The Next Generation of Scientists: The Development of a Model Intensive Research Experience for Undergraduates

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Abstract

When undergraduates engage in hands-on research experiences, particularly intense mentored experiences, they are more likely to pursue graduate studies in the sciences and take a more assertive role in their learning and career activities. Such early career experiences have been identified as essential in the development of the next generation of researchers. The authors describe the decade long development, structure, and evaluation outcomes of a summer research experience for undergraduates designed to provide an intense, yet supportive, research experience that helps inspire the next generation of scientists. Future considerations for the program are also provided.

Keywords: undergraduate research, summer, mentors, next generation

1. Introduction

The high positive impact of undergraduate research experiences on successful career trajectories is well established (Linn, Palmer, Baranger, Gerard & Stone, 2015; Eagan et al, 2013; Lopatto, 2010; Page, Abramson, & Jacobs-Lawson, 2004). When undergraduates engage in hands-on research experiences, particularly intense mentored experiences, they are more likely to pursue graduate studies in the sciences and take a more assertive role in their learning and career activities (Lopatto, 2007; Hathaway, Nagda & Gregerman, 2002). Such early career experiences have been identified as essential in the development of the next generation of scientist and faculty researchers (Batsche, Boothroyd, Gum, & Stiles, 2008; Brown, Daly, & Leong, 2009). Moreover, research experiences that focus on personal relationships and mentoring, as well as intellectual and academic rigor have been related to better outcomes (Falconer & Holcomb, 2008; Taraban & Logue, 2012). This paper describes the development, structure and outcomes of a summer research experience for undergraduates that was designed to provide an intense, yet supportive, research experience that helps inspire the next generation of scientists. It is hoped that other institutions can build upon these efforts to expand the research opportunities for undergraduates.

Behavioral health disorders, including mental and addictive disorders, are among the leading causes of disability world-wide. The Louis de la Parte Florida Mental Health Institute (FMHI) conducts research on numerous social issues such as mental illness, substance abuse, neuroscience, health care financing, disability law, juvenile justice, involuntary commitment, child abuse, and developmental disabilities. Since 2005, with funding from 3 different federal entities (NSF, NIDA and NIMH), FMHI faculty have conducted the Summer Research Institute at the Florida Mental Health Institute (SRI@FMHI) at the University of South Florida. The SRI@FMHI developed into an intensive 10-week summer institute for undergraduates providing a hands-on research experience for student-scholars and graduate school preparation. We offer a discussion of the evolution and structure of the program as well as the results of our comprehensive evaluation over the 10+ years the program has trained undergraduates. Finally, future considerations for the program are provided.

2. Evolution and Structure of a Program

2.1 Funding the Effort

The SRI@FMHI began as an initiative by several FMHI faculty to provide a comprehensive research experience over the summer of 2005. It served as a pilot project for submission of a proposal to the National Science Foundation

(NSF – www.nsf.gov) to fund a Research Experience for Undergraduates (REU). For that initial summer cohort, 20 students applied, 12 were admitted and 11 completed the program. The structure was only 6 weeks long, and consisted of a full time program that guided students from study conceptualization through development of a final project proposal. Students were not expected to carry out the proposed study in the short 6-week experience, which in retrospect was a mistake, as some projects were unrealistic and not grounded in the practical aspects of conducting research. For more details about this initial program and a discussion of the evaluation, see Gum et al. (2007).

Addressing the many lessons learned that first summer including both challenges and successes, we applied for a NSF grant as a REU. The proposal was successful and was funded for 3 years (summers of 2006-2008) and through a no-cost extension and additional supplemental funding from the National Institute of Drug Abuse (NIDA - www.drugabuse.gov), the program continued through the summer of 2009. The program was expanded to 9 weeks, to allow the students to complete a research project, including pilot data collection, and to present their results orally in a symposium and submit a written paper. The NSF funding (and NIDA supplement) provided a stipend for 12-15 student-scholars each summer for 4 years as well as funding for housing, which allowed us to better recruit nationally.

In 2009, we pursued continued funding from NSF. Despite our successes in program alumni being accepted into graduate programs and starting productive research careers, the review committee and project officers indicated that the program would be better suited to be funded by the National Institutes of Health. When the National Institute of Mental health (NIMH - www.nimh.nih.gov) issued a program announcement in 2011 encouraging applications for undergraduate program similar to our program, we submitted an application with a particular focus on mental health and the neurosciences. The proposal was approved and funded for 5 years in early 2012. Twelve student-scholars were admitted to the SRI@FMHI each summer from 2012-2016 for a 10-week program. We also received a no-cost extension for a 2017 summer program to fund 6 additional undergraduate participants.

2.2 Recruitment and Selection Process

Over the decade of funding, we marketed the program and recruited applicants nationally through email distribution lists of academic social science department chairs, clearinghouses for undergraduate programs, and governmental websites. We also focused on recruiting a diverse applicant pool by partnering with administration and student groups at several Historically Black Colleges and Universities (HBCU) and Hispanic Serving Institutions (HSI) across the country and in Florida. Moreover, we focused recruitment on programs that specialize on preparing first generation students from under-represented groups, e.g., McNair Scholars program, NIMH CORE, and MARC U*STAR programs. These efforts were successful in that the cohorts averaged 12 participants from an annual applicant pool ranging from 158-274, yielding a 4-7% admission rate. Participants or "student-scholars" typically ranked in the top 10% of their class with respect to GPA, represented 35 states, and had a wide range of behavioral health research interests. Of the 135 total program participants, 85% were female, 53% were from racial/ethnic minorities, and 5-10% had a treated disability. Seventy-five percent of the student-scholars were recruited from institutions other than the home institution, the University of South Florida. Thus, we were able to achieve our goals to increase intensive research training for underrepresented groups.

2.3 Structure of the Program (Didactic and Experiential)

Beginning with the expanded program funded by NSF grant, there were 6 primary components to the SRI@FMHI: the mentored research project; a weekly research seminar; a weekly pro-seminar; a series of research skills workshops; numerous community/field experiences; and research ethics training series.

2.3.1 Mentored Research Project

The central experience of the SRI was the mentored research project. Student-scholars were matched with a faculty mentor during the admission/selection process and that relationship was cultivated even before the participants arrived at USF. The mentor-mentee dyad initially worked to together develop a learning plan that included development of a research project (from conceptualization to dissemination of findings) as well as professional (e.g., graduate school) goals. The learning plan served to align expectations, and identify individual goals for the summer project and broader career development. Sometimes the research project was generated completely by the student-scholar, and other times it was an extension of the faculty mentor's own research. Regardless, the student-scholar was expected to develop an independent research project. The only limitations were the scope of the project, because it needed to be completed in the 9-10 week summer time frame. We found that mentor-mentee relationships and collaborations often continued (even at long distance) well beyond the intense summer session.

2.3.2 Research Seminar

Although student-scholars spent a majority of their time in labs and/or working on their research projects, they also participated in a weekly, 2-hour research seminar that was designed to enhance their knowledge of research methods and processes. Topics included research design and sampling, data collection and analysis, results and interpretation, literature reviews and scientific writing, as well as neuroscience, and mental health and/or substance abuse. This seminar served as a didactic vehicle for providing foundational knowledge that student-scholars needed for conducting their research project.

2.3.3 Professional Development Seminar

A weekly, 2-hour pro-seminar was also held to provide student-scholars with the tools to make a number of professional choices as they pursued research careers. Sessions on professional ethics and responsible conduct of research were included as well as sessions on graduate programs and career options, funding of training and research, and writing for publication. Panels of graduate students and graduate program directors were held to convey their own experiences in graduate school and research careers. A mock grant review session to give student-scholars a view of the grant process from the reviewer's perspective was also convened. The professional culture that was established with the student-scholars was designed to help them transition from being student assistants to being colleagues and collaborators with faculty. Student-scholars were given respect and great responsibility as they participated in the program.

2.3.4 Skills Workshops

Weekly research skills workshops were also held for student-scholars to receive hands-on training in completing IRB applications, conducting qualitative analyses with software such as NVivo and Atlas.ti, conducting quantitative analysis with software such as SPSS and SAS, presenting a study at a conference poster session, and public speaking and professional presentations. This last public speaking skill was part of the focus in the final several weeks of the program. The SRI@FMHI culminated with a Research Day where each student-scholar gave a 10-minute scientific presentation on their summer research project to the FMHI faculty and staff. In the week prior to the Research Day, each student-scholar was individually video recorded giving their presentation, and feedback was provided while the student-scholar watched the recording with core faculty and their mentor. Student-scholars did not always enjoy seeing themselves on the recording, but this rehearsal was a highly effective tool for improving public speaking skills. Each scholar also prepared a written research report describing their research project and was encouraged to submit the completed paper for consideration at an Undergraduate Research Symposium as well as regional and national conferences. Many projects were also expanded and prepared for submission to scholarly research journals.

2.3.5 Field Experiences

In order to "foster the training of individuals who will be facile translators from bench to bedside to the community" (NAMHC, 2008), student-scholars participated in community field experiences to gain insight on mental health services related to their mentored research project. These experiences were not just observational but were designed to allow students to interact with stakeholders. For example, students who were working on a project with an involuntary commitment program visited a crisis stabilization unit (CSU) and interviewed staff about the services they provided, evidence-based practices utilized, and areas in need of additional research. Other community research sites included acute care crisis centers, psychiatry centers, community mental health centers, and residential treatment programs for youth with serious mental health disorders. Some student scholars involved in criminal justice issues attended drug court hearings (and interviewed the judge), participated in over-night police "ride-alongs", and/or participated in on-going DUI checkpoints. Community partners were also invited to present at several community forums held at FMHI over the summer so that student-scholars could directly interact and question a variety of stakeholders in the mental health, substance abuse and criminal justice systems.

2.3.6 Research Ethics Training

The responsible conduct of research (RCR) was a key part of all SRI seminars. We explored a breadth of ethics and RCR issues relevant to the biomedical and behavioral science fields (e.g., consent, confidentiality, conflict of interest, risk, dissemination/publication). Student-scholars completed a web-based foundation training in human subjects research required by the USF IRB office, web-based network security training required by FMHI, and the Responsible Conduct of Research on-line course required of NSF/NIH researchers (the CITI course – www.citiprogram.org; see Stiles, Batsche, Gum, & Boothroyd [2007] for an expanded discussion of this topic). In addition, several pro-seminar sessions were exclusively devoted to instruction in the responsible conduct of research. Student-scholars also attended a meeting of committees/boards that monitor the responsible conduct of research

(IRB, IACUC) and participated in post-meeting question and answer sessions with Board members. Finally, a research ethics film and discussion series was held over a 4-week period featuring films related to important research ethics cases and issues such as the Tuskegee experiment, Milgram's obedience studies, Zimbardo prison studies, the Breuning scientific misconduct case, and other recent cases of scientific misconduct. A USF faculty member who was herself a whistleblower in a famous medical case joined students-scholars to discuss her experiences and the impact on her professional life.

3. Program Evaluation

3.1 Evaluation Design

A comprehensive outcomes evaluation including pre-post testing and longitudinal data collection provided insights into the effectiveness of various components of the program. The SRI@FMHI was evaluated using a framework developed by Kirkpatrick (1959, 1975, 1994). Although proposed more than 50 years ago, it continues to be one of the most widely used frameworks for monitoring training activities (Medsker & Roberts, 1992). Kirkpatrick's model involves 4 levels: (1) Level I focuses on measuring training effectiveness; (2) Level II assesses changes in trainees' knowledge; (3) Level III examines changes in trainees' behavior; and (4) Level IV measures longer term impact after the program has been completed.

Kirkpatrick's framework is based on 4 fundamental principles, that: (1) evaluation is a continuous process; (2) although trainee perceptions and knowledge acquisition (Levels I, II) are necessary for program improvement, the more critical indicators of program success are behavioral change and longer-term impacts (Levels III, IV); (3) evaluation must be linked to specific program objectives; and (4) benchmarks must be specified to denote program success.

Four measures were developed and administered as part of the evaluation of the SRI@FMHI. To elicit scholars' reactions to the programmatic and logistical aspects of their experience (Level I), scholars completed the ***Post Program Evaluation*** (PPE) at the end of the program to assessed issues such as the quality of time spent with mentors, adequacy of resources available to complete their research projects, extent to which program objectives were met, and effectiveness of instructional materials, strategies, and activities. The benchmark was that 85% of students would report high levels of satisfaction.

To assess the extent to which scholars gain knowledge related to the content present during the SRI@FMHI, a pre and post-test ***Knowledge Assessment*** (KA) consisting of 100 true-false questions was administered at the start and end of the SRI@FMHI. A table of specifications was developed annually to ensure each question was linked to a specific learning objective as the program was revised based on evaluative feedback, therefore improving the validity of the assessment (Chase, 1999). Benchmarks included: (1) significant group gains from pre-to-post scores on the KA; and (2) a minimum of 80% of the students will attain a score of 80% or higher on the post-test. Effect size was also examined.

Knowledge obtained through the SRI@FMHI was considered a critical but not sufficient condition for program success. Level III evaluation was based on the concepts of performance assessment which require scholars to demonstrate specific skills and competencies associated with knowledge they mastered through the use of "authentic" or "performance" assessment (Stiggins, 1987). This ongoing assessment was achieved through faculty review and evaluation of scholars'' performance portfolios (Mitchell 1992), open-ended questions, and direct observations. Portfolios involve a collection of work completed by scholars'' such as literature reviews, research papers, recorded research presentations, article critiques, and research budget. The SRI@FMHI was considered to have met its objective if, based on faculty assessment, 85% of SRI@FMHI students successfully demonstrate the skills taught.

The final measure developed for the evaluation of the SRI@FMHI was the ***Follow-up Evaluation Form*** (FEF) to assess longer-term impact (Level IV). At the end of each program scholars were asked to identify specific information or skills learned during the SRI@FMHI that they perceive will be helpful to them in the short-term and to develop a brief plan on how they will use the information or skills. Nine months later, the FEF was mailed to each scholar to determine if their expectations were met, to identify any barriers or problems encountered, and to track dissemination activities. They were asked to provide both formal and informal activities such as whether they shared SRI@FMHI research information and materials with other students, conducted presentations related to their SRI@FMHI experiences, or published scholarly work. Additionally, information was solicited on the scholar's graduate school status (e.g., applied, accepted, type of program). Benchmarks included the following: (1) 75% of the

scholars would report applying concepts from the SRI@FMHI within 9 months of program completion; (2) a minimum of 65% would be enrolled in graduate school within 2 years of obtaining their baccalaureate degree.

3.2 Data Analysis

Analysis of scholar responses was largely descriptive to determine if scholar's reported level of satisfaction met projected benchmarks. Analysis of pre-post assessment involved paired *t*-test. To assess the magnitude of significant effects, Cohen's *d* (Cohen, 1988) was calculated. Given the calculation of effect size with repeated observations, the Morris and DeShon (2002) formula was used to account for the fact that scholars' pre and post observations were correlated.

Although this was an evaluation and did not meet the federal definition of research, to protect SRI@FMHI scholar's rights and to ensure the evaluation methods adhered to the highest ethical standards, an application was submitted and reviewed by the University's Social/Behavioral Institutional Review Board (IRB) detailing all proposed evaluation procedures and measurement instruments. In addition, scholars were informed that their participation in the evaluation was voluntary.

The evaluation produced both process and outcome information (Scriven, 1967) and data were used formatively to modify and improve the mentored research experience, research seminars, research materials, and research lab experience. The data were used in a summative manner to determine the extent to which the program produced changes in scholars' knowledge, attitudes, and behaviors related to research.

The evaluation results aided in improving the SRI@FMHI each year. For example, results of evaluative feedback from previous years led to changes such as adding the weekly skills workshops, sessions on peer review of writing, increasing the number of verbal presentations to enhance student confidence, adding a panel of graduate program directors to better prepare students for applying to graduate school, and increased the amount of time students had to collect and analyze data just to name a few.

3.3 Outcomes

The primary evaluation findings are provided below.

3.3.1 What Were Scholars Overall Reactions to the SRI@FMHI?

At the end of the SRI@ FMHI scholars completed a *Post Course Evaluation* form (Level I) providing their overall reactions regarding the effectiveness of various aspect of the program. Between 2005 and 2017, 116 scholars completed this assessment. An examination of selected items from this form indicated that 86 of the scholars (74.1%) rated the overall quality of the SRI@FMHI as "Excellent," 28 scholars (24.1%) rating it as "Good," with 2 scholars (1.7%) rating it as "Fair". The 98.2% of the scholars rating the SRI@FMHI as "Excellent or Good" exceeded the 85% criterion established as demonstrating a high level of scholar satisfaction.

One hundred and five scholars (90.5%) reported the SRI@FMHI was "Very Worthwhile" with 11 scholar indicating it was "Fairly Worthwhile" (9.5%). In terms of recommending the SRI@FMHI to others, 84.5% of the scholars indicated that they would "Definitely Recommend" the program to other while the remaining 15.5% reported that they would "Probably Recommend" it to others. These responses also met the established 85% criterion for satisfaction.

In terms of the quality of the scholars' mentorship experiences, 104 of 115 scholars who responded (90.4%) reported this aspect of the program to be "Excellent", exceeding the 85% predicted criterion. The remaining scholars rated their mentored experiences as "Fair" (7.0%) or "Poor" (2.6%). Of the 113 scholars who responded, 86.7% reported that their research experience during the SRI@FMHI was "Definitely Better" (61.9%) or "Somewhat Better" (24.8%) than their previous student research experiences. Fourteen scholars (12.4%) reported it was "About the Same" and one scholar reported it was "Somewhat Worse." These results were at the 85% criterion for satisfaction.

3.3.2 Did Scholars Demonstrate Gains in Knowledge From Participating in the SRI@FMHI?

Completed pre and post *Knowledge Assessment* forms (Level II) were available for 121 scholars who participated in the SRI@FMHI during this 12 year period. A paired sample *t*-test was performed on the aggregate sample to assess the change in these scholars' pre-to-post scores. The results indicated that overall, total scores Knowledge Assessment increased significantly from a pre mean of 68.5% correct (SD = 7.63%) to a post mean of 71.9% correct (SD = 9.74) $t(120) = 3.96$; $p < .001$. Further examination of the magnitude of this change using Cohen *d* revealed an effect size of $ES = .367$, which falls in the small to moderate range. Although an overall significant gain in knowledge was demonstrated by the scholars and met the established benchmark in this area, the effect size

associated with this gain was small. The percentage of scholars meeting the 80% correct post test score benchmark failed to meet the 80% threshold that was proposed.

Further examination of changes in knowledge across individual implementation of the SRI@FMHI as well as within specific content areas (e.g., research ethics, measurement, research design) revealed consistent and similar findings (data not shown); statistically significant albeit small gains, with less than 80% of the scholar's attaining 80% correct on the post Knowledge Assessment.

3.3.3 Did the Scholars Demonstrate Changes in Their Behavior as a Result of Participating in the SRI@FMHI?

Throughout the SRI@FMHI, scholars were provided numerous opportunities to demonstrate various skills and competencies they were gaining during the skills workshops, professional development seminars, and research seminars (Level III). Completing IRB applications, conducting article critiques, and presenting summaries of their research projects were just a few examples of the activities scholars engaged in during which they could showcase their newly enhanced skills and behaviors. These activities provided the core faculty with important evaluative information about the effectiveness of the Institute in developing scholars' core competencies. Over the years, this information was used formatively to make programmatic changes in the SRI's content and format as well as to provide individual feedback to scholars. Based on our observations, we concluded that, in general, scholars gained significant growth in skills, particularly in terms of developing their presentation skills. This conclusion is supported by comparing the dramatic improvement between the practice and final videotaped recordings of our scholars' research presentations.

3.3.4 To What Extent Were Scholars Able to Implement Skills Learned During the SRI@FMHI After They Returned to Their Home Institutions?

As previously noted, at the end of the Institute, each scholar identified specific information or skills learned during the SRI@FMHI that they perceived would be helpful to them in the short-term. They were asked to develop a brief plan on the ***Follow-up Evaluation Form*** (FEF) describing how they would use these skills when they returned to their home institution. Six month later, this form was returned to them to determine if they implemented their plan as well as to gather other information (Level IV). Scholar's goals were quite broad and ranged from conducting additional independent research to preparing manuscripts publication or abstracts presentation to preparing application for graduate school. Of the 64 scholars who returned the FEFs, findings from selective items indicated that 91.8% of the scholars were able to fully (62.3%) or partially (29.5%) implement their first identified plan and 85.2% were able to fully (59.0%) or partially (26.2%) implement their second identified plan. These results suggest that the 75% criterion for applying concepts from the SRI@FMHI within 9 months of program completion was met.

Many of the scholars (87.7%) maintained contact with their mentors who assisted them in their professional endeavors. In addition, 79.7% of the scholars continued to work on the research projects they initiated during the SRI@FMHI.

In terms of scholars' dissemination activities in the 6 months following the Institute, 66.2% had prepared conference abstracts, 56.9% had submitted one, and 49.2 % had had an abstract accepted. In terms of manuscripts, 55.4% of the scholars were in the process of preparing manuscripts at the time of completing the FEF, 15.4% had submitted a manuscript for publication, and 3.1% had had a manuscript accepted for publication. In addition, 42.2% of the scholars had won additional awards since participating in the SRI@FMHI. When asked to once again reflect on the value of the SRI@FMHI, 93.8% of the scholars reported that the program had been "Very Worthwhile."

3.3.5 What Were the Long-Term Outcomes of the Program?

The SRI@FMHI has provided strong follow-up and outreach to our program alumni, allowing us to collect data on their professional activities. The long-term outcomes for the SRI@FMHI suggest that the program has been highly successful at launching student-scholars towards research careers.

Graduate School. Seventy-five percent of SRI participants are currently enrolled in or have recently completed advanced graduate degrees. An additional 15% are currently submitting applications to graduate school. This outcome meets the established benchmark set for the program as part of the evaluation. The vast majority of alumni are enrolled in graduate studies related to behavioral health.

Publications and Presentations. SRI@FMHI alumni have published 172 articles in peer-reviewed journals. One example is a doctoral student who recently completed her post-doctoral fellowship at the University of Massachusetts Neuroscience and Behavior program. She served as first author on an article published in *Journal of Neuroscience*, in which she describes the evolution of her research and study results. SRI@FMHI alumni have

presented their research at over 500 state, regional, and national conferences. One of our scholars recently presented at the American Psychological Association (APA) Annual Convention and won an Outstanding Poster Award for "*Findings from a drug court program of female offenders with trauma-related symptomatology*."

Other accomplishments. A SRI alumnus received a two-year Biomedical Ethics Fellowship from NIH and another alumnus was funded for 3 years on a R01 supplement from NINDS. Two SRI alumni have received Fulbright Scholar awards. SRI alumni have received over 175 scholarships and awards including: (1) National Research Service Award from the National Institute on Aging, (2) University of Florida Outstanding Research Award, (3) Outstanding Research Award at the Embry-Riddle Research Conference, (4) Honors College Outstanding Research Award, (5) USF Outstanding Undergraduate Research Symposium award for the best undergraduate peer-reviewed publication, and (6) USF Outstanding Research Awards in the Behavioral and Social Sciences. Finally, 8 alumni received grants from their universities to continue their research projects. Thus, the foundation provided by the SRI@FMHI program helped an already talented group of student-scholars with achieving their professional goals – with most pursuing academic and research careers.

4. Future Considerations

Continuation of funding through NIMH has not been possible as they no longer support undergraduate programs. However, the National Institute of Drug Abuse (NIDA) offers support for such initiatives, and thus we applied in 2017 to continue the program with a new focus on substance use disorders. The NIDA proposal has been funded and we will thus be continuing the SRI@FMHI during the summers of 2019-2023. Although the substantive focus has shifted a bit, the overall objectives remain the same – to enhance the training of the next generation of social science researchers so that they can address the needs and challenges of some of the most vulnerable members of society through high quality, impactful, and ethical research and evaluation.

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