Evaluation of a Summer Undergraduate Research Program in Material Science Engineering

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Abstract:

In the last decade, there has been a significant increase of undergraduate programs that offer research experiences in STEM related disciplines. They range from Biological sciences to all kinds of engineering fields. While a lot of resources have been put facilitating these programs, research and evaluation of these programs is necessary. Specifically, evaluation of the program will provide pertinent knowledge on what aspects of the program produce an impact, to what type of students the program does a great good, and what program processes and characteristics are transferable to similar programs across the country. The purpose of this study is to examine the impact the relationships and interactions with faculty, graduate student mentors, and other undergraduate researchers in a summer program at Oklahoma State University career paths. Results indicated that students knowledge and skills on material science and future careers, increased from the pre to post test.

Introduction

Undergraduate research has been identified as an educational practice that directly addresses challenges facing science, technology, engineering and mathematics (STEM) education[1, 7, 8]. Specifically, engaging undergraduates in research is expected to increase interest in careers in STEM, improve retention of undergraduates in STEM fields and increase the number of people interested in advanced STEM degrees. The Council of Undergraduate Research (CUR), NSF-funded Research Experiences for Undergraduates (REU) program, and the Boyer Commission Report are major reform efforts advocating for undergraduate research, with the primary focus being the enhancement of undergraduate education.

The NSF has funded undergraduate research for over 30 years[2, 4-6]. Specifically, undergraduate research has received strong support from the NSF through the development and funding of many research opportunities, including Research Experiences for Undergraduates (REU), Research in Undergraduate Institutions (RUI), Historically Black Colleges and Universities Undergraduate Program (HBCU-UP), and Louis Stokes Alliance for Minority Participation (LSAMP) Program. In spite of the increase of these programs, research on their impact is required. The potential that materials based solutions hold for global challenges such as in energy and aerospace is undisputed. Therefore, it is imperative to groom undergraduate engineering and science students with a broad-based materials science and engineering background, in order to maintain technological leadership position of the US in the 21st century.

While undergraduate research has received substantial attention from funding agencies

and academic institutions, fundamental understanding of the characteristics of a successful program is paramount. This study examines the impact of the summer Oklahoma State University Material Science REU on a cohort of undergraduate students.

Approach to Undergraduate Research

A 9-week program was set up with the goal of introducing students all the steps starting from advanced manufacturing, materials processing, testing, characterization, examples of entrepreneurial activities based on various materials technologies and finally, the connection between what is learnt in the lab and its use in real-world applications. In addition, a series of interactive seminars and workshops on topics related to lab safety, handling chemicals, research best practices, communication styles, and learning styles Faculty mentors from the Helmerich Research guided participants to work on student driven projects that were integral to well-established research programs. Students received technical and professional training designed to increase their ability to conduct independent research as well as excel in professional opportunities in their area of technical interest. Throughout their experience, students communicated their progress with their faculty mentors and cohorts. REU students were introduced to the graduate students working on each individual project.

Survey

The survey was designed to evaluate 1) scientific processes and procedures to conduct materials science and engineering research 2) the academic and career plans 3) influences and roles of the mentoring relationships with faculty and graduate students. The survey items were likert type scale with scores ranging from 1 to 10 for each item. With "1" indicating very little knowledge and "10" very knowledgeable. The survey was administered to the participants three times (pre; mid; post) during the 9-week program.

Results

In the first year of this program the NSF has provided support for 11 undergraduate students. Of these 11 students, 73% (8) were men and 27% (3) were women students. The ages of the participants ranged from 19 to 38 years. A summary of demographics is provided in Table 1

Table 1: Demographics of participants

		Count	Column N %
Gender	Male	8	72.73%
	Female	3	27.27%
	Other	0	0.00%
	Subtotal	11	100.00%
Age	19	3	27.27%
	20	1	9.09%
	21	3	27.27%
	22	1	9.09%
	23	1	9.09%
	24	1	9.09%
	38	1	9.09%
	Subtotal	11	100.00%

On the impact of the REU on students in the three areas identified, both descriptive statistics and independent t-test were conducted to examine the mean differences from pre to post test. Statistical significance increases were found in all areas. However, in some areas we found that there was a slight dip on the mid assessment. Figures 1 to 8 show the results.

Fig. 1

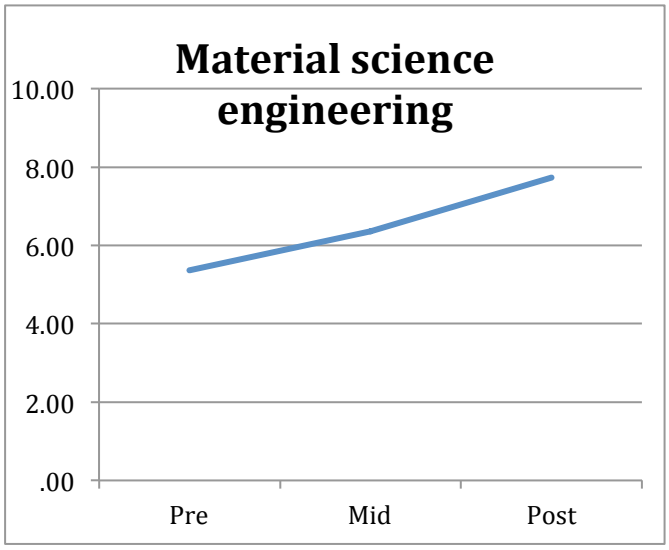


Fig. 2

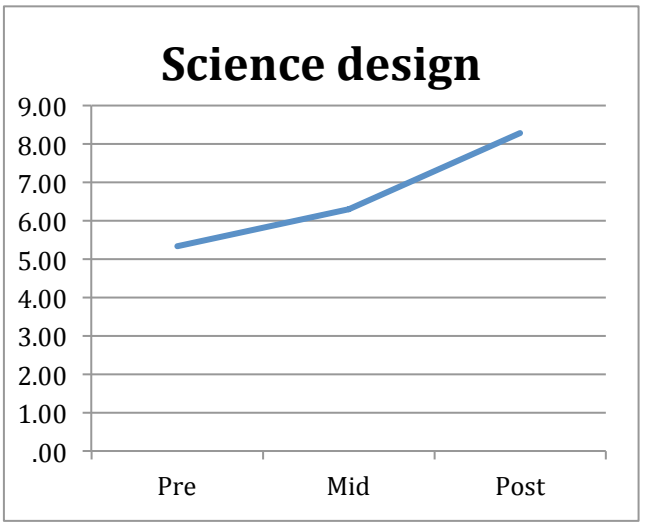


Fig. 3

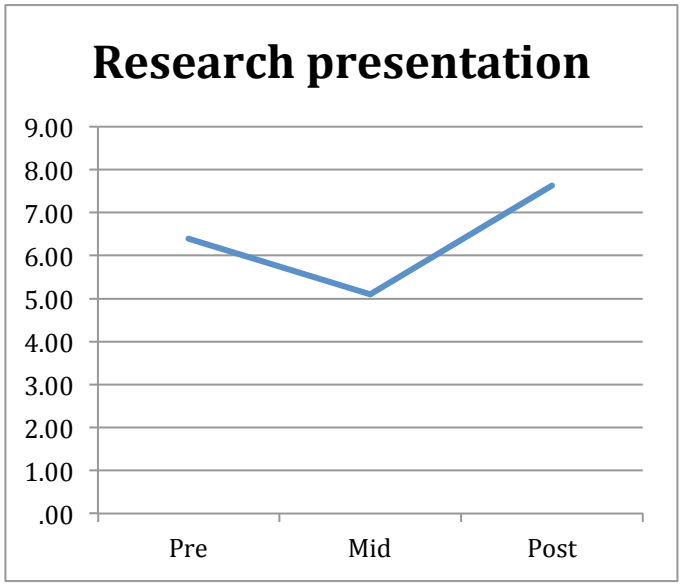


Fig. 4

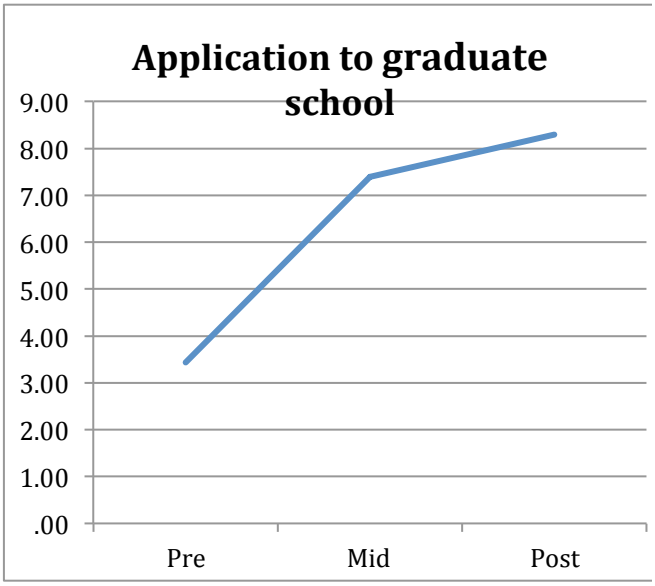


Fig. 5

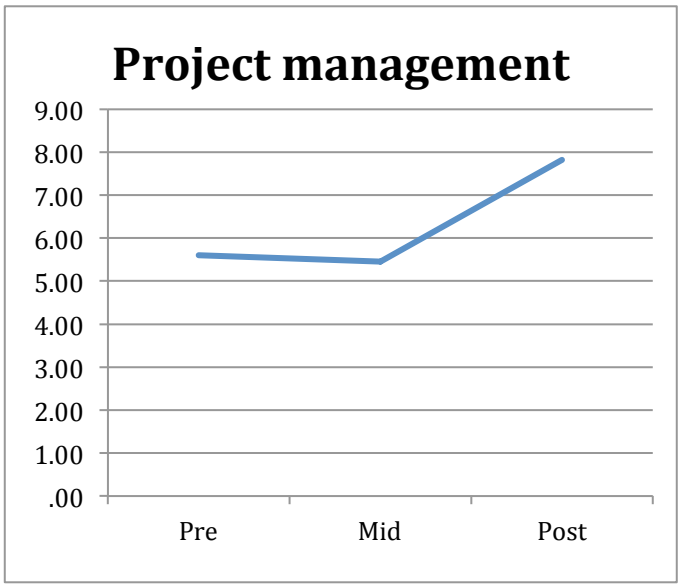


Fig. 6

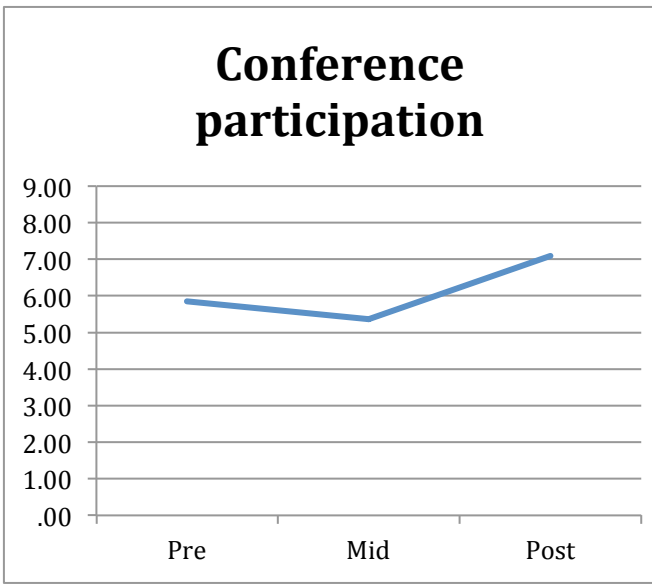


Fig. 7

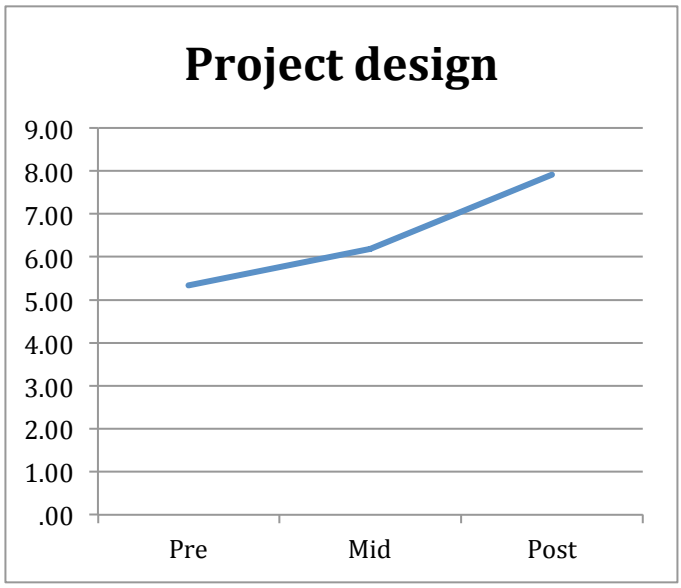
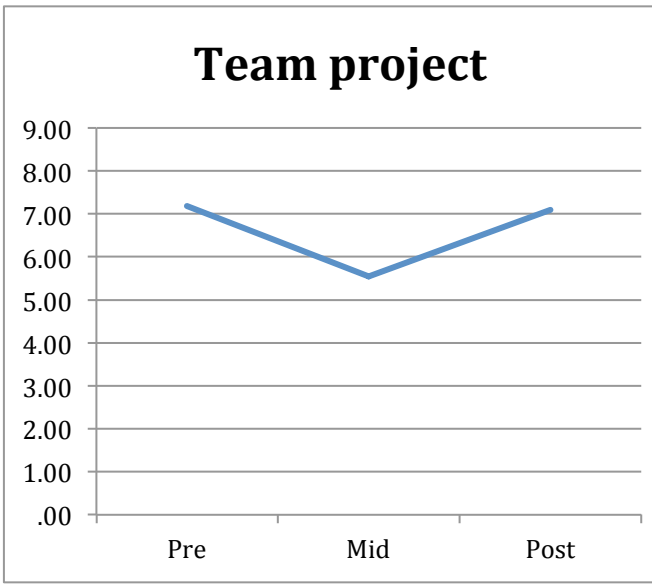


Fig. 8



On the specific questions of the survey the results confirms that the participants experience in the program had a positive impact. See results

Item Description	Item Number			Pre				Post				Mid			
	Pre	Post	Mid	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max
I place a high value on the role of research in my future career.	8	4	4	4.18	0.98	2	5	4.45	0.69	3	5	7.36	2.77	1	10
Participating in research during graduate school is not a major priority for me.	9	9	5	2.73	1.27	1	5	4.09	0.83	3	5	4.45	3.93	1	10
Developing research skills is an important part of my career goals.	10	10	6	4.36	0.92	2	5	4.73	0.47	4	5	7.45	2.73	1	10
I would not enjoy working on a research project.	11	11	7	1.82	1.47	1	5	2.00	1.41	1	5	3.20	2.86	1	10
I would enjoy a research oriented job or a job.	12	12	8	4.27	0.79	3	5	4.73	0.65	3	5	8.09	2.66	1	10
I would like to obtain a Master's degree in Material science.	13	13	9	3.09	0.83	2	5	3.00	1.26	1	5	5.00	3.20	1	10
I would like to obtain a PhD degree in Material science.	14	14	10	3.00	0.89	2	5	2.82	1.08	1	5	4.30	3.02	1	10
I would like to attend graduate school in another filed.	15	15	11	3.45	0.82	3	5	3.00	1.26	1	5	5.56	3.00	2	9
I would like to obtain an MBA.	16	16	12	3.00	0.77	1	4	2.91	0.83	1	4	5.70	3.30	1	9
I would like to work before going to graduate school.	17	17	13	3.55	1.04	2	5	3.00	1.10	1	5	5.91	3.42	1	10
I am not interested in graduate school.	18	18	14	2.09	0.83	1	3	2.55	1.69	1	5	3.22	2.44	1	7

Discussion

These results provide a foundation for understanding how and what this REU program works. It is clear that the students had come in with less knowledge on the aspects that are vital for students pursuing careers and or academics in the STEM fields. The activities and interactions that the participants experienced during the 9 weeks in the program did influence both their knowledge and skills. It was clear that students grew in the areas examined by this study. While these results are from one year's cohort is not to be taken as conclusive, however they do provide some implications for further research in this program. As such, based on the results, the researchers plan to collect another wave of data from this cohort a year later after this program to find out how their knowledge, career, and interest in material science. In addition, we plan to use the lessons learned in this first cohort into the second cohort. Finally, we shall compare the two cohorts on the three questions posed in this paper.

Bibliography

1. Boyer Commission. (1998). Reinventing undergraduate education: A blueprint for America's research
universities. Stony Brook, NY: State University of New York.
2. Hancock, M. P., & Russel, S. H. (2008). Research experiences for undergraduates (REU) in the directorate for engineering (ENG) 2003–2006 participant survey. Menlo Park, CA: SRI International.
3. National Science Foundation (2013). Research experiences for undergraduate (REU) program solication (Document Number: NSF 12-569). Retrieved from http://www.nsf.gov/pubs/2012/nsf12569/nsf12569.htm
4. Russell, S. H., Ailes, C.P, Hancock, M.P., McCullough, J., Rosesner, J.D., & Storey, C. (2004). Evaluation of NSF support for undergraduate research opportunities: 2003 NSF-program participant survey. Menlo, CA: SRI International.
5. Russell, S. H., Hancock, M. P., McCullough, J., Roessner, J. D., & Storey, C. (2005). Evaluation of NSF support for undergraduate research opportunities: survey of STEM graduates. Menlo, CA: SRI International.
6. Russell, S. H., Hancock, M. P., & McCullough, J. (2007). The pipeline: benefits of undergradaute research experiences. Science, 316, 548-549.
7. Smith, S. J., Pedersen-Gallegos, L., & Riegle-Crumb, C. (2002). The training, careers, and work of Ph. D. physical scientists: Not simply academic. American Journal of Physics, 70(11), 1081-1092.