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UNDERGRADUATE STUDENT EXPERIENCES AS PART OF THE NSF-IUSE GEOSCIENCE EMENT AND OUTREACH PROGRAM: OVERVIEW, PROJECTS, RESULTS FROM YEARS 1 AND 2

Corene J. Matyas[1] *, Kathryn Stofer[1], Jasmeet Judge[1], Heidi Lannon[2], Brandan Lanman[3]
[1]University of Florida, Gainesville, Florida; [2]Santa Fe College, Gainesville, Florida, [3] Orlando Science Center, Orlando, Florida

1. INTRODUCTION

Few students enter undergraduate programs understanding what the geosciences are or that geosciences are part of a science or STEM curriculum. Yet high-paying, high-demand jobs in the geosciences and the need for diversity in these fields means these students may miss an opportunity to put their interests in science to work if they do not see the connection (Levine et al. 2007; O'Connell and Holmes 2011). This is especially true of students at two-year institutions, who may have had limited exposure to a variety of science disciplines and the corresponding research, industry, and career opportunities. In turn, undergraduate research programs also need to recruit from populations that are not intending to pursue science (Linn et al. 2015).

Our project is comprised of a collaboration among Santa Fe College (SF), a two-year teaching institution; the University of Florida (UF), a four-year research institution; and the Orlando Science Center (OSC), a non-profit informal education and outreach venue. The Geoscience Engagement and Outreach (GEO) project offers students positive undergraduate geoscience experiences (Holmes and O'Connell 2005), specifically authentic geoscience research experiences explicitly integrated with practical applications via geoscience outreach and scaffolded by classroom work. We aim to increase the number and caliber of faculty available to mentor undergraduates (Frantz et al. 2014) and foster continued education in geosciences.

The GEO project is a 3-year project funded by the National Science Foundation's IUSE (Improving Undergraduate STEM Education) Pathways into Geoscience Program. It uses a three-phase model of seminar-style teaching, research mentoring with outreach project development and delivery, and a culminating capstone experience that grounds the program elements in an emerging geoscience associates degree at Santa Fe College. Using a cohort system engaging at least six students each year, built on peer- and supervisor-mentoring and collaborations among three institutions, the project recruits under-represented populations and supports their retention in geosciences fields. Activities include skill-building for careers, to produce graduates prepared for the expectations of future employers, and authentic faculty-mentored research in the geoscience subdisciplines of geography/meteorology, soil hydrology, and geoscience and STEM education. Various team-building activities (Fig. 1) build the cohort and strengthen relationships with mentors. Finally, the project assists GEO cohort students in completing their two-year degree and transferring to a four-year geosciences program prepared to continue and thrive alongside their four-year institution peers.

Fig. 1 Team-building field trip to bat cave Spring 2017 featuring Geopaths students, SFC and UF mentors, and staff from OSC.

* *Corresponding author address:*
Corene J. Matyas, Univ. of Florida, Dept. of Geography, Gainesville, FL 32611-7315; e-mail matyas@ufl.edu

2. PROJECT GOALS AND PHASES

GOAL A - Recruit, retain, and transfer primarily underrepresented Santa Fe College students in a two-year Associates degree to Bachelor's degree programs in geosciences.
GOAL B - Establish collaborations among Santa Fe College students, University of Florida faculty mentors, and Orlando Science Center informal science educators.
GOAL C - Increase cohort interest in careers in geosciences through education and outreach.
Phase I – Spring: Orientation, SFC Courses, and Initial UF Research Collaboration (A, B, C)
Phase II – Summer: Research at UF, Education and Outreach at Orlando Science Center (B, C)
Phase III – Fall: Capstone Experience at SFC, Research and Outreach Presentations (A, B, C)

3. PROJECT TIMELINE

Activities for each cohort span 17 months (Fig. 2). Recruitment of SFC students begins in August. Interviews of prospective participants are conducted in October and November with representatives from all three institutions participating. The cohort is accepted in December, and a welcoming reception is held prior to the holiday break. Two courses (Seminar featuring team-building activities and additional background on research in the geosciences; Physical Geography) and research with UF mentors are undertaken in the spring. Students make multiple visits to UF to learn about research opportunities and select their UF mentors (Fig. 3), with whom they work in pairs plus a UF undergraduate peer mentor. They commit 5 hours per week to research during the spring and regularly meet with UF faculty and peer mentors, presenting their progress to the whole cohort and collaborators at OSC approximately monthly. Summer A (first 6 weeks of summer semester) program time is dedicated to more intensive research with UF mentors (at least 10 hours per week), with a presentation of their work to date delivered to all SFC, UF and OSC participants. Students receive a stipend to live in Orlando during Summer B and develop public engagement and school educational activities at OSC. In the fall, students take a capstone course that includes exposure to geosciences careers, preparation of a transfer application to a 4-year degree program, finalizing their research, and formal presentations of their OSC activities and research results.

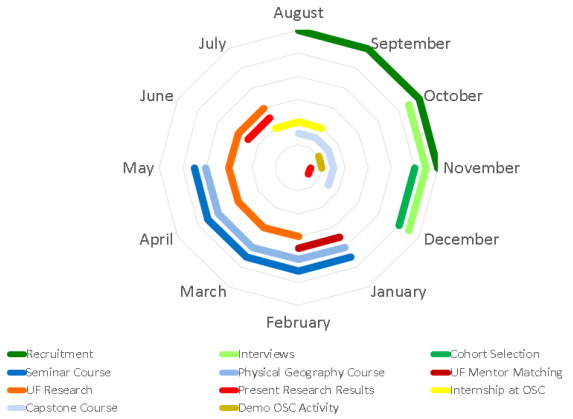

Fig. 2. Timeline of activities for each cohort. Plot should be read clockwise from outside to inside. Student selection is depicted in green, coursework in blue, research in red/orange, and internship in yellow/gold.

Fig. 3. Research mentoring in UF Geography's computer lab**.**

4. RESEARCH WITH UF MENTORS

During the research experience, UF PI Stofer, Co-PI Judge, and Co-PI Matyas meet regularly with their GEO students to mentor them them in research activities such as planning meetings, protocol preparation, data collection and analysis, and writing and presentation At research group meetings, undergraduates, graduate students, postdocs, and faculty report their research goals and problems they face as part of the scientific process of discovery. GEO students also meet with other students from each project discipline to learn more about research, receive near-peer mentoring, and grow their networks in geosciences (Edgcomb et al. 2010).

Co-PI Matyas is an Associate Professor of Geography, focusing on meteorology for analysis of rainfall from tropical cyclones. She has developed multiple courses in atmospheric science and coordinates graduate and undergraduate certificates in Meteorology and Climatology. In her NSF CAREER Award, she has mentored STEM undergraduate students from Geography, Geology, Environmental Science, and Engineering, as well as students majoring in business, journalism, and the social sciences. Out of 29 students connected with the CAREER Award, 16 were undergraduates, and 17 were minorities.

Research with Dr. Matyas features data and techniques from atmospheric science and geography. This project combines previous research methods developed by Matyas and students on the spatial analysis of rain rates (Matyas 2014; Zick and Matyas 2016; Zhou and Matyas 2018) and research conducted by Matyas and colleagues on tropical cyclones (Ash and Matyas 2012; Matyas 2015) and their impacts on Mozambique (Matyas and Silva 2013; Silva and Matyas 2014; Silva et al. 2015). Examining satellite estimations of rain rates (Fig. 4a), students gain skills performing spatial analysis using GIS with provided Python scripts and making figures, organizing and updating spatial databases, making calculations and graphs in Excel, and conducting statistical analysis using SPSS. Students acquire these skills while pursuing these research questions: How do the spatial extents of rain rates produced by tropical cyclones moving over the SW Indian Ocean and Mozambique Channel vary amongst the storm's four quadrants (Fig. 4b) and across storms? Do these variations have a spatial bias from topographical influences? Are they related to storm intensity?

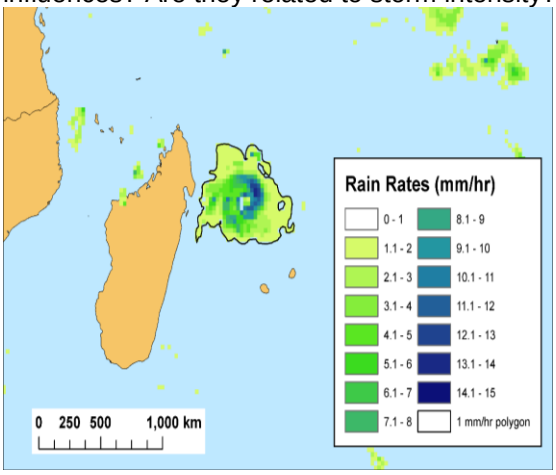

Fig. 4 Rain rate data for TC Hudah (2000).

UF PI Stofer is a Research Assistant Professor of STEM Education and Outreach at the University of Florida. Dr. Stofer researches public engagement with science and agriscience learning. She has worked in science museums since 2001 and specifically geoscience and data visualization research since 2008. She mentors undergraduate and graduate researchers from a variety of scientific disciplines.

Geoscience education through public engagement is the focus of the research led by Dr. Stofer. The projects build on existing work by Dr. Stofer and others with public audiences and data visualizations on spherical screens. Visualizations produced by scientists for scientists need a great deal of translation of colors, labels, and background information to be meaningful to broad audiences (Phillips and Rowe 2010; Rowe et al. 2010; Stofer 2013). Specifically, to examine the effectiveness of providing local context to orient and engage audiences with global datasets, UF PI Stofer's students design and test visualization prototypes of a global datasets using both quantitative and qualitative measures. Students have designed a survey instrument and interview protocol with various test versions of visualizations used by Dr. Matyas and Dr. Judge and submitted human participant protocols to the Internal Review Board. They collect data from the public, calculate simple statistics to analyze survey results, and code qualitative interview transcriptions. Research questions include: which color scheme is best for presenting rain rate data for hurricanes on the ocean and soil moisture data on land? Can public audiences recognize the structure of a hurricane in a rain-rate satellite image? Do public audiences express better familiarity with political maps or real-color satellite imagery for recognizing geographic features such as rivers and ocean basins? Finally, Dr. Stofer's students advise their other cohort members on visualization design at the OSC internship as they create and present Science on a Sphere® shows.

Co- PI Judge (UF) is an Associate Professor of Agricultural and Biological Engineering and the Director, Center for Remote Sensing. Her research focuses on improving soil moisture quantification in the vadose zone for heterogeneous and dynamic agricultural terrain. She has been a PI of a distributed REU Program in water resources, during which 26 undergraduates were mentored over the three years.

Dr. Judge guides research in hydrology and soil science. GEO students working with Co-PI Judge in the soil moisture project during will participate in the ongoing experiment (MicroWEX-12) with data collection and analysis of extensive dataset from the previous experiments. Students will expand their knowledge base by using various statistical and programming tools to answer research questions and to assimilate macro-level data into a format for public engagement. Field work experience is gained by students as they dig pits and place instruments to measure soil temperature and moisture. They are part of a large collaborative project to examine the role of soils in the carbon cycle under different moisture conditions. Test sites provide ground truth for remotely-sensed observations.

5. PROJECTS CREATED DURING OSC INTERNSHIP

Students pursue one of two projects during their paid summer internship. The first is to create public engagement for visitors of the OSC in Dr. Dare's Lab or a show displayed using Science on a Sphere® (SOS). The second project is to create geoscience educational activities that meet Sunshine State standards in the Geosciences that can be shared with K-12 teachers. In Florida, there is a special challenge, which is to avoid using phrase "climate change" as it is viewed by some Floridians and OSC visitors as controversial.

The students in Years 1 and 2 have created the following activities tying into the UF mentors' research: Dr. Dare's Lab: Activity 1: visitors explore soil properties and create soils for plants to take home small plants in the correct soil for that plant. Activity 2 (Figure 5a): use a shaking table to simulate earthquakes. Visitors created structures out of note cards and tape and these were placed on the table to be shaken. SOS show: Our Changing World (Figure 5b). This display teaches about the carbon cycle, which included an activity with balls representing carbon and methane. K-12 Activity: Use inexpensive probes to measure temperature and moisture in different types of soil layers and relate to latent and sensible heat exchange.

a)

b)

Fig. 5. GEO participants facilitate public engagement activities at OSC's Otronicon with a) earthquake table, and d) Science on a Sphere®.

6. RESULTS: RECRUITMENT, RETENTION, AND SUCCESSES

While we had hoped that our recruitment numbers would be higher, we are attracting a diverse group of applicants (Fig. 6). Around half are female and about half are first-generation college students. In the future, we aim to attract more non-white and non-traditional students to apply to the program. More than 80% of the students are pursuing majors outside of the Geosciences when they apply to the program (Fig. 7).

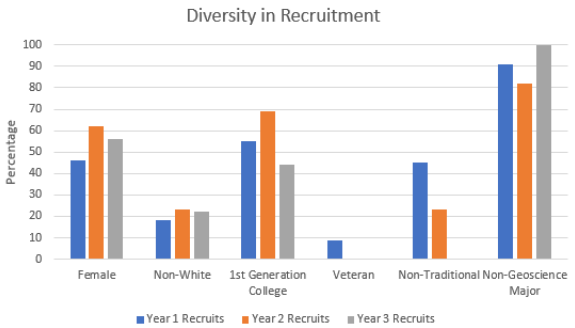

Fig. 6. Recruitment by diversity category for each year.

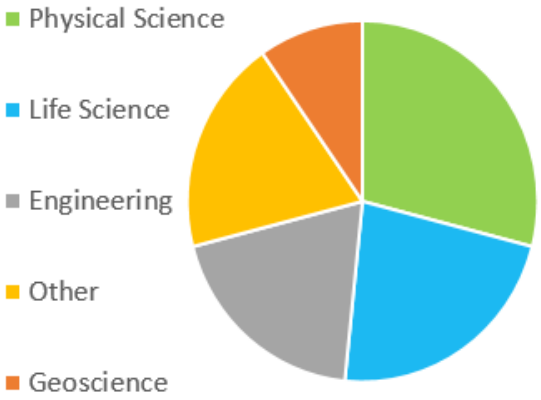

Fig. 7. Major pursued by program applicants. Geoscience includes Geography, Geology, and Meteorology. Other includes undeclared, Accounting, and Music.

Up to nine students are selected each year, though only six can obtain the paid summer internship. In Years 2 and 3, we have allowed students to be in the program even if they indicate that they cannot participate in the OSC internship, and any of the nine students who are not chosen for the internship can continue the UF-mentored research. In selecting students to enter the program and finding replarements for those that dropped out almost immediately, we have great success in admitting women and first generation college students (Fig. 8). We have had similar percentages of non-white and non-traditional when comparing the applicants and ultimate student participants.

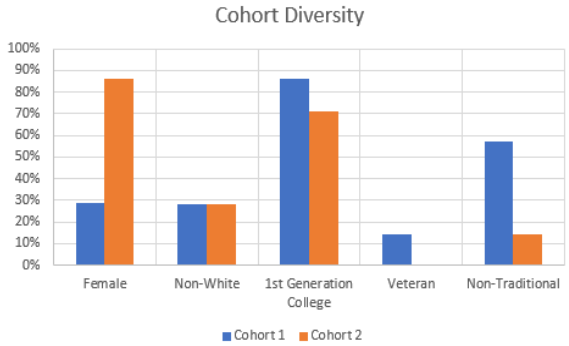

Fig. 8. Diversity of students admitted into the Geopaths program.

Overall, we have a higher completion rate for Year 2 as compared to Year 1 (Fig. 9). Once admitted into the program, students have their own academic advisor at SFC (Bobby Hom) and they report that he aids their success in college. This is particularly important for first-generation college students. All students have completed Phase I, although one student had to retake the physical geography course to achieve a passing grade. The most difficult phase for retention is Phase II that involves dedicated research with UF faculty mentors and the summer internship. Those that successfully complete the internship report that it was a valuable experience. Although research with UF mentors has led to publication-quality results in some cases, some students are not able to appropriately budget their time or acquire skills to work with data in spreadsheets, or simply stop communicating with their group. In terms of transferring to a 4-year program, 50% have successfully done so. Several students from Year 2 are still taking classes at SFC and plan to transfer in future semesters.

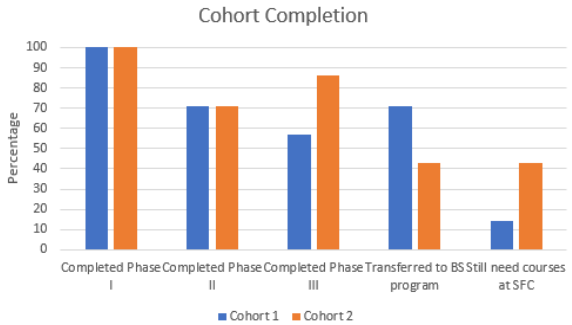

Fig. 9. Completion rates for each phase of the program and transfers to a 4-year program. Note that students who did not qualify for the summer internship are not listed as completing Phase II, yet may return for the capstone course and complete Phase III.

7. OVERCOMING YEAR 1 CHALLENGES

In Table 1, we summarize seven key challenges that we identified during the exit interviews for the Year 1 cohort. We then list steps that we have taken to overcome these challenges for Year 2's cohort. An ongoing challenge that is beyond our control is the ability for SFC students to utilize the software they need to conduct their research. At UF, students have access to all software needed for teaching courses through a web-based portal. This service is not available at SFC. We have had to work closely with staff at UF to allow the six students access to UF resources, taking our case to the Provost's office to secure permission.

Table 1. Challenges faced by Year 1 students and steps taken to overcome them.

Challenge	Steps to Overcome
Students don't own laptops for research	OSC purchased laptops that students borrow each year
Communication methods	Use Slack to schedule meetings, share files, upload research notes
Software and data exchange across campuses	Get SFC students access to UF resources for data storage and software for analysis
OSC internship did not reach full potential	Incorporate OSC mentors in research updates, trip to OSC in spring, OSC mentors participate in team-building activities, reserve part of stipend for completion
Research did not progress as planned	Hire UF undergrads to be peer mentors, weekly progress reports, monthly update presentations, feedback with rubrics, solving of tech issues
Students not understanding time commitment and challenges for research	Incorporate research activities in the first class. Students dropped out early in Year 2 due to time commitment issues an improvement over Year 1 where they dropped out in summer and fall.

8. EDUCATIONAL RESEARCH PLAN

In addition to the goals for the cohort's personal development, we have research questions about the educational value of the opportunities. First, we want to know if any of the program components (physical geography course, research, outreach internship, and/or cohort) have a bigger impact on student knowledge, science identity (Carlone and Johnson, 2007), or career intentions. Second, we want to investigate these program elements compared to non-participants, and finally, we want to examine long-term impacts of the program on these participants.

Using a combination of quantitative and qualitative methods, our preliminary results indicate that different program elements impact students differently (Stofer et al., 2017). Results are mixed as to improvement over non-participants (Stofer et al., 2016). However, we see promising results in the program's impact on students transferring to 4-year degrees and in increasing their science identities (Stofer et al., 2017).

9. ACKNOWLEDGEMENTS

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