Structure of Professional Components for a Multidisciplinary REU Program

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Professional Development Needs

The professionalism of engineering students is a key factor to their career success after graduation. Achieving this objective requires integrating training across hard science skills (e.g., calculus, statistics, and mechanics) and softer communication and management acumen (e.g., technical writing, technical presentations, and project management). Such an approach is essential to preparing future engineers for the workplace [1]. The challenge becomes providing students with effective exposure to both kinds of skills within engineering programs.

Traditionally, the development of such skills has been a matter of content-specific coursework integrated into a school’s engineering program(s). (A classic example is the technical writing course often offered by English or communication departments and required of engineering undergraduates.) As institutional resources shrink and student demand increases, the need to find alternative methods for offering training in these “soft-skill” areas grows. Ideally, such approaches would provide students with educational experiences that allow them to transfer their learning in these areas across a range of academic and professional contexts. Summer REU programs could be an effective venue for offering such soft-skill training in ways students recognize as effective and portable.

The REU Option

Research Experiences for Undergraduates (REUs) are National Science Foundation (NSF)-sponsored summer educational programs hosted at different universities. REU programs generally focus on providing students with focused training in a particular area of science, engineering, or mathematics. REUs are often apprenticeship-style experiences where students work closely with a faculty member (from the sponsoring university) on a project connected to the faculty member’s work. Participation in REU’s is competitive and generally done through a process designed to pair students interested in a particular research area with faculty doing work in that area. REUs are also generally flexible in design with hosting institutions having a great deal of control over the organization and content of the program. These factors allow hosting universities to create REUs that can maximize local resources to provide unique educational programs to best benefit student participants.

An interdisciplinary approach to summer REU programs can help address the challenge of providing soft-skill training within an engineering education environment (see for example [2], [3], [4]). In so doing, interdisciplinary REUs can help students understand how to transfer the soft- and hard-skill they learn across other courses and experiences beyond the classroom. Achieving this objective is a matter of configuring REUs to help students see and apply connections across different learning experiences within the REU context. This paper presents a pilot study that assesses how an interdisciplinary summer REU program provided STEM students with professional development training. The objective of this experimental program was to provide educational experiences that allowed participants to integrate soft and technical skills in an overall biomedical engineering context.
Interdisciplinary REUs

This paper describes an REU program funded by the National Science Foundation’s Experimental Program to Stimulate Competitive Research (EPSCoR) Research Infrastructure Improvement (RII) program, Track-2 Focused EPSCoR Collaborations (FEC) under the grant OIA-1632891. The project involves three collaborating institutions: Louisiana Tech University (lead), the University of Alabama-Birmingham, and the University of Arkansas for Medical Science – with researchers at each location collecting data on different aspects of epileptic seizures (e.g., rat data and human data) and developing related sensing technologies. The initial grant proposal also included a commitment to providing students with unique educational experiences related to this research collaboration.

The overall project – entitled Probing and Understanding the Brain: Micro and Macro Dynamics of Seizure and Memory Networks (NeuroNEM) – focuses on developing technologies for mapping epileptic seizures in rats and humans. The summer REU, in turn, focused on providing students with different hands-on experiences related to developing and testing such technologies under the mentorship of faculty participating in this research project.

The NeuroNEM REU is a parallel summer program for undergraduate students, and its primary focus is providing STEM undergraduate students with the opportunities to collaborate on brain science research related to neuronal networks in epilepsy and memory. Each of the three collaborating institutions developed its own summer REU program with its own unique focus based on the work being done by researchers there. As such, each site took a different approach to the topics covered in the REU offered at a given local setting.

Within this context the team at Louisiana Tech involves an interdisciplinary group of faculty from across a range of disciplines (e.g., engineering, math, psychology, and English). The collaborators at Louisiana Tech decided to leverage this factor and develop a summer REU program that included a secondary focus that allowed non-engineering faculty to participate. This secondary focus involved providing REU students with different professional development opportunities via workshops that focus on soft skills in engineering (e.g., writing, usability testing, and behavioral research). The Louisiana Tech NeuroNEM team agreed the best way to achieve this objective was through dedicated 2-3 hour workshops scheduled throughout the REU.

Structuring Soft-Skills Sessions

For these workshops, instructors from non-engineering disciplines (e.g., technical writing and psychology) provided focused instruction in a soft-skill area (e.g., resume writing and fundamentals of usability testing). These sessions involved applying concepts students learned in lab-based REU activities as the subject for teaching different soft skills. The objective was to provide students with an integrated educational experience to help them understand how such factors co-exist in engineering as a profession.
The general format of the soft-skills sessions involved a three-part format (three 20-minute blocks of time) based on subdividing an hour of instruction time into different blocks dedicated to a particular activity. These sessions usually involved the REU students meeting with an instructor in a classroom or conference room and most sessions proceeded as follows:

- **Part 1 – Lecture and Introduction:** The instructor began the session (the hour) with a 20-minute lecture on a particular aspect of a soft-skill topic (e.g., the notion of context of use in usability).

- **Part 2 – Activity and Application:** The instructor next assigned the students an in-class activity that asked them to apply the ideas covered in the lecture to a particular case (e.g., how to enhance the usability of an interface based on the concepts covered in the lecture). Students were given 10 minutes to devise their own, individual solutions to the activity and another 10 minutes present their solutions to and discuss them with the group.

- **Part 3 – Discussion and Extension:** The final 20 minutes of the hour involved the instructor asking attendees to discuss how to apply the ideas they had examined to the work they were doing for their summer REU projects. As students discussed ideas, the instructor provided input on how to modify the more general ideas covered in the original lecture to the specific situation associated with a particular project. During these discussions, other students provided suggestions on how to apply ideas from the lecture and the instructor used guided questions to facilitate these discussions (e.g., “Why do you suggest person X do Y to address this item?”). The instructor also provided examples of how to adapt ideas covered in the lecture engineering and product design contexts.

As most of these soft-skill sessions involved 3 hours of meeting/instruction time, the instructor used this format to introduce and examine three central concepts associated with a given topic during each overall session. Each hour of these longer sessions followed this three-part format with the instructor presenting a new topic each hour. In so doing, the instructor also connected each new lecture topic (presented at the start of the hour) to the topic(s) that preceded it during that session (e.g., connecting the new idea of cognitive prototypes of usability to a previous lecture on contexts of use).

**Piloting Interdisciplinary Approaches**

The Louisiana Tech NeuroNEM team used these workshops to undertake a pilot study to examine how such workshops might serve as a mechanism for providing engineering students with a mix of technical and soft skills. The investigators piloted this approach in the summer of 2017 and repeated it in the summer of 2018 with 10 students total participating in both sessions (5 students per session). In both instances, soft-skill training was offered via a series of three-hour workshops that occurred once during the course of the summer REU program. Each of these workshops focused on a particular area (e.g., usability and design, cognition and communication, and developing and delivering engineering poster presentations) associated with soft skills related to successful professional engineering practices.
After the completion of the second summer session, the authors sought to assess this pilot approach to teaching soft skills within an REU program. The objective was to determine how effectively this workshop-based method was at imparting skills in ways students view as effective and transferrable. To this end, the authors sent prior REU participants a survey asking them to provide their perceptions of these workshops and what they learned from them. (See Appendix.) The authors designed the survey to collect data on student perceptions of both their summer REU experiences and post-REU activities. The authors planned to use this data to assess the efficacy of this interdisciplinary approach in terms of teaching soft skills to engineering students.

Study Design

Research Questions and Objectives
The question guiding the data collection for this project was

RQ: To what extent do STEM students participating in integrated summer REU program believe this approach provided them with effective training in hard and soft skills essential to contributing in the epilepsy research space?

The overall research objective was to determine how effective participants felt the interdisciplinary approach to summer REUs was at providing them with soft skills associated with their REU engineering experiences.

The data collected in relation to addressing this objective can also help address two related sub-questions that also focus on student perceptions:

- SQ1: What aspects of this integrated program were effective and should be continued for future REU programs?

- SQ2: What aspects of this integrated program were ineffective and need revision within the context of future REU programs?

The answers to these different research questions can provide important insights on developing interdisciplinary summer REU programs students consider beneficial to their professional development.

Methods
The authors decided to use an online questionnaire as the primary method for collecting the data needed to address the research objective and related questions noted previously. They selected this method based on the effectiveness with which it could be distributed to geographically dispersed subjects (i.e., students located in different geographic areas) and the ability to collect quantitative and qualitative data for analysis. The authors then used the resulting data to examine how effective the piloted interdisciplinary approach to REU education might be as a mechanism for providing students with professional development training.
IRB approval was secured to include a follow-up, online survey distributed to the ten NeuroNEM REU students at the Louisiana Tech site. (The 2017 and the 2018 NeuroNEM REU programs each involved 5 students.) The survey was administered 17 months after the conclusion of the 2017 REU program and 5 months after the conclusion of the 2018 REU program. The authors believed these differences in time since completing the related REU program would help assess student perceptions of the approach over the short and long term (relative to the age of the program). This time factor could also help assess how transferrable students felt skills learned through this approach were over time.

For this project, authors used each former REU participant’s email address – as was provided on her/his REU application form – to contact all 10 past REU participants and ask each of them to complete a short, online survey on their NeuroNEM summer REU experiences. (See Appendix.) The authors also sought out updated contact information via LinkedIn for cases in which REU participants had graduated from their undergraduate institutions. The related email also provided individuals with a link they could click on to access and complete the online survey created in Google Forms. The authors designed the survey so that the data provided was completely anonymous with no mechanism for determining which former REU student had accessed the online survey to provided responses.

**Mechanism**
The survey used a variety of closed and open questions to collect data on different factors associated with student’s perceptions of their REU experiences. In particular, the authors sought to assess student perceptions of the following factors:

- Transferability: How well students believed they could apply concepts learned in a given REU session or workshop to other REU experiences
- Applicability: How effectively students thought they could apply what they learned beyond the summer REU context
- Value: How valuable students felt the overall approach was as a learning experience
- Revisions: What suggestions students had for how the pilot approach could be revised or improved for future REU sessions

The authors also sought to collect data on student perceptions of both the engineering-related experiences and the soft-skill sessions provided during their summer REU program. To this end, the survey included a number of questions designed to capture student perspectives on these experiences. The objective was to compare students’ perceptions of both kinds of educational experiences. The authors felt such a comparison could provide insights on how to revise the overall pilot approach to REU education to provide students with more effective educational experiences.

The specific questions used to collect such data were as follows:

1. In which year did you participate in the NeuroNEM REU program?
   a. Summer 2017
   b. Summer 2018
2. Please rate your perceived benefit of each of the NeuroNEM REU workshops (5-point Likert scale: Extremely helpful, Moderately helpful, Neutral, Moderately unhelpful, Extremely unhelpful)
a. Overview of scientific research
b. Engineering Grand Challenges
c. Graduate school funding and NSF fellowships
d. 3D printing
e. Electrochemistry
f. Light fantastic (physics of light)
g. Neurotransmitters
h. EEG and MEG
i. Presentations and posters do's and don'ts
j. Resumes and job searches
k. Usability and design of medical devices
l. Statistics
m. Cognition, language, & writing

3. What do you feel you learned through your participation in these REU workshop sessions?

4. Were you able to apply any of what you learned in one or more of these workshops to other activities you performed during your summer REU? If yes, please explain how you applied such acquired knowledge to the REU experience.

5. Were you able to apply any of what you learned in one or more of these workshops to other kinds of activities after the REU, including courses you took, internships you participated in, etc.? If yes, please explain how you applied such acquired knowledge to these activities.

6. What, from your perspective, were the benefits of these workshop sessions?

7. What, from your perspective, were the limitations of these workshop sessions?

8. Do you have any suggestions for how we might revise these workshops to make them more effective for future REU sessions?

9. Are there any topics we should add as the focus of future workshops? If yes, which topic(s) and why should we add it/them?

10. In your opinion, should we continue to include such workshops in the summer REU project? If yes, why? If no, why not?

11. In terms of the activities directly related to the REU project on which you worked during your summer REU program, what do you feel you learned through your participation in these REU-related activities?

12. Were you able to apply any of what you learned from your REU-related research experiences to other kinds of activities after the REU, including courses you took, internships you participated in, etc.? If yes, please explain.

The resulting responses were collected into an Excel spreadsheet for review in order to identify trends in student perceptions of their REU experiences.

Results

Three of ten (30%) REU participants responded to the survey. One responder was from the Summer 2017 program while two responders were from the Summer 2018 program. While this number of responses might seem numerically small, a response rate of 30% is considered
average for online surveys according to a 2007 report from the University of Texas Center for Teaching and Learning [5].

**Overall Perceptions**

Responses indicated individuals had an overall positive impression of the value and benefit of the soft-skill workshops integrated into the pilot REU program. All three respondents, for example, responded they perceived the following workshops as either *moderately helpful* or *extremely helpful*:

- Overview of scientific research
- Neurotransmitters
- Usability and design of medical devices
- Cognition, language, and writing

The next highest rated workshops (rated by two as *moderately helpful* or *extremely helpful* and one as *neutral*):

- Engineering Grand Challenges
- Electrochemistry
- EEG and MEG
- Presentations and posters do’s and don’ts

The other workshops (e.g., graduate school funding and NSF fellowships, 3D printing, physics of light, resumes and job searches, statistics) included ratings that were neutral or some level of unhelpful.

**Specific Perceptions**

In terms of perceptions of the workshops dedicated to teaching soft-skills, respondents noted the following:

- **Transferability**: All three respondents reported they were able to apply what they learned in one or more of the workshops to other activities performed during the summer REU program.

- **Applicability**: Two of the three respondents indicated they were able to apply what they learned in the workshops to activities following the conclusion of the REU.

- **Value**: All three respondents agreed that the workshops should be maintained as part of the REU program.

- **Revision**: The students did make recommendations for future workshops to include in the program. In some cases, the recommendations were for more general topics (e.g., interview workshop for a job or graduate school, preparing for industry experiences, preparing and applying for graduate school), while other ideas related to specific labs and projects (e.g., animal models of human illness, types of animals for modeling, conditions for the use of animal models).

Such information will be beneficial in planning future NeuroNEM REU programs to provide students with more effective learning experiences.
Perceptions of Research Projects
In terms of the actual research projects (i.e., dedicated engineering/hard-skill experiences) in which the students participated, respondents agreed they learned from their projects and have been able to translate that knowledge to other efforts after the conclusion of the REU program. (The authors plan to use this information to guide the development of future NeuroNEM Summer REU programming.)

Discussion
While responses were relatively limited, they do constitute the perceptions of a third of the individuals who participated in the pilot REU program. They also represent a relatively effective sampling of perspectives in relation to dynamics of time (i.e., duration of time since participating in the REU program). The data collected through this survey can therefore provide insights on how other institutions might use similar kinds of workshop-based designs to integrate the teaching of soft-skills into summer REU programs.

Connection to REU Context
To begin, all respondents reported a relatively high degree of value associated with integrating such soft-skill sessions into the summer REU experience. All respondents, for example, ranked workshops in the soft-skill areas of “Usability and design of medical devices” and “Cognition, language, and writing” as “moderately helpful” or “extremely helpful.”

The fact that both of these workshops were connected to the overall focus of the related REU program might have contributed to this perspective. The workshop on “Usability and design of medical devices” connected relatively directly to the overall REU program’s focus: developing technologies designed to sense brain activity. Likewise, the workshop on “Cognition, language, and writing” focused on brain activities and functions – factors central to the REU program’s focus and the engineering experiences students were encountering in the program.

This connection to the REU’s overall focus could also explain why other workshops, while more directly connected to engineering practices, were perceived as less helpful by former REU participants. Respondents, for example, ranked the workshop focused on “Engineering Grand Challenges” after the workshops on “Usability” and “Cognition and language” in terms of perceived helpfulness despite the former’s direct connection to engineering. Similarly, the workshop on “Presentations and posters do’s and don’ts” was ranked last in terms of perceived helpfulness even though such presentations are often part of engineering education – and regular professional engineering practices (e.g., participating in professional conferences).

The fact that these less-highly ranked workshops covered more general aspects of engineering vs. more direct connections to the REU’s focus could explain why they were ranked after soft-skilled workshops that connected more directly to the focus of the 2017 and 2018 REU programs. This connection between perceived helpfulness and the focus of the overall REU would also explain why those soft-skill workshops not directly connected to this focus (e.g., “Resumes and job searches”) and technical workshops not directly connected to this focus (e.g., “3D printing”) were ranked as less helpful by respondents.
Such factors might also explain why all three respondents noted they were able to apply what they learned in the workshops on “Usability” and “Cognition and language” to the overall summer REU program (i.e., transferability). These factors would also explain why respondents agreed these workshops should be continued as part of future summer REU programs.

*Contextualizing Soft Skills*
This factor of connection to REU focus might also account for notions of applicability – or use beyond the REU context. In this case, those soft-skill workshops more directly connected to the REU focus seemed to be more transferrable based on student responses. This connection could have provided participants with a context for understanding how such soft skills related to the engineering practices they were learning. This association could mean that when students began to apply the engineering-related skills learned in the REU program to other contexts, they were also able to better understand how to apply related soft skills as they’ve been able to previously understand and apply them in an engineering context.

*Substance vs. Style*
It could be argued that teaching styles played a role in student perceptions of helpfulness as well as applicability and transferability. The various workshops included in both the 2017 and 2018 summer REU sessions involved different faculty lecturing on different topics. This variable might be a factor influencing student perceptions. However, there is evidence this is not necessarily the case.

While two of the soft-skills workshops (“Usability” and “Cognition and language”) ranked as “moderately helpful” or “extremely helpful” were taught by the same instructor, so was one of the workshops that did relatively poorly in terms of perceptions of usefulness (i.e., “Resumes and job searches”). This factor might provide initial support for the idea connection of the workshop to the REU’s focus is a better indicator of perceived helpfulness than style or method of instruction.

Instructor familiarity with and experience teaching a topic could also be a factor affecting perceptions of usefulness. One could argue the less experience an instructor has in teaching the topic, the less effectively s/he will be at offering a workshop on that topic. This situation might explain certain student perceptions. However, in the case of the workshops on “Resumes and job searches,” the instructor covered a topic he regularly teaches as part of a technical writing class for engineers. Additionally, that same instructor only teaches aspects of usability – rated third in terms of usefulness – every other year (less frequently) to more general audiences (i.e., a mix of engineers and non-engineers). Moreover, prior to the summer 2017 REU, that instructor had never taught a course in “Cognition and language,” which was ranked fourth in terms of usefulness by respondents. While far from definitive, such factors might support the idea that the perceived usefulness of a workshop reflects its connection to the focus of the related REU program vs. instructor familiarity with teaching the related topic.

*Prospects for Future Research*
While the ideas noted here are interesting in terms of a pilot study, more work needs to be done to determine how effective such workshops are within the context of an REU program.
Similarly, collecting and analyzing more data over longer periods of time is essential to determining what factors seem to affect the perceived usefulness former REU students associated with such workshops. The initial results noted here, however, do provide ideas researchers can investigate in future studies of this topic including assessing aspects such as

- Connection to focus of overall REU program
- Approach to teaching a topic
- Instructor familiarity with the teaching of a topic

The results of such future work could have a great deal to offer engineering educators in relation to the organization and implementation of future summer REU programs.

Conclusion

In the current educational context, effective engineering programs must continually struggle to integrate needed soft-skills into a full and often growing curriculum. Approaches that can offer new ways to provide students with effective soft-skill training can help mitigate such pressures. Summer REU programs can serve as a mechanism for achieving these objectives. Through the integration of targeted, soft-skill workshops into REU programs, educators and administrators can provide students with meaningful learning opportunities. The challenge becomes configuring REU programs to achieve such objectives.

This paper has presented the results of a pilot study of an REU program that sought to address such needs. These results indicate effectively integrated soft-skills workshops can provide students with educational experiences they consider useful. Initial findings reveal that the more closely such workshops are connected to the focus of the related REU program, the more likely students are to perceive such experiences as effective and valuable. While further research is needed, pilot results indicate REU workshops that effectively integrate soft-skills topics via a common thematic focus could be an effective way for teaching such skills to engineering students.

References

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Appendix

Dear ____,

We are in the process of studying and assessing Louisiana Tech University’s summer NeuroNEM REU Program. Based on your participation in the program, we would like to ask you to provide your perspectives on your experiences during your REU. To help with this process, we ask for your completion of a brief survey in Google Forms, with the first question being a formal consent describing the study:

https://goo.gl/forms/Elelp8HGh94iCszV2

Below is more information about the study.

Overview
During your NeuroNEM summer REU at Louisiana Tech, you also participated in a series of weekly workshops that focused on both engineering and non-engineering topics. We would now like to get your perspective on those sessions to assess theme and plan for future REU sessions. Specifically, we are conducting a study on student perceptions of these workshops as part of the overall REU experience.

Request
For this reason, we’d ask you to consider responding to a series of questions designed to determine how you and other members of your summer REU program perceived these sessions.

Privacy
Please note we will share the overall results of this data collection process with others; we will not, however, share your name or any other any identifying information with others. Additionally, participation in this process is voluntary, and if you would prefer not to respond to these questions, simply email the address above and note “Do not wish to participate in this review process.”

Risks
____ is not able to offer financial compensation nor to absorb the costs of medical treatment should you be injured as a result of participating in this research. The server may collect information and your IP address indirectly and automatically via “cookies”.
**Benefits/Compensation**
No benefits and compensation for participation will be offered to participants for this study.

**Dates**
To participate in this process, we would ask you please respond to the survey in Google Forms by January 16, 2019. (Again, if you would prefer not to respond to these questions, simply email the address above and note “Do not wish to participate in this review process.”)

**Questions**
If you have questions on this study, please feel free to contact us at any time.

Thank you for your consideration with this process; we greatly appreciate it.

Sincerely,
Drs. Katie Evans and Kirk St.Amant