for two consecutive summers of participation. The program also allows graduate students, as well as undergraduate students, to participate. In addition, it is designed to help build new fields of study that are inherently interdisciplinary.

This study was conducted through site visits, phone interviews with principal investigators (PIs) and BBSI directors, and through surveys of former BBSI students, faculty participants, and PIs whose proposals were not awarded. SRI surveyed 444 students[2] and 152 faculty members who participated in the

[1] The average stipend amount provided to each undergraduate student was $3,389. Most BBSIs also provided support for housing and meals, estimated roughly at $2,000 and $1,000, respectively, per student. Travel allowances ranged from $300-$500 across the BBSIs. Graduate students typically received $1,000-$2,000 more than undergraduate students; the $6,889 estimated direct cost per student does not take into account the additional funding received by graduate students. The calculation is based on undergraduate students only because the vast majority of BBSI students in 2003-2006 were undergraduates.

[2] According to the BBSI annual reports, the total number of student participants in the BBSI Program was 451. One BBSI provided a list of students that was one person short of the number given in its annual report, leaving a total of 450 to be surveyed. Five of these 450 students responded that they did not participate in the BBSI Program and one student was deceased. Eliminating these six students as ineligibles leaves a total survey population of 444 students.

BBSI Program between 2003 and 2006. Also surveyed were the 21 PIs who applied for BBSI grants in the 2002 competition but who were not awarded.

The surveys were administered online, with e-mail notifications and reminders. A total of 282 students completed the Survey of Student Participants, for a response rate of 63.5%. When the 87 students whose contact information could not be located are excluded from the base, the student response rate becomes 79%. A total of 107 faculty members responded to the Survey of Faculty Mentors – a 68% response rate based on the total survey population and a 70% response rate when the 4 faculty members who could not be located are excluded from the base. Fourteen non awardees responded to the Survey of Non-Awardees, for a response rate of 67% for the total survey population and 70% when the one person who could not be located is excluded.

All data shown in the figures and tables are derived from the BBSI surveys and interviews conducted in 2008 by SRI International.

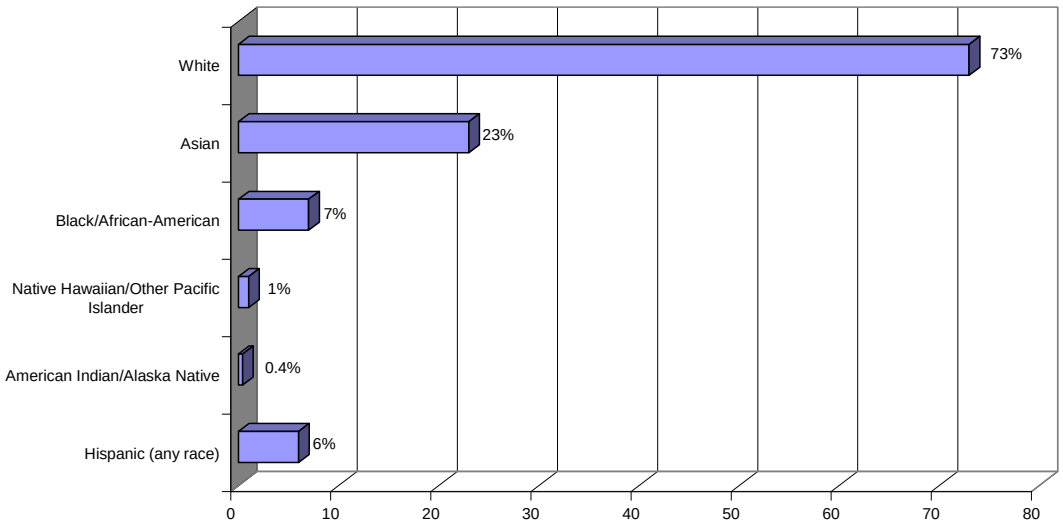
II. MAJOR SURVEY FINDINGS

Profile of Survey Participants

Women were well represented among BBSI students but not among faculty participants or non-awardees. There was very little participation from underrepresented minorities among students or faculty.

Women comprised 45% of BBSI student respondents but only 21% of BBSI faculty respondents and 14% of non-awardee respondents. About 6% of both student and faculty respondents were of Hispanic ethnicity (regardless of race). Racially, all faculty were white (85%) and/or Asian (15%), as were most students. Less than 9% of students were underrepresented minorities (Figure ES-1).

Figure ES-1. BBSI Student Respondents, by Race/Ethnicity: 2003-2006
(%, including multiple responses)

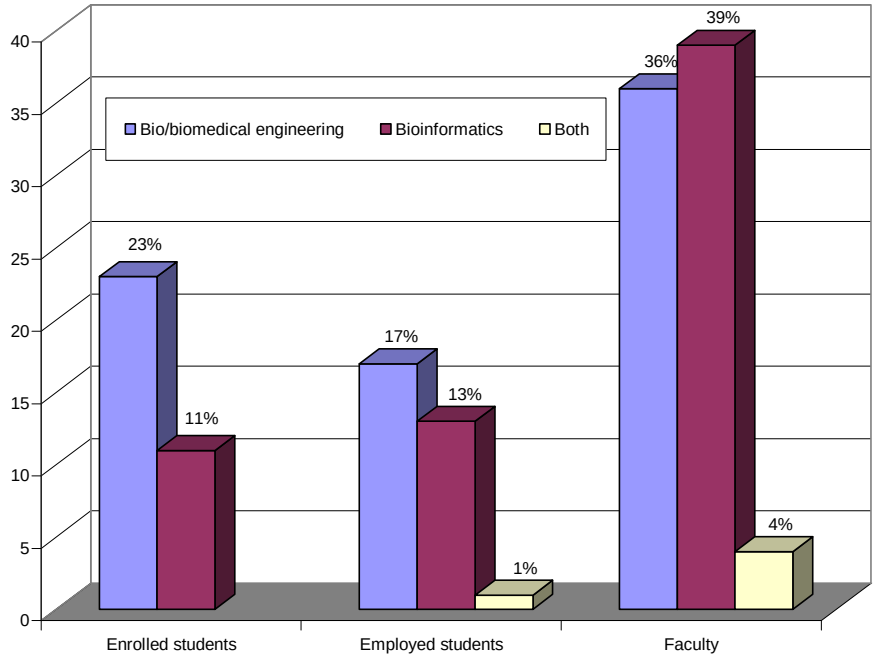


Note: Students count once in each category they reported. Only 15 of 264 students who gave race/ethnicity reported more than one category.
Source: NIBIB/NSF, BBSI Survey of Student Participants, 2008.

Most former BBSI students were still in undergraduate or graduate school at the time of the survey. More than a third of those currently enrolled and 30% of those currently employed were studying or working in bio/biomedical engineering or bioinformatics. Almost 4 in 5 faculty participants were working in these fields.

Nearly two-thirds (64%) of BBSI students were enrolled in either an undergraduate or graduate program at the time of the survey. Of these 175 students, 14% (N=24) were still in an undergraduate program and 86% (N=151) were in a graduate program: 55% research doctorate, 3.4% joint MD/PhD, 15% professional degree, 14% master's. More than a third (34%, N=58) of all current students were specializing in a BBSI target field (Figure ES-2) – a net increase of 13 BBSI majors since these students participated in the BBSI Program. At both the undergraduate and graduate levels, more current students were majoring in biomedical engineering or bioengineering than in any other field.

Figure ES-2. Current Enrollment and Employment in Bio/Biomedical Engineering and Bioinformatics: 2003-2006 (% of total enrolled or employed)



Source: NIBIB/NSF, BBSI Surveys of Student Participants and Faculty Mentors, 2008.

A third of student respondents (34%) had a job other than a research/teaching assistantship or an internship at the time of the survey (including some students who were also enrolled in school). About 30% of this subset of students were working in a BBSI target field, as were 79% of faculty participants. Most faculty (94%) were employed by universities or colleges. Close to two-thirds of these academics (63%) said their department encouraged, but did not require, faculty to mentor undergraduates in research.

Most student respondents had received a bachelor's degree and some also had earned a master's degree by the time of the survey. Very few students had attained a more advanced degree. Nearly a fourth of all degrees earned by BBSI students were in BBSI target fields.

By the time of the survey, 91% of former BBSI students had earned a bachelor's degree; 14% a second bachelor's degree; 22% a master's degree; 2% a professional degree (N=5); and 3% a research doctorate (N=9). About 8.5% had not received a 4-year degree yet.

As Table ES-1 shows, nearly one in four (23%) of the degrees already earned by student respondents was in a BBSI target field: bio/biomedical engineering (15.7%, N=58); bioinformatics (7.3%, N=27). A comparison of these data with majors at the time of BBSI participation indicates that bioinformatics, in particular, has benefited from the BBSI Program: 27 degrees to date vs. 16 majors at the time of BBSI participation. The 58 degrees earned in bio/biomedical engineering exceed the number of majors in that field at the time of BBSI participation, but only by 2 degrees.

A fourth (25%) of all students with bachelor's degrees earned their degree in a BBSI target field, as did a third (33%) of all students with master's degrees (including both first and second master's degrees). One of the 9 PhDs received a doctorate in a bioinformatics-related field.

Table ES-1: Degrees Received by BBSI Students in BBSI Target Fields, by Type of Degree: 2003–2006 BBSI Cohorts (student responses, number of degrees, % distribution)

	Type of degree earned							
Field of degree	1st BS/BA	2nd BS/BA	1st MS/MA	2nd MS/MA	1st prof'l degree	1st research doctorate	Number of degrees in field	% of all field reports
Number of students reporting degree field & type (duplicated)	254	38	60	3	5	9	370	100%
Bio/biomedical engineering	48	0	10	0	0	0	58	15.7%
Bioinformatics	16	0	8	2	0	1	27	7.3%
Total BBSI fields	64	0	18	2	0	1	85	23.0%
% of degree type	25.2%	0.0%	30.0%	66.7%	0.0%	11.1%		

Note: Bio/biomedical engineering includes biomedical optics. Bioinformatics includes computational biology and similar fields. Degrees include those earned by students before BBSI participation as well as those earned after completion of the BBSI Program. Students who reported multiple degrees count once in each category. Percents are based on the number of field reports in each category.

Source: NIBIB/NSF, BBSI Survey of Student Participants, 2008.

Selection of Students for BBSI Program

Faculty used a diversity of criteria in selecting students for the BBSI Program. Most important was a student's motivation or enthusiasm. Least important was previous experience in bioengineering or bioinformatics.

About 46% of faculty respondents were involved in selecting students for the BBSI Program. Of the 18 selection criteria listed in the survey, a student's motivation or enthusiasm was considered most important to acceptance into the program (a mean importance of 3.5, based on a 4-point scale where 1 = not at all important and 4 = extremely important). Three in five faculty participants involved in the

selection process (60%) considered a student's motivation or enthusiasm to be extremely important and another 33% said fairly important

Next most important to the selection decision, with a mean importance of 3.2, were letters of recommendation, the student's essay, and the student's GPA in the major or selected courses. Achieving a good mix of men and women and a good mix of racial/ethnic groups scored a mean 3.1 and 3.0, respectively. Less important were bringing in students with disabilities, with a variety of majors, or from different types of institutions (including those where research opportunities are very limited); a good match between the student's interests and the interests of faculty participants; previous research experience or experience in bioengineering or bioinformatics; the student's major, courses taken, and overall GPA.

Although faculty did not consider the student's academic level to be as important as several other selection criteria, 37% preferred juniors and 10% preferred sophomores. About 45% of faculty preferred a mix of classes or indicated "no preference." An even larger percentage of faculty (72%) showed no preference between undergraduate students who were already committed to going to graduate school and those who were undecided.

Motivations for Participating in BBSI Program

Getting an opportunity to do hands-on research was the primary reason students applied to the BBSI Program, and giving undergraduates this opportunity was the primary reason faculty participated in the program.

Nearly all students cited the opportunity for a hands-on research experience as a major reason for applying to the BBSI Program; 85% of students said this was extremely important to their decision, resulting in a very high mean importance of 3.8, based on a 4-point scale. The second most important reason for applying (a mean 3.5) was getting a chance to learn more about what it is like to be a researcher; 65% of students said this was extremely important to them. Third most important (a mean 3.3) was having an opportunity to see if bioengineering and bioinformatics are fields the student might be interested in pursuing; 54% of students said this was extremely important to their applying. Although students may not have had prior exposure to bioengineering or bioinformatics, 87% of students were "interested" in bioengineering or bioinformatics when they applied to the BBSI Program.

Less important to students, but still rated above a mean 3.0, were the stipend and support package; the research projects of the BBSI faculty; and having an experience that might help them get admitted to graduate school.

Students obtained information about the BBSI Program from a variety of sources, but mainly from websites. Half of student respondents applied for other research opportunities for the same summer, including other BBSIs.

Three-fourths of students (75%) accessed websites to learn about the BBSI Program. In contrast, only 15% learned about the program from past or current BBSI students. Students also received information about the program from BBSI faculty or researchers (21%); BBSI program directors, coordinators, or other administrators (22%); non-BBSI faculty or researchers (23%); and BBSI brochures (24%).

Half of BBSI students applied for other research opportunities for the same summer: 63% to the Research Experiences for Undergraduates (REU) program; 39% to the NIH Summer Research Program;

33% to another BBSI; 32% for a non-university internship; 31% for a university research assistantship; 2% for federal work-study; and 10% to one or more other summer research programs.

Giving undergraduate students a hands-on research experience was by far the most important factor in faculty decisions to participate in the BBSI Program (a mean importance of 3.7 out of 4); 75% said this was extremely important to their decision.

The second most important impetus for faculty participation (a mean 3.2) was the opportunity to work with a diverse group of students, which was extremely important to 45% of faculty participants. Advancing the field of bioengineering or bioinformatics was the only other factor to receive a mean importance score above 3.0, although not far behind were having an opportunity to interact/collaborate with colleagues in other departments or schools at one's institution and having an opportunity to give back for one's own personal experiences with college mentors. Advancing one's career was cited least frequently as a reason for participating (a mean 1.9), perhaps because 84% of faculty participants were already tenured or on tenure track and 69% were already full or associate professors.

Perceptions of Key Features of BBSI Program

Both students and faculty agreed that the four key features of the BBSI Program are important, with some variation in degree of agreement. Embedded in each feature is faculty mentoring of students, which received high satisfaction marks from students.

Students felt strongly that all four features are important, while faculty were less positive about the need for a second-summer experience and including graduate students in the program (Table ES-2). There was nearly unanimous agreement about the importance of the hands-on research experience, and the groups shared the view that the didactic experience (courses, lectures, research seminars) was less important than hands-on research but still very important. Students were mentored by BBSI faculty throughout the summer. Overall, they were very satisfied (a mean 3.5 out of 4) with the support provided by their faculty mentor.

Table ES-2. Perception of Importance of BBSI Program Features: 2003–2006 (mean agreement)

BBSI Program feature	Mean level of agreement that feature is important	
	Students	Faculty
Hands-on research	3.9	4.0
Courses/lectures on academic subjects and research seminars	3.7	3.7
Second-summer experience	3.8	3.6
Graduate student participants	3.7	3.1

Notes: The mean is based on a 4 point scale, where 1 = disagree, 2 = disagree somewhat, 3 = agree somewhat, and 4 = agree. Responses for second-summer experience and graduate student participants are limited to faculty at BBSIs that had the feature and to students who experienced a second summer or were in a BBSI Program that included graduate students.

Source: NIBIB/NSF, BBSI Surveys of Student Participants and Faculty Mentors, 2008.

A. Education Component

Didactic activities are included in the BBSI Program to give students coming from a variety of majors and experiences a grounding in the fundamentals of the subjects and tools needed in bioengineering and bioinformatics. Students learn these subjects and tools through a variety of formats.

Most students (96%) attended courses or lectures on academic subjects taught by BBSI faculty during their first BBSI summer, and presented or discussed their research findings in seminars. More than 90% of students attended research seminars led by BBSI faculty and/or seminars and lectures given by outside speakers. Students were most satisfied (a mean 3.5 on a 4-point scale) with the research seminars led by BBSI faculty, seminars or lectures presented by outside speakers, and seminars in which students presented their research. Instruction in academic subjects and professional development were rated somewhat lower by students but still above a mean 3.0. Except for professional development, a majority of students were "very" satisfied with all didactic activities.

Faculty deemed the seminars in which students present and discuss their research results to be the most important didactic activity (a mean 3.7 out of 4): 75% said these seminars were extremely important, 21% said fairly important, and 4% said somewhat important. Faculty considered the courses and lectures on academic subjects to be next most important for students (a mean 3.2).

The courses, seminars, and lectures offered by the BBSIs expose students to a variety of academic subjects and tools, as well as professional development. The most common academic subjects were research tools/techniques and biology. The most common professional development topic was communication/presentation skills.

According to Table ES-3 (see next page), at least 4 in 5 student respondents received instruction or training in research tools/techniques (87%), biology (86%), and communication/presentation skills (80%). More than three-fourths of students received instruction in bioinformatics and/or bioengineering. A majority received training in career planning. Fewer students received instruction in proposal writing and resume preparation. Faculty responses about the topics covered in their BBSI's first-summer curriculum were very similar to student reports except for communication/presentation skills and career planning, for which faculty reported greater coverage than students reported. Students also benefited from the education component through exposure to career professionals and by forming bonds with other BBSI students in class.

B. Research Component

The BBSI Program focuses on giving students a research experience in bioengineering and bioinformatics.

About 93% of students and 84% of faculty reported bioinformatics and/or bioengineering as the focus of their BBSI research. About the same percentage of each group (47% of students, 46% of faculty) reported a research focus on bioinformatics. Bioengineering was reported by 42% of students and 38% of faculty. Some respondents said their research involved both fields.

Students spent almost two-thirds of their time in their first BBSI summer doing "hands-on" research and the other third attending courses, lectures, or seminars. Students in some BBSIs would like more research time and less time in courses or seminars.

Although 70% of students thought the distribution of time between hands-on research and didactic activities was about right, 30% said they had too little time for hands-on research and 21% felt the time

spent on BBSI courses, seminars, and lectures was too much. The students who felt they spent too much time on course work were concentrated in three BBSIs. About 37% of students continued their research from their first BBSI summer into the academic year.

Faculty participants more often thought the distribution between hands-on research and didactic activities was about right for students. About 22% of faculty thought the time available for hands-on research was too little for students, and only 12% of faculty thought the time spent on course work was too much.

Table ES-3. First-Summer Curriculum of Education Component: 2003–2006 (% of student and faculty respondents reporting coverage of subject/topic in their BBSI Program)

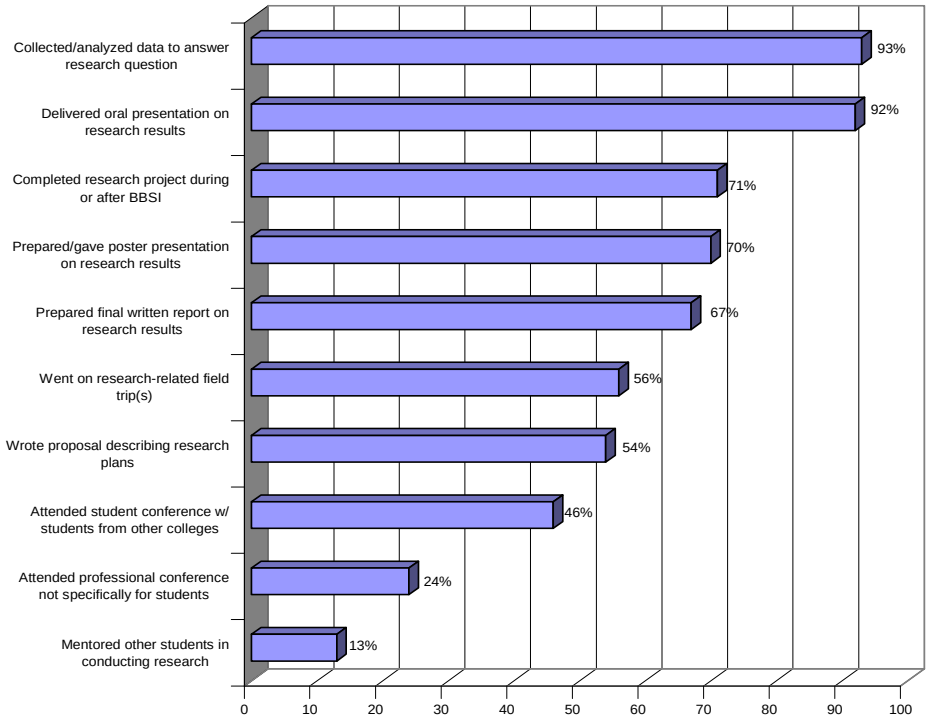
Subjects/topics	Students	Faculty
	(N = 282)	(N = 104)
Academic subjects		
Bioinformatics	76%	75%
Bioengineering	77	71
Other engineering	45	34
Biology	86	83
Statistics	52	58
Computer programming	63	64
Ethics	70	68
Research tools & techniques	87	88
Other academic subject	8	17
Professional development		
Communication/presentation skills	80	87
Proposal writing	41	40
Resume preparation	29	25
Career planning	54	65
Other professional development topics	3	6

Source: NIBIB/NSF, BBSI Surveys of Student Participants and Faculty Mentors, 2008.

Most BBSI students collected and/or analyzed data and delivered an oral presentation describing their research and results. Fewer completed their research project during the BBSI Program or afterward.

Figure ES-3 presents a selection of the research activities in which BBSI students participated. The most common research activity was the collection and/or analysis of data (reported by 93% of students). The second most common activity was an oral presentation of the research results (92%). Only 71% of students completed their project during or after the BBSI Program. For the most part, faculty indicated greater student participation in the different research activities at their BBSI than students reported for themselves. Faculty also reported that a majority (55%) of students in their BBSI authored/co-authored papers or articles for publication in peer-reviewed journals during the first BBSI summer.

Figure ES-3. Research Activities of BBSI Students: 2003-2006 (%)



Source: NIBIB/NSF, BBSI Survey of Student Participants, 2008.

Students reported high levels of satisfaction with the research component, especially with the independence they had in doing their BBSI work. Students were least satisfied with their role in selecting or designing their research project and the degree to which they felt they were an integral part of a research team.

Nine in 10 students (89%) said they learned how to conduct research independently, and 93% were at least somewhat satisfied (66% very satisfied) with the independence they were given (a mean satisfaction level of 3.6). Students rated collaboration and teamwork somewhat lower than independence, perhaps because they worked more on their own. About 85% of students said they learned how to collaborate with others on research, and 80% were at least somewhat satisfied with the extent to which they felt they were an integral part of a research team (a mean satisfaction level of 3.2).

From various results it appears that students would like to be more involved in selecting and designing their research projects.

Students were less involved in developing their research project than in other activities and reported less satisfaction with their involvement than with most other aspects of the research component. Only 20% of students had primary responsibility for designing their project. About 50% were able to provide input but someone else had primary responsibility for designing the project. Almost 29% had no involvement.

C. Second Summer

The BBSI Program allows the institutes to bring back students for a second summer of research training. Practices vary with respect to which students can return for a second summer. Some BBSIs open it up to all students who completed a first summer, some invite back only certain students, and some do not operate a second-summer program.

About 7 in 10 students were informed about a second summer of training at their BBSI. About 6 in 10 wanted to return for a second summer, but only 4 in 10 actually came back. More than 9 in 10 students learned about the second-summer opportunity from their BBSI program director, coordinator, or other BBSI administrator, and about 7 in 10 learned about it from BBSI faculty or researchers. A majority of students obtained information from a website (56%) and/or other BBSI students (54%).

There is more emphasis on research and less emphasis on course work in the second summer. Students spent more than three-fourths of their time on hands-on research in the second summer, compared to two-thirds of their time in the first summer.

More than 9 in 10 second-summer students participated in the different types of research-oriented seminars or lectures, compared to 7 in 10 who participated in courses or lectures on academic subjects. Participation in courses/lectures during the second summer was significantly lower than in the first summer, when 96% participated. Second-summer students spent 77% of their time on hands-on research and only 23% of their time on didactic activities (Table ES-4). Students and faculty agreed that the time required for course work in the second summer should be less than in the first summer and that the content of the course work should be different.

Table ES-4 Time BBSI Students Spent on Hands-on Research vs. Courses/Lectures/Seminars in Second Summer Compared to First Summer: 2003–2006 (mean % time spent)

	Mean % time students spent, as reported by	
Time students spent on …	Students	Faculty
Second summer	(N = 75)	(N = 50)
Hands-on research	77.2%	76.2%
Courses/lectures/seminars	22.8	23.8
First summer	(N = 281)	(N = 103)
Hands-on research	65.7%	65.2%
Courses/lectures/seminars	34.2	34.8

Source: NIBIB/NSF, BBSI Surveys of Student Participants and Faculty Mentors, 2008.

Three-fourths (76%) of second-summer students thought the amount of time spent on hands-on research during the second summer was about right, but 13% would have liked still more time. About 90% of faculty thought the research time in the second summer was about right.

Nearly all students and faculty agreed that a two-summer program promotes a longer, more continuous connection between faculty and students (mean agreement of 3.8, out of 4). Both groups also showed a high level of agreement about students being able to jump right into their research in the second summer because they have a summer of research behind them. Their views diverged on other matters.

Faculty agreed more than students that the second summer allows students to focus a lot more on research than they could in the first summer, that second-summer students resemble graduate students by the end of the second summer, and that they help orient first-summer students and serve as peer mentors.

In other ways, faculty participants appeared to be less supportive of the second summer. About 22% of faculty thought one summer would be enough for most undergraduates, compared to 10% of students who felt one summer would have been enough for them. While 87% of faculty agreed that the second summer produces a higher quality student, only two-thirds felt the real payoff for the BBSI Program comes in the second summer. More than a fourth of faculty (28%) thought it would be better to maximize the number of student participants by keeping the number of second-summer students low, and 20% thought it would be better to fund students for a second summer using non-BBSI resources. While only 6% of faculty felt the second summer should be dropped altogether, 50% thought only outstanding students should be invited back.

D. Graduate Students

More students (86%) than faculty (81%) thought including graduate students was important. About 46% of students and 29% of faculty said their BBSI included graduate students who had to meet the same basic didactic and research requirements as the undergraduate participants. A significant number did not know if graduate students participated in their program.

More than three-fourths of each group agreed that graduate students help undergraduates in considering graduate school and career choices, and more than two-thirds of each group agreed that the BBSI Program gives graduate students an opportunity to change direction or narrow their focus. Interestingly, faculty (81%) were more inclined than students (76%) to think that undergraduate students benefit from observing the maturity and work ethic of graduate students.

E. Faculty Mentoring

Most faculty participants have mentored BBSI students. According to both faculty and students, the mentor:student ratio in the BBSI Program is very low.

A third of faculty mentors had mentored a total of 1 or 2 students (counting all summers), another third had mentored 3 or 4 students, and the final third had mentored 5 or more students. About 39% of students said they were the only BBSI students advised by their faculty mentor during their first summer. Another 31% shared their mentor with just one other student.

Almost two-thirds (63%) of faculty mentors spent at least 5 hours per week mentoring each of their students. The other mentors spent 1-4 hours with each student. Mentors assisted their students after the BBSI Program as well as during the program.

During the program faculty mentors were far more likely to advise their BBSI students on the direction of their research (92%) than on graduate school plans, career choices, or what undergraduate courses the student should take (see Table ES-5). Overall, students were very satisfied (a mean 3.5 out of 4) with the support provided by their faculty mentor during the first BBSI summer.

Once the students completed the BBSI Program and advanced academically, mentors' advising of students on research, undergraduate courses, graduate school plans, and career choices decreased, and their writing of recommendation letters for students' applications for employment, graduate school, and fellowships/grants increased. For both time frames, mentors reported a much higher level of helping students than students reported receiving.

Table ES-5. Assistance Given Student by Faculty Mentor During and After the BBSI Program: 2003-2006 (% reporting assistance received/given)

Did the faculty mentor ...?	During BBSI Program		After BBSI Program	
	Students (% yes)	Faculty (% yes)	Students (% yes)	Faculty (% yes)
	(N = 279-282)	(N = 98-103)	N = 263-267)	(N = 90-97)
Advise the student on the direction of her/his research	92%	99%	28%	42%
Advise the student on graduate school plans	53	83	38	57
Advise the student on career choices	43	72	30	48
Advise the student on courses to take in undergraduate school	19	32	8	18
Write recommendation letters for the student's graduate school applications	21	45	48	78
Write recommendation letter(s) for the student's fellowship/grant/etc. applications	14	31	30	53
Write recommendation letters for the student's employment applications	8	20	14	38

Note: Students reported about their personal experiences with their BBSI mentor during their first BBSI summer. Faculty reported about their activities with all BBSI students they have mentored across summers.

Source: NIBIB/NSF, BBSI Surveys of Student Participants and Faculty Mentors, 2008.

Students interacted informally with their mentors as well as with other students. Communications between faculty and students continued after the BBSI Program.

A majority of students (53%) reported socializing with their faculty mentor at least twice a month, and 38% said they socialized 4 or more times a month. A third (34%) of faculty mentors reported socializing with their students at least 4 times a month, but another third did not socialize at all with their students. More faculty (83%) than students (69%) said they stayed in touch with each other after the BBSI Program.

Students socialized much more often with other BBSI students. More than three-fourths of students (78%) socialized with other BBSI students 4 or more times a month during their first BBSI summer, and the same percentage said they stayed in touch with other BBSI students after the program.

Effects of BBSI Experience on Students

The BBSI experience increased students' awareness and understanding of bioengineering and bioinformatics, related careers, and graduate school, as well as their research skills and self-confidence.

Both students and faculty reported the greatest increases (a mean 3.6 out of 4) in students' understanding/awareness of what bioengineering and bioinformatics are, including the variety of applications (Table ES-6). About 62% of students said their understanding/awareness of these fields increased a great deal, and another 31% said a fair amount. Faculty reported 61% and 35%, respectively, for the BBSI students they mentored.

Table ES-6. Effect of the BBSI Experience on Students' Awareness, Understanding, Skills, and Abilities: 2003-2006 (student and faculty respondents, mean increase)

To what extent did the BBSI experience increase students' …?	Mean increase	
	Students	Faculty
	(N = 276-280)	(N = 103-106)
Understanding/awareness of what bioengineering and/or bioinformatics are, including the variety of applications	3.6	3.6
Understanding/awareness of the variety of fields related to bioengineering and/or bioinformatics that you could specialize in	3.4	3.5
Skills/abilities in working independently	3.3	3.4
Skills/abilities in delivering oral/PowerPoint research presentations	3.3	3.5
Understanding of the nature of the job of a researcher	3.3	3.5
Understanding/awareness of how your work contributed to the "bigger picture" of research in bioengineering and/or bioinformatics	3.2	3.4
Ability to clarify your interests and to make informed decisions about your future plans	3.2	3.3
Confidence in your ability to succeed in graduate school	3.2	3.4
Understanding/awareness of career options in bioengineering and/or bioinformatics	3.2	3.4
Skills/abilities in preparing written research reports, papers, or posters	3.2	3.4
Confidence in your research skills generally	3.2	3.4
Intellectual and social network of professional colleagues and friends	3.1	3.3
Qualifications for jobs in bioengineering and/or bioinformatics	3.1	3.2
Skills/abilities in working collaboratively with others	3.1	3.4
Understanding of what graduate school is like	3.0	3.5

Note: The mean is based on a 4-point scale, where 1 = not at all, 2 = somewhat, 3 = a fair amount, and 4 = a great deal.
Source: NIBIB/NSF, BBSI Surveys of Student Participants and Faculty Mentors, 2008.

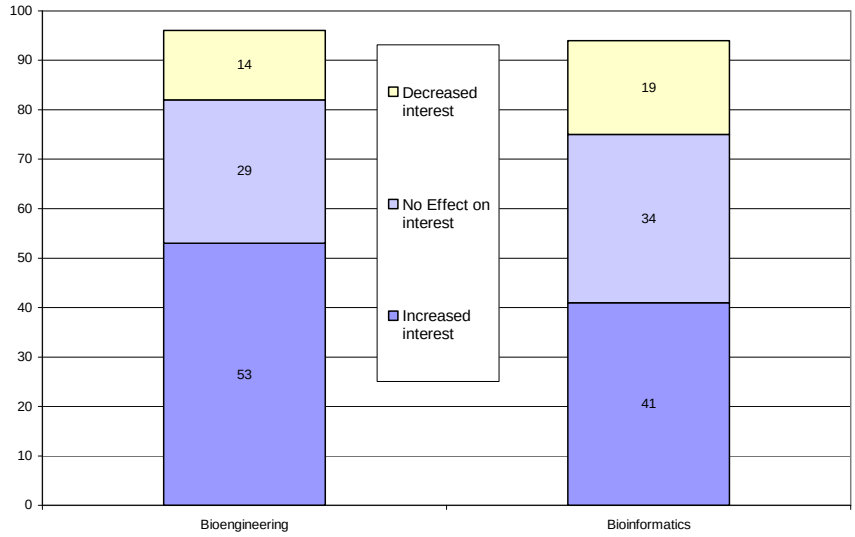
Except for the last four items in Table ES-6, at least 80% of students reported a great deal or fair amount of increase for every item, and at least 40% reported a great deal of increase. Faculty were even more positive about what students gained from the BBSI experience. For all but two items, 85-96% of faculty reported a great deal or fair amount of increase in their students' understanding, awareness, skills, or abilities.

Many students authored or co-authored articles about bioengineering or bioinformatics during or after the BBSI Program. Nearly a fourth of students (23%, N=65) said they wrote articles that were, or will be, published in peer-reviewed academic journals. About 46% of faculty respondents (N=49) said they co-authored articles with students they mentored. About 73% of each group reported writing one article, and 27% wrote two or more articles.

The BBSI experience increased students' interest in both graduate work and a career in bioengineering or bioinformatics. It also increased their interest in working in academe and industry.

A majority of students (53%) said their interest in pursuing graduate work in bioengineering increased at least somewhat because of their BBSI experience; 41% of students became more interested in pursuing a graduate degree in bioinformatics (Figure ES-4). On the other hand, 14% of students reported less interest in bioengineering after their BBSI experience and 19% reported less interest in bioinformatics. Percentages for increased and decreased interest in a career in these fields as a result of the BBSI experience were about the same. Interest in working in academe increased for 62% of students and interest in the for-profit sector increased for 51% of students.

Figure ES-4: Effect of BBSI Program on Students' Interest in Graduate Work in Bioengineering and Bioinformatics (% of student respondents)



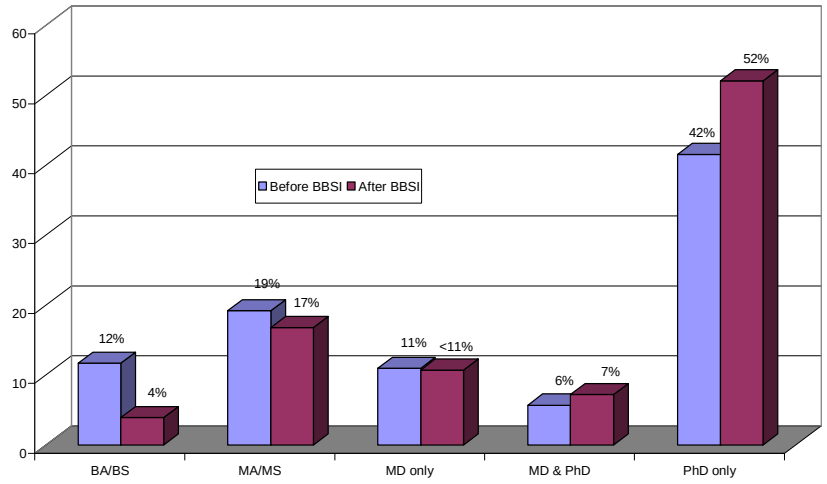
Source: NIBIB/NIBIB, BBSI Survey of Student Participants, 2008.

More than a fifth of students (22%) have applied for a job related to bioengineering or bioinformatics since they completed the BBSI Program. Of this group, 62% (N=39) were hired into a job in one of these fields. Most said their BBSI experience helped prepare them for the job.

Degree expectations of about a third of the students were raised following their BBSI experience.

About a third of students (32%) have higher degree expectations today than they had before their BBSI experience. Only 9% lowered their expectations (including switches from a PhD to an MD or other professional degree). About 47% of students had plans to earn a PhD before they entered the BBSI Program (Figure ES-5). By the time of the survey, 3 in 5 BBSI students (60%, N=166) were planning to pursue a PhD, an increase of 13 percentage points.

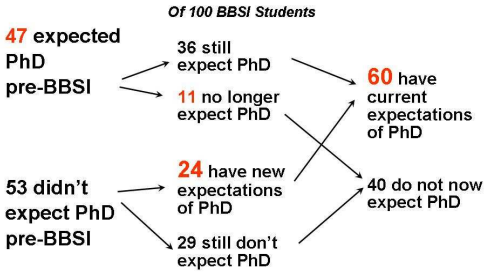
Figure ES-5. Highest Degree Expectations of BBSI Students: 2003-2006 (% of all students before and after BBSI experience)



Source: NIBIB/NSF, BBSI Survey of Student Participants, 2008.

Of those students who did not expect to attain a PhD before their BBSI participation, a little less than half (45%) now expect to earn a PhD. Of those students who planned to pursue a PhD before entering the BBSI Program, more than three-fourths (77%) still plan to do so (Figure ES-6).

Figure ES-6. PhD Expectations Flow Chart for BBSI Students



Source: NIBIB/NSF, BBSI Survey of Student Participants, 2008.

The BBSI experience helped students prepare for graduate school.

Almost two-thirds of former BBSI students (63%) have attended graduate school since finishing the BBSI Program; 55% were still enrolled at the time of the survey. More than 9 in 10 of these students (92%) felt the BBSI experience helped prepare them for graduate school, and 32% said it was extremely helpful.

Student Satisfaction with Overall BBSI Experience and Organization

Students were highly satisfied with their overall BBSI experience and with several organizational aspects of the programs.

About 69% of students were "very satisfied" and 28% were "somewhat satisfied" with the overall BBSI experience, for a mean satisfaction score of 3.6 out of 4, where 1 = very dissatisfied and 4 = very satisfied. Students were also highly satisfied with the stipend and support package (a mean 3.6) and the organization of the program (3.5). They were a little less satisfied with the living arrangements (3.4) and social/cultural activities (3.3). A majority of students (58-62%) were "very satisfied" with every aspect except social/cultural activities.

Effects of BBSI Participation on Faculty

Participation in the BBSI Program has had less effect on faculty interests and actions than on students, probably because faculty are already fairly established in their careers and routines. Being able to work with undergraduate students has had the greatest effect on faculty, although the mean extent of effect is only 2.6 (based on a 4-point scale, where 1 = no effect and 4 = great deal of effect).

BBSI participation has affected faculty most by: *

- Giving them an opportunity to work with undergraduates that they wouldn't have had otherwise (78%)
- Increasing their interactions with faculty in other departments/schools at their institution (77%)
- Bringing greater visibility to their academic activities (68%)

- Increasing their involvement in interdisciplinary research (65%)
- Leading to new collaborations with faculty in other departments/schools at their institution (56%)

  * %s represent faculty who reported somewhat, a fair amount, or a great deal of effect. Mean extent of effect ranges from 2.6 to 1.9 for these potential effects (based on a 4-point scale, where 1 = no effect and 4 = great deal of effect).

A majority of faculty also said their BBSI participation has resulted in new articles getting published in peer-reviewed journals, more interactions with faculty at other institutions, and needed teaching experience. A significant majority (56-85%) said their BBSI participation has had no effect at all on redirecting their research, making new collaborations with faculty at other institutions, reducing their usual publication output, limiting their time doing research, limiting their time with family and friends, getting a promotion in academic rank, or getting tenure. The good news is that there seems to be very little negative effect on faculty.

Effects of BBSI Program on Institution, Department, or Program

The BBSI Program appears to have had more effect on institutions, departments, and programs than on faculty participants, although the mean extent of effect is not much higher. The program has had its greatest effect on interdisciplinary research within the institution (a mean 2.7 extent of effect, based on a 4-point scale).

A substantial majority of faculty reported that the BBSI Program has affected their institution, department, or program at least somewhat by: *

- Promoting interdisciplinary research (87%)
- Increasing interactions/collaborations among faculty in different departments or on different campuses at the faculty participant's institutions (85%)
- Bringing new recognition/prestige to the institution, department, or program (80%)
- Helping with recruitment of high quality students (80%)
- Changing perceptions about what undergraduates can do (76%)
- Increasing interactions/collaborations with other institutions (62%)

  * %s represent faculty who reported somewhat, a fair amount, or a great deal of effect. Mean extent of effect ranges from 2.7 to 2.0 for these potential effects (based on a 4-point scale, where 1 = no effect and 4 = great deal of effect).

More than a third of faculty (36%) reported the BBSI Program having an effect on creating new graduate programs in bio/biomedical engineering, bioinformatics, or related fields. Considering that many institutions had programs in place before their BBSI Program began, the goal of the program in helping institutions build new programs in these fields has been met successfully.

Actions of Non-Awardees after Being Declined a BBSI Grant

Despite having been declined a BBSI grant, most non-awardees also have been involved in activities that contribute to giving undergraduates a research experience in bioengineering or bioinformatics. Several non-awardees applied for new funding to give undergraduates such an experience, although only one was successful in obtaining funds.

Of the 14 non-awardee respondents, 6 (43%) subsequently applied for new funding that would give undergraduates a research experience in bioengineering or bioinformatics. Two PIs reapplied for BBSI funding in 2006 and were declined again. One applied for a Research Experiences for Undergraduates

(REU) grant from NSF or NIH and received an REU grant. Three PIs applied for other types of undergraduate research funding and were declined.

Although most non-awardees did not receive subsequent funding, 11 respondents said they have engaged in activities that contributed to undergraduate research experiences in bioengineering or bioinformatics, for example, through departmental support of undergraduate research funded by individual PI grants and NSF REUs.

III. RECOMMENDATIONS

1. The BBSI is meeting its program goal of attracting students to graduate study and careers in bio/biomedical engineering and bioinformatics, and should continue to be funded.

The results from the surveys of faculty and student participants confirm that the BBSI Program has achieved its main goal of attracting students to graduate work in bioengineering and bioinformatics. This is evidenced by positive changes in PhD expectations before and after a student's BBSI experience. Students and faculty generally said their BBSI experience was positive. Almost all students who advanced to graduate school or found jobs in related fields reported that their BBSI experience was helpful in preparing them for graduate school or employment. The BBSI faculty also helped them by writing recommendation letters.

2. The BBSI Program should continue to support hands on research.

Having an opportunity for a hands-on research experience was the primary reason students applied to the BBSI Program, and giving students a hands-on research experience was the primary reason faculty participated in the program. Almost all students and faculty who responded to the surveys felt that hands-on research is an important feature of the BBSI Program.

3. SRI recommends that NIBIB/NSF provide guidelines for the proper balance between hands-on research and the educational component of the BBSI Program.

Didactic learning is an important feature of the BBSI, according to both faculty and student participants. Considering the high level of importance both students and faculty attributed to the didactic learning component, the BBSI Program was successful in this area. However, a substantial number of both students and faculty expressed the view that, in the first year of the BBSI, too little time was spent on hands-on research and too much time was spent on courses on academic subjects and research seminars. Upon closer examination, the students who felt that too much time was spent on the educational component were concentrated in three BBSIs.

4. SRI recommends that NIBIB/NSF continue to support the second-year option and to provide explicit guidelines about it. The majority of faculty and students thought the second-summer option is an important feature of the BBSI Program.

NIBIB/NSF should consider providing explicit guidelines about the allocation of resources between first-time and returning student cohorts just as they provide guidance about the proportion of students that should come from the host institution. Many PIs found it difficult to decide how to allocate funds between the first- and second-year students. Different BBSIs made different choices – some decided to invite all or most students back while others decided not to invite anyone back.

The guidelines should require BBSIs to inform students in the application package about the second-summer option and should state whether all or only deserving students should have the opportunity for a second summer.

5. SRI recommends that the BBSI Program continue to accept graduate students.

From the interviews with the BBSI PIs and directors, graduate students accepted to participate in the BBSI Program are generally in an early stage of their graduate study and their academic backgrounds do not differ qualitatively from the undergraduate students. Since the goal is to encourage students to consider careers in bio/biomedical engineering and bioinformatics, allowing early-stage graduate students to participate in the BBSI is logical. Furthermore, the majority of students and faculty responded positively about the interaction with graduate students in the BBSI Program, noting that graduate students served as role models and helped undergraduate students.

6. SRI recommends that NIBIB/NSF continue to support the BBSI Program as an independent program distinct from the REU program.

The BBSI Program's didactic learning component and second-year option are innovative features that may be adopted by the existing NSF REU Program. Furthermore, the BBSI Program has led to institutions creating new undergraduate or graduate programs or majors. As newly formed interdisciplinary fields of study, both bioengineering and bioinformatics are in the process of being established as disciplines. The BBSI Program, as intended, has helped accelerate this process, which justifies maintaining it as an independent targeted program.