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Benefits of Research Fellowships for Undergraduates with Disabilities

The purpose of this article is to contribute to the understanding of how undergraduate students with disabilities experience and benefit from mentored research opportunities in the STEM (science, technology, engineering, and mathematics) disciplines. To accomplish this goal, the article focuses on the following questions: (a) How do students with disabilities experience undergraduate research opportunities? And (b) How do these opportunities influence students' sense of themselves, their participation, retention, academic success in STEM and transition to graduate school? Analysis revealed that although students who participated in undergraduate research fellowships (URFs) experienced some disability-related challenges, they were fully engaged in research processes, by and large remained on track to complete their degrees, were more likely to enter graduate school and jobs in STEM fields than non-participants in the program, and enjoyed personal and social benefits.

The national shortfall in college graduates in STEM fields is well documented (National Research Council 2007). Graduating more students in these fields requires systemic efforts to effectively support and provide experiences for students as they move through critical transitions on their way to STEM careers (Science and Technology Action Plan 2008). Undergraduate research has been established as important in the career development of students in the STEM disciplines (Gibson and Bruno 2012; Junge et al. 2010; Russell et al. 2007; Russell 2006; Seymour et al. 2004; Wood and Gentile 2003; Mervis 2001).

For many students, participation in research at the undergraduate level represents their first opportunity to apply what they have learned in formal coursework and to integrate the sometimes seemingly disparate aspects of their academic curricula—thus providing a capstone experience of considerable value. Undergraduate research can be paramount in students' decisions to attend graduate school (Eagan et al. 2011; Barlow and Villarejo 2004; Bauer and Bennett 2003; Gonzalez 2001; Russell et al. Kardash 2000; Sabatini 1997). Undergraduate research programs provide students with an idea of what a career in scientific research entails (Lopatto 2006; Kinkead 2003) and enhance students' identity as scientists (Hurtado et al. 2009). Students who participate in research while they are undergraduates are significantly more likely to persist to degree completion in their STEM discipline than other students (Chang et al. 2011; Carlone and Johnson 2007).

Undergraduate research is an inherently social-learning context by virtue of the fact that students are mentored by faculty members and work with others in laboratory and field settings. Fenichel and Schweingruber (2010) point out that "learning is enhanced through engagement with others, experimentation, and interaction with artifacts" (99), and mentorship appears to be critical to student success (Willis, Krueger, and Kendrick 2013; Thiry and Laursen 2011). A growing body of evidence demonstrates that mentored undergraduate research opportunities are critical in expanding and diversifying STEM fields (Eagan, Hurtado, Chang, Garcia, Herrera, and Gariby 2013; Jones, Barlow, and Villarejo,2010; Strayhorn 2010). The majority of this research, however, focuses on students from racial and ethnic-minority backgrounds, as well as women; there continues to be limited research that addresses the participation of students with disabilities.

Persons with disabilities are a smaller proportion of the STEM labor force than they are of the labor force in general (National Science Foundation 2004). Students with disabilities are less likely than other students to pursue postsecondary education, especially in the STEM fields, for a number of reasons. These students are often not encouraged to take the necessary high school classes either because of limited knowledge of what is required in postsecondary education (Burgstahler 1994) or because of low expectations (Dymond et al. 2008). Students with disabilities are at greater risk of finding themselves in a science curriculum that lacks depth and challenge (Dymond et al. 2008), and students in self-contained, special-education settings often receive "little or no science instruction" (Bodzin, Waller, Santoro, and Kale 2007, 273).

Nevertheless, findings are beginning to emerge that show benefits for students with disabilities who participate in undergraduate research (Langley-Turnbaugh et al. 2007). Further, findings specific to students with disabilities show that these individuals often gain knowledge about effective accommodation strategies through internships or other mentored professional opportunities (Burgstahler and Bellman 2009). Students with disabilities are more likely to ask for assistance and accommodations if their student-faculty relationships are strong and if faculty members are perceived as being supportive (Orr and Hammig 2009). Students with disabilities have also been found to perceive their student-faculty interactions more favorably than students without disabilities—even when students with disabilities perceive their campus as less than supportive (Hedrick, Dizen, Collins, Evans, and Grayson 2010).

While these emerging findings are promising, research on participation by students' with disabilities in undergraduate research remains limited, as is our understanding of its impact on these students.

The purpose of this article is to contribute to the understanding of how students with disabilities experience and benefit from these mentored opportunities. To accomplish this, we focused on the following questions:

- How do students with disabilities experience undergraduate research opportunities?
- How do these opportunities influence students' sense of themselves, their participation, retention, academic success in STEM fields, and transition to graduate school?

Methods

The University of Southern Maine (USM) enrolls a student population of 10,000, and has assumed a strong and growing role in science and technology education, both on campus with its approach to degree programs and in the community through outreach to K-12 students and their teachers. USM has hosted the Eastern Alliance in Science, Technology, Engineering and Mathematics (EAST) for the past 10 years. Funded by the National Science Foundation's Research in Disabilities Education Program, EAST is one of ten alliances across the country with the mission of increasing the numbers of students with disabilities who enter STEM majors and advance to graduate school or STEM careers. An important component of the EAST Alliance is its undergraduate research experiences, which provide students with hands-on, real-world experience in STEM research with faculty. These research experiences are called Undergraduate Research Fellowships (URFs) to highlight the financial and professional-development aspects of the program.

Students primarily learn about URFs through presentations in their classes, at workshops, conferences, and through faculty members. Students are likely to be invited to assist in faculty research or to have been working with faculty using work-study funds, prior to applying for an URF. Students submit an application that includes a personal statement, project description, work plan, budget form, letter of recommendation from the research supervisor, and a copy of a current college transcript. Applications are reviewed by a panel of higher education faculty, and students are selected based on the match between the student's proposal and a faculty member's research agenda and academic criteria (a GPA of at least 2.5 is required). If chosen for a fellowship, students are paid $3,000 for an eight-week summer experience (or the equivalent time during the academic year) with the option of an additional $500 for equipment and supplies. Faculty advisors are paid $1,000 for supervising summer fellows, although they often donate their stipends back to the project. Once an URF is awarded, the student and his or her faculty mentor determine the structure for their work. Students present their research at Thinking Matters, the annual undergraduate research conference at USM, as well as at national conferences when opportunities arise.

Data-Collection Tools

Data for this investigation came from three convergent data sources: surveys that were administered before and after students' completion of a research fellowship, academic records collected annually throughout students' enrollment at USM, and interviews with a subsample of students who received research fellowships.

Survey instruments. Pre-fellowship and post-fellowship surveys were developed collaboratively by EAST staff and project evaluators in order to capture a range of variables related to the undergraduate research opportunities, student outcomes, and demographics. The results provided feedback on the program. The survey-development process included peer review and pilot testing. The surveys (http://east.cct.edc.org/instr.html) were designed to collect students' assessments of the undergraduate research fellowship as well as summative information about the impact of the fellowship on students' mastery of key research skills and on their interest and confidence in pursuing STEM courses and careers. The pre-survey contained 19 items and the post-survey included 29. The final questionnaires were delivered annually and monitored online via Survey Monkey by program evaluation staff at the Education Development Center, Inc. (EDC) in New York City between fall 2008 and spring 2013. Students who completed multiple research fellowships completed separate pre- and post-surveys for each fellowship. Forty-two students completed both a pre-fellowship and a post-fellowship survey.

Academic records. Another data source is a longitudinal database used to track EAST participants' demographic background and academic progress and performance. Data include enrollment patterns, grade-point-average, participation in EAST activities, and date of graduation.

Interviews. In-depth interviews were conducted with a subsample of 22 students who participated in EAST over multiple years. In the interviews we asked questions to elicit information about respondents' pursuit of STEM and postsecondary education, their involvement in research fellowships (including any impact of their involvement and suggestions for improving the fellowships), and other STEM-related activities in which they participated.

Results

Between 2008 and 2012, a total of 42 students with disabilities participated in research fellowships at USM. Two-thirds of these students (68 percent) were male, and a third (33 percent) were female (percentages add up to more than 100 per-

cent due to rounding). Students had a variety of disabilities, with emotional disabilities (33 percent), attention-deficit disorders (28 percent), and physical disabilities (20 percent) occurring the most frequently. Lower proportions of students had other health impairments (e.g., epilepsy, asthma) (15 percent), learning disabilities (10 percent), hearing impairments (3 percent), and Aspergers syndrome (3 percent) (percentages add up to more than 100 percent because several students reported multiple disabilities).

Students' grade-point-averages (GPAs) at the beginning of their first fellowship ranged from 2.5 to 4.0, with the average GPA being 3.11. About a third of the undergraduate research fellows (30 percent) were juniors, 25 percent were seniors, 23 percent were sophomores, 20 percent were freshmen, and 3 percent were pre-college. The students majored in a variety of STEM disciplines, with biology (28 percent), information technology (13 percent), environmental science (13 percent), and engineering (13 percent) being the most frequently reported majors. Sixty percent of the students had one fellowship, 35 percent had two, and 5 percent had three.

The demographic profile of students who participated in the URFs was particularly interesting because it differed from that of the national population of undergraduates with disabilities. The EAST undergraduate research fellows included larger percentages of male students and students with emotional or psychiatric conditions, attention deficits, autism, health impairments, and learning disabilities, and smaller percentages of female students, and students with sensory and physical impairments and brain injury.

Students' Outcomes

The fellowships varied in length, ranging from less than a month to more than six months, and ranged from involving fewer than 50 hours of experimental work to more than 501 hours. For more than half (51 percent) of the students, the fellowship lasted three to four months. Students indicated that they had a variety of responsibilities during their fellowships (and could select multiple answers). The most frequently reported responsibilities were data collection (84 percent), data analysis (78 percent), report writing (78 percent), data entry (64 percent), research design (58 percent), literature reviews (51 percent) and presentation or explanation of findings (49 percent). Less frequently reported responsibilities included technical work (e.g., modifying equipment, creating data-collection instruments, 33 percent), and computer programming (18 percent).

The students responding to the post-fellowship survey reported receiving a variety of accommodations during their fellowships. The most frequently reported accommodations included flexible pacing (82 percent) and flexible scheduling (82 percent). Other accommodations included extra time (51 percent), flexible location (e.g., ability to complete work at home, 51 percent), help with writing/editing (47 percent), extra help or support other than writing (29 percent), assistive or adaptive equipment (13 percent), and safety equipment (e.g., epi pen, cell phone, 7 percent).

Generally speaking, students who participated in EAST activities experienced success in postsecondary education and employment in STEM fields. Ninety-seven percent of the EAST Undergraduate Research Fellows are either on track to complete their BS in a STEM field (meaning their progress is aligned with their program of study), are pursuing an MS or PhD in a STEM field, or are employed in a STEM field. Thirty-three percent of the EAST students who graduated from a four-year college are attending graduate school. Sixty-seven percent of respondents to EAST surveys are currently employed; 38 percent of those held science-related positions, another 38 percent held technology-related positions, and 26 percent held positions in education. College retention rates of students with URFs are higher than those reported for students with and without disabilities who participated in the National Longitudinal Transition Study-2 (Newman et al. 2011). This study found that eight years after graduating from high school, the college graduation rate for students with disabilities was 34 percent and 51 percent for students without disabilities. Similarly, fellowship recipients are enrolling in graduate STEM programs at a higher rate (33 percent) than that reported for the national population of students with disabilities (9 percent) and students without disabilities (13 percent) (National Center for Education Statistics 2005).

Students' Experiences

Fellowship students reported both personal gains in skills, knowledge, and accomplishments and "relational" benefits such as interpersonal connections with faculty, fellow students, and others in their field of study.

Personal Gains. Students were motivated by a variety of factors to participate in a URF. The most-often-reported reasons for applying for an URF were primarily related to students' personal gain. More than two-thirds of the students indicated that they hoped to increase their knowledge about STEM fields (95 percent), to gain experience with conducting research (86 percent), to inform their future education and/or career decisions (75 percent), to take advantage of the funding provided (75 percent), and/or to include the fellowship on their resumes (74 percent).

When asked, 100 percent of EAST students indicated that they found the undergraduate research fellowships very valuable in terms of their preparation for college, graduate

school, and/or careers, rating the URFs an average of 3.70 on a four-point scale (1=not valuable, 4=very valuable). Nearly all students (98 percent) also indicated that they would recommend a research fellowship to a friend, saying things such as, "[I] wish everyone could experience an URF," and "I would recommend this to any of my engineering major friends."

Personal gains included skills learned and refined. One student said, "This has been a great experience to be able to work in my degree and further refine my skills in a practical environment." The most frequent set of skills that students reported developing were research skills and techniques (27 percent). Other students mentioned learning how to write reports (15 percent). Ten percent said that they learned about the research process in general. Other students enjoyed having the opportunity to experience research (20 percent) and to deepen their understanding of STEM topics (15 percent). One student wrote: "I learned a lot about the research process in general during this fellowship. The experience helped me to believe that it is possible for me to pursue research in my career." Another student suggested that the URF provided a unique benefit: "I gained a lot of experience that my fellow classmates did not."

Twelve percent of students found that they gained personal insight, confidence, and a greater sense of their own "potential" through their URF. One student expressed an understanding that was both specific to his or her disability as well as empowering, "It was a life-changing experience that helped me address my disability and understand that while I don't function in the same way as others, I am just as capable of accomplishing great things." Another newly confident student wrote, "I can go into [research] without my disability blocking it."

Relational Benefits. Relational benefits are the interpersonal connections URF participants developed with faculty, fellow students, and others in their field of study. While a relatively low number of students specifically reported benefits such as interactions with peers, faculty, and other researchers in the field (7 percent) or improving interpersonal skills (5 percent) on the surveys, students emphasized the importance of relational benefits in other ways. Sixty percent of the respondents said they applied in order to work with a specific professor. Further, students rated their mentor highly (mean = 3.17 on a 4-point scale). One student wrote, "The most important benefit of working with EAST was the inspiration that I found in my mentor."

In addition to the importance of their mentor, students talked about the fact that their URF helped them expand their personal and professional networks. One student said, "It is a great opportunity to put classroom skills to practical use and work collaboratively with other people, [who are] at different places in their pursuit of a degree or with professors outside of a classroom environment."

These developing social and professional networks often led participants to opportunities to present themselves as researchers and members of a team. Close to two-thirds of the students (64 percent) reported that their fellowships provided them with an opportunity to present or co-present findings from their research at a conference or in a publication. Twenty percent of the students have presented their research results at the Thinking Matters conference, while 10 percent of the students have presented their work at national conferences in their discipline (e.g., at meetings of the Society of Toxicology and Soil Science Society of America). One student wrote, "I upped my game this time by presenting my findings at two national conferences. This experience was amazing, and I was able to make many connections with others in the field and with possible grad schools." Another student said, "I was proud to contribute to advances in the functionality of the GAMI software project I worked on." In fact, one student pointed to the connection between the personal gains and the relational benefits of a research fellowship, saying "[I gained] confidence in my ability to design and complete a research project that contributes to my field."

Challenges

While the students with disabilities who participated in URFs experienced many benefits, they also encountered some challenges. Forty-four percent of the students reported disability-related challenges, including difficulties with staying focused (reported by 11 percent), time management (11 percent), managing emotional states (9 percent), writing (7 percent), organization (4 percent), and working around a physical disability (2 percent). Another 44 percent of the students reported challenges, but did not attribute them to their disability. The challenges reported by this group of students included dealing with complications in research procedures (13 percent), time management (11 percent), scheduling conflicts (4 percent), communication (4 percent), data collection (4 percent), equipment (4 percent), writing (4 percent), organization (4 percent), making sense of the data (2 percent), being unfamiliar with the content area (2 percent), and the payment schedule (2 percent).

It is important to note that some of the disability-related challenges that survey respondents described (e.g., time management, writing) also are frequently reported by students without disabilities, and that some students with disabilities did not attribute these types of challenges to their disability. Whether and how students experienced disability-related challenges appeared to be related to their specific disabilities and the particular demands of the research activities in which they were engaged. In particular, maintaining focus was a challenge for students with attention-deficit disorders when they were engaged in detail-oriented, repetitive work. One student wrote, "I also faced the usual challenges for a person with attention-deficit disorder, in terms of maintain-

ing my focus on detail-oriented work, especially as we were working in an occasionally noisy environment." The time-management issues that students reported related to the challenge of having to juggle multiple responsibilities such as, as one student said, "Balancing time between working and school, as well as timing between lab work and computer work."

Managing emotional states was an issue for some of the students with emotional disabilities. Two students mentioned the challenge of managing anxiety, and one student wrote about the challenge of, "Having to get up and go in on what I refer to as my 'bad mood' days. This doesn't mean I am in a bad mood, but my mood is weird. I have a mood disorder, and sometimes it is difficult for me to be around people on my bad mood days." Writing was an integral component of the research fellowships since all students had to write a report, and 7 percent of the students reported that this was a challenge for them. As one student noted, "Writing the final report was a challenge mostly because I am a slow writer."

Conclusions

Analysis of data revealed that students who participated in URFs through EAST engaged fully in research processes, by and large were on track for completing their degrees, were more likely to enter graduate school and jobs in STEM fields than non-URF students, and enjoyed benefits that could be described as both personal and relational. These findings align with a growing body of literature on the effects of undergraduate research opportunities on students from a wide range of underrepresented population groups (Bowers and Parameswaran 2013; Gibson and Bruno 2012; Harsh, Maltese, and Tai 2011). The findings converge with other research that underscores the importance of the student-mentor relationship (Strayhorn, 2010; Thiry and Laursen 2011) and the design of hands-on science experiences that emphasize the social and collective work of scientists (Fenichel, and Schweingruber 2010). When mentors guide students, individually and in groups, through the "intellectual and emotional process of pursuing research problems," (Hernandez, Schultz, Estrada, Woodcock, and Chance 2012, 103) they facilitate "cognitive apprenticeships" (Jones, Barlow, and Villarejo 2010, 86) and usher novices into the community of professionals.

While our findings demonstrate that undergraduate research experiences benefit students with disabilities in ways similar to the benefits provided to students without disabilities, they also illustrate experiences that are unique to students with disabilities. Nearly half of the students who participated in our study reported encountering disability-related challenges during their research fellowship. It is important to note that students encountered these challenges even though they had already received a variety of standard accommodations, such as flexible timing and specialized technology and equipment. To facilitate the participation of students with disabilities in undergraduate research, it is important that program administrators and faculty mentors be made aware that students may encounter such challenges and that standard accommodations may not be sufficient to meet all students' needs. Individual students may need support that is tailored to their specific strengths and needs. Students also offered several suggestions for how their experience with the research fellowship could be improved. Recommendations included having more opportunities to meet with other research fellows to interact and share their experiences, being given clear deadlines, and being able to access writing support (e.g., editing, review, and feedback).

The personal and relational benefits described by the URF participants can be collectively understood as "social capital." Social capital has been defined as accumulated interpersonal commodities such as trust, reciprocal relationships, membership in a community, and other behaviors that allow individuals to act collectively (Bourdieu 1986; Putnam 1995). Conversely, individuals or groups that lack social capital often lack the resources and power to participate in larger communities or dominant cultures.

In the fields of disability services and vocational rehabilitation, social capital has become a concept used to frame initiatives designed to increase the community-based employment and inclusion of individuals with disabilities (Curran 2008; Devine and Parr 2008; Zimmerman 2008). Whitney, Langley-Turnbaugh, Lovewell, and Moeller (2012) documented the importance of a STEM learning community in the development of social capital among students with disabilities. Increasing the social capital of individuals with disabilities may increase the likelihood that they "are 'of' the community, not merely in the community" (Williams 2008, 159). Further, the social capital of individuals with disabilities is enhanced as their contributions to the wider community accrue and are recognized as valuable (Parris and Granger 2008). Overwhelmingly, the EAST URF experiences led participants to realize that they could do research successfully and make contributions to STEM fields.

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Lynn Lovewell is currently director and project manager of the EAST-2 Alliance for Students with Disabilities in Science, Technology, Engineering, and Mathematics (STEM) at the University of Southern Maine (USM). Lovewell has more than 25 years of experience teaching K-16 science, and is dedicated to improving science education for all, including persons with disabilities. She leads workshops and seminars on assistive technology and universal design for learning (UDL). She earned a BS in horticulture from Michigan State University and an MS in education from Northern Michigan University.

Jean Whitney was the director of educator preparation and associate professor of teacher education at the University of Southern Maine. In 1998 she was awarded a Switzer Fellowship from the National Institute for Disability and Rehabilitation Research, which funded her research on the school-to-adult-life experiences of students with and without disabilities in a Massachusetts high school. Whitney's current scholarship focuses on critical factors that support students and facilitate their advance to majors and graduate school in STEM fields, the influence of learning communities on students' individual and collective social capital, and pre-service teachers' emerging professional identities. She has a doctorate in special education from the University of Wisconsin-Madison

Babette Moeller is a senior scientist at the Education Development Center in New York City. She researches and develops technology-enhanced programs in mathematics and science to help ensure that students with disabilities and from other traditionally underrepresented groups will be included in and benefit from educational reform efforts. She serves as the external evaluator for EAST.