# Stretching the CURE into a Multi-year, *Curriculum*-based Undergraduate Research Experience (MY-CURE): An NSF-IUSE Study

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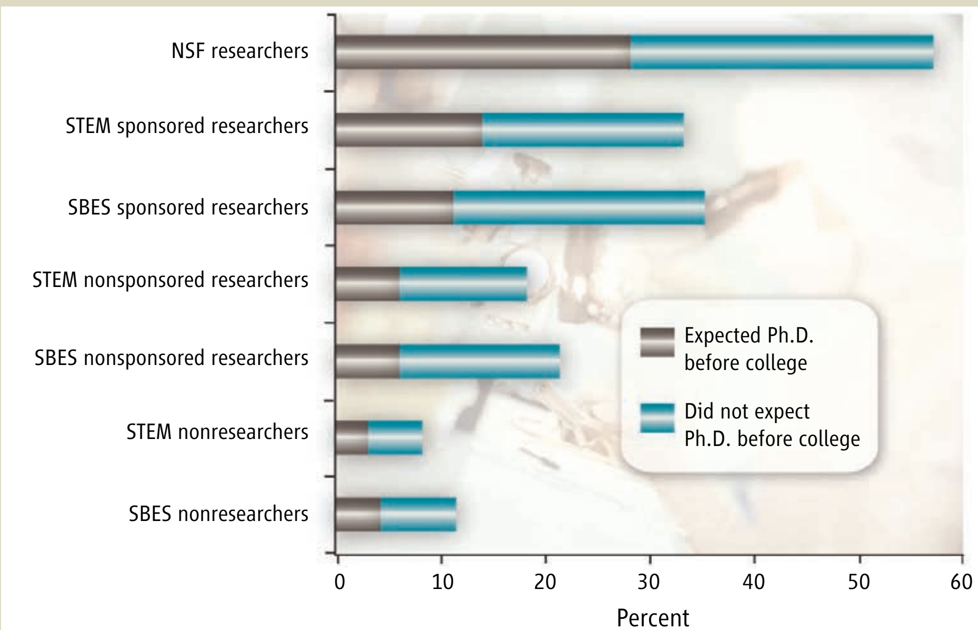
# Benefits of UR

- Increased interest in science as a career
- Increased understanding of how to conduct a research project
- Increased confidence in research skills
- Increased awareness of nature of graduate school




**Ph.D. expectations.** Participation in undergraduate research opportunities affects expectations of obtaining a Ph.D.



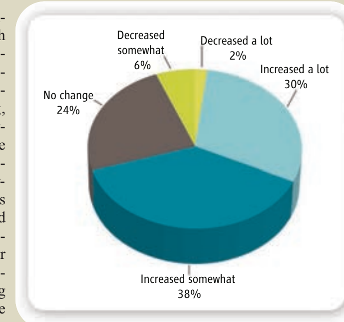
THE PIPELINE

## Benefits of Undergraduate Research Experiences

Susan H. Russell,[1]* Mary P. Hancock,[1] James McCullough[2]

Surveys indicate that undergraduate research opportunities help clarify students' interest in research and encourage students who hadn't anticipated graduate studies to alter direction toward a Ph.D.

Undergraduate students' participation in hands-on research is widely believed to encourage students to pursue advanced degrees and careers in science, technology, engineering, and mathematics fields. SRI International conducted a nationwide evaluation of undergraduate research opportunities (UROs) to understand who participates, what effects the experience has on them, and what factors favor positive outcomes. Our study included four Web-based surveys, conducted between 2003 and 2005 and involving almost 15,000 respondents. The survey instruments, detailed data tables, and analytical reports are available online (*1*).




**Raising interest.** UROs often increase a student's interest in STEM careers.

Respondents to the first survey were approximately 4500 undergraduates and 3600 faculty, graduate student, and postdoc mentors who participated during 2002 or 2003 in UROs funded by any of eight NSF programs with a substantial undergraduate research component. Two years later, about 3300 individuals who were undergraduates in the initial survey responded to the follow-up survey.

In 2003, we surveyed a nationally representative sample of individuals (ages 22 to 35) who had received a bachelor's degree in science, technology, engineering, or mathematics (STEM) ($n = 3400$); in 2004, we conducted a parallel survey of individuals who had received a bachelor's degree in a social, behavioral, or economic science (SBES) ($n = 3200$). Of the STEM and SBES survey respondents, some (sponsored researchers) knew their research to be sponsored by NSF, NIH, or NASA. Others (nonsponsored researchers) did research that was not (as far as they knew) sponsored by NSF, NIH, or NASA. A third group (nonresearchers) did not participate in UROs.

About half of STEM and SBES survey respondents had participated in UROs. For about 1 in 15, this research was sponsored by NSF, NIH, or NASA. The experiences and outcomes reported by sponsored researchers in the STEM and SBES surveys proved to be similar to those of the NSF-participant surveys.

### Profile of Undergraduate Researchers

The efforts of NSF and other entities to encourage the representation of groups historically underrepresented in STEM fields appear to have been effective. In all of our surveys, undergraduate researchers were demographically diverse, with women, blacks, and Hispanics/Latinos represented at rates at least equivalent to their rates in the overall college population. Those who began their undergraduate education at a 2-year college were as likely to participate in research as those who started at a 4-year college or university. However, URO participation rates differed across various disciplinary fields. In the STEM survey, participation rates ranged from 34% in mathematics and 37% in computer sciences to 72% in chemistry and 74% in environmental sciences. In the SBES survey, rates ranged from 38% in economics and political science to 63% in psychology.

Undergraduate researchers were mainly juniors and seniors, and they tended to have relatively high grade point averages, reflecting the competitive nature of many undergraduate research programs. They also were more likely than nonresearchers to expect to obtain an advanced degree (*2*). The STEM survey found that those who participated in UROs were twice as likely as those who did not to have pre-college expectations of obtaining a Ph.D. (14% versus 7%) (*3*). Interest in STEM was likely to have begun in childhood: 59% of NSF researchers reported that they had been interested in STEM "since I was a kid," and another 29% said they became interested when they were in high school. This suggests that an effective time to attract students to STEM may well be while they are in elementary school (*4*). In contrast, interest in SBES was most likely to have developed during high school or college.

### Undergraduate Research Outcomes

We found that UROs increase understanding, confidence, and awareness (*5–8*). Most (88%) of the respondents to the NSF follow-up survey reported that their understanding of how to conduct a research project increased a fair amount or a great deal, 83% said their confidence in their research skills increased, and 73% said their awareness of what graduate school is like increased.

UROs also clarify interests in STEM careers (*9*). Of respondents to the NSF follow-up survey, 68% said their interest in a STEM career increased at least somewhat as a result of their URO (see figure above).

Finally, UROs increase the anticipation of a Ph.D. (*10*). Of respondents to the NSF follow-up survey, 29% had "new" expectations of obtaining a Ph.D.—that is, they reported that before they started college they did not expect to obtain a Ph.D., but now (at the time of the survey) they did expect to obtain one. In the STEM survey, "new" expectations of obtaining a Ph.D. were reported by 19% of sponsored researchers, 12% of nonsponsored researchers, and only 5% of nonresearchers (see figure, page 549).

Students who participated in research because they were truly interested and who became involved in the culture of research—

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Benefits of long-term UR?

CBE—Life Sciences Education
Vol. 11, 260–272, Fall 2012

*Article*

# The Benefits of Multi-Year Research Experiences: Differences in Novice and Experienced Students' Reported Gains from Undergraduate Research

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Submitted November 10, 2011; Revised April 3, 2012; Accepted April 9, 2012
Monitoring Editor: Mary Lee S. Ledbetter

This mixed-methods study explores differences in novice and experienced undergraduate students' perceptions of their cognitive, personal, and professional gains from engaging in scientific research. The study was conducted in four different undergraduate research (UR) programs at two research-extensive universities; three of these programs had a focus on the biosciences. Seventy-three entry-level and experienced student researchers participated in in-depth, semi-structured interviews and completed the quantitative Undergraduate Research Student Self-Assessment (URSSA) instrument. Interviews and surveys assessed students' developmental outcomes from engaging in UR. Experienced students reported distinct personal, professional, and cognitive outcomes relative to their novice peers, including a more sophisticated understanding of the process of scientific research. Students also described the trajectories by which they developed not only the intellectual skills necessary to advance in science, but also the behaviors and temperament necessary to be a scientist. The findings suggest that students benefit from multi-year UR experiences. Implications for UR program design, advising practices, and funding structures are discussed.

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Benefits of long-term UR?

Good technicians → (time) independent scientific thought

H. Thiry *et al*.

**Table 6.** Frequencies of Thinking and Working Like a Scientist codes from student interviews[a]

| | Novice students | | Experienced students | |
|---|---|---|---|---|
| Code | *n* | % of novices | *n* | % of experienced students |
| Gains in data-collection skills | 27 | 93 | 44 | 100 |
| Gains in data analysis and interpretation | 12 | 41 | 28 | 64 |
| Gains in problem solving | 13 | 45 | 42 | 95 |
| Gains in figuring out the next steps of an experiment | 3 | 10 | 12 | 27 |
| Gains in understanding experimental design | 4 | 14 | 22 | 50 |
| Gains in identifying a research question | 1 | 3 | 7 | 16 |

[a]Novice students: $n = 29$; experienced students: $n = 44$.

**Table 7.** Individual item means and SDs for URSSA Personal/Professional Gains scale[a]

| Item. How much did you gain in the following areas as a result of your most recent research experience?[b] | Novice students | | Experienced students | | All students | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| Confidence in my ability to do research | 2.82 | 1.1 | 3.38 | 0.68 | 3.26 | 0.81 |
| Confidence in my ability to contribute to science | 2.75 | 1.0 | 3.32 | 0.78 | 3.19 | 0.87 |
| Comfort in discussing scientific concepts with my research mentor | 3.18 | 0.60 | 3.40 | 0.82 | 3.33 | 0.76 |
| Comfort in discussing scientific concepts with other research students | 2.85 | 0.84 | 3.45 | 0.69 | 3.31 | 0.76 |
| Comfort in working collaboratively with others | 3.09 | 0.70 | 3.64 | 0.57 | 3.47 | 0.65 |
| Confidence in my ability to do well in future science courses | 2.98 | 0.94 | 3.26 | 0.79 | 3.19 | 0.83 |

[a]Novice students: $n = 29$; experienced students: $n = 44$. Overall scale mean = 3.23; overall SD = 0.72.
[b]1 = no gain; 2 = a little gain; 3 = good gain; 4 = great gain.

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## Goals of our project

- To determine how a multi-year, curriculum-based undergraduate research experience (MY-CURE) impacts student learning

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•CURE model is scalable and non-selective

•Student base: Sophomore to senior geology majors; largely first generation; mean ACT 21.8

| **Location** | **College-going fraction** | **Adults with Baccalaureate degree only** | **Adults with graduate or professional degree** |
|---|---|---|---|
| McDowell Co., WV | 36.8% | 4.3% | 2.0% |
| Mercer Co., WV (Concord U. home) | 52.6% | 10.7% | 5.7% |
| Raleigh Co., WV | 48.8% | 9.6% | 5.8% |
| Wyoming Co., WV | 50.4% | 5.5% | 3.8% |
| **West Virginia average (ranks $50^{th}$)** | **59.3%** | **10.6%** | **6.7%** |
| **United States average** | **68.3%** | **17.6%** | **10.3%** |

*Source: WV Higher Education Report Card, 2010; American Community Survey Briefs, 2011; and Concord University McNair Scholars office

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With respect to known UR benefits, which aspects of a multi-year experience most directly enhances students' knowledge of geology, research process skills, and communication ability?


GEOL 205 Environmental and Applied Geology (Fall) →

GEOL 370 Earth Materials and Minerals (Spring) →

GEOL 380 Structural Geology (Fall) →

GEOL 375 Petrology (Spring) →

GEOL 404 Field Camp (Summer)

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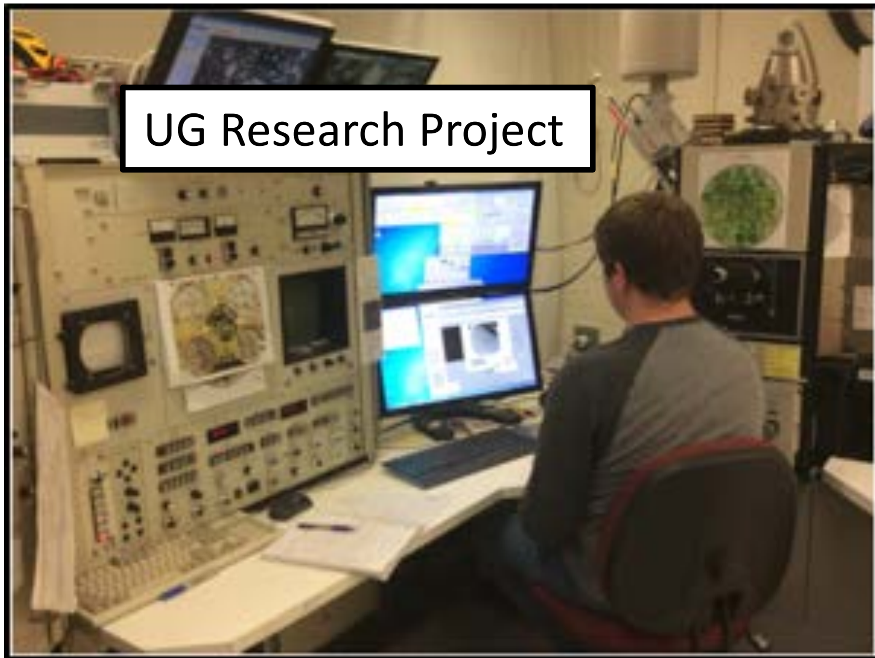
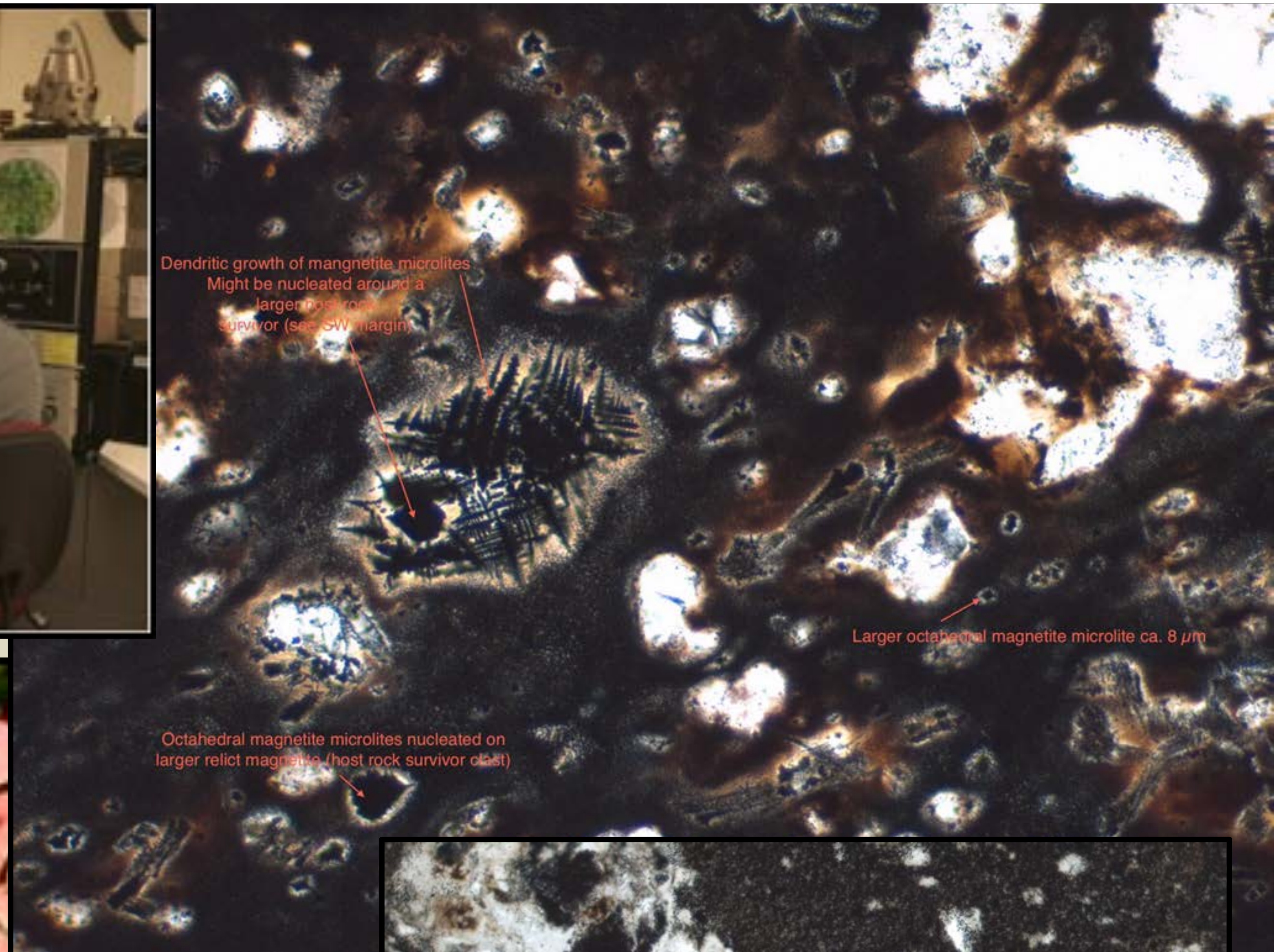
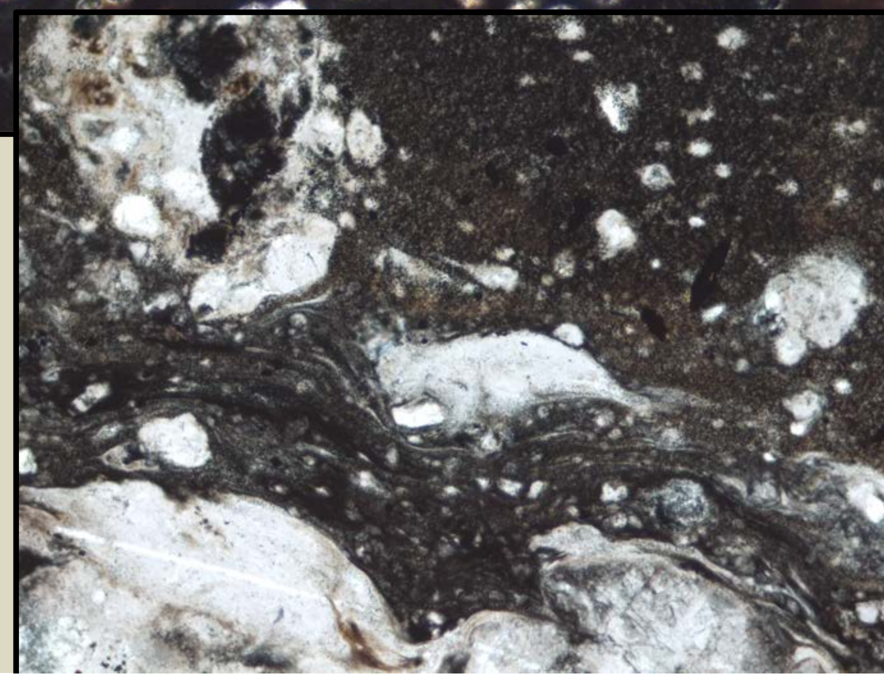
UG Research Project

Seismogenic fault rocks (Homestake shear zone, Colorado)


UG Research Project


Dendritic growth of mangnetite microlites
Might be nucleated around a
Octahedral magnetite microlites nucleated on


BSE
Si
Fe
Na
40 µm
MAG: 600x HV: 14kV WD: 6.3mm



UG Research Project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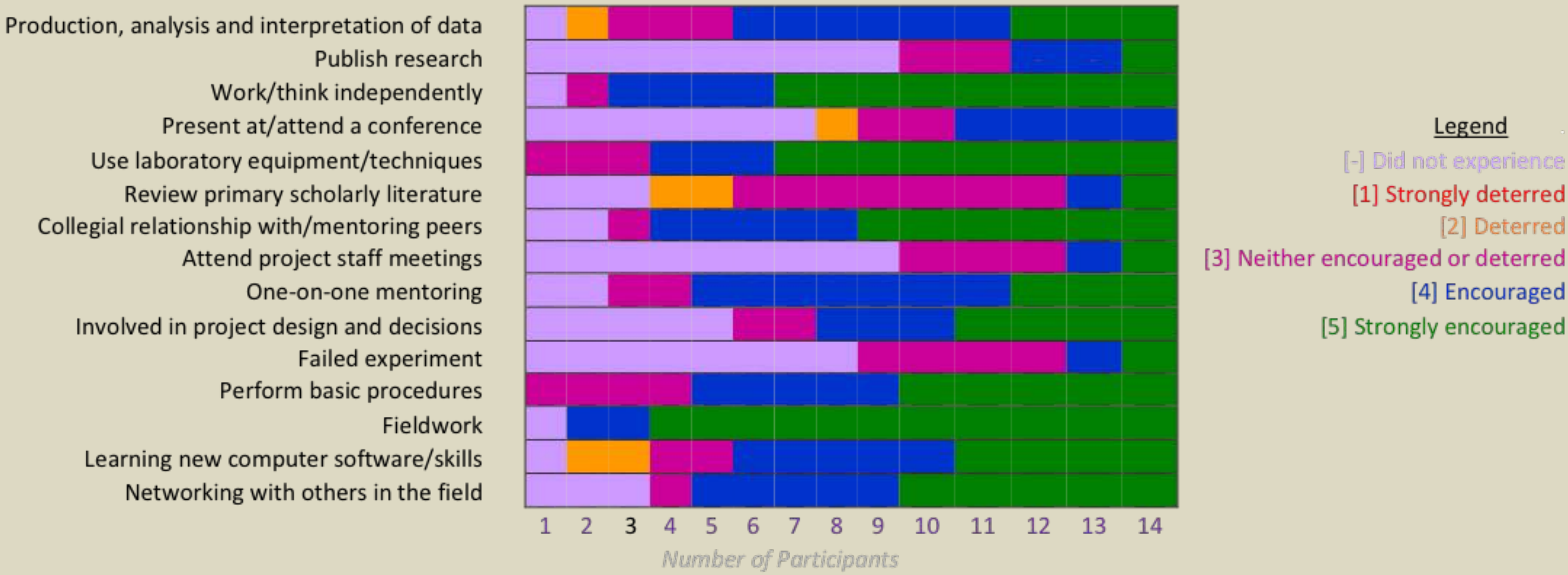
# Assessment

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Assessment

**Summary of Baseline Data from Q-Sort and Interview Transcripts (Feb. 2016):**

**Top attractors to geology:**

1. Collegial relationships with faculty
2. Opportunity to use laboratory equipment (e.g., electron microprobe)
3. Opportunity to engage in fieldwork
4. Concreteness of geology as compared to other sciences
5. Availability of jobs

**Deterrents:**

1. Hours of tedious homework (e.g., in geology, physics, chemistry, math)
2. Mathematics courses required for the degree
3. Time invested in failed experiments/sample preparation

**Expected gains that were not yet observed:**

1. Confidence in ability to be a scientist
2. Interest in graduate school
3. Higher-order research skills

**Ongoing work: Second year of first cohort**:

1. Cohort will continue with research during AY 2016-17 and complete the field camp in summer 2017

Conclusion

**Does Longer Engagement in Undergraduate Research Lead to a More Sophisticated Understanding of the Nature of Science?**