New Orleans JAZZED about Engineering Education

Paper ID #14708

Undergraduate Research Experiences: Qualitative Results from a Multi-Year Survey

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Abstract

We identify and discuss themes that emerged from a study of undergraduates participating in a summer research program at Michigan State University. The goals of this study were: (1) to examine the degree to which program participation diverted students from summer activities that did not further their academic or career goals; (2) to better understand students' goals for participating in research; and (3) to assess student satisfaction with the research program. Students were asked to complete pre- and post-experience surveys; these two survey instruments were deployed during multiple summer programs over a four-year time period (2011-2014), resulting in four sets of pre- and post-survey data from more than 300 students. Student responses to short-answer survey questions were analyzed using a web-based application for mixed methods research. 31% of respondents indicated that the research program diverted them from a summer job or other plans that were not aligned with their academic or career goals, and respondents consistently cited the faculty-mentored research experience as highly valuable.

Introduction

Engaging in undergraduate research is significantly correlated with students' selection of a science-related program of study and pursuit of a postgraduate degree in science.[1] Undergraduate research experiences can also help students increase self-confidence;[2] identify a career focus;[3] enhance analytical skills and improve oral and written communications.[4] Participating in undergraduate research is also a proven strategy for recruiting and retaining students from diverse backgrounds into STEM (science, technology, engineering, mathematics) fields.[5–9]

Well-structured undergraduate research programs provide opportunities for students to engage in knowledge discovery, production and meaning-making.[10] Undergraduate research programs can also promote what Hodge, Baxter Magolda, and Haynes[11] have described as an **engaged learning** approach:

- "Guid[ing] students to develop an internally defined and integrated belief system and identity, which prepare them personally and intellectually for lifelong learning.
- Actively engag[ing] students in discovering new knowledge in a sequenced, developmentally appropriate way to enable them to evaluate evidence critically, make informed judgments, and act ethically.
- Creat[ing] a vibrant campus learning community that blends curricular and cocurricular learning opportunities and capitalizes on the roles of all constituents (faculty, staff, and students) in promoting student learning." (p. 19)

In the summer of 2011, the College of Engineering at Michigan State University (MSU) introduced a comprehensive professional development program to complement its existing undergraduate summer research internships.[12–16] As part of this EnSURE (Engineering Summer

Undergraduate Research Experience) program, students participated in weekly professional development seminars and periodic networking activities. Each student also worked full-time for 10 weeks on research mentored by a faculty member in the College of Engineering. More than 300 students from across the United States participated in the EnSURE program between 2011 and 2014; Table 1 summarizes key demographics for these students. Eligibility criteria include current full-time undergraduate status in any major at a postsecondary institution in the U.S. with a minimum cumulative GPA of 3.20 (on a 4.0 scale). Admission to the program is competitive (only 20%-30% of candidates are typically accepted) and the program has grown from a cohort of 50 in 2011 to over 100 students in 2014.

Table 1: Demographic Summary of Program Participants, 2011-2014

	Total Participants	Female Participants		Domestic Participants		Underrepresented Participants*	
Year	Number	Number	% of Total	Number	% of Total	Number	% of Domestic
2011	50	17	34%	44	88%	2	5%
2012	97	18	19%	82	85%	12	15%
2013	108	37	34%	100	93%	17	17%
2014	124	36	29%	97	78%	27	28%

* Underrepresented participants include domestic students (US Citizens or Permanent Residents) who identify as Black/African American, Hispanic, Native American/Pacific Islander, or Multiple.

Survey Instruments and Methodology

Student participants were asked to complete two separate and anonymous surveys—a "Pre-Experience" survey administered at the beginning of EnSURE, and a "Post-Experience" survey at the end of the program. The pre-experience includes a number of questions with Likert-scale response options, which ask participants to assess their prior experience with the research process, the application process for graduate school, and skills typically associated with academic persistence and success (e.g., time management, interpersonal skills). Results of these Likert-scale questions have been reported previously,[14] along with detailed descriptions of the EnSURE professional development program[15] and a case study conducted by student participants on their own experiences in EnSURE.[13]

This paper is the first time that the qualitative data from participants' responses to open-ended survey questions have been analyzed. On the pre-experience survey, students were asked to provide short-answer, freeform responses to the following questions:

- If you were not participating in this research experience, what would you be doing this summer instead?
- What knowledge or skills do you hope to gain from your summer research experience?

- What specific topics or information do you hope will be covered as part of the professional development activities during this summer research experience?

The focus of the post-experience survey was to assess academic and developmental outcomes associated with program participation, as well as students' experiences. Many of the questions from the pre-experience survey were repeated in the post-experience survey, which allowed direct comparison of individual answers across the 10-week program. The post-survey also included a set of open ended questions:

- What part(s) of the summer program did you find **most** valuable or helpful?
- What part(s) of the summer program did you find **least** valuable or helpful?
- Please share any additional comments, suggestions for changes, or feedback about the summer program.

These two survey instruments were deployed over a four-year time period (2011-2014), resulting in four sets of pre- and post-survey data. These surveys were also aligned with a larger, ongoing research study at MSU that examines the experiences of undergraduates participating in faculty-mentored research in a variety of disciplines and contexts.[17–19]

While participants were not required to complete the survey, both pre- and post-tests were distributed and collected during structured program activities. This generally resulted in a high completion rate. For example, 96% of 2011 participants completed the pre-experience survey. Participants were not required to answer every question, and—with regard to the short answer portion—could provide more than one response (e.g., listing three different activities as alternate summer plans). Thus, the total number of responses to any given question does not always equal the number of completed surveys; the response number (n) for each question is indicated in the data tables provided in this paper.

Students' responses were compiled and uploaded to a web-based data analysis program called Dedoose (www.dedoose.com). A preliminary codebook was created and used to code the data, and continually refined so as to more accurately represent themes as they emerged. EnSURE program administrators were asked to review the data to ensure acronyms and other discipline- and program-specific words and phrases were transcribed correctly. The results of this study are reported in the next several sections, followed by an overall analysis and concluding discussion.

Alternative Plans for Summer

In the pre-experience survey, the first open-ended question asked students to describe what they would likely have done over the summer had they not participated in the EnSURE research experience. Since a primary goal of the EnSURE program is to attract students to graduate programs and/or career paths in STEM, we were interested in the extent to which participation diverted students from summer activities that were unlikely to advance those interests.

Respondents' answers to this question were coded and grouped into categories that captured these possible alternatives. In the interest of protecting respondents' confidentiality, we removed descriptive information like home institution from students' comments to reduce the likelihood

of participants being recognized by the reader. As the question was open-ended, students could list as many alternatives as they liked, or none at all. Thus the number of responses is not equal to the number of participants or the number of completed surveys. Table 2 summarizes the most frequently occurring student responses about alternative summer plans; categories containing less than 5% of responses across all cohorts are not reported here.

Table 2: Alternative Summer Plans

If you were not participating in this research experience, what would you be doing this summer instead?	**2011** **Percent of (n = 64)**	**2012** **Percent of (n = 87)**	**2013** **Percent of (n = 85)**	**2014** **Percent of (n = 82)**	**Total** **Percent of (n = 318)**
Job not related to academic/career goals	**33%**	**27%**	**28%**	**38%**	**31%**
Nothing / no idea	0	6%	8%	0	4%
Family	5%	0	0	0	1%
Internship or job related to academic/career goals	**28%**	**15%**	**28%**	**30%**	**25%**
Research activities	14%	14%	12%	7%	12%
Summer class(es)	11%	7%	11%	20%	12%

In analyzing the results in Table 2, it is interesting to note the division between alternate activities that relate to students' academic or career goals (bottom three rows), and those that do not further these interests. For example, the most common response to this question across all four cohorts (31% of all responses) was that participating in the summer program was an alternative to taking a job that was not related to students' academic or career aspirations. Examples of responses that fell within this category include:

- "Working in [town name] in a grocery store"
- "Unskilled labor"
- "Probably working a dead end job"
- "working a low-skill position"
- "Finding another summer job, w/o much professional benefit"

Other responses indicated that some students had no alternative plans in mind if they were not accepted into the summer research program, or that they would spent their time with family instead.

While 31% of all responses to this question indicated non-academic/career alternatives, these survey data also indicated that many students had robust options for advancing their professional interests if they did not participate in the summer research program. For instance, a quarter of all responses over the four-years of data indicated that students would pursue an internship or job related to their academic or career goals. Examples of responses in this category include:

- "Go back to China [for] an internship in [the] medical device field"
- "Working another job at [academic research building]"

Other common alternative plans included involvement in research activities (e.g., "I would be continuing my research experiences at [student's home institution]") or completing summer coursework.

Students' Desired Outcomes

The pre-experience survey also included an open-ended question that asked respondents what they hoped to learn through the summer research experience. Students could list as many items as they liked, or none at all. Again, responses were coded so as to identify emergent themes. Table 3 summarizes the most frequently occurring student responses across all four cohorts; categories containing less than 5% of responses from all cohorts are not presented here.

Table 3: Students' Desired Outcomes

What knowledge or skills do you hope to gain from your summer research experience?	**2011** **Percent of (n = 74)**	**2012** **Percent of (n = 148)**	**2013** **Percent of (n = 100)**	**2014** **Percent of (n = 106)**	**Total** **Percent of (n = 428)**
Research skills	**26%**	**29%**	**26%**	**31%**	**28%**
Content knowledge in chosen discipline	18%	18%	14%	19%	17%
Academic writing skills	12%	11%	6%	8%	9%
Laboratory skills	9%	12%	11%	5%	10%
Preparing for graduate school	8%	5%	2%	3%	4%
Problem solving	7%	2%	3%	3%	3%
Clarification of career path	5%	3%	0	4%	3%

In examining students' desired outcomes, the most frequently occurring responses highlighted students' interest in developing knowledge, skills, and experience related to the research process. A desire for discipline-related content knowledge acquisition was the second most common category of responses to this open-ended question. Examples of responses from these two categories include:

- "Hope to improve my knowledge in bioprocessing while using the knowledge I learned in my classes"
- "Research techniques, increased knowledge in evolutionary computation"

- "I hope to learn more about protein engineering (chemical engineering) and I hope to learn more about how research is conducted"

Other frequently-cited desired outcomes suggest that many participants are at least familiar with the types of skills needed to pursue graduate school and careers in research, such as academic writing and presentation skills. Examples of student responses from these categories include:

- "I'd like to get experience writing a paper, making a poster, and presenting my work"
- "An in-depth understanding of research and graduate school opportunities"
- "I hope to learn how to operate the equipment used in analysis or material systems"

The EnSURE program is marketed as an "internship in graduate school" so it is both unsurprising and reassuring that nearly all responses to this question involved students' desires to gain research skills, disciplinary knowledge, and other experience that will assist them in reaching their academic and/or career goals.

It is interesting that very few students (3% of total responses) indicated that they were hoping that EnSURE would help them clarify their career path. Many other researchers [3,3,4,9,20–23] have documented the positive impacts of undergraduate research experiences on helping students identify or clarify their career options, and this is one of the outcomes we have found in prior analysis of quantitative data from the post-experience EnSURE surveys.[14] Yet, these open-ended, pre-experience survey data indicate that few students are articulating a specific career focus as one of their initial goals.

Most Valuable Program Components

In the post-experience survey we asked students to indicate which elements of the summer research experience they found most helpful. Students regularly cited specific program components (e.g., seminars, networking dinners) as well as more comprehensive aspects (e.g., the opportunity for engagement with faculty). Example responses to this question include:

- "Seeing what goes on when you are in graduate school"
- "The freedom of answering questions my way"
- "I really liked being close to a graduate student and see[ing] what they think about the experience and their journey"
- "I got to engage in a complete research process, not just part of it."

In Table 4, we summarize the most frequently occurring student responses to this question across all four years; categories containing less than 5% of responses were not included. Responses referencing the research experience were consistently among the most valuable components across all four years. Students also cited the professional development workshops as being most valuable over the past three years—but in the first year of the survey (2011), the seminars were not nearly as well received. This is interesting, as student responses are much more consistent in other parts of the survey, and may reflect changes to the EnSURE program over time (such as refining the professional development seminars based on feedback from students in prior years).

Table 4: Most Valuable Program Components

What part(s) of the summer program did you find most valuable or helpful?	2011 Percent of (n = 78)	2012 Percent of (n = 58)	2013 Percent of (n = 47)	2014 Percent of (n = 76)	Total Percent of (n = 259)
Research experience	19%	**17%**	19%	17%	**18%**
Professional development seminars	6%	**17%**	13%	**22%**	15%
Preparing for graduate school	**24%**	0	**21%**	14%	15%
Interaction with faculty	13%	14%	6%	18%	14%
Written assignments	22%	0	0	7%	8%
Laboratory experience	0	7%	9%	12%	7%
Interactions with graduate students	6%	3%	11%	7%	7%
Presenting research	6%	3%	11%	5%	6%

Least Valuable Program Components

The post-experience survey also asked students to name the program components they found least helpful. Table 5 summarizes the most frequently occurring student responses about least valuable aspects of the summer program; categories containing less than 5% of responses are not reported here. Student comments about least-valuable aspects of EnSURE largely focused on two areas: the professional development seminars and written assignments. Examples include:

- "Some of the seminars were repetitive or uninformative"
- "Given that I am a rising sophomore, I found some of the seminars a little useless"
- "The academic/personal statements were really hard for me to write because I'm only a sophomore and don't have everything figured out"
- "Lots of the presentations didn't apply to me"

The program's intake and admissions criteria may help explain why some students perceived a mismatch between their interests/aptitudes and program requirements. Unlike other summer undergraduate research experiences that require students to enter with disciplinary knowledge or prior research experience, students from across the disciplines are eligible to participate in the EnSURE program and no prior research experience is required. As such, students enter the program in different places along a continuum of disciplinary and research knowledge and experience. Once arrived, students are assigned to work with faculty members and their research teams across a wide range of disciplines while attending (mandatory) workshops and other events as a group. The challenge of designing a curriculum to meet the needs and aptitudes of such a diverse cohort make it difficult to customize the learning experience for different students.

Table 5: Least Valuable Program Components

What part(s) of the summer program did you find least valuable or helpful?	2011 Percent of (n = 45)	2012 Percent of (n = 36)	2013 Percent of (n = 29)	2014 Percent of (n = 35)	Total Percent of (n = 145)
Professional development seminars	**36%**	**39%**	**24%**	**54%**	**50%**
Writing assignments	24%	6%	24%	17%	19%
N/A, nothing, no complaints	4%	19%	7%	9%	10%
Networking events	16%		21%		9%
Interactions/relationship with faculty	4%	6%			3%
Program structure, length		11%			3%

Concluding Discussion and Future Work

This paper examines four years of data drawn from more than 300 students' open-ended responses to pre- and post-experience surveys about their participation in a summer research program in Engineering. Perhaps the most interesting finding is that **EnSURE diverts a significant percentage of students from a summer spent working in non-academic/research-related jobs.** 31% of all respondents indicated that participating in EnSURE diverted them from a summer job or other plans that were not aligned with their academic or career goals. While students frequently mentioned other opportunities to advance academic and research interests, for many students EnSURE provided them with the only means to do so. Future work might examine whether this response varies based on students' GPA or class standing—in other words, do junior/senior students report more academic- or career-related summer options than first-/second-year students? While students are required to have a minimum 3.20 GPA to participate in this program, do students with higher GPAs report more summer options? Regardless of the results of this future analysis, the current work indicates that there is substantial value to undergraduates in providing summer research opportunities that allow them to further their academic or professional goals.

In all four years of pre-experience surveys, **students' primary goals for participating in EnSURE were to acquire research skills and/or disciplinary knowledge**. Students' secondary goals included gaining familiarity and exposure to research and laboratory environments, and the chance to practice academic writing. Given these stated goals, it is not surprising that in the post-experience survey **students consistently cited the research experience as one of the most valuable components** of the EnSURE program, along with opportunities to network with faculty and graduate students, and gaining greater familiarity with the graduate school application process.

Comparing these pre- and post-survey results indicates that the EnSURE program succeeded in meeting the needs of many students. However, the post-experience survey also identified areas of student dissatisfaction. Interestingly, **students named the professional development workshops as both the most and least valuable components of the EnSURE program**. Individual responses suggest a low tolerance among some students for content that they conclude is not directly applicable to their individual research interests or aptitudes (e.g., guest speakers from another discipline; subject matter that does not align with their research project).

Students also had very mixed responses about written assignments. For example, in 2011 writing assignments were noted as a "most valuable" component by 22% of respondents, but 24% of the same cohort of students deemed these assignments a "least valuable" aspect of the program in 2011. Overall, 19% of respondents across the four years indicated that writing assignments were of low value—although a closer examination of the individual responses suggests that the task of drafting academic and personal statements for (potential) graduate school applications was the most burdensome assignment. In comparison, many students indicated that they found the assignment to create an academically-focused resume (appropriate for a graduate school application) helpful, in part because that assignment included a peer-review component where students got immediate feedback during small group interactions.

Some of these concerns have been addressed as the EnSURE program evolved over time: for instance, writing assignments were refined to better align with students' research activities, and more instruction was provided on the value of interdisciplinary interactions—as well as practical suggestions for finding value and connections with work beyond one's own interests. The survey data suggest that these efforts have had mixed results; for example, more students found the professional development seminars and workshops to be highly valuable in years 2012-2014, which may reflect changes in the curriculum that were implemented in response to students' feedback after the first year (2011). Yet students' satisfaction with the writing assignments is still very uneven across the four cohorts—ranging from 22% finding them "most valuable" in 2011, to 24% finding them "least valuable" in both 2011 and 2013. Clearly, more work is needed to determine whether and how to address these student concerns.

While the survey instrument was not designed to assess the impact of participation on development of self-authorship,[11,24] some student responses—discerning which program components were most and least relevant; exulting in the freedom to define a research question and pursue the answers; and developing meaningful relationships with peers, graduate students, and faculty—suggest that EnSURE provided a conducive environment and highlight a promising direction for future research.

The EnSURE program is ongoing, and data is continuing to be gathered and analyzed through pre- and post-experience surveys, as well as the collection of participants' artifacts (research reports, graduate school application statement drafts, academic resumes, etc.). In Summer 2015, the professional development curriculum was revised substantially to provide more up-front instruction in research methods, and to engage students in interdisciplinary, team-based exercises throughout the 10-week summer program. These changes were made in part based on data gathered through the four years of surveys discussed here. Another area of ongoing work is to explore the integration of online materials to provide a "flipped" classroom experience,[25–27]

where students review lectures, videos or class notes online in advance, and then spend the in-person seminar working together on exercises and assignments. A number of exercises were integrated into the most recent program offering, in Summer 2015, but all of the lectures were traditional in-class experiences. For Summer 2016, we hope to begin experimenting with the flipped classroom model in earnest.

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