Investigating 2-year STEM Student Motivation for Participating in Undergraduate Research

Pamela Leggett-Robinson, Brandi Campbell Villa, Cynthia Lester and Naranja Davis

Georgia State University/Belay Consulting/Georgia State University/Kennesaw State University

Abstract

Over the past two decades there has been increasing evidence of the benefits to students and faculty regarding their participation in undergraduate research. Student participants build critical thinking skills, increase problem solving, and have more positive attitudes toward STEM. Faculty participants become more aware of student learning needs and outcomes, thus improving teaching in courses that typically do not involve undergraduate research. Despite the evidence of these benefits, challenges remain for increasing the number of 2-year college STEM students who participate in undergraduate research. Therefore of the students who do engage in research at the 2-year college level, it is important to understand the factors that fuel their participation. Yet, there have been very few studies conducted in this area. Consequently, this paper examines the 2-year college STEM students' motivation for engaging in research activities with hopes of providing a discourse for STEM educators on how to increase student participation.

Keywords

Extrinsic motivation, intrinsic motivation, two-year colleges, undergraduate research experiences

Introduction

The United States Department of Commerce, Economics and Statistics Administration in its July 2011 report stated that science, technology, engineering, and mathematics (STEM) occupations are projected to grow by 17.0 percent between 2008 and 2018, compared to 9.8 percent growth for non-STEM occupations.[1] According to the U.S. Bureau of Labor and Statistics in its January 2017 report, there were nearly 8.6 million STEM jobs in 2015, representing 6.2 percent of the U.S. employment.[2] Moreover, STEM degree holders enjoy higher salaries, regardless of whether they are working in STEM or not and they command higher wages earning 26 percent more than their non-STEM counterparts.[1] In fact, ninety-three out of 100 STEM occupations had wages above the national average.[2] But these increased wages come at a price. According to the report, over 99 percent of STEM employment included occupations that require some postsecondary education.[2] Additionally, of the ten fastest growing STEM occupations, nearly all required at least a bachelor's degree[2]. So, where does this leave students who are attending 2-year institutions?

In a report entitled, "The Role of Community Colleges in Postsecondary Success," by the National Student Clearinghouse Research Center, it is noted that community colleges play a critical role in increasing the opportunity for many to experience post-secondary education.[3] In

particular, these institutions provide a critical pathway for the underserved and disadvantaged student, working adults, and students with family and employment responsibilities.[3] In a report by the Community College Research Center, the leading independent authority on 2-year colleges in the U.S., it was reported that in fall 2015, 38 percent of undergraduate students attending college, were attending a public or private 2-year institution.[4] Moreover, the report stated that of the students who completed a degree at a 4-year institution in 2015-2016, nearly 49 percent had enrolled in a 2-year institution during the previous ten years.[4] Additionally, 63 percent of those students were enrolled at a 2-year institution for three terms or more.[5] While for many students their ultimate goal may be to attain a bachelor's degree, it is still very critical that students attending 2-year institutions not only receive the educational acumen needed to compete in the global marketplace, but also be exposed to co-curricular opportunities that will help heighten their learning experience. For that reason, research opportunities, internships, and apprenticeships are key, and some would even argue necessary, especially for students studying STEM.

Research experiences are effective avenues for allowing students to apply theoretical concepts learned in class. They provide students with the opportunity to explore solutions to real-world problems while encouraging them to hone their problem-solving skills, improve their analytical and critical thinking, practice the soft skills of communication, and engage in teamwork. These experiences have been shown to impact student retention as well as influence students' decision to persist in and pursue STEM careers.[6-8] Therefore, research experiences for undergraduate students, especially in STEM disciplines, are an essential instrument for developing the next generation of STEM professionals. Hence, the National Science Foundation has established a program that supports the effort of research experiences for undergraduate (REU) students.[9-11] There a numerous REUs in various STEM disciplines offered at institutions across the country.

However, REUs are often very competitive and many require students to have completed upper-level division courses in their major disciplines. This is especially difficult for students at the 2-year level because core courses needed to conduct research are not typically offered and due to the high teaching demands of the faculty, there is very little time outside the classroom environment to work with students on research projects. Therefore, innovative programs must be developed that provide 2-year college students with experiences that not only help them to advance their knowledge but also help them differentiate themselves in an ever changing global marketplace.

This paper presents the STEP program at Georgia State University – Perimeter College, a 2-year college within the University. STEP (STEM Talent Expansion Program) is an NSF-funded program aimed at expanding and diversifying the STEM pipeline. One of its goals it to increase the number of opportunities for participating students to engage in research experiences. The paper also examines their intrinsic and extrinsic motivation for participation. The paper is organized into the following sections. The background introduces the project framework. The next section provides an overview of the implementation of the program, followed by methodology and results. The last sections present challenges, future work and concluding thoughts.

Background

Motivation for participating in undergraduate research can be categorized as intrinsic or extrinsic. Students with intrinsic motivation tend to participate in certain activities voluntarily and enjoy the inherent pleasure which drives their participation.[12,13] Studies also show intrinsic motivation is associated with positive behaviors and better performance and can be linked to positive self-perceptions.[14] In contrast, extrinsic motivation refers to activities engaged in to receive a reward. Both intrinsic and extrinsic motivations are used to encourage participation in undergraduate research programs. Despite the positive outcomes of participating in undergraduate research, i.e., increasing self-efficacy, persistence, and retention rates in STEM, many 2-year college students choose not to participate, thus, it is important to investigate the extent to which intrinsic motivation and extrinsic motivation can be a useful tool in encouraging 2-year college students to participate in undergraduate research. Throughout the Plus 8 Undergraduate research program, students were surveyed regarding the motivational factors, both intrinsic and extrinsic, that influence their decision to participate in and complete the research program.

STEP Program

Program Information

Beginning in Spring 2012, through National Science Foundation funding, a STEP program was developed for 2-year, full-time students, with a minimum 2.8 grade point average. To participate, students must have U.S. citizenship or status as permanent resident alien or refugee alien and be majoring in a STEM field of study. The objectives of the program are two-fold: 1) to increase the number of students (U.S. citizens or permanent residents) who enroll in all STEM fields (chemistry, biology, math, geology, physics, computer science, and engineering) and 2) to increase the number of students who graduate and/or transfer to four-year colleges/universities to complete their STEM baccalaureate degrees. STEP (at this 2-year institution) does this through a number of student support mechanisms for accepted STEM students:

- Implementing SI in many first-year courses (math and chemistry in particular)
  Summer Bridge Research Opportunities (3 week, 8 week, and Research Experiences for Undergraduates (REU) options)
- Civic Engagement (students are required to complete 10 hours per semester)
- Industry Visits (day-long trips to local STEM-relevant companies)
- University Visits (tours of campuses and research labs at 4-year institutions)
- Student Stipends (variable and determined by participation in program elements)

Students participate in the program for an average of 3 semesters (including a summer semester). Stipends are given to those participants that meet the following criteria each semester: (1) be enrolled as a full-time student (12 credit hours during the fall and spring semester); (2) maintain a cumulative minimum GPA of 2.8 and a minimum semester GPA of 2.5; (3) participate in a minimum of 10 hours of STEM civic engagement activities per semester; (4) participate in a minimum of six STEM–related activities (STEP-sponsored and others). Stipend amounts vary depending on the classification of the participant. Additional stipends are given for participation in Summer Bridge I undergraduate research experience (3 weeks), Summer Bridge II Plus 8 undergraduate research experience (8 weeks), and REU participation. STEP sponsors multiple STEM activities each semester, including STEM industry visits and college visits.

Plus 8 Undergraduate Research Program

The GSU-PC Plus 8 Undergraduate Research program follows a half-day format (20 - 25 hours per week) at a 4-year institution in the metropolitan Atlanta area. GSU-PC students work in the labs with graduate students or other undergraduate students from a 4-year institution. The program is designed to allow students at the 2-year college to participate in research while keeping their family and work obligations intact. This aspect is particularly important since studies show that students attending a 2-year college can experience conflicts with work and family responsibilities that lead to the inability to participate in undergraduate research programs.[15] The students join active research groups at the 4-year institution, which meet on a weekly basis to discuss research and current journal articles. As members of research labs, students have the opportunity to interact with other undergraduate students in the labs and be mentored by graduate students and postdoctoral fellows in their respective research groups. They also receive training in the research methods applicable to their research project, analyze their data, and create written and oral presentations of their results. The oral presentation at the end of the 8-week period supports the articulation and reflection of knowledge gained throughout the program.

Methodology

Students were asked to complete surveys each year to measure changes in their attitudes as a result of participating in the program; during the summers of 2016 and 2017, 25 students participated in the plus 8 research program. Of these 25 students, 20 completed the surveys after the program. Surveys were administered online after each summer research experience; they utilized a retrospective pre- post- design where both time points were captured in a single administration. This approach has been shown to eliminate loss of data through difficulty in matching and also reduce response shift bias, wherein students tend to overestimate on a pre-assessment their confidence and positive regard for a program, activity, or psychosocial state they have not yet experienced.[16-18] Surveys measured changes in student attitudes in regards to their scientific self-efficacy, scientific identity and belonging, and intent to persist in STEM.

In addition to surveys, students participated focus groups and individual interviews. Focus groups were held annually, and student participation was voluntary; these groups included students who did and did not participate in the plus 8 research component of the program. In contrast, individual student interviews were held biweekly with those students who conducted research over the summer. Questions during the focus group and individual interviews probed into student motivations for participating in the program activities, gains they made as a result of participating, and any challenges they faced or additional supports they needed. Individual interviews were conducted with plus 8 research students 3 and 6 weeks into their experiences in order to determine how their motivations and perceptions of gains changed over time.

Results

The student survey asked students to rank motivating factors in terms of which played the most important role in their initial decision to participate in the research experience. Similarly, they were asked to rank the same factors in terms of which would be most important in determining whether to participate in future experiences. Not surprisingly, all students indicated that they were much more likely to pursue future research opportunities as a result of having participated in the summer plus 8 program. Though the sample size was small (n=20), we were also able to

note that the students' motivations for participating in the experience change over time; with the perspective gained from conducting research, students become more driven to pursue future opportunities for reasons related to career growth (Table 1).

Table 1. Top motivating factors for students to participate in research experience (n=20)

Factor	# of times ranked as top factor for decision to participate (BEFORE)	# of times ranked as top factor for decision to participate (FUTURE)
Gain research experience	12	15
Financial support	5	3
Networking opportunity	2	--
Work as a STEM professional	1	2

Discussion

Students participating in the Plus 8 program worked five to six hours per day, four to five days a week for a total of 25-30 hours in University research labs. Each student self-selected into the program and had the freedom to withdraw at any time. The results of this study offer some insight into the intrinsic and extrinsic motivations of 2-year college students participating in a STEM undergraduate research program. As with all undergraduate researchers, there are challenges. However, none of the challenges were significant enough to derail the progress of anyone participant. The most significant challenge for the participants was navigating their way around the campus (parking, auxiliary services, etc.) at the research institution.

When asked about participating in an unpaid undergraduate research program in the future, the answers varied over the course of the program. However, *most* participants expressed a desire to receive a stipend in order to participate in an undergraduate research program in the future. These responses aligned with the student socio-economic demographic of the non-traditional student attending the 2-year college. All participants reported a gain in academic knowledge, laboratory skills, confidence and experience in the lab, and networking and communication skills. Each student participant also indicated their participation in the Plus 8 undergraduate research program solidified their desire to pursue a STEM degree.

The data suggests both intrinsic and extrinsic motivators are needed to encourage the 2-year STEM college student to participate in an undergraduate research program. The extrinsic motivator (stipend) may be an straight-forward means to increase the exposure of 2-year college STEM students to undergraduate research and scaffold the development of intrinsic motivating factors (skills gained, increased self-efficacy, etc.). Overall, data gathered during this study indicate exposure to research may be a driving factor for the students' pursuit of a STEM degree.

Conclusion

Despite the limited sample size, data indicate that student motivations to participate in research opportunities change over the course of their participation. This underscores the importance of early research opportunities, especially for community college students who often have financial obligations that require them to work. While many of our students do not have the luxury of taking on work without pay, we note that their valuation of opportunities to participate in research changes with experience. Through conducting research, students shift to a more intrinsic motivation to pursue future opportunities.

References

1. D. Langdon, G. McKittrick, D. Beede, B. Khan and M.Doms. "STEM: Good Jobs and for the Future," 2011. U.S. Department of Commerce, Economics and Statistics Administration. http://www.esa.doc.gov/sites/default/files/ reports/documents/stemfinalyjuly14_1.pdf. [Retrieved: October, 2015].

2. U.S. Bureau of Labor and Statistics, Spotlight on Statistics. https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf [Retrieved: November 2017].

3. National Clearinghouse Research Center. The Role of Community Colleges in Postsecondary Success. https://studentclearinghouse.info/onestop/wp-content/uploads/Comm-Colleges-Outcomes-Report.pdf

4. Community Colleges for International Development. https://www.ccidinc.org/single-post/2017/05/04/Community-College-Enrollment-and-Completion [Retrieved: November 2017].

5. National Clearinghouse Research Center. The Role of Two-Year Institutions in Bachelor's Attainment. https://nscresearchcenter.org/snapshotreport-twoyearcontributionfouryearcompletions26/ [Retrieved: November 2017].

6. Nagda, B. A., Gregerman, S. R., Jonides, J., von Hippel, W. and Lerner, J. S.,(1998). "Undergraduate Student-Faculty Research Partnerships Affect Student Retention," *Rev. Higher Educ.*, Vol. 22, pp. 55-72.

7. Boylan, M., "The Impact of Undergraduate Research Experiences on Student Intellectual Growth, Affective Development, and Interest in Doing Graduate Work in STEM: A review of the empirical literature," *Doctoral Education and the Faculty of the Future,* Cornell University, Ithaca, NY,, Oct. 2006, Last accessed: November 15, 2010: http://www.ilr.cornell.edu/cheri/conferences/doctoralEducation.html

8. Fitzsimmons, S. J., Carlson, K., Kerpelman, L.C., and Stoner, D., "A Preliminary Evaluation of the Research Experiences for Undergraduates (REU) Program of the National Science Foundation," Washington, D.C.: National Science Foundation, 1990.

9. NSF's Research Experiences for Undergraduates (REU) Programs: An assessment of the First Three Years, *NSF Report 90-58,* May, 1990.

10. Russell, S., et *al.,* (2005). "Evaluation of NSF Support for Undergraduate Research Opportunities; 2003 NSF-Program Participant Survey: Final Report," *SRI International*, June 2005.

11. Singer, J., Mayhew, M., Rom, E., Eisenstein, K., Kuczkowski, R., and Douglas, L., "The Research Experiences for Undergraduates (REU) Sites Program: Overview and Suggestions for Faculty Members," *Council on Undergraduate Research Quarterly*, June 2003. pp. 158-161.

12. Amabile T. M., Hill K. G., Hennessey B. A., Tighe E. M. (1994) The work preference inventory: Assessing intrinsic and extrinsic motivational orientations. *Journal of Personality and Social Psychology* 66(5): 950–967.

13. Ryan R. M., Deci E. L. (2000) Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist* 55(1): 68–78.

14. Burton K. D., Lydon J. E., D'Alessandro D. U., Koestner R. (2006) The differential effects of intrinsic and identified motivation on well-being and performance: Prospective, experimental, and implicit approaches to self-determination theory. *Journal of Personality and Social Psychology* 91(4): 750–762.

15. Packard, B. W.-L., Gagnon, J. L., LaBelle, O., Jeffers, K., & Lynn, E. (2011). Women's experiences in the STEM community college transfer pathway. *Journal of Women and Minorities in Science and Engineering, 17*(2).

16. Howard, G.S. (1980). Response-shift bias: a problem in evaluating interventions with Pre/Post self reports. *Evaluation Review,* 4, 93-106.

17. Howard, G. S., Ralph, K. M, Gulanick, N. A., Maxwell, S. E., Nance, D., & Gerber, S. L. (1979). Internal invalidity in pretest-posttest self-report evaluations and the re-evaluation of retrospective pretests. *Applied Psychological Measurements*, 3, 1-23.

18. Pratt, C., McGuigan, W. & Katzev, A. (2000). Measuring program outcomes: Using retrospective pretest methodology. *American Journal of Evaluation*, 21,341-349.

Biographical Information

Pamela Leggett-Robinson

Dr. Pamela Leggett-Robinson is the Associate Department and an Associate Professor of Chemistry on the Decatur campus of Georgia State University-Perimeter College. She earned her B.S. in Chemistry from Georgia State University, M.S. in Bio-Inorganic Chemistry from Tennessee Technological University, and her Ph.D. in Physical Organic Chemistry from Georgia State University. Dr. Leggett-Robinson has served as a program director for several NSF and NIH initiatives and is currently the Principal Investigator of GSU-PC's NSF STEP grant. Her research and scientific presentations focus on natural product chemistry, surface chemistry, and student support programs in STEM Education.

Brandi Villa

Dr. Brandi Villa did her graduate research in areas of applied and environmental microbiology as well as program evaluation of a science education outreach organization. She has been a science educator at middle school, high school, and undergraduate levels for more than a decade, and thus brings an educator and researcher's perspective to the design and implementation of education research and program evaluation. In addition to her passion for all aspects of STEM education, Dr. Villa particularly enjoys challenges related to evaluation design, reporting and data visualization. She has led evaluations of a number of health and STEM education programs and collaborated world wide with many public and private institutions and government organizations.

Cynthia Y. Lester

Dr. Cynthia Lester is the Department Chair of Computer Science and Engineering and Associate Professor of Computer Science at Georgia State University, Perimeter College, where she also serves as

the Executive Director of STEM Initiatives. Prior to that, she was an Associate Professor at Tuskegee University. Her peer-reviewed published and internationally presented research focuses on computer science education, human computer interaction and software engineering. She holds a B.S. degree from Prairie View A&M University and M.S. and Ph.D. degrees from the University of Alabama. Dr. Lester is an International Academy, Research and Industry Association Fellow and has been a White House invitee discussing STEM Inclusion.

Naranja Davis
Ms. Davis is a Grant Manager in the Office of Research, Division of Research and Advanced Studies at Kennesaw State University. Prior to this role, Ms., Davis served as the NSF GSU-PC Step coordinator. She has worked as a coordinator on several other NSF STEM initiatives over the past 10 years. She is experienced in student data systems. Ms. Davis has a BS in communication with a minor in Public Relations.