ARTICLE
Engaging Undergraduate Summer Research Students and Faculty in a Regional Neuroscience Network

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Students who engage in experiential research programs and who form communities of learning are more likely to persist in Science, Technology, Engineering, and Math (STEM) programs. Faculty who collaborate are more likely to publish and to stay engaged in their field. With funding from the Great Lakes Colleges Association (GLCA) Expanding Collaboration Initiative, we engaged in a series of summer seminars with neuroscience faculty and their research students at five regional institutions, the College of Wooster, Ohio Wesleyan University, Earlham College, Oberlin College and Kenyon College. Our goals were to provide an opportunity for faculty and students to learn about the methods used in the labs at these institutions, to increase collaborative relationships across these institutions, to develop a community of learning among participating students, and to provide students with professional development opportunities. Pre- and post-assessment data indicate knowledge gains in demonstrated methods and increased comfort performing the methods with supervision or collaboration. In addition, several collaborative relationships were formed and significant assistance with planning, materials, and/or apparatus was provided across institutions. In open-ended post-experience questions, students indicated valuing the relationships formed with other students in this community of learning. We will continue this program with continued funding through the GLCA Expanding Collaboration Initiative and submission of a multi-center National Science Foundation Research Experience for Undergraduates grant and encourage others to engage in similar practices at their own institutions.

Key words: summer undergraduate research, community of learning, faculty collaboration, student training

There are several benefits to be gained by engaging students and faculty in summer research experiences. Additionally, particularly at smaller schools, there is value in faculty and students interacting and collaborating with colleagues at nearby institutions.

Benefits of undergraduate student research and research communities

As stated by Moore (2010) "experience is the best teacher." Essentially, students learn more from the doing of science than from the reading of or hearing lectures about science. Experiential Learning (EL) theory states that EL is based on four different phases: experiencing, reflecting, thinking, and acting (Figure 1; Kolb, 1984). The summer seminar series described herein provided concrete experiences with, and abstract conceptualization of seven different neuroscience methodologies.

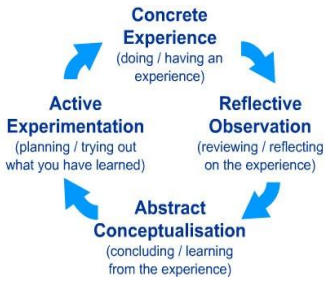

Figure 1. The cycle of experiential learning as taken from Kolb (1984). Students repeat the cycle in increasing understanding of information with experience in the subject.

In being recognized as high-impact practice by the Association of American Colleges and Universities, EL programs achieve positive outcomes in student engagement and academic success. These high-impact programs, according to Kuh (2008): are effortful, help students build substantive relationships, help students engage across differences (e.g., race, culture, level of experience in science), provide students with rich feedback, help students apply and test what they are learning in different situations, and provide opportunities for the students to reflect on their personal growth.

In addition to the research experiences themselves, students benefit from the interactions that they have with other students and with faculty collaborators.

> "It may be said that undergraduate researchers are gaining expertise. A feature of this expertise is professional, that is, the experts that the student emulates are researchers and teachers in the field. … College students learn best in a supportive environment, which includes faculty mentoring, state-of-the-art instrumentation and modern physical facilities… They may form a community of learners, becoming part of a group of active researchers that includes faculty mentors and more experienced students." Lopatto (2004)

Of key concern to faculty in neuroscience and other scientific disciplines is the persistence (retention) of students in these fields. Persistence (retention) of

students in STEM fields is increased with membership in a learning community such as those formed by shared research experiences (Graham et al., 2013). “Involvement with other students who are aspiring scientists also strengthens professional identity." (Figure 2, Graham et al., 2013). Communities of practice are "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise by interacting on an ongoing basis" (Wenger et al, 2002). Allowing students interested in research to interact, create peer networks, and engage intellectually creates strong relationships that have been demonstrated to increase retention in STEM (Vision and Change, 2009). The summer seminar series described herein, provided just this opportunity by bringing as many as 25 Neuroscience faculty and undergraduate researchers together on five different occasions. Particular cohorts may benefit even more by participating in a community of learning. In fact, women of color that persist in STEM are more likely to have engaged in student organizations focused on learning (Espinoza, 2011).

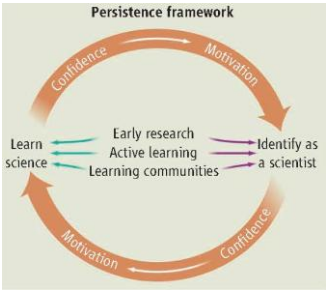

Figure 2. Graham et al. (2013) illustrate the cycle of persistence/retention in STEM fields. Learning communities feature prominently in positive influences on students’ persistence in STEM.

Benefits of Faculty Collaboration

Faculty at small primarily undergraduate institutions (PUIs) may feel isolated from professional interaction and discussion of one’s specialized field (Sandquist et al., 2013, Kaplan, 2011). While teaching is emphasized, research with students and publication in one’s field are required for tenure and promotion at most PUIs (Lee et al., white paper, 2003; Sandquist et al., 2013; Bowne et al., 2011; Kaplan, 2011), but lack of equipment or other materials may impact the ability of PUI faculty to complete research projects (Kaplan, 2011). Collaboration can be a way to combat this lack of materials or equipment and, in fact, faculty who collaborate with others publish more than those who do not (Whicker et al., 1993).

These isolation and resource issues are not limited to early-career, tenure-seeking individuals. Vital post-tenure faculty (as opposed to those that are disengaged) are more likely to engage in collaborative work and are more likely to have concrete and immediate goals and to take professional risks (Baldwin 1979, as cited in Mills, 2000).

Grant opportunities for faculty at PUIs exist through the National Institutes of Health (R15) and the National Science Foundation (RUI, REU, Early Career Development Program), but are becoming increasingly competitive (Kaplan, 2011). Collaboration, and thus leverage of greater resources, may increase competitiveness for these grants.

To increase the collaboration among faculty at neighboring PUIs, to develop a community of learning among summer research students working for those faculty, and to increase student professional development, we engaged in a series of visits for those faculty and students at each of five neighboring institutions (Ohio Wesleyan University, The College of Wooster, Oberlin College, Earlham College and Kenyon College) in the summer of 2014.

FUNDING AND LOGISTICS

The Great Lakes Colleges Association (GLCA) is a consortium with thirteen associated PUIs in northern Ohio, Michigan, Indiana and Pennsylvania. The new GLCA Expanding Collaboration Initiative is a professional development program launched in 2013 with major funding from the Andrew W. Mellon Foundation. Its purpose is to support collaborative curricular initiatives involving faculty and key professional staff who share common academic interests. We received funding through this initiative to provide significant and meaningful opportunities for conversation, collaboration and education for GLCA Neuroscience faculty and their summer research students. All institutions chosen for participation were within a 2-hour drive of each other, except for one, which was 3.5 hours driving distance from some other institutions.

Though the number of Neuroscience research topics, methodologies and techniques used at each individual PUI is limited, the breadth used across the GLCA institutions is vast. Therefore, we tapped this reservoir of expertise by having faculty members at each institution teach the group the unique technique(s) they use. By harnessing the breadth of research expertise at these GLCA institutions, we could deepen the knowledge and hands-on experience of all faculty on several techniques. We argued that not only would this enrich classroom and laboratory instruction, but also knowing the research projects and techniques that are used in close proximity to our own campuses would allow for future research collaborations. Summer research students would also benefit by learning all of the techniques, from professional development opportunities related to career planning, writing personal statements and public presentation of scientific results, and by working within a community of learners with common interests and goals.

Faculty colleagues at all five institutions were initially contacted to determine level of interest and commitment to the project. The requirements were simply an interest in presenting their technique, having summer research assistants in the lab, and a willingness to drive a few hours once each week. The grant was written by two faculty, with recognition that specific faculty member involvement could vary, but institutional support would remain. As the goal of the GLCA Initiative was faculty driven, there was no funding for student research stipends. Therefore, all student stipend funding was the responsibility of each home institution, and each of the associated institutions

was known to have internal support for summer research experiences.

Our grant provided $12,000 to support travel to each other's institutions, stipends, supply funds, meals and programming at each location. For four consecutive weeks, we all traveled to one location for a one-day workshop (see Figure 3 for weekly schedule). Each week followed a slightly different pattern, but always involved an overview of the method and a hands-on (or as much as the method could warrant) component, a social lunch hour, and student professional development (led by and attended by faculty). The final session was a research symposium in which the student researchers presented their work in presentation or poster format, along with a keynote address by an ABD Ph.D. candidate in Neuroscience.

College of Wooster – June 3
Rodent learning and memory
EEG/ERP
Research project overviews

Ohio Wesleyan University – June 11
Spinal cord injury surgery (CNS trauma)
Computational neuroscience
Research ethics

Earlham College – June 18
Electrophysiology
Interviewing skills
Faculty career paths

Oberlin College – June 25
Western blots
Stereotaxic rodent surgery
CVs and cover letters

Kenyon College – July 9
Research presentations

Figure 3. Schedule of institutional location, method(s) presented and professional development opportunity.

Each faculty member that presented their method received a $600 one-time stipend and $250 of consumable supply funds. The funding allowed for overnight hotel stays as necessary and reimbursed travel at the cost of $.30/mile (or institutional rental cars if needed). In addition, funding provided coffee service for breakfast, a meal at lunch, and an honorarium for our keynote speaker during the research symposium.

Ethical approval was obtained from both the College of Wooster and Ohio Wesleyan University for the assessment employed in this study.

ASSESSMENT

The goals of this project were to increase knowledge about and provide some hands-on training with the specific research methodologies used by a group of regional Neuroscience faculty. We hypothesized that students and faculty would demonstrate both knowledge and comfort gains following exposure to the seven different research methodologies presented in the summer seminar series. We measured this by presenting a questionnaire assessing participant experience, and confidence in knowledge and proficiency on each method before the summer training session began, and again on the final week of the program. We also asked about experience in presenting the participant's own research at a symposium, and in research ethics training; professional development opportunities provided for the students. There were a total of 8 faculty and 15 students that completed the survey at each time point. Each method had a pre and post question phrased as follows:

Please indicate your confidence in your knowledge of and proficiency with western blot methods. Please check all that apply:

- *I do not understand western blot methods and results.*
- *I understand western blot methods and results when they are summarized in a textbook or review article.*
- *I understand western blot methods and results when they are reported in a primary empirical article.*
- *I would feel comfortable using western blot methods with supervision/collaboration.*
- *I would feel comfortable using western blot methods independently.*

Because participants were asked to respond to "all that apply," we were able to assess the shift in our response frequencies toward higher order skills associated with each method independently. In order to address improving knowledge, we statistically analyzed the frequency of responses to the first option, "I do not understand the method or results" with expectations that this response would decrease following the summer seminar series. In order to address our goal that knowledge would either lead to new methods being used independently or in collaboration with faculty colleagues, we analyzed the frequency of the fourth option, "I would feel comfortable using the method with supervision/collaboration." Though we collected data on previous experience with each methodology, we did not factor out this variability because of our already limited sample size. Faculty and students were grouped together for statistical analysis for the methods with the expectation that, if anything, including faculty would decrease statistical change due to enhanced previous knowledge.

Chi-square tests were run on response frequency data. The observed pre-test response frequency was set as the expected frequency and the post-test response frequency was compared against this prediction. If the seminar series had no impact on the knowledge or comfort level with a method, then the pre-test frequency of response should remain largely unchanged, resulting in a nonsignificant chi-square test. If, instead, the seminar series did have an impact, then the resulting post-test frequency would be different from that which was predicted, resulting in a significant chi-square test. All chi-square tests on methods were run with an N of 23, except

Electrophysiology. Only half of the participants were able to attend the session on Electrophysiology, therefore skewing the post-test data toward a lack of change. For this method only, we assessed change in response frequency by using post-test data from only the 11 participants who were able to attend. We used the whole group (N=23) pre-test frequency as the expected frequency (first creating a true ratio of 23 to 11 scores) and compared that to the post-test of the 11 in attendance.

Knowledge Gains

Participants reported significant learning gains in the areas of Computational Neuroscience, Western Blot and Stereotaxic surgery. For these three chi-square tests, the observed frequency of post-test responses to the question "I do not understand this method" was significantly lower than what was expected, indicating a shift toward higher level understanding (see Figure 4; CompNeuro χ^2=9.47, p<0.002; Western χ^2=6.29, df=1, p<0.01; Stereotaxic χ^2=5.23, p<0.02; all df=1). Chi-square results for the remaining methods were not significant, indicating no meaningful shift in the distribution (all χ^2<3.29, df=1, p>0.07).

Comfort using a Method

Participants reported an increase in comfort using every method with supervision or in collaboration. For all chi-square tests the observed frequency of post-test responses was significantly higher from the expected value (see Figure 5; EEG/ERP χ^2 =37.10, p<0.001; Rodent L&M χ^2 =16.30, p<0.001; CompNeuro χ^2 =33.10, p<0.001; CNSTrauma χ^2 =10.09, p<0.001; ElectroPhys χ^2 =5.12, p<0.02; Western χ^2=5.36, p<0.02; Stereotaxic χ^2=22.28, p<0.001; all df=1).

Professional Development gains

The final session of the seminar series was a research symposium dedicated to the students' summer research projects, therefore all student participants gave either a formal scientific talk or a poster presentation. As reported on the pre-survey, only 25% had presented their own data in a symposium talk, and 38% had presented their own data in a poster. At the end of the summer seminar series, 70% reported presenting their own data in a symposium talk and 80% in a poster format, this represents a statistically significant increase (Talk χ^2=12.41, p<0.001; Poster χ^2=8.12, p<0.005, all df=1). Additionally, 38% of the students reported having no formal ethical training prior to the summer series, with only 1 person (7%) reporting no ethical training at the end of the series, this represents a statistically significant decrease (χ^2=6.08, p<0.01). That student was unable to attend the Ohio Wesleyan presentation week.

Increase in Collaboration

Prior to the seminar series, no faculty or students were actively collaborating across campuses. At the end of the session, 26% of the participants had begun or were planning to begin a research collaboration. Interestingly, the level of engagement was about equal for the faculty and the students; 38% of the faculty were planning a collaboration and 20% of the students. Forty-eight percent received research materials or an apparatus from another participant, with 63% of faculty and 40% of students reporting positively in this category. And nearly 90% of the participants indicated that they had a conversation with another participant that aided them in their own research; 88% of the faculty and 87% of the students.

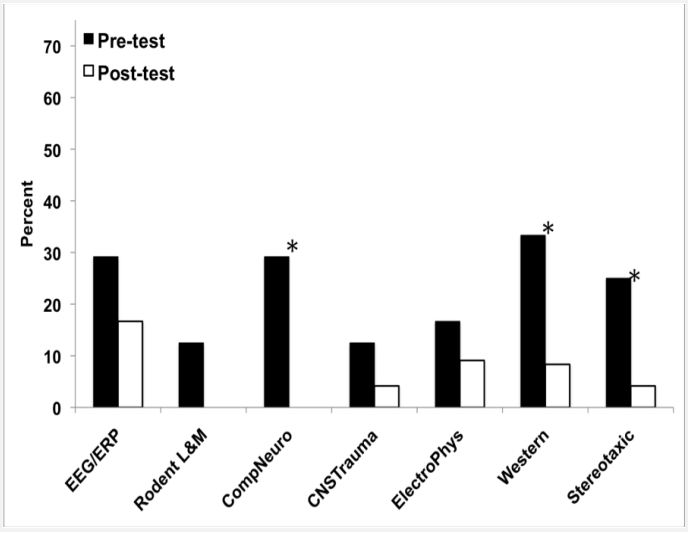

Figure 4. Participant responses to the question, "I do not understand this method or its results" for pre- and post-testing.
* Indicates a significant decrease in post-test frequency when compared to the expected pre-test frequency with chi-square, p<0.02.

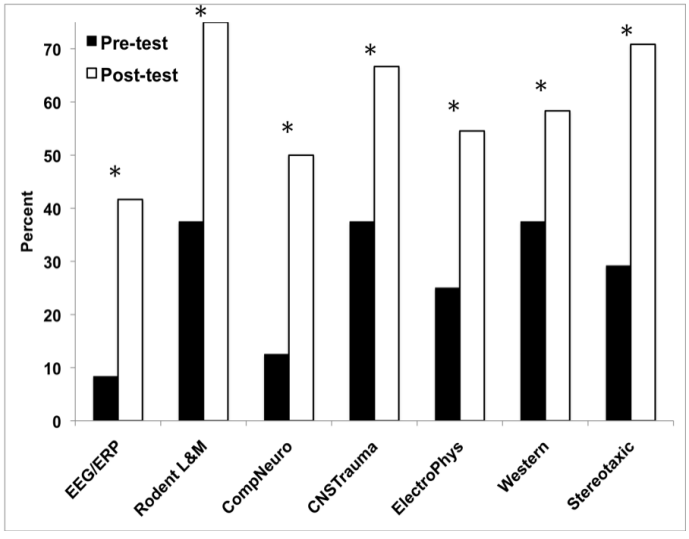

Figure 5. Participant responses to the question, "I would feel comfortable using this method with supervision/collaboration" for pre- and post-testing. * Indicates a significant increase in post-test frequency when compared to the expected pre-test frequency with chi-square, p<0.02.

BROADER IMPACTS & FUTURE DIRECTIONS

We had several goals for this project. Among them were to increase knowledge and understanding of Neuroscience methods used at each of the institutions, to allow students at different home institutions to create a community of learning, to provide student professional development opportunities to learn skills necessary for careers in neuroscience and related fields, and to increase collaboration among students and faculty at geographically close PUIs.

Increased Knowledge

Inherent in collaboration is the knowledge of what others' contributions would be to the collaborative work. For instance, it is important to know what behavioral methods a colleague might have to evaluate a group of rats or mice on which you've performed stereotaxic surgery. To be able to determine those relationships, one must know what the methods do and how they work. Clear knowledge gains occurred over the course of this summer experience indicating that participants are better consumers of scientific information (fewer did not understand the method at all) for many of the demonstrated methods (Figure 4) and they are more likely to use the methods with supervision from or in collaboration with another colleague (Figure 5).

Experiential Learning and Community of Learning

Kolb's (1984) experiential learning model includes experience, reflective observation, abstract conceptualization, and active experimentation. Student participants in this program engaged in all of these practices, either directly through the summer seminar series, or at home in their research lab. The concrete experience came in the performance of research projects at home institutions and in the observation and participation in demonstrations of new methods at other institutions. Students engaged in some reflective observation when they answered assessment questions about how their research was enhanced by participation in the program (receiving support in the form of discussion, research apparatus/materials, or development of a collaboration). The step of abstract conceptualization came in the planning of research at home institutions, and in preparation for final presentations (poster or talk) as a group. Finally, the active experimentation stage is ongoing for these students, most of the students who participated in the program are now conducting independent study or honors work at their home institutions, with a much broader methodological knowledge base than before. In some cases, methods learned, materials gathered, or collaborations formed will be a key component of these new projects.

In putting these experiences into the context of Kuh's (2008) framework for experiential learning, we find that this program met four of six primary characteristics for students: the experience was effortful, it helped students build substantive relationships, it helped students engage across differences, and it helped students apply and test what they learned in different situations. Students engaged in several active processes including planning, conducting, and analyzing research projects, discussing their research with colleagues and faculty at the different site visits, and presenting their research at the final gathering of the group. The students built relationships with students at their home institutions, students at other participating institutions, and faculty from all locations. They developed a community of learning and practice that was noted in reflections in the final assessment. Some example insights into what student participants valued most were:

- "Having an informal community of like-minded peers to bounce ideas off of"
- "Having an opportunity to network with other professors and students in my field of interest"
- "Having the opportunity to present work in a friendly and well-intentioned setting"
- "Seeing the generation of ideas from students my age, with approximately equal amounts of experience. It was very rewarding to see successful research being conducted by my own peers"
- "It was especially invigorating to speak with so many students just as involved and informed as myself"
- "Getting advice from other faculty and other students about approaching your own research and how to get started"

Also reflected in these open-ended statements is the engagement of students across differences. Students engaged with others with varying research interests, different levels of experience (both students and faculty), and varying background preparation. Students will be able to apply and test what they have learned in different situations by taking these methods and this knowledge back to their own research. This intention was assessed with participants indicating whether they have learned something applicable to their own research, engaged in the exchange of ideas and/or research materials, or began a new collaboration.

Professional Development

Many of us train our students in skills such as research ethics, curriculum vitae (CV), and cover letter construction, and interviewing skills. We often share the story of our own professional development, but there is benefit to engaging in these conversations with a group of students together. It minimizes time spent by each individual faculty member to train their students and encourages conversation amongst the students and faculty about the issues raised and allows for the consideration of different perspectives and experiences. Several students noted what they valued from these experiences in their final assessment comments:

- "Hearing from various professors how they came to do what they do and their advice on how to succeed in the field or with the major"
- "Getting information about graduate school"

- "Gaining experience presenting research/fielding questions at Kenyon College [the location of the final research presentations]"

Collaboration

The funding for this project came from the GLCA Expanding Collaboration Initiative and as such, a primary goal was to increase sharing of information and resources, and collaborative relationships across these institutions. Outcomes noted in the results section indicate that these relationships were certainly generated in this program. Six of the participants indicated starting or intending to start a collaborative relationship. Many indicated getting assistance from others in the form of research materials or apparatus, and most indicated having a conversation about their research that resulted in insights about their work and learning a technique that could be useful in their work from another participant. Notably, the percentage of the faculty and students that benefited in these collaborative ways were equal. Therefore, the opportunity to create research cohorts was not limited, or biased toward the faculty. These results indicate the value of bringing students and faculty together to discuss their known research techniques and research questions to determine where beneficial collaborative relationships might be formed.

Future Directions

Several options exist for the continuation and evolution of this project. Opportunities for continued funding come from two sources and suggestions for improvement of the program will be incorporated into later iterations. One of these suggestions was to have a time, perhaps at the end of each visit, for student and faculty researchers to discuss their ongoing projects and explore additional opportunities for collaboration. Logistical considerations for the next offering of this program will include determining the schedule of events earlier in the year (to allow more pre-planning of logistical considerations), a task that was not possible this year because of the timing of notification of funding. Based on the feedback, efforts will be made to allow more "hands-on" experiences where appropriate during the demonstrations, understanding that sometimes (e.g., for surgical procedures) this may not be possible. It will likely be the case that meetings will move to either the beginning or end of the week; the Wednesday meetings were occasionally disruptive to research flow in certain labs. Professional development topics covered may expand to include career options outside of academia and more direction in preparing different kinds of presentations (e.g., posters vs. talks, etc).

Our priority now is to ensure continuation of this project. This will necessitate further funding. Two funding options are being explored. The first is to seek renewal funding through the GLCA Expanding Collaborations Initiative. This will fund a very similar program and again rely on students being funded by their home institutions for their work. The second potential funding source is the National Science Foundation Research Experience for Undergraduates (NSF REU) program. This grant would allow participation not just by students from our institutions, but from others across the United States. The grant would provide for all funding required for the weekly travel, would cover stipends for students and faculty, would provide travel funds for those from institutions at a distance from these five schools, and money for room and board for student research assistants while on campus.

In summary, we engaged neuroscience faculty and their summer research students from five regionally located institutions in research demonstrations, professional development, and building collaborations over five weeks with a modest budget. Students and faculty evaluated the program positively and valued their experiences in the program. Funding will be sought to continue this program and collaborations started will be encouraged to continue.

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